The Learning and Development Process of Pilots During Initial Airline Training

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Abstract

The aviation industry has undergone rapid growth due to technological advancements, globalisation, and economic imperatives. In just over a decade, the Asia-Pacific region grew to become the largest air transport market in the world. In 2018, Boeing (2018) forecasted that 790,000 pilots would be required to meet air transportation demands in the next 20 years. Aviation is a rapidly expanding industry that requires continual and effective means for training pilots. This growth, however, has not always been well managed with recent accidents being attributed to reducing pilot standards within the airline industry. Consequently, the pressure is on airline training systems to ensure new pilots become effective and safe operators.

Despite the emphasis of airlines to improve their training system, little attention has been given to trainees themselves. The focus of regulatory rules and research has been on standards, training tools, and sometimes, on instructors. However, the fundamental aspects of pilots’ learning within airline training programs have received little formal examination. What is seen as desirable for an airline pilot seems to be well understood, yet how trainees become a pilot with those qualities remains unknown.

This study was an exploratory investigation to understand better the learning processes of new pilots entering the airline industry. The three concepts of curriculum theory—intended, enacted, and experienced curriculum—were used to structure the course of this research as lenses to explore the utility of training programs and illustrate the current training curriculum from different perspectives with an emphasis on trainee learning experiences. The aim was to explore how new pilots experience the training programs and some of the difficulties they encountered, specifically, how they learn to become a first officer of an airline.

Through a qualitative case study approach, extensive fieldwork was conducted at two airlines in the Tasman region. Ten pilot trainees undergoing initial first officer training were involved in the study. Three main methods of data collection were used including document reviews, interviews, and observations. Data was analysed using thematic analysis with the assistance of NVivo. The researcher followed each pilot trainee during the entire course of the program during field research as well as remotely. The complex
and dynamic nature of the aviation environment required the researcher to refine the research methods and tools progressively during the study.

The findings led to the construction of a heuristic model called the First Officer Development Model (FODM) that illustrates pilot trainees’ learning during initial training. The FODM allowed the researcher to illuminate the areas trainees found important at specific stages of training. Essentially, the different iterations of the model provide a visual representation of what pilot trainees learned at specific stages of training and how they develop over the course of a training program. For example, learning aircraft type-specific knowledge was challenging for pilot trainees, especially in early phases, when they were trying to understand links within and between systems. However, as training progressed, this area of difficulty quickly reduced. Automation was a problem that evolved over the course of training. While not considered problematic in early phases of training, the ability to understand automation function, and putting it into practice in the aircraft, became increasingly difficult. Other instances of difficulty that occurred in later phases were learning and mastering procedures. Here procedures included becoming skilled at tasks (motor or verbal skills), the ability to correctly sequence tasks, their correct timing, and finally recalling or recognising a trigger to commence a task. Furthermore, the FODM assisted the researcher to view multi-crew operations differently. Here the study synthesised multi-crew to be a complex combination of procedural mastery and social skills as factors working interdependently during flight operations.

The study identified that there is a theory-practice gap between what is taught during training and what is required as part of work. The existing methods of describing learning tend to have a single person focus. While these theories were able to explain some aspects of the study’s findings, they overlook other important factors the pilot trainees need during work. The thesis concludes with a discussion of the potential contributions and limitations of the study, and direction for future research.

**Keywords**

Pilot training; type rating; airline; curriculum; first officer; learning; socio-technical system
Statement of originality

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

(Signed)  

Kassandra Soo Kim Yoke
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<td>Aeroplane (Aircraft category rating)</td>
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<td>AA</td>
<td>Aerial application rating</td>
</tr>
<tr>
<td>AIP</td>
<td>Aeronautical Information Package</td>
</tr>
<tr>
<td>AS</td>
<td>Airship (Aircraft category rating)</td>
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<tr>
<td>ATC</td>
<td>Air Traffic Controller</td>
</tr>
<tr>
<td>ATO</td>
<td>approved training organisation</td>
</tr>
<tr>
<td>ATPL</td>
<td>Airline Transport Pilot License</td>
</tr>
<tr>
<td>ATR</td>
<td>Aerei da Trasporto Regionale or Avions de transport régional; Regional Transport Airplanes (English)</td>
</tr>
<tr>
<td>BEA</td>
<td>Bureau d’Enquêtes et d’Analyses pour la sécurité de l’aviation civile</td>
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<tr>
<td>C</td>
<td>Cadet</td>
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<tr>
<td>CAA</td>
<td>Civil Aviation Authority</td>
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<tr>
<td>CAANZ</td>
<td>Civil Aviation Authority of New Zealand</td>
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<tr>
<td>Cap</td>
<td>Captain</td>
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<tr>
<td>CAR</td>
<td>Civil Aviation Rules</td>
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<td>CASA</td>
<td>Civil Aviation Safety Authority (Australia)</td>
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<td>CASR</td>
<td>Civil Aviation Standards Regulation</td>
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<tr>
<td>CBT</td>
<td>Computer-based training or e-learning</td>
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<tr>
<td>CDU</td>
<td>control display unit</td>
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<tr>
<td>CPL</td>
<td>Commercial Pilot License</td>
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<tr>
<td>CRM</td>
<td>cockpit resource management/crew resource management</td>
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<td>CSE</td>
<td>Cognitive Systems Engineering</td>
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<td>CTL</td>
<td>checked to line</td>
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<td>DE</td>
<td>Direct entry</td>
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<tr>
<td>FAA</td>
<td>Federal Aviation Administration (USA)</td>
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<td>FCLTP</td>
<td>Flight Crew Licensing and Training Panel</td>
</tr>
<tr>
<td>FCOM</td>
<td>flight crew operations manual</td>
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<tr>
<td>FDODAR</td>
<td>Fly aircraft, Diagnose the problem, determine Options, Decide on course of action, Assign duties to crew, and Review</td>
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<td>FER</td>
<td>Flight examiner rating</td>
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<tr>
<td>FFS</td>
<td>Full Flight Simulator</td>
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<td>FIR</td>
<td>Flight instructor rating</td>
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<tr>
<td>FMC</td>
<td>flight management computer</td>
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<td>flight management system</td>
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<tr>
<td>FNPT</td>
<td>Flight Navigation and Procedures Trainer</td>
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<td>FO</td>
<td>First officer</td>
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<td>FODM</td>
<td>First Officer Development Model</td>
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<td>Flat Panel Trainer</td>
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<td>FTD</td>
<td>Flight training device</td>
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<td>Gyroplane (Aircraft category rating)</td>
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<td>GA</td>
<td>General aviation</td>
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<td>GNSS</td>
<td>Global Navigation Satellite System</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>GT</td>
<td>Ground training</td>
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<td>H</td>
<td>Helicopter (Aircraft category rating)</td>
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<td>I</td>
<td>Instructor</td>
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<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
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<td>ICAO</td>
<td>International Civil Aviation Organisation</td>
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<tr>
<td>ILS</td>
<td>Instrument landing system</td>
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<td>IMC</td>
<td>Instrument meteorological condition</td>
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<td>IR</td>
<td>Instrument rating</td>
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<tr>
<td>JAA</td>
<td>Joint Aviation Authority (Europe)</td>
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<td>JCS</td>
<td>Joint cognitive systems</td>
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<td>KLM</td>
<td>KLM Royal Dutch Airlines, (Koninklijke Luchtvaart Maatschappij)</td>
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<td>LCD</td>
<td>Liquid crystal displays</td>
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<td>LL</td>
<td>Low-level rating</td>
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<td>LNAV</td>
<td>Lateral navigation</td>
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<td>LOFT</td>
<td>Line oriented flight training</td>
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<td>Line training</td>
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<td>MAPP</td>
<td>Model of Assessing Pilot Performance</td>
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<td>MCP</td>
<td>Mode Control Panel</td>
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<td>MFD</td>
<td>Multi-function display</td>
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<td>MOS</td>
<td>Manual of Standards</td>
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<tr>
<td>MPL</td>
<td>Multi-crew Pilot License</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration (USA)</td>
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<tr>
<td>ND</td>
<td>Navigation display</td>
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<td>NDB</td>
<td>Non-direction beacon</td>
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<td>NGAP</td>
<td>Next Generation of Aviation Professionals</td>
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<tr>
<td>NTSB</td>
<td>National Transportation Safety Board (USA)</td>
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<tr>
<td>NVFR</td>
<td>Night VFR rating</td>
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<td>NVIR</td>
<td>Night vision rating</td>
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<td>P</td>
<td>Powered-lift aircraft (Aircraft category rating)</td>
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<td>PA</td>
<td>Passenger announcement</td>
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<tr>
<td>PANS</td>
<td>Procedures for Air Navigation Services</td>
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<td>PF</td>
<td>Pilot Flying</td>
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<td>PFD</td>
<td>primary flight display</td>
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<td>pilot in command</td>
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<td>Private instrument rating</td>
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<td>Pilot Monitoring</td>
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<td>Private Pilot License</td>
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<td>procedures training</td>
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<td>Part task trainer</td>
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<td>resolution advisory</td>
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<td>Required Navigation Performance</td>
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<td>regular public transport</td>
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<td>RVAV</td>
<td>Area Navigation</td>
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<td>SARP s</td>
<td>Standards and recommended practices</td>
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<td>SARS</td>
<td>Severe acute respiratory syndrome</td>
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<td>SIM</td>
<td>simulator training</td>
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Kassandra Soo Kim Yoke
Chapter 1. Why study airline pilot training?

1.1. Introduction

There has been enormous growth in commercial aviation, both nationally and internationally, since the end of World War II (Kearns, Mavin, & Hodge, 2017). This growth continues each year despite significant political, social, natural, and economic events that have impacted the use of air transportation (e.g., 9/11, volcanic eruptions, SARS, fluctuating fuel prices, and economic crises). In 2013, Mohamed Elamiri, the Deputy Director of Safety Management and Monitoring of the International Civil Aviation Organisation (ICAO), reported that the commercial aircraft fleet in ICAO member states increased from 18,972 planes to 25,252 planes between the years 2003 to 2012, and that within the next twenty years, there would be a shortage of up to 160,000 airline pilots in the commercial aviation industry (Elamiri, 2013). Four years later, the Boeing pilot and technician outlook, a reputable industry forecast for aviation personnel demand, reported an industry-wide requirement for 637,000 pilots in 2017, and only twelve months later this number had increased to 790,000 (Boeing, 2017, 2018). If the increasing demand for pilots is not met, local and worldwide transportation networks will be negatively impacted (Air Transport Action Group, 2018).

Based on these reports, there is little doubt that the industry is facing a pilot shortage. The topic of pilot shortages and its legitimacy has been debated throughout the years, however, recent news reports about various airlines, both nationally and internationally, having insufficient pilots to meet commercial demands highlight that there is indeed a shortage (e.g., Gall, 2018; Shepherd, 2018). However, it must be clarified that the impact of pilot shortage differs across different regions and sectors. For example, the Asia region is most affected by the pilot shortage due to its enormous growth in air transportation (Santorelli, 2018). In the United States of America, rather than pilot shortages due to economic growth, they face difficulty in replacing pilots leaving the industry (Laboda, 2018). For Australia, the shortage refers to the insufficient number of pilots that meet the minimum requirements to fly and command in commercial airlines. According to an industry report produced by the Australian Aviation Associations Forum (TAAAF), most new pilots entering the industry and holding a commercial pilot license lack the required skills and experience to fly large multi-engine aircraft while those with more flight
experience, for one reason or another, lack the ability to become pilots in command (TAAA, 2018).

According to ICAO (n.d.-b), the key factors contributing to the pilot shortage were related to:

- retirements of current aviation professionals,
- lack of interest and awareness of the younger generation towards aviation professions,
- skilled employees competition with industry sectors,
- insufficient training capacity for aviation professional to meet operational demands,
- outdated instructional methodologies to teach new generation aviation professionals,
- little accessibility to affordable training, and
- lack of uniformity of competencies in some aviation disciplines for transferability.

While there have been several schemes carried out by ICAO to try and address these issues, such as the Next Generation of Aviation Professionals (NGAP) initiative which aimed to “attract, educate and retain the next generation of aviation professionals” (ICAO, n.d.-a), the benefits of such actions have yet to translate into outcomes for airlines. Nonetheless, the various Global Summits organised by NGAP provides a shared platform for discussion amongst key stakeholders at an international level, and to promote interest in people seeking careers in the aviation field (ICAO, 2018). In terms of training, ICAO had created the International Pilot Training Consortium to address pilot training issues and standardisation through industry-wide collaborative efforts (ICAO, 2013).

The cost of training and the hiring freeze in aviation market in previous years has also deterred many aspiring pilots from the industry and discouraged many others from considering the aviation field as a viable career path (Delibasic, 2018; Pilot Career News, 2016). Furthermore, interested parties entering university may not be able to afford the tuition fees and loan repayment. For example, a search on the Australian government website (My Skills), a national directory of vocational education and training website, revealed that a Diploma of Aviation to obtain a Commercial Pilot License (aeroplane)
had an average cost of $76125, and that the middle range of salary post-qualification was about $43800 (Department of Education and Training, 2019). While the course is eligible for a loan of up to $77571, the initial debt amount to be paid back, for the 2017–2018 income year, was $55874. Compared to other career paths, this illustrates a poor rate for return of training investments. Additionally, Mr Fankhauser, deputy chair of aviation at Swinburne University, Australia, stated that the amount offered by the government loans may not even be enough to cover the full training costs (Delibasic, 2018).

Airlines worldwide are under pressure to ensure that their training programs keep up with this growing demand; however, the burden is more significant for regional airlines than larger carriers. Regional airlines are smaller airlines that are either subsidiaries of larger airlines (e.g., QantasLink in Australia and Mount Cook Airlines in New Zealand) or are independent airlines (e.g., Regional Express Airlines in Australia) that provide air service to remote regions within a country. There are debates relating to the reason why regional airlines are heavily impacted by the shortage. Some say that there is actually no pilot shortage but an issue of poor pay rates, however, recent reports show that reasons much more complex than just remuneration are at play, such as quality of life (e.g., Lutte, 2018; Valenta, 2018). Further, the recruitment of regional airline pilots by larger carriers such as Emirates, Qantas and Air New Zealand (Gall, 2018; Shepherd, 2018; Zillman, 2018) adds additional pressure for regional airlines to recruit more pilots and conduct more training to meet the demands of new and existing flight operations. Because pilot training at airlines and commercial flight operations are often linked, there are limits to how much time and resources can be allocated to training before losses to airline productivity occur. One reason for this limited resource is due to the competing demands between the organisation as a revenue-generating company and the training system of the airline (Telfer & Moore, 1997). Thus, airline training managers face the challenge of determining how to improve existing training programs, within the limits of training budgets, in order to maximise training effectiveness.

1.2. **Industry challenges: Pilot shortage and safety concerns**

The expansion of commercial flights worldwide has led to a need for more pilots in the aviation industry, and this demand has resulted in regional airlines hiring pilots with less flight experience than was previously required (Kearns & Sutton, 2012). In some airlines,
low experience pilots or *ab initio* cadets have been hired and trained straight into the airlines; however, this practice is still not the conventional recruitment method for most regional airlines (Orlady, 2010). What many airlines face today is the challenge of ensuring their training programs can train pilots with different experience levels than previously. Furthermore, these new pilots must be able to maintain current safety standards as they replenish the supply of experienced pilots who will retire in the coming years (Belayneh, 2017).

The aviation industry is complex and multifaceted, involving different types of professionals working as teams and using a wide range of intricate, highly automated machines. These professionals include aircraft engineers, air traffic controllers, and airline pilots (Harris, 2013). Together they work as part of what is called a complex socio-technical system, where human and machine must interact to perform complex tasks (Harris, 2013; Hollnagel & Woods, 2005; Strauch, 2017a). Typically, industries with complex socio-technical systems are hyper-vigilant about safety, as repercussions are significant when something goes wrong (Bozzano & Villafiorita, 2010; Flin, O'Connor, & Crichton, 2008), and failures can result in tragic events that are remembered by civilians and practitioners alike (e.g., the terrible runway collision accident at Canary Island involving two Boeing 747 aircraft, resulting in 583 fatalities).

Though the commercial aviation industry is considered complex, it is also an “ultra-safe system” where accidents are estimated to be below one per 1,000,000 safety units (Amalberti, 2001, p. 111). In such ultra-safe systems, accidents are unlikely to occur, and if they do, it is generally a result of a combination of factors rather than a single cause. Another feature of ultra-safe systems is their resistance to change, and if change does finally transpire, it is almost always additive, meaning that existing protocols are rarely removed (Amalberti, 2001).

Recent aircraft accidents, specifically among smaller regional airlines, have generated significant interest in improving safety procedures and standards. For example, the 2009 crash of Colgan Flight 3407 instigated a wave of investigations into regional airlines in the United States and globally (Federal Aviation Authority, 2013a; The Official Committee Hansard, 2010). The accident investigation by the National Transportation Safety Board highlighted several issues, including pilot selection, training, fatigue, and crew communication (NTSB, 2010). In response, the United States Congress enacted
legislation to increase the prerequisite number of flying hours for first officers from 250 to 1,500 (Federal Aviation Administration, 2013a). Whether this increase in flying hours results in safer flights or better performance has yet to be adequately explored (Todd & Thomas, 2013b).

In 2010, the Australian government had also conducted a review of aviation safety practices in response to the global effort to improve aviation safety in the aftermath of the Colgan accident. A Senate inquiry revealed concerns that pilot standards in Australia slipping and would worsen as the demand for pilots increased (The Official Committee Hansard, 2011). Despite the steady overall trend towards greater aviation safety (IATA, 2018), there was still some apprehension about potential adverse effects of meeting flight operation demands and training quality. Included in the recommendations of the Senate’s report was the imperative to ensure that airline pilot standards are maintained and that pilots are adequately prepared for both routine and unforeseen situations.

1.3. Reviewing current training methods
Advancements in aircraft technology and a growing demand for pilots contribute to the need for regulators and airlines to ensure that pilots are provided adequate training to prepare them for entry into the aviation workforce (Kearns, 2010, 2017; Todd & Thomas, 2013a). However, before any changes are made to training programs, an analysis of the current state of training should be conducted to ensure that any changes will be beneficial, or if other interventions are required (Kearns, 2010; MacLeod, 2001).

Traditionally, pilot training in Australia begins with individuals conducting *ab initio* training (basic flight training) at flying schools within general aviation. Here general aviation is seen as an extensive category of civil aviation consisting of both commercial and private operations; such as initial pilot training, recreational flying, agriculture, and search and rescue, to name a few. Pilots in general aviation usually fly aircraft below 5700kg maximum take-off weight, a much smaller aircraft when in contrast to aircraft used by airlines in this study, which is 35,000kg. Typically, new pilots will undergo general aviation training to obtain their pilot license and continue to work there as a flight instructor or as a charter pilot, gaining valuable flight experiences, before entering commercial airlines (Mavin & Murray, 2010). After joining regional airlines, these pilots accrue valuable flight experience by flying for extended periods alongside more
experienced airline captains, before being promoted to the captain position themselves (Beaumont, 1997; Mavin & Murray, 2010). However, increasing demand for pilots has reduced this form of on-the-job training. This means that young pilots within regional airlines now tend to have less experience and fewer opportunities for on-the-job training, yet they are being promoted to airline captain sooner than they would have been in the past (Kearns & Sutton, 2012; Todd & Thomas, 2013b). While flight experience as defined by hours is not an accurate measure or indicator of better performance (Todd & Thomas, 2013b), the process of learning still not sufficiently understood to identify what leads to the development of a proficient first officer or captain. Furthermore, recent accidents have suggested current training syllabi may not be meeting the current needs of pilots to prepare them for the realities of work (Mavin & Murray, 2010; Strauch, 2017a; Wood & Huddlestone, 2006). Nonetheless, as a means of mitigating gaps in pilot experience and the pilot shortage, some regional airlines in Australia have implemented cadetships or even set up their own training programs to attract new pilots and offer opportunities for them to gain the types of experience that the airlines require (Chong, 2018; Frawley, 2018).

It should be noted that *ab initio* training and airline training are two fundamentally different types of training (Dahlström, 2002). While airlines have invested interest in ensuring pilots are trained well, they are often not involved during the early stages of training (i.e., *ab initio*). *Ab initio* training involves training to achieve the requirements for licenses required for employment in civil aviation (e.g., obtaining commercial pilot licenses), whereas airline training includes training to maintain skills or develop new competencies (e.g., initial company training, conversion training, upgrade training, and recurrent training). Hence, it is only after pilots have been successfully recruited into airline do they start formally investing company resources into the pilot’s training.

Training is one of the major expenses made by airlines, but little has been spent on researching and teaching aircrew members how to learn the material effectively (Gebers, 1997). In a recent review, Smith (2016) revealed that for regional airlines, the estimated cost for a non-completion was $20345, and the cost for one additional training event was $1336. While these findings were based on American airlines, as no data was available for the Tasman region, their estimates show that training failure or retraining events are a major cost to airlines, not just monetary but also time-wise. Therefore, the need to
ensure current training methods can improve pilot learning is paramount. While acknowledging the possibility that pilot trainees from the recruitment process may be unsuitable for pilot work (MacLeod, 2001), it is still expected that their perspectives can also offer interesting insights into the current state of training.

There is a plethora of research into specific aspects of pilot training, such as efficacy of simulator use (e.g., Burki-Cohen, Soja, & Longridge, 1998; Burki-Cohen, Sparko, & Bellman, 2011; Dahlström, 2008; Dahlström, Dekker, van Winsen, & Nyce, 2009; Sparko, Bürki-Cohen, & Go, 2010), crew resource management training (e.g., Helmreich & Foushee, 2010), automation use (e.g., Strauch, 1999, 2017a, 2017b), pilot selection and recruitment (e.g., Martinussen, 2016), and pilot assessment (e.g., Flin et al., 2003; Mavin, 2010; Mavin, Roth, & Dekker, 2013). What is lacking is the detailed investigations into the process of training from the beginning to the end of a particular training program. While there are books and suggestions for conducting training (e.g., Henley, 2003; Kearns et al., 2017; Koonce, 2002; MacLeod, 2001; Telfer, 1993; Telfer & Moore, 1997), the actual trainee experience is largely unexplored.

1.4. Understanding learning during training

An often overlooked but crucial aspect of any training is the concept of learning. This is not to say that training programs do not consider learning outcomes—indeed, learning objectives, or competencies, are central to the design of all pilot training programs. Instead, what is often disregarded is the actual process of engagement by pilots that lead to learning during training.

While a training program may be based on certain knowledge paradigms (e.g., behaviourism, cognition, humanistic) rooted in particular beliefs and understandings about how learning takes place, how training practices are experienced by the learners themselves has received little attention in general (Billett, 2009), and less so in aviation. There are many texts about pilot training in aviation (e.g., Henley, 2003; MacLeod, 2001; Telfer & Moore, 1997); however, these texts often writes about the learner, not from the perspective of the learner. Furthermore, previous studies suggest that distinct forms of learning or developmental change occur as pilots accrue work experience, but the process that leads to this change is not yet understood (Mavin & Roth, 2014).
Telfer and Moore (1997) stated that understanding a learning process should include not just the outcome of training and instruction, but also consider what occurs before and after training programs. They explained that trainees, instructors, and organisations come with certain “baggage” or presage that can influence an instructional setting. For example, how pilots learn during training are affected by their age, pilot experience, abilities and personalities; instructors have similar influences that shape their assumptions on how to teach and instruct. Organisations, on the other hand, determine the resources available for the training program. This holistic portrayal of understanding a learning process is similar to conceptualisations of a workplace curriculum espoused by Billett (1996, 2006a, 2011).

Billett (2006a), borrowing concepts used within traditional curriculum theories (i.e., developed within educational institutions), conceptualised the workplace curriculum using the intended, enacted and, experienced curriculum. He further argues that due to the crucial role workplaces have in the learning and development of people throughout their careers, workplaces should be viewed as a legitimate learning environment. However, Billett (2006a) stated that learners have a much larger influence of a learning context than Telfer and Moore’s (1997) notion of learner’s presage. The influence of an individual’s agency and subjectivity when engaging with the environment should be understood when trying to understand how they learn the skills required for work.

In this thesis, the concept of curriculum was used to explore the learning experiences of pilot trainees going through their initial airline training program. The airline training program is understood to be a legitimate learning environment and was conceptualised as a workplace curriculum (Billett, 2006a). By conceptualising pilot training programs as a curriculum, learning must be understood in view of the relations between the people who organise and carry out the training process and the learners who have their own goals and needs that influence how they engage with the training environment (Billett, 2006a). Learning, defined as the permanent or semi-permanent changes in how individuals think and act, occurs whenever people engage in or think about a task more actively than just the mere execution of task (Billett, 2004b). Therefore, learning experiences do not just occur in specific settings, although some instances or interludes, such as training programs, provide more opportunity for richer learning outcomes (Billett, 2004b).
aviation, these interludes include multiple settings such as ground school, simulator lessons and real aircraft training (Lehrer, 1993).

As the goal of training or any learning experiences is to develop the required knowledge, skills, concepts, attitudes, or habits for work (Lehrer, 1993), it would be prudent to have a closer look at how one might understand actual pilot work. This thesis used the theory of joint cognitive systems (Hollnagel & Woods, 2005) and functional systems (Luria, 1973) to better understand pilot performance during aircraft operations (e.g., Hutchins, 1995; Roth, Mavin, & Munro., 2015; Soo, Mavin, & Roth., 2016). The joint cognitive systems theory adopts a perspective that cognition is situated, embodied, and distributed across the environment (Hutchins, 2010; Roth & Jornet, 2013). This method of understanding cognition stresses that all parts of the resultant cognitive system have a mutual dependence with each other and is only fully understood by accounting for their relations to other parts and to the whole system (Hollnagel & Woods, 2005; Weber & Dekker, 2017).

All performances are, therefore, an emergent property of the joint cognitive system (Weber & Dekker, 2017) that are influenced by the components within it that can change due to various factors or influences (Travieso, 2007). From a training perspective, to ensure safe performances, the only component that can be enhanced is the trainee. Therefore, examining the process of how one learns to become part of the functional system of aviation, in other words, understanding how a new pilot learns to become part of the airline pilot workforce that is understood to be a joint cognitive system, is important. The understanding of pilot work using a system approach leads to learning theories that emphasise situational contributions (Billett, 2006b). However, an individual’s role in learning processes should not be discounted as they shape how they engage with the learning environment (Billett, 2006b; Telfer & Moore, 1997).

In summary, this thesis used Billett’s conceptualisation of a training curriculum and the importance of individual agency (2006a, b) and, the joint cognitive systems perspective (Hutchins, 1995; Soo et al., 2016), to conceive learning as being more than just the pilot acquiring knowledge and skills for first officers, but also the actual process of becoming part of a functional system. The argument is that this way of understanding learning can improve current pilot training systems by showing those responsible for designing training programs the processes of learning and development a pilot trainee goes through.
1.5. **Scope and focus of the study**

The current study forms part of a larger Australian Research Council (ARC) Linkage Project (LP140100057) investigating learning and development of pilots at two different stages in their airline careers. The first stage is when pilots are initially recruited into airlines as first officers, and the second stage is when first officers, after gaining experience within airlines, are promoted to captains. This trajectory is typical across all airlines and is considered a natural progression for pilots unless they move to different airlines or change careers. This thesis focuses only on the first stage—initial training for the position of first officer.

Due to the increasing demand for pilots, for reasons outlined in earlier sections, airlines—especially regional airlines—are under pressure to ensure that their training systems can cope with the need to train pilots in a shorter period of time or make current programs increasingly effective while remaining within training budgets. The current study was one of the many initiatives conducted by partner airlines to investigate how they could improve their current training systems. Rather than imposing changes to training holistically (e.g., including more sessions or more content within the existing time frame), both the research team (in this study was the researcher and supervisor) and training managers agreed that a thorough review of the current training system should be conducted followed by recommendations for changes based on findings.

Accordingly, this study investigated existing initial training programs within two regional airlines (Airline A and Airline B), which included a *type rating*, and *line training*. Here the type rating included specific courses on aircraft engineering systems, aircraft performance, crew resource management, procedural training in low fidelity simulators (part task trainers and flight training devices), and finally, training in a high-fidelity, full flight simulator on normal and non-normal procedures. Airline A recruited pilots who had work experience in general aviation, while Airline B recruited pilots who had completed a dedicated university program that streamlined them into airline employment (training was based in commercial pilot licensing standards). On completion of type rating, pilots are licenced to fly the particular aircraft type (e.g., DHC8-400 or ATR72-500), though further training is required in the form of line training to familiarise the pilot with the real aircraft, airline procedures, and the normal working environment. On completion of line training, pilots are assessed as competent to join the airline pilot workforce.
1.5.1. **Aims and research questions**

The study aimed to explore current training practices, as experienced by pilot trainees, in order to describe and suggest improvements to training, so that future practices are based on empirical evidence. The overarching research question for this study was:

How effective are current airline training systems at preparing new pilots to become first officers?

The contention was that little is known about how airlines implement training and that there is potential that there is a disconnect between pilot needs and current methods of training (Kearns et al., 2017; Mavin & Murray, 2010; Strauch, 2017a; Wood & Huddlestone, 2006). To be clear, this study was not an evaluation of training methods, which seek to identify if trainees have achieved learning outcomes as per syllabus; rather it looks at training effectiveness, where the objective is to explain why training did or did not achieve in a specific outcome (Kraiger, Ford, & Salas, 1993). Specifically, this exploratory study aimed to identify areas of difficulty that trainees encounter and to understand why they were having issues.

This study was undertaken based on the premise that improving the effectiveness and efficiency of training programs from a pilot trainee’s perspective, has the potential to improve pilot learning, therefore limit pilot failure during training and reduce the cost of retraining. To begin the journey of understanding how new pilots become first officers, it is important to know what the current training system is and what issues pilots have to overcome on their training journeys. To this end, the following sub-questions were formed:

**SQ1**—What is the nature of current training programs for training new first officers?

The purpose of this question was to describe in detail current initial training processes as planned by training managers. The aim is to identify the *intended* curriculum.

**SQ2**—How is the training program implemented during the course of training?
The purpose of this question was to illustrate how instructors enact the training curriculum, with an emphasis on methods and tools used.

SQ3—How do pilots engage in the current provisions for training and development?

The intention with this question was to identify the experienced pilot training curriculum, across an entire training program, from the perspective of the pilot. Responses to this question identified pilots’ experiences during training and any struggles they encountered. As learning is attributed to this level of curriculum, additional focus was given when answering this question. The final research question (SQ3) was the main focus of this study.

By reviewing the nature of the current training program (intended curriculum), how it is implemented (enacted curriculum), and ways that pilots engage in it (experienced curriculum), an understanding of the current state of training was recorded. This was achieved by identifying the challenges faced by new pilots entering airlines and interpreting these challenges according to contemporary theories of learning and system performances. Recommendations for improvements in training to better prepare pilots to operate in complex socio-technical environments are proposed based on the study’s findings.

1.6. Overview of thesis

This thesis consists of six chapters. Chapter 1 provides the rationale for and aim of the study. It also defines the boundaries of this thesis, which is part of a larger research project. Chapter 2 begins with a description and overview of the aviation context. It reviews the history of aviation regulation and training before summarising current airline training approaches. Using curriculum theory developed in educational and vocational research, it argues that researching training programs, through the lenses of intended, enacted, and experienced curriculum will reveal the difficulties encountered by trainees during their first officer training program.

Chapter 3 describes the theoretical framework and research approach of the qualitative case study adopted for the study. It outlines the methods of this study and details the procedures that were carried out during data collection and analysis, and also the steps
that were taken to ensure the credibility of the study, including issues of ethics, and methods of validity and reliability for studies of this nature. Chapter 4 presents the findings of the study, including short narratives of pilot learning experiences, key issues experienced by trainees during training, and a model that describes the development of first officers.

Chapter 5 is the discussion of the findings and their implications and recommendations for airline partners and researchers. It also includes a discussion of the strengths and limitations of the study and potential directions for future research. The thesis concludes with Chapter 6, which summarises the main points of the thesis.
Chapter 2. Airline pilot training as an educational curriculum

2.1. Introduction
Chapter 1 addressed the purpose of this thesis and why an in-depth review of current training practices was required. The chapter developed the argument that little is known about which methods are most effective to conduct pilot training and how to understanding pilot learning during training. Chapter 2 will elaborate upon the argument that little consideration has been given to the learners themselves in the training process, even though they are the true determinants of training success.

It begins by briefly introducing the United Nations’ aviation regulation agency, the International Civil Aviation Organisation (ICAO), and its role in setting international standards for licensing of aviation personnel. It then outlines how these standards are implemented and enforced in the countries where this study took place—Australia and New Zealand. The argument of that section will be that to improve aviation safety, the focus of research should not only be on examining current licensing standards, but also on how those standards are achieved by those experiencing them; in other words, there should be some focus on the perspective of pilots. Knowing how pilots progress through the various stages of training as they can reveal different ways of learning that have not been considered by training managers.

The next section is an overview of the history of pilot training and the major influencers that played a role in transforming how it is conducted. Here, it is highlighted that despite significant changes to pilot work and training tools arising from technological advancements, the structure of pilot training remained relatively the same since its inception in World War I. While there has been the addition of procedures, checklist, crew resource management training and increased use of simulators in the recent years, the focus of training remains centred on flight manoeuvre techniques, emergency recovery practice, and single-pilot operations.

This is followed by a review of the current issues faced by the aviation industry and concludes with the justification for the current study. In this study, a curriculum theory
was proposed to provide a structure for analysing current training systems, and the concepts of intended, enacted, and experienced curriculum are introduced as categories of processes to be understood. At this stage, the case is made that the *experienced curriculum* has received little attention in existing aviation literature, which was why it was chosen as the focus of this study.

### 2.2. International Civil Aviation Organisation

The main international regulatory agency for aviation is the International Civil Aviation Authority (ICAO), an active and influential sovereign body of international civil aviation. As of 2018, 192 countries—or Contracting States—are members of the ICAO and agree to adhere to the rules of its Convention. As the ICAO holds such importance in the civil aviation sector, it is appropriate to provide an overview of how it was formed and the role it plays in determining standards for pilot training and licensing. Unless otherwise indicated, the information in this section was sourced from the ICAO website.

The aims of the ICAO are to “achieve the sustainable growth of civil aviation” and “to serve as the global forum of States for International Civil Aviation”. The ICAO consists of an Assembly, which includes all representatives from Contracting States and is the sovereign body of the ICAO; a Council, which is an elected group of members from 36 States that meet to discuss and formulate various standards and other aviation training provisions; and a Secretariat. The Assembly is in charge of considering proposals for amendments to the Convention to ensure that it remains up-to-date with changes in the field of civil aviation. In terms of training, ICAO sets the standards of training and provide provisions for States to assist in developing their own rules and regulation. It is interesting to note that any decisions made during meetings are decided by a majority vote. Even though evidence is discussed during meetings, standards are ultimately made through consensus, rather than on research evidence (Kearns et al., 2017).

#### 2.2.1. Standards and recommended practices (SARPs)

There are four types of standards and provisions in the Convention that are monitored by ICAO: Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS), Regional Supplementary Procedures (SUPPs), and Guidance Material. Of these, the most important provisions are SARPs, which standardise function and performance requirements for air navigation facilities and services and play a valuable
role in establishing and influencing international aviation safety standards (Kearns et al., 2017).

SARPs are adopted by Contracting States, sanctioned through national transport regulations, and enforced by relevant national authorities (the role of national authorities will be discussed in the following section). The ICAO’s definitions of “Standard” and “Recommended Practice” were officially put into force after the 21st Assembly in 1974 and continue to be used today. The definitions are provided below (ICAO, 2011a):

**Standard:**

Any specification for physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognized as necessary [italics added] for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38 of the Convention.

**Recommended Practice:**

Any specification for physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest [italics added] of safety, regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention. States are invited to inform the Council of non-compliance.

SARPs for various civil aviation issues are written into Annexes. Currently, the ICAO manages over 12,000 SARPs contained in 19 Annexes to the Convention. For example, Annex 1 of the Convention contains the SARPs for pilot licensing. Within Annex 1, Chapters 1, 2 and 6 pertain to pilot personnel. Chapter 1 contains a list of definitions for the terms used in the document and the general rules concerning all types of aviation licenses. Chapter 2 specifically covers licenses and ratings for pilots. Chapter 6 states
medical provisions for licensing. As pilot licensing in Contracting States is based on the SARPs in Annex 1, all States should, in theory, have similar training and licensing pathways depending on license type.

One of the ICAO’s main tasks is to minimise differences in licensing standards between States, and ensure standards are relevant to current practices and potential future developments. When Contracting States submit proposals for SARP amendments or the creation of new SARPs, the Council and relevant committees within the ICAO follow a set protocol for reviewing these proposals and seek assistance from specialised working groups if required. Over the years, there have been several amendments and additions to the ICAO’s SARPs and related manuals (i.e., accompanying document that supplements SARPs). These changes have led safer flight operations by means of standardisation and creating awareness amongst Contracting States. For example, after World War II, the ICAO identified human factors as the causal reason for some aircraft accidents, and improvements in safety could be achieved by human factors training for pilots (ICAO, 1998). This led to the 1986 adoption of Resolution A26-9 on Flight Safety and Human Factors, which raised awareness among States of the importance of human factors issues in aviation. In 1989, human factors training requirements were added to Annex 1, and in 1996, the ICAO released a SARP recommending human factors training for airline flight crews (ICAO, 1998). Soon afterwards, the Organisation published a manual containing a compilation of publications on human factors pertinent to airline operational training (see ICAO, 1998).

2.2.2. **Bringing international standards to a local context**

The bridging of international standards to a local context is done through the government of Contracting States, which often establishes a specific authority to manage and ensure compliance of the relevant parties to international standards. The related aviation authorities of this study are Australia’s Civil Aviation Safety Authority (CASA) and the Civil Aviation Authority of New Zealand (CAANZ). Both aviation authorities have dedicated websites which, amongst other aviation related news and report, provide information pertaining to aviation licensing and compliance to ICAO. A brief background of both organisations and the roles they have played in establishing and maintaining pilot standards within their respective countries is provided in the next section. Unless
otherwise indicated, the information in the sub-sections was sourced from CASA and CAANZ websites, respectively.

Australia was among the 52 States that signed the Chicago Convention on December 7, 1944. In 1988, the **Civil Aviation Act 1988** was established for the purpose of managing issues within the field of civil aviation, specifically those relating to safety and regulation. To carry out this role, the Act stated that an authority known as the Civil Aviation Safety Authority (CASA) would function as an independent statutory authority responsible for enforcing safety regulations for civil air operations within the Australian territory, and the operation of Australian aircraft in international territories. CASA is responsible for issuing civil aviation certificates, licenses, registrations, permits and maintaining safety oversight across industry management. CASA is also required to review national and international safety developments, monitor the safety performance of the aviation industry, and ensure that the aviation industry within Australia acts in accordance with any additions and amendments made to existing regulations.

Recently, CASA instigated a regulatory reform to make Australian regulations more aligned with the SARPs published by the ICAO. As part of this process, CASA updated and reorganised existing regulations into “Parts” for easy access and use, and in accordance with ICAO conventions (CASA, 2018c). To further align themselves with the latest international practices, as of September 2014, it was decreed that all CASA flight crew qualifications must be completed using a competency-based training standard, before licenses, ratings, or endorsements could be issued (CASA, 2009). That is, CASA took a stance in line with ICAO that assessment of aviation personnel was to follow the competency model of education. An interesting point is that since the adoption of competency standards, there have been two publications coming from Australia that is critical of the use of competencies for pilot training (Franks, Hay, & Mavin, 2014; Kearns et al., 2017).

CASA published the Manual of Standards (MOS), a document which contains technical details of the contents of the **Civil Aviation Standards Regulation 1998** (CASR, 2018b). CASR that are relevant to regional airlines and current/future pilots working in airlines are Parts 60, 91, 119, and 121 under Flight Operations, and Parts 61 and 141 or 142 under Flight Crew Licensing (CASA, 2018a). In Australia, all training for a Part 61 license, rating, or endorsement must be undertaken by the holder of a Part 141 or Part 142
certificate—like the airline in this study. While the MOS prescribes what trainees need to achieve and CASA may provide guidance or recommendations, it is up to individual training organisations to decide how they will meet MOS training objectives (CASA, 2009).

In New Zealand, the New Zealand Minister of Transport is responsible for ensuring that New Zealand remains compliant with the ICAO standards as agreed upon in the Convention. The New Zealand Civil Aviation Act 1990 came into force on September 1, 1990, with the purpose of promoting and maintaining aviation safety through the establishment and maintenance of operational rules and responsibilities and ensuring that New Zealand complied with the Convention. The Act led to the 1992 establishment of the Civil Aviation Authority of New Zealand (CAANZ), a licensing authority and Crown entity that is the responsibility of the Minister of Transport. According to CAANZ, all aviation organisations and personnel, including pilots, are “trainees” in the New Zealand civil aviation system and have a shared responsibility for maintaining aviation safety and security. Each participant is responsible for meeting at least the minimum standards prescribed within New Zealand’s Civil Aviation Rules (CARs). As in Australia, the airline in this study conforms to the standards of licensing are also listed in Part 61. Again, while regulators may offer advice, it is up to training organisations to decide how to conduct training.

CASA and CAANZ have various roles that they play to ensure the safety and efficiency of the aviation sector of their country. They ensure that SARPs for pilots licensing, aircraft registration, training organisation licensing, amongst other responsibilities, listed as CASR or CAR, are implemented by the relevant parties. Pertinent to this thesis are the sections related to pilot licensing and training standards and are discussed next.

2.2.3. Pilot licensing

One of the earliest standards for pilot licensing was the Pilot’s Flying Certificate for Flying Machine Used for the Purposes of Public Transport. This Certificate was established according to the Annexes from the Paris Convention of 1919, which was the predecessor of the current Chicago Convention (Dow & Defalque, 2013). Alongside other requirements, such as a medical certificate, the Pilot’s Flying Certificate was needed to obtain a pilot’s license. The Certificate was obtained by passing a series of difficult tests.
within a one-month period. These tests were practical assessments of a person’s ability to fly a single pilot aircraft (Dow & Defalque, 2013; Kearns et al., 2017). At that time, there were no minimum training hours required to obtain the Certificate; rather, the emphasis was on flying performance, and passing the tests was considered as sufficient proof of ability. By the 1920s, recommendations for experience were introduced, and along with them, the concept of measuring flight hours (Kearns et al., 2017). This led to the formulation of what is termed the traditional approach to licensing, which in turn impacted training requirements and practices.

Today, there are four types of civil aviation licenses, each offering different privileges: Private Pilot License (PPL), Commercial Pilot License (CPL), Airline Transport Pilot License (ATPL), and Multi-crew Pilot License (MPL). All pilot licences have specific authorisations attached. They include licence type, aircraft category, aircraft class and ratings, aircraft design feature endorsements, operational ratings and endorsements, and finally flight activity endorsements (see Figure 2.1 for an example of the CASA authorisations). Depending on the type of flight career pursued, different authorisations are required.

![Figure 2.1](image)

Figure 2.1 Example of a license structure listing CASA authorisations (retrieved from CASA, 2014).
Table 2.1 below further expands some of the specific authorisations that are applicable to airline pilots. For example, all pilots within this study—whether they were new pilots or instructors—held a licence type of CPL or ATPL under Part 61. Additionally, they all had the aircraft category rating of aircraft (A), as opposed to say helicopter (H). Different licenses afford pilots different flying privileges on different classes of aircraft. For example, pilots holding PPL and CPL licenses are restricted to operating as pilots-in-command on aircraft below 5,700 kg. With a CPL, pilots can also act as co-pilot/first officers on larger commercial aircraft. Pilots holding an ATPL may fly high-capacity commercial aircraft above 5,700 kg, such as the Boeing 747. Further, all pilots would have been required to have an aircraft design feature endorsement of retractable undercarriage. The final rating required by all pilots is the instrument rating (IR) with multi-engine endorsement. Here the pilot will also require both 2D and a 3D validation. The IR allows pilots to fly aircraft in instrument meteorological condition (IMC). Basically, it allows the pilot to fly a suitably equipped aircraft in poor weather, and at all times of day and night.

<table>
<thead>
<tr>
<th>Type of authorisation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licence type</td>
<td>PPL, CPL, ATPL and MPL</td>
</tr>
<tr>
<td>Aircraft category ratings</td>
<td>The licence includes at least one category ratings:</td>
</tr>
<tr>
<td></td>
<td>Aeroplane (A)</td>
</tr>
<tr>
<td></td>
<td>Helicopter (H)</td>
</tr>
<tr>
<td></td>
<td>Powered-lift aircraft (P)</td>
</tr>
<tr>
<td></td>
<td>Gyroplane (G)</td>
</tr>
<tr>
<td></td>
<td>Airship (AS)</td>
</tr>
<tr>
<td>Aircraft class</td>
<td>Single-engine aeroplanes</td>
</tr>
<tr>
<td></td>
<td>Multi-engine aeroplanes</td>
</tr>
<tr>
<td></td>
<td>Single-engine helicopters</td>
</tr>
<tr>
<td></td>
<td>Single-engine gyroplanes</td>
</tr>
<tr>
<td></td>
<td>Airships</td>
</tr>
<tr>
<td>Aircraft type rating</td>
<td>Multi-crew aircraft require specific training and ratings (e.g., ATR72- 500, ATR72-600 or DHC8-400)</td>
</tr>
<tr>
<td>Aircraft design feature</td>
<td>Tail wheel undercarriage</td>
</tr>
<tr>
<td>endorsements</td>
<td>Retractable undercarriage</td>
</tr>
<tr>
<td></td>
<td>Manual propeller pitch control (piston engine)</td>
</tr>
<tr>
<td></td>
<td>Gas turbine engine</td>
</tr>
<tr>
<td></td>
<td>Multi-engine centre-line thrust</td>
</tr>
<tr>
<td>Type of authorisation</td>
<td>Example</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Pressurisation system</td>
<td></td>
</tr>
<tr>
<td>Floatplane</td>
<td></td>
</tr>
<tr>
<td>Floating hull</td>
<td></td>
</tr>
<tr>
<td>Ski landing gear</td>
<td></td>
</tr>
</tbody>
</table>

**Operational ratings**

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument rating (IR)</td>
</tr>
<tr>
<td>Private instrument rating (PIR)</td>
</tr>
<tr>
<td>Night VFR rating (NVFR)</td>
</tr>
<tr>
<td>Night vision rating (NVIR)</td>
</tr>
<tr>
<td>Low-level rating (LL)</td>
</tr>
<tr>
<td>Aerial application rating (AA)</td>
</tr>
<tr>
<td>Flight instructor rating (FIR)</td>
</tr>
<tr>
<td>Flight examiner rating (FER)</td>
</tr>
</tbody>
</table>

**Operational endorsements**

<table>
<thead>
<tr>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument rating IR</td>
</tr>
<tr>
<td>Single-engine airplane</td>
</tr>
<tr>
<td>Multi-engine airplane</td>
</tr>
<tr>
<td>Instrument approach 2D</td>
</tr>
<tr>
<td>Instrument approach 3D</td>
</tr>
<tr>
<td>Flight instructor rating (FIR)</td>
</tr>
<tr>
<td>Grade 1 training</td>
</tr>
<tr>
<td>Grade 2 training</td>
</tr>
<tr>
<td>Grade 3 training</td>
</tr>
<tr>
<td>Multi-crew pilot training</td>
</tr>
<tr>
<td>Type rating training</td>
</tr>
</tbody>
</table>

Note: light grey outlines minimum requirement for trainees in this study. Dark grey is additional requirements for instructor requirements.

New pilots entering the airline would then be trained on a specific “type” of aircraft, such as the ATR72-500, ATR72-600 or the DHC8-400 (referred to as the Dash8). As would be expected, all instructors and examiners would already be “type rated”. In accordance with Part 141/142 standards for “approved persons” for training, instructors would also require further operational rating such as flight instructor rating (FIR) before they can train pilots, while flight examiners require an additional flight examiner rating (FER). Finally, airline instructors who are not pilots but are involved in the simulator training for the type rating would have required the “type rating” endorsement.

To obtain the specific licence, authorisations and ratings in aviation, there are generally two approaches: the traditional, hour-based, and the competency-based approach. The PPL, CPL, and ATPL generally follow the traditional hours-based approach to training,
while the MPL uses the competency-based approach. The competencies required to be achieved and how it should be assessed is located within the relevant documents provided by the regulatory organisation (e.g., CASA Part 61 Manual of Standards).

2.2.3.1. Traditional licensing pathway

The traditional hours-based training system, which has established impressive safety records during its long history in pilot training and aviation regulations (Kearns et al., 2017), uses a prescribed number of flight hours as a prerequisite, prior to being allowed to be examined by a flight examiner. As mentioned previously, the use of flight hours as a measure of pilot experience was introduced when Annex 1 was first drafted, and every standard listed in the ICAO (and subsequently CASA and CAANZ) includes a minimum number of hours as a main requirement before any form of license, rating, or endorsement can be issued. It is unclear what these numbers of hours if flight experience were based on, though it is likely that it came from the consensus of those present at the meeting during the drafting of Annex 1.

The traditional licensing pathway generally starts when individuals become new pilots within an approved training organisation (ATO). New pilots are trained in classrooms, aircraft, and sometimes in simulators, if available. For example, in Australia pilots will progress through training to achieve a CPL after approximately 200 hours. However, as the pilots require multi-engine and IR ratings, most pilots will generally have approximately 240 hours prior to being able to fly as a paid pilot in commercial operations (Wikander & Dahlström, 2016). As pilots continue to gain more experience in terms of flight hours, they become qualified to move into roles with increasing levels of responsibility, for example, airline captain. However, to move into the role of captain, a pilot would first need to obtain an ATPL, which requires 1,500 hours of flight experience, as well as complete additional training, classroom-based exams on advanced aeronautical knowledge, and an assessment of flying skills on a more sophisticated aircraft above 5700kg.

The practice of measuring experience and training quality by hours is a convenient approach for regulators, but it may not necessarily be an accurate measurement of pilot preparedness. Todd and Thomas (2012, 2013a) questioned the validity of equalling flight hours to experience and therefore skills that supposedly ensures safe performances. To
test their assertion on whether pilot experience, as measured by total flight hours, influences pilot performances (in terms of technical and nontechnical performance), Todd and Thomas (2012) conducted a field investigation on 302 crew members. Based on their findings, they found no evidence for any systematic differences between low hour pilots and their more experienced colleagues. In a later study conducted across three airlines, Todd and Thomas (2013b) found similar results regarding pilot performance and pilot experience, such that there was no difference between low-hour pilots and cadets when compared to the more experienced entry pilots. Further, with the high levels of fidelity available for modern simulators, flight hours can also be obtained by operating flight simulation training devices, meaning that pilots can obtain certain ratings with little exposure to air traffic control or real-world environments (Kearns et al., 2017).

While simulator training appears to be very well integrated and supported in pilot training (Mavin & Murray, 2010) there have been some critics of its use. As Wikander and Dahlström (2016, p. 176) argue in initial pilot training for the MPL, “to simply replace time in actual aircraft with time in simulators will not provide better training”, specifically, simulator training is no better than actual flight training, and proper planning using instructional systems design and having a dedicated learning management systems must be present to ensure effective learning and training.

These facts raise the question of why there continues to be an emphasis on hours as the main requirement for pilot licensing, and the answer appears to be that “hours are easy”, straightforward and quantifiable method of measurement (Kearns et al., 2017, p. 46). For instance, increasing the number of hours pilots are required to spend on a specific aspect of flight in response to a safety concern offers tangible proof that corrective action has been taken to overcome an issue, but in fact the root cause of the problem may not have been addressed (Kearns et al., 2017). The Colgan Air Flight 3407 accident is a good example of this. According to the United States of America (USA) National Transportation Safety Board (NTSB), who investigated the accident, the probable cause of and, influences to, the accident was the poor handling/recovery of the aircraft by the captain, failure of the flight crew to manage the flight, and the airline’s inadequate procedures in handling icing conditions (NTSB, 2010). In other words, the crash was due to poor training from the airline that led to poor work practices.
However, instead of addressing the issue of poor pilot performance that was cited as the cause of the accident, and possible training issues, there was a change in national standards and license privileges. Following the crash, the USA Airline Safety and Federal Aviation Administration (FAA) Act of 2010 (Airline Safety and Federal Aviation Administration Extension Act, 2010) mandated several new standards for licensing and privileges, amongst them was that for pilots who want to work as first officers (co-pilots) in an airline, they must obtain an Airline Transport Pilot Certificates (equivalent to an ATPL). This requires at least 1,500 flight hours, rather than the previous Commercial Pilot Certificate (equivalent to a CPL) that required only 250 flight hours (FAA, 2013a). Not only does increasing hour requirements prolong the pilot training process without necessarily leading to improved pilot performance, but the repercussions of such changes in standards are also unknown. The root cause of the Colgan crash was not the lack of hours or aeronautical experience. For example, the captain had 3,379 hours and the first officer had 2,244 hours (NTSB, 2010, pp. 7 and 11, respectively). Given the flight experience of the pilots involved were both above the 1,500 hours limit, the effectiveness of simply using hours to mitigate future pilot performance is questioned.

2.2.3.2. Competency-based licensing pathway

In 2000, an ICAO meeting was held with the aim of discussing the future of licensing and training standards (Dow & Defalque, 2013). During this meeting, Annex 1 to the Convention was identified as being “essentially an inventory of knowledge, skill and experience requirements, without specific performance criteria”, with current standards “often constituted an obstacle to best industry practice” (ICAO, 2011b, p. 1). This meeting led to the development of a specialised panel called the Flight Crew Licensing and Training Panel (FCLTP) in 2002 (Dow & Defalque, 2013). The role of FCLTP was to “explore the options and opportunities to address the shortcomings of some current licensing requirements” (ICAO, n.d.-c). During their explorations, the Panel learned that the focus on hours as a requirement for pilot licensing was problematic for several reasons (Kearns et al., 2017). The first was that it was deemed unreasonable for new pilots training to go directly into the airlines, that operate solely in multi-crew environments, be required to have 70 hours of pilot in command (PIC) on single pilot aircraft. The second reason was that an hours-based curriculum was problematic and not necessarily valid; for example, having 1,500 flight hours for ATPL does not necessarily correlate with piloting
competence. It was argued that the challenges and activities performed can vary significantly between pilots as they fly in different contexts and environments (Kearns et al., 2017). Yet, here again, the arguments being made are the difference between the educational systems that train a pilot to competence, verse a system that mandates hours. None of these arguments focus on the learner and how pilots learn.

Based on these findings, the FCLTP recommended the development of an alternative pathway to training that would be more efficient and would not compromise safety, which was the competency-based concept, and the multi-crew pilot license (MPL). The Panel chose to recommend this avenue as opposed to modifying existing requirements for ATPL and CPL for the practical reason that any change in existing licensing standards would have put all 191 Contracting States out of compliance (Kearns et al., 2017).

In the 10th edition of Annex 1 to the Chicago Convention, a definition of the word competency was introduced as the result of the ICAO adopting the competency-based MPL (ICAO, 2011b). The MPL is a new type of pilot license whose requirements are based on pilot performance in multi-crew environments (Wikander & Dahlström, 2016; Dow & Defalque, 2013). This is an important and unique point, because the traditional approach to training (i.e., through CPL) focuses on single-pilot operations, which is a mismatch with how airline pilots work (i.e., always multi-crew). For example, the practice in multi-crew environments is for pilots to work as a team and help each other during flight operations. However, in single pilot training, and during a CPL flight test, if the candidate seeks help or assistance from the flight examiner (the only other pilot), he or she will fail (Kearns et al., 2017). In fact, if a pilot’s intention was to enter a multi-crew environment, what is learnt during ab initio training as a single pilot could have a negative impact to airline operations, with some techniques having to be unlearned in order for pilots to fit into the multi-crew environment (Dow & Defalque, 2013). Therefore, MPL training was designed to develop competencies appropriate for multi-crew operations and reduce the effects of inappropriate habits obtained from single pilot operations (Schroeder & Harms, 2007).

While the MPL opened a new pathway for licensing, it would be unusable if there were no provisions in the existing regulatory structure for training organisations to conduct the competency-based approach to training. Therefore, appropriate amendments were made to Annex 1 prior to the implementation of the MPL (Schroeder & Harms, 2007). One of
the amendments led to new provisions being made for approved training organisations with regards to the authorisation of their training programs (Kearns et al., 2017):

A licensing authority may approve a training program for a Private Pilot License (PPL), Commercial Pilot License (CPL), or Instrument Rating (IR) that allows an alternative means of compliance [emphasis in original] with the experience requirements established by Annex 1 provided that the Approved Training Organization (ATO) demonstrates, to the satisfaction of the authority, that the training provides a level of competency at least equivalent to that provided by the minimum experience requirements for personnel not receiving such approved training. (ICAO Annex 1, quoted by PIL3, cited in Kearns et al., 2017, p.56)

Based on this provision, any training organisation, regardless of license type the program aims to achieve, is now allowed to establish alternative means of training, if they can demonstrate to its local licensing authority, that the new training is at least equivalent to that set out by the licensing authority (Kearns et al., 2017). This provision had a major impact on pilot training, as it not only provided the permission to conduct MPL training, but also the opportunity for training organisations to provide an alternative means of complying with regulations with regards to the design and content of their training programs (e.g., using different assessment models).

2.2.4. Shifting the focus

This section reviewed the ICAO and State aviation regulators’ (CASA and CAANZ) influence on pilot standards. The focus on standards is fundamental to aviation safety and has been an underpinning reason for the high safety levels achieved by aviation today (Amalberti, 2001). Standards are set for the most inexperienced pilots entering the aviation industry, all the way to standards for the most experienced pilots. However, there have been some concerns to the commercial impact high standards can have on an ATO. For example, there have been some ATO concerns that setting high standards creates difficulty attracting and retaining capable flight instructors or flight examiners, especially in regards to the pilot shortage. Yet, these concerns are rejected by some who argue, “downgrading standards cannot be a response to an increasing demand, regardless of the context of unwanted financial consequences” (Wikander & Dahlström, 2016, p. 176). While these comments are fully supported, the focus on standards for instructors misses a fundamental issue, the pilot under instruction.
While international and national standards are an important part of increasing uniformity across the aviation industry, ATOs (like the two airlines in this study) are directly responsible for ensuring those standards are met. Therefore, pilot training is the main determinant in ensuring that pilots meet the standards set by regulators. What appears to be underrepresented is the actual process under which pilots reach standards. What kind of training are pilots receiving, how do pilots engage with that training, and how effective are these programs for developing competent pilots, should see increasing focus. For this reason, this study focuses specifically on pilot training, which will be outlined in the next section.

2.3. Becoming a pilot

The work of a pilot is complex. Flying an aircraft involves not only understanding large amounts of information but also having the skills to fly an aircraft within the parameters set by regulators and company procedures. In addition to flying skills, multi-crew operations require pilots to coordinate with other pilots and crew members to ensure the overall safety of each flight. A safe flight operation also involves managing environmental factors such as adverse weather and terrain, whilst at the same time adhering to strict laws, rules, and regulations dictated by governing bodies in the countries and regions where one is operating (Harris & Thomas, 2005). Furthermore, a commercial airline flight is more than just pilots and cabin crew on board the aircraft. Engineers, ground crew, and air traffic controllers all work together to ensure the aircraft is well maintained and has a safe flight operation.

Figure 2.2 Flight deck of an (a) ATR72-600 with glass cockpit and (b) ATR72-500 with analogue cockpit.
Figure 2.2 shows two examples of the flight decks of airline industry aircraft. Figure 2.2a is an example of a glass cockpit, which is what most airline pilots fly today. The second flight deck (Figure 2.2b) is a traditional/analogue flight deck, which is still used in the industry, though it is slowly being phased out (Mavin, Roth, Soo, & Munro, 2015). The captain sits in the seat on the left, and the first officer sits in the right seat.

The flight deck in Figure 2.2a consists of five interchangeable liquid crystal displays (LCD). The two outer screens are both called the primary flight display (PFD), and are duplicated for both the captain and first officer. They provide primary flight information for pilots to fly the aircraft and include such as attitude, altitude, airspeed and vertical speed. The next two inner screens are referred to as the navigation display (ND). They are also duplicated for both pilots and provide primary navigation information. In fact, the ND is very similar to a modern car GPS navigation device.

The middle screen between the pilots is the multi-function display (MFD) and displays: engine instrument; current systems status, such as fuel quantity, engine instruments, hydraulic pressure and quantity; and emergency flight warning systems. The MFD is multi-paged, and separate information can be accessed by toggling each screen using buttons located in the middle console. In both flight deck types, radio and navigation systems are located between the pilots in the lower section of the middle console.

The complexity of a pilot’s workspace and work has led to it being classified as a complex socio-technical environment, where human and machine must interact to perform specific goals (Billings, 1997; Hollnagel & Woods, 2005). While a full description of the functions and capabilities of each flight deck instrument and system is beyond the scope of this thesis, the purpose of the above description was to illustrate the possibility of information and instruments pilots work with in order to highlight the wide range of skills required to perform these tasks. A brief explanation of aircraft automation system is required so that its use is better understood.
Figure 2.3 Flight deck controls and displays.

The ATR72-500, ATR72-600 and DHC8-400 aircraft have very different autopilot and navigation computers. Therefore, for simplicity, the study will not differentiate. As shown in Figure 2.3, the PFD is the main instrument pilots use to fly aircraft. The ND provides navigation information. The flight management computer (FMC) is the computer that can calculate flight plans, instrument approaches, and fuel calculations. To aid in navigation, the FMC receives inputs via a global positioning system (GPS). No different than the navigation behind the modern car. The control display unit (CDU) is the unit in the flight deck where pilots load and receive information from the FMC, similar to how a keyboard and screen (CDU) works with a home desktop computer (FMC). The Mode Control Panel (MCP) is the panel that pilots use to engage or change autopilot modes. The autopilot is a combination of servos and linking arms that allow the pilot to fly the aircraft hands-free. The pilot, via the MCP, can engage simple modes such as altitude hold or heading, here, the FMC is not needed. More sophisticated aircraft guidance, such as weigh point tracking, or vertical guidance, can be provided by the FMC (with signals from GPS). Here the pilot would select a button on the MCP, such as LNAV (lateral navigation) or VNAV (vertical navigation), to command the autopilot to follow FMC guidance. The entire
system; FMC, GPS, CDU, MCP and autopilot are referred to as the flight management system (FMS).

It is important to understand that in aviation, and in the research literature, the FMS system is often referred to as automation. This is different to the autopilot, which is a unit that allows the pilots to fly the aircraft hands-free. For simplicity sake, automation and FMS are understood as being the same in this study, and referred to as automation for the remainder of this thesis.

2.3.1. The early history of pilot training

The field of aviation and the role of pilots emerged after the successful flight of the Wright brothers on December 17, 1903 (Mavin & Murray, 2010). During the early years, pilot training involved learning the fundamentals of flight (e.g., aerodynamics, flight control systems) and aircraft manipulation skills, on the ground (e.g., starting the aircraft, taxiing) and in the air (e.g., take off, landing, general handling techniques) (Mavin & Murray, 2010). Training methods included classroom instruction and practical application of flying techniques (Kearns et al., 2017). There were few, if any, restrictions on flight or other forms of air transportation (e.g., ballooning and gliding) during that time, but there were some rules associated with the operation of aircraft.

Until World War I, pilot training was essentially unstandardised, meaning there were a variety of training methods, leading to varying levels of pilot competence (Mavin & Murray, 2010). The dangers inherent in this lack of standardisation became evident during the first World War, when more casualties were caused by pilot training accidents than by the enemy. The increased demand for pilots during wartime, and the lack of training resources available only exacerbated the existing problem, and pilots were sent to battle virtually unprepared for combat (Philpott, 2013).

Major Smith-Barry, a World War I pilot himself, was very critical of the army’s pilot training program. He felt pilot recruits were not being trained to appropriately respond to and recover from dangerous situations, or maximise the potential of their aircraft (Kearns et al., 2017). In 1916, he was eventually given permission to carry out his methods of training, leading to a revolution in pilot training practices (Kearns et al., 2017). Major Smith-Barry’s approach to training was to intentionally expose pilots to dangerous manoeuvres, thus giving them opportunities to learn how to recover from challenging
situations and correct their errors in judgement (Kearns et al., 2017; Mavin & Murray, 2010). He used dual controlled aircraft for training, in which the trainee sat in the front cockpit and operated the aircraft while the instructor sat behind, offering advice and intervening when necessary. In addition to the new training methods he introduced, Major Smith-Barry also established a flight instructor school in order to improve instructing methods and increase the number of trained instructors available to teach new pilots. The instructor school also provided a means to standardise instruction methods and further develop existing training programs (Mavin & Murray, 2010).

Aircraft instruments, systems, and flight range capabilities improved considerably between World War I and II. For example, by the 1930s, pilots were able to navigate during flight solely by referring to flight instruments within the flight deck, which allowed them to fly even in poor weather conditions (Koonce & Debons, 2009). However, new aircraft capabilities meant more training was required for pilots to be able to handle increasing levels of complexity and advanced operations (Mavin & Murray, 2010). As aircraft became bigger and more sophisticated, more crew were required to operate them, leading to the coining of the term “aircrew” (Mavin & Murray, 2010, p. 270). While innovations to aircraft design and technology increased potential flight capabilities, these advancements were constrained by human limitations such as fatigue caused by airframe vibrations during flight, and the effects of prolonged exposure to high altitudes and cold temperatures (Nagel, 1988). Recognition of these limitations led to the requirement that pilots engage in more classroom-based training to teach them about human factors and team skills (Mavin & Murray, 2010).

Major Smith-Barry’s training regime was a success, and his legacy remains, as many of his methods continue to be embedded within pilot training programs. For example, the training structure wherein ground-based skills are taught first in preparation for aircraft-based training, as well as an emphasis on flight manoeuvre techniques, through to aircraft emergency recovery, continue to be taught today (Mavin & Murray, 2010).

2.3.2. Influencing factors in pilot training post-WWII

Before the 1960s, aircraft reliability was very poor, making aircraft-based training a dangerous activity. Fatal and hull-loss accidents were a frequent occurrence (Kearns et al., 2017) as the earliest aircraft were “extremely unstable and often barely controllable”
(FAA, 1996, p.15). As such, technological advancement has contributed to improvements in aircraft capabilities, and also in how pilots are trained. The following is a discussion of some key factors that have influenced the development of pilot training after the Second World War. It includes the increased use of simulation in pilot training, the implementation of non-technical skills and crew resource management, as well as increased technology and automation in modern aircraft.

2.3.2.1. Increased use of simulation in pilot training

The earliest aviation simulators were introduced around 1910. Among these were the Wright Brothers’ “kiwi bird,” a defunct Wright Type B Flyer mounted on a trestle, and the Antoinette Trainer, in which learners would sit in a barrel while instructors pulled or pushed the “wings” to simulate disturbances, requiring the learner to make control inputs through a series of pulleys (Moroney & Lilienthal, 2009). It was not until 1929 when Edward A. Link produced a trainer with three degrees of freedom (yaw, pitch, and roll), that modern flight simulators were born (Moroney & Lilienthal, 2009). Since then, simulators have become a fixture in aviation training. As simulators play a fundamental role in pilot training, they are regulated by aviation regulatory authorities.

Simulation as a teaching and assessment platform in commercial aviation has evolved over time, with modern simulators designed by engineers to replicate, as much as possible, the appearance and characteristics of real aircraft (Myers, Starr, & Mullins, 2018). These aspects are classified as fidelity—that is, how similar they are to a real aircraft, and how similar it can act to real-world aircraft failures (Kearns et al., 2017; Myers et al., 2018). Fidelity comprises of three features: physical fidelity (replication of instruments, feel, motion, visual, and sound), cognitive fidelity (ability to instigate psychological and cognitive factors such as stress, anxiety, decision making and situational awareness), and functional fidelity (degree to which it replicates the real equipment) (Lee, 2005; Myers et al., 2018). Fidelity of simulators and trainers are categorised according to levels, where higher-level fidelity indicates higher similarity to actual aircraft situation (Myers et al., 2018). Airline training usually uses simulators of low-level fidelity and progress to high levels as training become more complex (see Figure 2.4).
In Figure 2.4, each level of progression represents a higher fidelity simulation device, with each type of device used at different stages of pilot training. As higher fidelity devices are associated with higher purchase costs, it is strategic for training organisations to use the lowest fidelity devices needed to accomplish their training objectives (Kearns et al., 2017). For example, if the goal is to practice procedures, it is more efficient to use a less expensive Flight Navigation and Procedures Trainer (FNPT) than a more expensive Full Flight Simulator (FFS). For desktop simulators, studies found significantly better performances in the initial stages of flight training (zero flight hours) although these benefits were mostly in terms of developing a cognitive template of what a task looks like and the required performance rather than development of psychomotor skills (Dennis & Harris, 1998).

In fact, there is a group of researchers who argue that the relationship between learning and fidelity is not linear (Dahlström et al., 2009; Sparko et al., 2010). This was also a concern for early researchers in the field. Early literature reviewing the transfer of training from simulator to aircraft (Hays, Jacobs, Prince, & Salas, 1992) identified simulators were effective in training pilots to fly jet aircraft above and beyond just aircraft training. However, motion cueing was found to have little effects on training effectiveness and was even detrimental to learning in some cases. They concluded and emphasised that the benefits of training were dependent on the task being trained (e.g., take off, approach to
landing, and landing). A follow-up review was conducted by Carretta and Dunlap (1998) with 13 additional studies that had directly addressed the transfer of training from flight simulator to aircraft. Their review of literature further supported the findings of Hays et al. (1992) and added that for instrument procedures and flight controls, simulators were effective training tools, though transfer effectiveness was better for training exercises that were on critical components of the task as opposed to the whole task. Based on these reviews, it is clear that using the highest fidelity simulation is not always the most effective training pathway. Instead, the effectiveness of simulation training is determined by evaluating whether the performance of a desired task in an actual aircraft has been facilitated by learning done in a simulator (Moroney & Lilienthal, 2009).

A summary of training media used within the aviation-training curriculum and what they are used for is provided in Figure 2.2. Apart from aircraft training, which is classified as on-the-job-training, all other forms of flight training listed below are considered to be simulations. Simulation training is one of the most common and important methods of training and assessment in aviation (Lee, 2005; Mavin & Murray, 2010).

<table>
<thead>
<tr>
<th>Type of media</th>
<th>Description</th>
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<tr>
<td>Computer-based training (CBT) or e-learning</td>
<td>These platforms are used to teach pilots initial systems knowledge, such as electrical systems or hydraulics. Usually linear in delivery, or in some cases trainees may be allowed to choose areas of interest.</td>
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<tr>
<td>Part task trainer (PTT)</td>
<td>The PTT is an economical simulator that allows pilots to practice procedures. In the past, a PTT could be as simple as a poster of the aircraft’s flight instrument panel and switches, with the pilots touching each instrument/switch/dial in the required order.</td>
</tr>
<tr>
<td>Flight training device (FTD)</td>
<td>The flight training device is a simulator that replicates flight. Depending on the needs of the training organisation, the FTD may be a generic mock-up of an aircraft displaying primary flight instruments, system switches, and dials, or an identical replica of the aircraft the pilot will fly. FTDs generally do not have motion capability, although sometimes “seat movement” can be included to simulate turbulence.</td>
</tr>
<tr>
<td>Full flight simulator (FFS)</td>
<td>The FFS replicates motion, with a flight instructor acting as other aircraft, air traffic control, engineering, and cabin crew.</td>
</tr>
<tr>
<td>Aircraft</td>
<td>After completing the final assessment on an FFS, a pilot’s first flight operation will be on an actual aircraft loaded with passengers. These training pilots are paired with other highly-skilled pilots (e.g., flight training captains, flight examiners) as part of their on-job-training.</td>
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Roscoe (1991) proposed that when it comes to simulator fidelity, the cost of realism increases exponentially, with every increase in levels of fidelity resulting in more expensive simulators. For example, a $2000 desk-based flight simulator could see great benefits from the addition of a $250 control panel that replicates an aircraft’s control wheel, thrust levers, and rudder pedals. However, a $10,000,000 simulator that is already at the advanced level, may require $200,000 to be spent implementing a new traffic collision avoidance system (TCAS), with only minor improvements. Furthermore, if simulation is not used appropriately—for example, if a high-fidelity simulator is used during the early stages of training, it may be counterproductive for learners who are overloaded with information (Lintern, Roscoe, & Sivier, 1990; Moroney & Moroney, 1999; Roscoe, 1980). However, as technology improves and becomes cheaper, and more people and training organisation purchase simulators, the question shifts from cost of simulators to proper use of simulators as a teaching tool (Kearns, 2010; Salas, Bowers, & Rhodenizer, 1998; Salas, Rosen, Held, & Weismuller, 2009). As noted by Beringer (1994), if training organisations are able to provide more simulation for the same amount of money, decisions about training methods will be focused less on available resources and more on which types of training, and what fidelity level in simulation will be most useful to learners.

The aviation industry’s use of and trust in simulators is significant, and the effectiveness of simulator-based training is well accepted by the industry (Dennis & Harris, 1998; Kearns et al., 2017; Mavin & Murray, 2010; Moroney & Lilienthal, 2009; Salas et al., 1998). One testament to the industry’s trust in the effectiveness of simulator training is that pilots converting to new types of aircraft are trained with the use of simulators, and their first flights following training are commercial flights with paying passengers—albeit under the supervision of flight instructor, at least initially (Mavin & Murray, 2010). In general, simulators are regarded as an effective and environmentally-friendly alternative to real-world training resulting in saved dollars, materials, and even lives (Salas et al., 1998; Moroney & Lilienthal, 2009).

2.3.2.2. Non-technical skills and crew resource management

Following World War II, enhancements in aircraft propulsion systems took aviation into the “jet age” (Kearns et al., 2017; Mavin & Murray, 2010). This led to an exponential growth in air transportation, which was temporarily interrupted by various worldwide
incidents such 9/11 in 2001, the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, and the economic downturn in 2008 (Airbus, 2018). Improvements in technology and aircraft design led to increased aircraft reliability and reductions in travel time for intercontinental and oceanic flights, meaning that the likelihood of passengers safely reaching their destinations was greatly increased (Helmreich & Foushee, 2010; Mavin & Murray, 2010). By the 1960s, aircraft design and technology had become more reliable that a reverse trend in accident and incidents had started to emerge, revealing rapid improvements in flight safety (see Figure 2.5).

Figure 2.5 Accident rates and onboard fatalities by year of worldwide commercial jet sleet from 1959 to 2004 (Boeing, cited and retrieved from Mavin, 2010)

Pilot training the 1960s was still focused on developing technical skills that had been the focus since the Major Smith-Barry era. At that point, the focus on technical knowledge and flying skills were sufficient for handling malfunctions that occurred during flights (Mavin & Murray, 2010). In current times, the range of technical flying skills are outlined clearly in the relevant training documents (see CASA Part 61 and MOS or CAA Part 61 CAR). There are two components these skills: flying skills and technical knowledge of the aircraft and other factors related to flying (e.g., flight rules and air law, meteorology). Flying skills involve not only manual aircraft handling skills, but also navigation, radio operation, night flying, and flying solely based on instrument readings (Mavin, 2010). These skills, in addition to theoretical knowledge, require the development of psychomotor processes that are often taught intensively during ab initio training (Haslbeck, Kirchner, Schubert, & Bengler, 2014) and are assumed to be of an appropriate
standard by the time pilots enter airlines (Mavin, 2010). During airline training, technical skills are taught and assessed through the performance of various scenarios involving normal, non-normal, and emergency manoeuvres, as per company standard operating procedures (Mavin, 2010).

However, in the 1970s, several major accidents had occurred that highlighted the fact that existing pilot training was not sufficient for ensuring safe operations (ICAO, 1998; Mavin & Murray, 2010). ICAO (1998) provided a summary of 12 accidents that led to the topic of human factors becoming prevalent in the aviation industry. Of the several accidents that occurred, two were highlighted as being significant influences of training education (Mavin & Murray, 2010).

The first of these accidents was the 1972 Eastern Airlines Flight 401 incident involving a Lockheed L-1011 aircraft. While the aircraft was descending into Miami, Florida, the aircrew contacted the air traffic controller reporting that the forward landing gear had not extended. They were instructed by the tower to enter a racetrack holding pattern and maintain an altitude of 2,000ft, while the pilots diagnosed the problem. As all the pilots on the flight deck became engrossed in diagnosing and fixing the problem, they did not heed an alarm signifying that the aircraft’s autopilot had deviated off the selected 2,000ft altitude, initiating a slow descent. Medical studies later demonstrated that the descent was gentle enough not to be recognised by the pilots’ physiological balance system (Nagel, 1988). By the time the first officer commented on the altitude discrepancy, it was too late. The aircraft crashed three seconds later at a 28-degree left bank at more than 340km/h. The aircraft was destroyed, resulting in 99 casualties and 64 minor to serious injuries (NTSB, 1973). The report on the incident noted that the aircrew’s preoccupation with the malfunction had resulted in no one observing the flight instruments—in other words, no one was flying the aircraft.

The second accident, which occurred in Tenerife, Canary Islands, in 1977, involved Boeing-747s operated by KLM and PanAm (Mavin & Murray, 2010). Fog conditions at the airport had reduced visibility on the runway. The KLM crew reported to the air traffic controller that they were ready for take-off, and they were issued a departure clearance, but not a take-off clearance. The KLM crew repeated the instructions at the end of the runway and added “we are now at take-off,” meaning that they have begun the take-off phase. The air traffic controller immediately radioed to the KLM crew to “standby for
take-off,” as they were aware that PanAm was still on the active runway after landing. The PanAm pilots, who had heard the KLM radio call and were fully aware of its implications, radioed the tower controller, who was simultaneously calling KLM. This dual radio transmission resulted in loud squeals over KLM’s radio, which made it impossible for KLM’s pilots to hear the air traffic controller’s instructions. KLM’s flight engineer then asked the captain if they were cleared for take-off, to which the captain replied, “Yes.” PanAm, unable to clear the runway in time, was struck in the rear fuselage by the KLM aircraft when it commenced lift-off. The resulting collision destroyed both aircraft, killing all 248 people aboard the KLM flight, and 335 of the 396 aboard the PanAm flight. Sixty-one people on the PanAm aircraft, including the pilots and flight engineer, survived the collision.

These two accidents shocked the public and led to questions about the effectiveness of pilot training and assessment, putting pilot training programs in the spotlight. Amongst the reasons cited as causes of accidents were: poor duty allocation, poor management of flight resources, visual illusions, breakdown in communication, data entry errors, lack of assertiveness, layout confusion, and excessive reliance on automation (ICAO, 1998). Previous accident investigation had also stressed that human factors such as decision making, communication, and teamwork were a significant contributor to accidents (Helmreich & Foushee, 1993). These issues became the focus of a 1979 NASA conference, with the term cockpit resource management (CRM) arising around this time and the need to develop a training regime that can mitigate these issues.

The aim of CRM was to train aircrews to be able to use all available resources during a flight in a timely and effective manner by coordinating as a team (Helmreich & Foushee, 2010; Kanki, Helmreich, & Anca, 2010; Salas, Burke, Bowers, & Wilson, 2001). CRM was initially taught through conference-style classroom activities. Yet research that focused on the learners’—the pilots—perspective showed that the training was not well received (Helmreich, Merritt, & Wilhelm, 1999). Many pilots expressed negative attitudes toward the early versions of CRM that were introduced in the mid-1990s (Kearns, 2010), with some describing it as “charm school, psychobabble, or attempted brainwashing by senior airline management” (Helmreich & Foushee, 2010, p. 4). Despite its wide use in training programs, there are limited tools available to measure the effectiveness of CRM training and assessing pilot CRM performances. During the early
stages of its use, measurements of its performance were based on the subjective views of instructors to assess the performance of pilots and its apparent effectiveness in changing behaviour (Helmreich & Foushee, 2010). Doubts about the effectiveness of CRM began to arise because accidents rates in aviation continued to be attributed mainly to human influences (Edkins, 2002).

In the 1990s, after the Joint Aviation Authority (JAA) in Europe (following the CRM regulations set in Europe that mandated CRM be assessed for initial and ongoing training) initiated a major research project with the aim of developing a suitable methodology for assessing pilot CRM, a term now referred to as non-technical skills (Flin et al., 2003). Non-technical skills are “the mental, social, and personal-management abilities that complement the technical skills of workers and contribute to safe and effective performance in complex work systems. They include competencies such as decision-making, workload management, team communication, situation awareness, and stress management” (CASA, 2011, p. 8). Based on Wickens (1999) categories, non-technical skills include communicating, which refers to the pilot’s ability to verbally liaise with other aviation personnel such as the other pilot, cabin crew, and air traffic controller, and systems management, which relates to the ability to monitor aircraft systems. Flin et al. (2008) identified three further categories of non-technical skills: decision making, teamwork, and situation awareness.

Situation awareness is a much-contested concept in the literature (e.g., Dekker, 2015; Flach, 1995; Sarter & Woods, 1991). Despite this, it continues to be used and embedded within the aviation context and remains a highly researched topic due to its usefulness in training and assessment (Endsley, 1995, 2016; Flin et al., 2008; Parasuraman, Sheridan, & Wickens, 2008). For the purposes of this study, the debate around situation awareness is acknowledged but not explored, as it will not influence the interpretation of the study’s findings.

Since its inception, CRM/non-technical skills training has gone through multiple generations, but the basic principles of flight deck resource management have remained the same (Helmreich et al., 1999; Kanki et al., 2010). Specifically, Helmreich et al. (1999) describe these processes of growth and development, and the differences in content and foci of CRM programs, as different generations of CRM.
The first generation, which was adopted by United and KLM airlines, emphasised interpersonal behaviour, rather than team behaviour. The second generation emphasised teamwork, resulting in a shift from “flight deck resource management” to “crew resource management.” The third generation extended CRM training from pilots to cabin crew, focusing on better integration of technical and crew resource management (CRM) skills training. The fourth generation required aircrew members to be trained in CRM skills during “line oriented flight training” (LOFT) and to perform line oriented evaluations (LOEs) on full flight simulators. Here pilots moved away from classroom-based instruction to more workplace-orientated assessment. The fifth generation of CRM involved tackling the issue of error management. At this stage, human error was seen as inevitable, so countermeasures were developed to trap incipient errors and mitigate the consequences of errors that could not be trapped (Helmreich et al., 1999). The sixth generation CRM training—the one employed today—continues to offer key guidance on effective communication, task sharing, team building, and teamwork (Flin et al., 2008). Building upon the previous generations, training focuses on improving individual and crew threat management skills, also known as threat and error management, which involves teaching pre-emptive strategies for threat recognition, avoidance, and management (Maurino & Murray, 2009).

There are various models for assessing pilots’ technical skills and non-technical skills, and how assessment is performed depends on the airline. Testing pilots’ technical skills is a fairly straightforward process that requires pilots to pass written or multiple-choice assessments and demonstrate their ability to fly with strict adherence to flight parameters set by legislation (CASA and CAANZ). CRM skills, or non-technical skills, on the other hand, are more difficult to assess (Salas, Wilson, Burke, Wightman, & Howse, 2006). Non-technical skills training involves intensive classroom-based instruction and LOFTs in a simulator (Helmreich et al., 1999). A LOFT is essentially a normal flight, where pilots complete tasks and the check captain, or simulator instructor, incorporates malfunctions or problems into the training scenario that the pilots must solve or manage in real time (Mavin, 2010).

As outlined, in Europe during the 1990s the JAA initiated the assessment of non-technical skills via the NOTECHS. NOTECHS is an assessment system that provides a structure that flight examiner can use to grade the CRM performances of pilots. It also offers a
means of compliance for the assessment of CRM for training organisations. Here the categories are divided into specific elements. In NOTECHS, each element is provided with a specific word picture that prescribes poor and good performance. Note the NOTECH system does not focus on how to train CRM, but how to assess them (see Table 2.3).

### Table 2.3 Categories and elements of NOTECHS

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<tr>
<th>Area of interest</th>
<th>Category</th>
<th>Elements</th>
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<td>Conflict solving</td>
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<td></td>
<td>Leadership and Managerial skills</td>
<td>Use of authority and assertiveness</td>
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<td>Providing and maintaining standards</td>
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<td>Cognitive</td>
<td>Awareness of aircraft systems</td>
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<td>Awareness of external environment</td>
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<td>Awareness of time</td>
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<td></td>
<td>Decision-making</td>
<td>Problem definition and diagnosis</td>
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<td>Option generation</td>
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<td>Risk assessment and option selection</td>
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<td>Outcome review</td>
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Despite its use by various airline training organisations, there have been some concerns surrounding NOTECHS. For instance, Mavin (2010) argued that the separation of technical and non-technical skills was due to historical precedents rather than the reality of pilot work. In his doctoral thesis, Mavin used a phenomenology method to determine how senior flight examiner assesses pilots. From this, he developed the Model of Assessing Pilot Performance (MAPP) (see Figure 2 6). It combines technical and non-technical skills into a unified model (Mavin & Dall’Alba, 2010). Although the MAPP model is currently being used in various domains since its development (Munro & Mavin, 2012), there are still areas that need further developing, such as inter-rater reliability.
There have been suggestions stating that when it came to the instruction of CRM, facilitation, rather than direct instruction or lecture, should be used to train pilots (Dismukes, McDonnell, Jobe, & Smith, 2000). Facilitation as a practice is grounded in theories focusing on student-centred learning and involves—in the context of aviation training—the instructor helping pilots analyse issues, learn from experience, and work together to develop meaningful outcomes (Dismukes et al., 2000). However, facilitation is not always the best method for instruction and is dependent on the learner’s level of knowledge about the topic being learned as well as the type of lesson being taught (Smith, 2000). For the latter case, if a behavioural change or developing a personal attitude towards a topic is the objective (e.g., communication or procedural non-compliance), then facilitation would be more suitable than traditional instructional methods such as presentations.
Taken together, there is general consensus on the skills that pilots need to perform work, however, how to assess and train those skills, especially non-technical skills, is still a topic of interest in pilot training research. How to properly train those skills has also received some attention (Dismukes et al., 2000; Salas, Rhodenizer, & Bowers, 2000). How do pilots learn those skills, however, is less understood.

2.3.2.3. Technology, automation and manual flying skills

Since the 1970s, technological advancements, particularly the invention of the transistor in 1947 and subsequent miniaturisation of computers components, have led to major changes in the field of aviation, resulting in many aircraft manufacturers deciding to include automated aircraft systems and new flight deck designs (Billings, 1997; FAA, 1996). Furthermore, rapid improvements to systems engineering and the introduction of computers to the flight deck meant that flight engineers, radio operators, and navigators were no longer needed on board (Billings, 1997; Koonce & Debons, 2009).

Automation is the term used to describe the “systems or methods in which many of the processes of production are automatically performed or controlled by autonomous machines or electronic devices” in the flight deck (FAA, 1996, p. 3). Automation, albeit basic levels used to assist in aircraft handling, had been in use since World War I, and had become a major component of the flight deck since shortly after World War II. Until the 1960s, the purpose of automation was to maintain aircraft control so that pilots would have more resources available to complete other tasks such as navigating, communication and managing flight functions (FAA, 1996). Billings (1997) outlined in detail the evolution of aircraft automation since 1908 to the 1990s and the motivations behind these advancements.

As automation in the flight deck has increased, pilots have progressively faced the task of interfacing with aircraft systems through the flight management system, specifically, pilots are now at a significant distance from the control feedback loop (see Figure 2.7). Three categories of automation had been produced, control automation, which assists or supplants a human pilot in control and direction of the aircraft; information and communication automation, which are systems that handle the presentation of information to pilots; and management automation, where automation allows for strategic flight path management (FAA, 1996). The third form of automation came into effect
around the 1960s with the introduction of flight management systems (FMS) and computers into the flight deck (FAA, 1996), and led to term “human meta-control” and later “human supervisory control” for pilots as their role changes from operator to manager (Sheridan, 1999).

The main concern after the introductions of new cockpit technologies in the 1960s were human factors issues associated with automation in the flight deck (Billings, 1997). One issue at the time was the problem of forward transition, where pilots transfer from an analogue flight deck to the glass cockpit. During those times, most if not all of the issues with forward transition have been attributed to breakdowns in communication and coordination with flight deck automation (FAA, 1996). Fanjoy and Young (2004) stated that the initial transfer from traditional flight deck to first generation flight automation system was relatively straightforward. The main issue was that pilots transitioning to glass for the first time had difficulty understanding and properly utilising the autoflight modes, leading to mode errors, which are when pilots select “an inappropriate mode, not understanding the implications of choice of mode, not realizing what mode was engaged, and failing to recognize that a change in mode had been made not by pilot selection, but by the FMS” (Wiener, Chute, & Moses, 1999, pp. I-10).

Figure 2.7 Effects of increasing amount of automation between pilot and aircraft (retrieved from Billings, 1997, p. 36)
While automation has reduced some of the physical workload in the flight deck, it has also increased the cognitive load for pilots who now have to manage and understand much more sophisticated technologies, especially during non-normal situations (Billings, 1997; Sheridan, 1999; Wiener, 1988). The same type of issues with automation remains today as they did in the past (Strauch, 2017a), such as systems and performance awareness (Mouloua & Koonce, 1997) and automation surprise (Sarter & Woods, 1990, 1992, 1994; Sarter, Woods, & Billings, 1997). The advances of computer technology in the flight deck has led to the need to change training structures that historically focused on psychomotor and procedural competencies to training in consideration of the human pilot and automated systems interface (Fanjoy & Young, 2004, 2005; Wood & Huddlestone, 2006; Young & Fanjoy, 2003).

Following a series of tragic accidents and near-misses that occurred after the introduction of automated flight decks, the FAA appointed a committee to investigate the problems associated with flight deck automation (FAA, 1996). From their investigation, a list of recommendations was provided for the design of automation, and for changes in the standards for human factors and automation training and relevant certification (FAA, 1996). A recent report by the Flight Deck Automation Working Group (FAA, 2013b), (compiled from a large study to update the 1996 FAA report on flight deck system in addition to addressing issues related to current and projected use of flight deck systems for flight path management) stated that there have been significant changes to the use of aircraft automation system since its last review. These changes include increased aircraft onboard capabilities for flight path management, FMC functions, use of more advanced navigation systems (RVAV and RNP), reliance on automation produced digital data (information presentation or calculations), and changes to new hire pilot demographics. In this report, it was highlighted that “current training methods, training devices, the time allotted for training, and content may not provide the flight crews with the knowledge, skills and judgment to successfully manage flight path management systems” (p.4).

Other than the difficulty in properly preparing trainees for modern aircraft operations, concerns have been raised in the literature (Casner, Geven, Recker, & Schooler, 2014) and by aviation authorities (FAA, 2013b) that manual flight operations skills amongst pilots are in decline. One of the main reasons cited for the decline has been the overreliance on automation use (Ebbatson, 2009; FAA, 2013b; Haslbeck & Hoermann,
2016; Haslbeck et al., 2014) or a lack of training provided to develop and/or maintain manual flying skills for pilots (Ebbatson, Harris, Huddlestone, & Sears, 2010).

For instance, the 2009 accident of Air France 447, which killed 228 aircrew and passengers, was partially due to poor aircraft handling skills after automation failure by the co-pilots and the failure of the crew to accurately diagnose the situation. The situation was exacerbated as crew coordination/cooperation during the situation was poor (Bureau d’Enquêtes et d’Analyses pour la sécurité de l’aviation civile (BEA), 2012). In the finalised report, amongst the recommendations were the need to ensure manual aircraft handling for specific scenarios are well trained, the theoretical knowledge of particular flight mechanics was understood, training to manage crew resources when faced with the surprise generated by unexpected situations and to develop behavioural automatic responses in situations with highly charged emotional factors (see BEA, 2012 for full report). More specifically, the report describes that the co-pilots had not received any in-flight training for manual airplane handling:

In its current form, recognizing the stall warning, even associated with buffet, supposes that the crew accords a minimum level of “legitimacy” to it. This then supposes sufficient previous experience of stalls, a minimum of cognitive availability and understanding of the situation, knowledge of the aeroplane (and its protection modes) and its flight physics. An examination of the current training for airline pilots does not, in general, provide convincing indications of the building and maintenance of the associated skills. (BEA, 2012, p. 200)

The scenario above highlights the difficulty in ensuring current training practices reflect the needs of pilots and flight operations. Despite these concerns, there has been slow or little response in training modification by airlines (Haslbeck et al., 2014; Wood & Huddlestone, 2006).

The literature reviewed in this section highlighted some key issues faced by pilots as part of work. This leads to the question of how one can understand the ways in which work is done by pilots, especially when trying to understand the learning processes of pilots. The theory of joint cognitive systems provides one method of understanding complex performances (Hollnagel & Woods, 2005; Soo et al., 2016).
2.3.3. **Understanding pilot performance as a joint cognitive system**

Given the current state of pilot work, it is evident that understanding pilot performances would require accounting for multiple aspects. As pilot learning is the focus of this thesis, a review of what constitutes cognition in relation to the work of pilots is pertinent as this sets the boundary of what affects performances and therefore should be taught during training.

The study of human cognition traditionally focused only on the cognitive processes of individuals without accounting for any external factors (Adams & Aizawa, 2001). More recently, cognition has come to be conceptualised as a dynamic and emergent construct taking place in the context of a distributed process where there are interactions between different components of the brain, the body, and the social world (Harris, 2013; Hutchins, 1995; Salomon, 1993; Zhang & Patel, 2006). The joint cognitive systems framework developed in the field of Cognitive Systems Engineering outlines a suitable framework for analysing work practices in complex socio-technical systems (Hollnagel & Woods, 2005; Woods & Hollnagel, 2006). The fundamental goal of the joint cognitive systems framework was to shift the focus of measurement of human capabilities to the joint interactions between agents (human or automated) by examining systems as a shared responsibility between automation and human beings. Hollnagel and Woods (2005, p. 47) defined cognition in systems as the “ability for the system to modify its pattern of behaviour on the basis of past experience in order to achieve specific anti-entropic ends”—in other words, the system’s ability to maintain equilibrium and functioning during normal and non-normal situations.

A joint cognitive framework sees outcomes (good or bad) as an emergent result of the interplay between different components (and even another JCS) that are interdependent and adaptive to the environment, therefore, outcomes are difficult, or even impossible, to predict (Weber & Dekker, 2017). Based on this understanding, components of a joint cognitive system should not be assessed as being safe or unsafe, but in terms of their reliability. This method of thinking asserts that the focus should be on more than the individual practitioner, therefore, improving performance means considering whether the system which composes of, at the very least, pilots and technology, is performing well (Hutchins & Klausen, 1996). The goal of training then should also be to ensure that the
human components are reliable enough to ensure that the working system is always resilient.

Portraying the aircraft flight deck as a joint cognitive system is not new as other’s have investigated pilot work through this perspective (Harris, 2013; Henriqson, Winsen, Saurin, & Dekker, 2011; Hutchins, 1995; Roth et al., 2015; Soo et al., 2016). What is lacking, however, is understanding how pilots are expected to become a component of such a system. Current joint cognitive systems theory emphasises a pragmatic delineation of the boundaries of the joint cognitive system under analysis with two conditions: if an element can cause a significant change to the joint cognitive system and, most importantly, if the element can be controlled by the joint cognitive system (Hollnagel & Woods, 2005). However, this kind of pragmatic boundary offers limited insights when investigating processes involving influences of time—not in the sense of time pressures during periods of high-workload, but in terms of cognitive development processes (Soo et al., 2016) or in this study, learning of new knowledge. To supplement the understanding of JCS, the concepts by Luria (1973), specifically functional system and functional units, were used to understand the constellations or components of a system. Viewing the joint cognitive system as a functional system promotes the idea that components within the system (i.e., functional units) are always changing due to different reasons (Travieso, 2007). As human-machine interaction literature proposes a relationship between pilots and automation in which human and machine are a “team” (Degani, Goldman, Deutsch, & Tsimhoni, 2017, p. 212), aircraft automation is understood to be part of the cognitive system of the flight deck.

The question now then, is how can pilot learning be understood using the perspective of a joint cognitive system theory. It is understood that JCS, as conceptualised by Hollnagel and Woods (2005), focuses on functional aspects of the system, which means that the systems focus on what needs to be done, as opposed to how is the system built and what it is built for. However, the aim of this thesis is to understand how the components within the system react to one another. Therefore, the term and understanding of a joint cognitive system is borrowed without the aim of achieving the goals CSE (as described by Hollnagel & Woods, 2005). To be clear, this thesis postulates that in order to better understand the learning experiences of pilots and how training prepares them for the realities of work, these experiences should be understood in the framework of a joint
cognitive system. After all, while the aim of training is ensuring pilots learn the required skills and competencies for work, safe performances are determined by the resilience of the functional system.

2.4. Focusing on Airline Training Programs

Civil aviation training can be classified into two categories, each with their own issues with them. The first category can be called basic civil aviation training, including ab initio training, while the second group looks at airline pilot training where the focus seems to be more on maintaining and developing skills and competence (Dahlström, 2002). Airline pilots go through several types of training and assessment during their careers. These include type rating training, command upgrade training, and operational competency assessments. The next section will provide an overview of airline training with a specific focus on type rating training.

2.4.1. Airline training overview

Most airlines develop and design their own training, tailored to the practices and principles of their workplaces (Harris & Thomas, 2005). In general, commercial airlines keep the details of training confidential, and training programs are rarely evaluated by external agents (Salas & Cannon-Bowers, 2001). Despite this, the acceptable standards for pilots remain uniform and non-negotiable. As stated by (CASA, 2009, p. 7), “…the teaching methods may vary between training organisations, but the final result must be that a trainee meets a consistent and appropriate standard.” Although the processes of how airlines design their training program may vary, most airlines use similar training tools and methods. Training programs usually require pilots to undergo intensive training sessions using multiple instructional formats before being assessed and given a pass or fail grade (Kearns et al., 2017). The next section describes type rating training, which is usually the first training program that pilots go through when they enter an airline.

2.4.2. Type rating

As mentioned previously, holding a pilot license does not necessarily mean that a pilot has knowledge of the technical details of how to operate all classes of aircraft. For example, having an ATPL does not qualify an individual to operate a Boeing aircraft or an Airbus. As these aircraft are sophisticated machines, pilots must undertake specialised
training and obtain additional certification in order to fly them. This training and certification is referred to as *type rating*. Type rating training, where pilots learn to fly a different type of aircraft, can be provided in-house by the airline or outsourced to other training organisations (Orlady, 2010). While this training can also be provided by independent training organisations (Dahlström, 2002), this study focuses on training provided by the airline.

Type ratings vary across different types of aircraft, and which aircraft require a type rating is decided by national aviation authorities and is listed on their websites (CASA and CAA). Pilots entering airlines will generally undergo five phases of initial training. These include:

1. **Induction**: General introduction to airline culture, safety, uniforms (2 days)
2. **Type rating**:
   a. **Engineering school**: trainees undertake computer-based instruction in aircraft systems through modules on topics such as hydraulics, airframe, flight controls, pressurisation, fire, and engines. Upon completion of each module, pilots undertake exams on all topics studied. Some airlines also have a final exam that assesses all topics (2-4 weeks).
   b. **Procedures training**: trainees learn standard operating procedures (SOPS) for the specific type of aircraft being learnt. This occurs in a simulator such as an FTD or PTT (see Section 2.3.2.2, p. 36) (1 week)
   c. **Simulator training**: generally consists of 10-15 four-hour simulator sessions in a variety of simulator types such as an FSS (see Section 2.3.2.2, p. 36) (4-6 weeks).
   d. **Final type rating assessment**: conducted by flight examiner (1 day).
3. **Emergency procedure training**: pilots learn about emergency operation of aircraft. This includes position and use of emergency exits and equipment (e.g., life-jackets, fire extinguishers, life rafts, personal briefing equipment), life raft drills (usually in a swimming pool), and cabin crew procedures (1 week).
4. **Line training**: pilots fly real aircraft with real passengers on regular public transport (RPT) routes with a flight instructor. (4-6 weeks)
5. Final “check to line” conducted by a flight examiner. (at least 2 days)

After completing airline initial training program, pilots will undergo regular biannual training and assessments to ensure that they maintain a certain level of competency. If a pilot does not pass these assessments, he or she will receive retraining or further training. Failure in further training may result in dismissal from the airline.

2.5. The need to review training

As outlined in Chapter 1, there has been a significant expansion in the aviation industry with the latest numbers from Boeing (2018), suggesting over 790,000 pilots will be required in the next twenty years. The chapter outlined that the ICAO explored the reasons for this shortage was due to:

1. retirements of the current generation of aviation professionals;
2. reduced applicants to aviation due to its perceived attractive as a profession;
3. the competition other industries have for skilled employees;
4. the current training capacity is insufficient to meet demand;
5. current learning methodologies not responsive to new evolving learning styles;
6. the accessibility new pilots have to affordable training;
7. the lack of uniformity of competencies in some disciplines.

Furthermore, while major airlines around the world are being impacted by the shortage, regional airlines appear to be the most affected. This could be due to pilots wishing to fly for larger airlines as their first choice rather than the smaller regional airline. Also, larger or flag carrier airlines such as Qantas and Air New Zealand often recruit directly from the regional airlines they own, causing a knock-on effect for subsequent regional airline training (Gall, 2018; Shepherd, 2018).

An identified issue that was also raised in Chapter 1 is that there has been a growing concern regarding pilot standards. This was most exposed in accidents such as the 2009 crash of Colgan Flight 3407, and the loss of control of Air France 447 in 2013. However, in regard to pilot training, the emphasis has been the continual development of pilot licensing and standards. This was exemplified by the aviation industry using an hours-based approach to correcting accidents (e.g., Colgan Flight 3407). However, this increase
in hours was argued to not guarantee better performance and can, in fact, exasperate the issue of the shortage.

To streamline pilots into airline industries, a new license in the form of the MPL and competency-based training was developed with the aim of better preparing pilots for multi-crew flight operations. While there appears to be continued support for such a licence, there appears to be several concerns regarding the implementation. For example, while new pilots undertaking MPL training are performing well in carrying out procedures and using automation, there remains areas of improvement including situational awareness and workload management. Further, manual flying appears to be the most difficult skill to acquire, with questions still remaining on how to best train pilots in these skills (Wikander & Dahlström, 2016).

Other problems raised by Wikander and Dahlström (2016) with the MPL program was concerning standards of performance. Here it was identified that 90% of training managers believed that their training curriculums are aligned with the competency-based approach. Whereas only 50% of the pilots—both instructors and trainees—believed it to be based on competencies, with some organisations stating they did not use competencies, and several students and flight instructors stating they “have not even heard of this concept” (Wikander & Dahlström, 2016, p. 176). As summarised in the recommendations by Wikander and Dahlström (2016, p. 179) that:

Competency-based training is supposed to form the foundation that differentiates the MPL the more traditional pilot training. There are many recommendations that could be made about CBT based on the conflicting data in the survey but given the finding that there is lacking coherence in the understanding of CBT the usefulness of detailed recommendations is questionable.

They conclude with an important assertion that “either way, the industry has one important question to answer and that is what is expected of a newly graduated pilot” (p. 177).

Regardless of pilot licensing pathways, it is through training that pilots accumulate skills that will enable them to meet standards set by regulators. However, little is known about the actual state of contemporary airline training, and particularly how pilots learn the skills required for work. Nonetheless, there has been research into the skills required for
instruction. For instance, simulator use (Burki-Cohen et al., 2011) and debriefing (Mavin & Roth, 2014, 2015). There has also been extensive research into pilot performance such as non-technical skills (Flin et al., 2008) and the assessment of these skills (Flin et al., 2003; Mavin, 2010). There still remains a paucity of research into pilot learning through training.

As Salas and Bowers (2001, p. 491) state, “how learning environments are created and maintained in organizations needs to be researched and better understood.” They called for longitudinal studies to be conducted to understand how people learn and build expertise over the course of a training program (Salas & Bowers, 2001). Therefore, in order to adequately assess the effectiveness of a training program, it is necessary to review current training practices in a holistic and detailed manner. Furthermore, as the pilot’s perspective is noticeably lacking in aviation research—the focus instead being on standards and training activities—information about pilots’ learning processes should be gathered in order to create a holistic picture of the training context and its effectiveness.

Existing studies have mainly concentrated on aspects of pilot performance, there has been little review of current airline training practices. An in-depth investigation into current airline training programs, such as for this thesis, illuminates important considerations for appraising pilot training. This thesis was informed by the question: What framework can be used to record and represent how pilot training is conducted? More importantly, how learning takes place in complex socio-technical environments? The following section will describe curriculum theory and argue that it provides a helpful lens for understanding pilot training.

2.6. Curriculum theory

While there are multiple training design booklets in aviation itself that can be used to structure the investigation into pilot learning, the main focus is usually on the development of training and assessment instructor techniques, but always from the perspective of a designer, less so from the person who goes these experiences—the learner. Nonetheless, there are parallels between traditional aviation training design literature and curriculum theory, a common theory used to understand issues relating to educational programs (Billett, 2006a). The concepts of curriculum theory such as intended (i.e., training managers), enacted (i.e., instructors and training methods) and
experienced (i.e., pilots) curriculum can be used to tease apart issues of training and provide different ways to understand those issues (Billett, 2006a). This section looks at curriculum theory as a framework for teasing apart the pilot training program in order to better understand how it is conducted and what do pilots learn during training.

2.6.1. Curriculum concepts as categories

The term curriculum is usually used in the context of academic and vocational education, although is slowly entering into the domain of workplace learning (Billett, 1996, 2006a, 2009). Pilot training programs are a form of workplace learning consisting of a range of goal-directed activities designed to prepare trainees for the requirements of work. While the term curriculum is not often used within the domain of aviation training, aviation training programs are developed in ways that are similar/identical to how other educational curricula are developed. Therefore, in the context of this study, a curriculum is conceptualised as a training program for pilots encompassing learning experiences in practice settings and how they are organised and sequenced by training managers and enacted by instructors. However, curriculum pathways are likely to be particular to each workplace and to differ across different countries, despite occupational practices being similar across the industry (see Billett, 2001).

Typically, a curriculum is conceptualised in four ways: subject matter or objective, plan, experience, and outcome (Wiles, 2005). These elements can be divided into intended curriculum (subject matter or objective, plan) and experienced curriculum (experience and outcome). Put in another way, curriculum is usually understood to consist of syllabus, planned activities (Print, 1993; Smith & Lovat, 2003), and written documents that define course content (Null, 2011). This is mostly how aviation views the term curriculum as most literature on pilot training focuses on training program development.

In the field of workplace learning and vocational education, Billett (2006a) argued that workplaces should be considered as a legitimate learning environment, and therefore require a suitable workplace curriculum theory. He proposed that the curriculum which aims to ensure full participation of individuals within the workplace is affected workplace affordances that are influenced by the interest of managers, co-workers, and the intentionality of the workers themselves. He takes a different approach to traditional curriculum theories and proposed three elements of curriculum: (i) intended, (ii) enacted,
and (iii) experienced. His conceptualisation of curriculum includes not only what needs to be learned and assessed but also how it is implemented and experienced by instructors and learners. Hence, the development of a training curriculum is more than just having plans and a list of competencies (e.g., knowledge, technical skills, non-technical skills, and abilities) to be taught and learned; instead, it is a dynamic and complex process between the organisers who plan, instructors who enact, and learners who learn (Billett, 2006a). The three components of curriculum offer a basis for understanding and illuminating the different concerns or aims depending on the perspective adopted (e.g., planner, instructor, trainee). The holistic nature of this approach made it well-suited to exploring the different aspects of pilot training in a systematic manner.

2.6.1.1. The intended curriculum

An intended curriculum is what program designers and organisations intend—and expect—to occur when a curriculum is implemented. This type of curriculum includes other concepts such as prescribed curriculum (Schugurensky, 2002), written curriculum, entitlement curriculum (Print, 1993), and specific criteria curriculum (Bowers, 2006). At this stage, the curriculum is planned in alignment with the orientations of the program planners or developers—their values, intentions, expectations, and epistemologies—which in turn guide the aims, goals, and objectives of the curriculum (Print, 1993). These orientations determine what should be taught (e.g., emphasis on cognitive skills or communication skills), the manner of teaching (e.g., procedural or negotiated), and the way learners are treated. The key elements of the intended curriculum are outcomes, content, method, and evaluation (Billett, 2011). These elements are found, in various iterations, in all curriculum models. They represent what curriculum designers want learners to be taught (e.g., teaching objectives), and are usually presented within a documented format (e.g., company training document).

There are generally two approaches to planning an intended curriculum: the top-down approach, where the curriculum is highly prescriptive and provides specific methods to be followed, and the bottom-up approach, where the planning and design of the curriculum involves and engages the instructors who implement it (Billett, 2011). In the aviation industry, regulatory authorities are responsible for establishing minimum standards for pilot training. Airlines obtain standards from relevant regulatory authorities and create their own versions of intended curricula that can accommodate the distinct
practices and principles of their workplaces (Harris & Thomas, 2005). Airline training programs are generally much more “top-down” due to the pressure for standardisation and fixed resources.

Despite careful, standardised and highly organised planning of the intended curriculum of the same program, the experiences of each person going through training will be different for various reasons (Billett, 2006b). This is evident even in aviation where, in spite of, ICAO and state authorities standardised training requirements, the quality of training differs between training organisations (MacLeod, 2001). How the intentions of training are carried out (i.e., enacted) is influenced by situational factors and instructor discretion, which results in different learning experiences and knowledge by trainees that are sometimes unintended by planners (Billett, 2011; Smith & Lovat, 2003).

2.6.1.2. The enacted curriculum

Enacted curriculum occurs at the level of curriculum implementation. The enactment is shaped by available resources, trainers, and others in the workplace with experience and expertise that can be employed to instruct pilot trainees (Marsh, 2009; Roehrig, Kruse, & Kern, 2007). Enactment, which might also be called taught curriculum, involves putting an intended curriculum into practice (Print, 1993). In the process of enacting a curriculum, changes may be made to fit the reality of training and what instructors themselves feel to be appropriate ways of teaching; therefore, intended and enacted curricula rarely align (Billett, 2009).

During the enactment stage, various factors interplay and affect the implementation process in ways that deviate from the planned curriculum. These influencing factors can be external (contextual factors) or internal (personal preference or style). In the case of aviation, external factors may include training tools available (e.g., computers and simulators). Internal factors are the experiences, beliefs, and expectations of the instructors regarding the learning and development of pilots and their associated training needs, the airline’s established working culture (e.g., taking a top-down approach to training or allowing instructors to alter the training curriculum to suit each lesson), and pilot factors (e.g., pilots’ individual characteristics). The importance of instructors’ personal belief systems cannot be discounted as it can impact how they train, in spite of the company culture or company suggested practices (Owen, 2009).
Despite various technological advancements in training methodology, the instructor remains a constant in aviation. According to Kearns (2010), “technology will never be able to teach, good teaching will always depend on effective instructors (p. 8). Therefore, the role of the instructor is crucial at the enactment stage of a curriculum, and the alignment between the intended and enacted curriculum is often left to their discretion. However, aviation instructors tend to have limited training in pedagogical practices, and they often rely on their own expertise and personal beliefs when instructing trainees (Telfer, 1993). As a result, some of the practices used by instructors may lead to the reproduction of knowledge, skills, and attributes that may not be suited in the complex socio-technological work environment in which pilots work (Kearns, 2017; Owen, 2009).

2.6.1.3. The hidden curriculum

The learning that occurs within a curriculum is not only what has been planned by the curriculum’s designers but also includes what has been called the hidden curriculum (Print, 1993). This curriculum, which is an aspect of enacted curriculum (Billett, 2011), is made up of knowledge and information that is taken for granted as common-sense and thus remains unquestioned and often unacknowledged by the institution, teachers and students (Print, 1993). The hidden curriculum can lead to unintended learning in the form of embedded norms, values, and beliefs of the organisation that are reinforced through the procedures, rules, and social structure of the training program (Billett, 2011; Print, 1993; Smith & Lovat, 2003). The term refers essentially to the social lessons a trainee gains through experience and the ways s/he becomes familiar with the culture of the workplace via exposure to workplace practices and norms (Billett, 2004a, 2004b). The outcome of a hidden curriculum can be viewed as either detrimental or beneficial (Print, 1993). Different organisations will have different forms of hidden curriculum; that is, the exact same intended curriculum could be provided to two different airlines but could result in two completely different outcomes depending on the content of the hidden curriculum. As in the case observed by Owen (2009), instructors can influence how trainees experience the program by adopting certain roles that align or run against company intentions.

An example of hidden curriculum within aviation is the practice of safety culture—the norms that reflect an organisation’s approach and commitment to safety, including its definition of what safety is and how it is achieved and maintained. Safety culture might
be imparted formally (e.g., an official statement of the organisation’s safety culture), or it might be unofficially embedded into the organisation’s training program, in which case it is part of the program’s hidden curriculum. For example, certain critical phases of flight (such as landing) have higher workloads than others, and during these phases, it is necessary to maintain a “sterile flight deck” (e.g., only professional and operational calls) in order to maximise the effective communication and crew performance. Whether or not this practice is enforced depends on the safety culture of an airline, meaning that trainees who witness communication on the flight deck during landing may themselves engage in non-pertinent conversations during critical phases of flight.

2.6.1.4. The experienced curriculum

Experienced curriculum is known by many names. Schugurensky (2002) calls it tested curriculum, learned curriculum, and reported curriculum. Print (1993) calls it achieved or attained curriculum, and Bowers (2006) calls it assessed curriculum. Looking at experienced curriculum shifts the focus from the organisation’s perspective to the learner’s perspective (Brady & Kennedy, 2013; Kelly, 2009); however, given that curricula are developed with the aim of training learners, the focal point of the entire curriculum development process should be the learner.

The individual characteristics and past experiences of learners have a significant influence on how they will respond to a training program (the enacted curriculum) (Billett & Smith, 2006; Noe, Clarke, & Klein, 2014; Telfer & Moore, 1997). Past experiences also influence how individuals exercise their personal agency when engaging or participating in what is being suggested socially (Billett & Smith, 2006). Several authors describing pilot learning (e.g., MacLeod, 2001; Telfer & Moore, 1997) have stressed the importance of considering the learner during training planning and implementation, however, their discussion of the learner does not include the role agency and how it relates to training effectiveness.

The learning of trainees in the workplace is shaped by a reciprocal relationship between the learning opportunities offered by the workplace and each individual’s capacity to access, secure and make use of those opportunities (Billett, 2004a). Situational factors and social negotiations affect learning opportunities that the workplace offers, for example, the resources available for training programs are affected by the state and
intentions of the company (i.e., intended curriculum). However, just as important as resources available is the individual’s subjectivity, identity, and intentionality in the workplace, as those factors decide how individuals engage with the learning opportunities provided.

Human agency is exercised relationally within and through social structures (such as a training curriculum), but it is not necessarily ruled by those structures. Within the social structure are social suggestions or pressures that impose norms, practices, and values to engaging individuals (i.e., the enacted curriculum, in the case of a training program). However, being subjected to an enacted curriculum does not necessarily mean that an individual will learn or understand the intended curriculum. The relational interdependence between the individual and the social is inherent to and embedded within the processes of thinking, acting, and learning at work (Rogoff, 1995). That is, the degree to which individuals engage with what they encounter and what types of learning arise as a result is, in part, person-dependent because of the uniqueness of each individual’s cognitive experience (Billett & Smith, 2006).

Subjectivities are defined as a person’s conceptions and dispositions, be it conscious and non-conscious, constitute someone’s cognitive experience and shapes the way he or she understands the social and natural/brute world (Billett, 2009). In other word, people’s past shapes their subjective experiences of the world which in turn influences how they engage with learning and working experiences. Subjectivity is manifested in an individual’s ongoing and developing “sense of self,” which guides the degree and intentions of a person’s conscious thinking and acting in seeking to comprehend and respond effectively to experience. When learning in in the workplace, the formation and transformation of self is negotiated between individuals’ personal subjectivities and the kinds of social experiences they encounter at work. Billett and Smith (2006) describe that learning that takes place at work as a matter of “becoming”—in this case, the journey of pilots becoming first officers.

Learning is something that learners do for themselves, regardless of the environment they are in (Dismukes et al., 2000). There is some evidence to show that when training programs are designed with the learner as the central focus, there is an increase in productivity and effectiveness obtained from training (Karp, 1998, 2000). Based on these reviews, it seems that serious attention should be given to learner and how they choose to
interact with the training system. Previous studies that investigated learning approaches (e.g., Telfer & Moore, 1997) had used questionnaires to identify approaches to learning, therefore teaching. However, there has been no in-depth review of learner perspective during training. As emphasised by Billett (2006a, b), individual agency ultimately decides what is learned. Therefore, obtaining their perspective of the current training program should offer insights that would not be obtained by the perspective of others (i.e., instructors or researcher). As the aim to understand how they learn to become a first officer of the airline, they would be able to provide detailed feedback on the journey through the training process.

2.7. Summary
The airline industry is facing a global pilot shortage, placing pressure on current training programs to produce more pilots while maintaining standards. This means that there is a need for training programs that are both effective and efficient. However, little is understood about how specific airline training programs are conducted in current times, and even less about what and how pilots actually learn through these programs. Therefore, an in-depth review of these processes is required in order to determine which aspects of training need to be adapted or modified to maximise effectiveness and efficiency of pilot training.

This study was conducted with the aim of gaining an understanding of how new pilots engage in and learn during an airline initial training program. This includes initial type rating, and line flying training until the pilot is assessed as a competent first officer in a regional airline. The curriculum theory by Billett (2006a) was argued to provide the means to understand and investigate the state of current training programs. Specifically, the planned program by training managers was understood as the intended curriculum. The training program as carried out by instructors during each lesson was classified as the enacted curriculum. Finally, the perspective of pilots who were subjected to the program was known as the experienced curriculum. While a training curriculum consists of three main categories, and all three require in-depth investigations, it was the experienced curriculum that is the focus of the study, as this perspective has received the least amount of attention in aviation research. The next chapter discusses the research approach used to achieve this aim.
Chapter 3. Case study as a research approach

3.1. Introduction

This exploratory research used a qualitative case study method framed by curriculum theory to better understand the intended, enacted, and experienced processes of the first officer training curriculums offered by two different airlines. As discussed in Chapter 1, both intended (SQ1) and enacted (SQ2) elements of airline training curriculums, though limited in numbers, have received significant interest in terms of policy development and training research. However, as discussed in Chapter 2, the experienced element (SQ3) has received little attention in existing research but are the true determinants of training effectiveness. For this reason, this study focuses primarily on experienced curriculum (SQ3), with SQ1 and SQ2 included to provide context for this exploration of how pilots experience the process of training to become first officers within airlines (see Table 3.1). As this study was part of a larger ARC-Linkage Project, other data collection activities were conducted in addition to the activities for this study. Only aspects related to this study’s research questions were reported in this thesis.

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<th>Focus</th>
<th>Sub-Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1 Intended</td>
<td>What is the nature of current training programs for training new first officers?</td>
</tr>
<tr>
<td>SQ2 Enacted</td>
<td>How is the training program implemented during the course of training?</td>
</tr>
<tr>
<td>SQ3 Experienced</td>
<td>How do pilots engage in the current provisions for training and development?</td>
</tr>
</tbody>
</table>

This chapter begins by providing the rationale for the qualitative case study design, followed by a description of the study in two phases, where Phase 1 involved the research preparation of the study, which included (a) negotiation with the airlines and (b) pilot study; and Phase 2 was the main case study (see Table 3.3). Details of the methods, procedures, and instruments used during field research, followed by the data analysis process used to tease out findings around pilot trainees’ learning experiences, is provided. The chapter concludes with a discussion about ensuring credibility in research.
3.2. **Overall case study design**

Aviation places a strong emphasis on maintaining safety in a highly standardised and regulated industry. Therefore, there is a tendency among researchers studying this field to conduct studies through positivistic perspectives, which are meant to provide “unambiguous and accurate knowledge of the world” (Crotty, 1998, p. 18). Ferroff, Mavin, Bates, and Murray (2012, p. 2) identified two reasons for the prevalence of positivist perspectives in aviation research. The first was that aviation’s regulatory bodies have always been driven by numerical metrics, which are often produced in positivistic research that are mostly quantitative in nature, and the second was that results are understood to be “free of subjectivity” and therefore the best form of evidence. However, some researchers have highlighted issues with using solely quantitative/positivistic approaches to study aviation and underlined needs for more interpretive and naturalistic styles of research in aviation (e.g., Bennett, 2006; Bennett, 2018; Mavin, 2010; Mavin & Roth, 2014; Roth, Mavin, & Munro, 2014; Roth et al., 2015).

Positivistic methodology (e.g., laboratory research) primarily involves careful experimental investigations where data is collected and analysed to explore assertions, corroborate claims, and to distinguish between plausible claims (i.e., hypotheses) (Patton, 1990); therefore, influences of context and environment, as well as interactions and interrelations of people within them, are often disregarded in this type of approaches (Patton, 1990; Wiggins & Stevens, 2016). While there is no denying the majority of laboratory or applied research in aviation has greatly contributed to aviation safety (Wiggins & Stevens, 2016), more field type research is required to better understand actual work. Ferroff et al. (2012) suggested that research in aviation must recognise and account for complex relationships and cultures because “[a]t the heart of all large complex systems…there is a coupling of both technical and human sub-systems [which] results in highly specific operational and safety cultures” (p. 8). Furthermore, Helmreich and Merritt (1998) pointed out the limitations of quantitative/positivistic research findings generated in laboratories. They claimed that meaningful data could only be obtained with more naturistic approaches in real-world settings. Therefore, studies into human behaviour are best understood in the contexts in which the behaviours occur (Marshall & Rossman, 2006).
As this study aimed to contribute to knowledge about pilot learning during training, the context within which trainees learn (i.e., training program) was paramount. Therefore, the study was underpinned by a constructivist perspective and an interpretive approach. Qualitative research methods were used in the study as they can collect data that provide deep insights into the meanings and purposes embedded within a pilot’s initial training program—with a focus on pilot trainee experiences—while accounting for the effects of context on the learning process (Lincoln & Guba, 1985). The interpretivist stance (Creswell, 2013; Crotty, 1998) recognises that knowledge is constructed by individuals’ and their construction are influenced by their social surroundings, and that any meaningful research should be conducted in the natural settings of work with a mandate to examine “culturally derived and historically situated interpretations of the social life-world” (Crotty, 1998, p. 67).

To better understand the perspectives of pilot trainees, specifically their learning within the context of training, a case study approach was used. Stake (2003) describes case studies as “not a methodological choice but a choice of what is to be studied” (p. 134) and involves multiple methods to gather evidence about the case (pilot learning) to yield rich and thick descriptions of the phenomenon (Merriam, 1998; Stake, 1995; Yin, 1994). The case study approach also allows for the exploration of a of such phenomenon, where a “bounded system”, like the initial first officer training program, of which the case—pilot trainee—is embedded in, is investigated through an in-depth and detailed process of data collection, with unique strategies for sampling, collecting, and analysing each source of information (Stake, 2003, p. 135). Importantly, the case study approach is useful when the boundary between a phenomenon and its context is not clear; such as the process of pilot trainee learning which cannot be understood without knowing training program as part of the context (Baxter & Jack, 2008; Yin, 2012).

Figure 3.1 illustrates the focused phenomena of this study (i.e., pilot’s learning experiences) which was bounded with several layers of contexts: (1) enacted curriculum, (2) intended curriculum, (3) pilot training at the airline, and (4) international and national framework. The phenomenon of interest was the learning experiences of the cases of the study (pilot trainees) undertaking the first officer training program.
Figure 3.1  Pilot trainee learning experiences as focused phenomena in the layered contexts

Figure 3.2 illustrates the overall qualitative case study approach to develop an understanding of pilot learning during their initial training for becoming a first officer and the methods used in the study. Each research site (the two airlines) were themselves multifaceted cultures (Ferroff et al., 2012) consisting of own subsections (e.g., training department, rostering department, flight operations department), schedules (e.g., training days, holidays, break days), and groups (e.g., lesson types, different groups of people, and most importantly the pilots), which together formed a concentration of domains so complex that at best it could only be sampled (Stake, 2003). In this study, these complexities were examined as part of surrounding contexts via literature review (Chapter 2); research preparation activities (Phase 1) which included gaining site access at the airlines and conducting a small pilot study; and then conducting the main study (Phase 2) (see Table 3.2).
The parameters of the current training curriculum were investigated via field research. Heath (2011) argued that being in the field is invaluable for researchers doing qualitative research, as it allows the researcher to gain the trust and cooperation of trainees and other key contacts in the study. Furthermore, being in the field allowed the researcher to get a sense of the complexity of the activities that pilots engage in during training and the organisational constraints that affect those tasks, and to learn more about the tools, technologies, artefacts and objects that were used as part of training.

As outlined in Figure 3.2, three methods were employed to collect evidence for three aspects of curriculum. Site document review was conducted to gather information about the intended curriculum as well as other relevant information around the related training program. Direct and indirect observations were then utilised to gather evidence on the enacted curriculum or how training was carried out. Finally, to collect information on the experienced curriculum, a series of individual interviews were employed.

Figure 3.2  Overall case study design and its methods employed for this study
### Table 3.2 List of data collection activities for this study

<table>
<thead>
<tr>
<th>Data collection activities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong></td>
<td></td>
</tr>
<tr>
<td>• Negotiation</td>
<td></td>
</tr>
<tr>
<td>• Pilot study</td>
<td></td>
</tr>
<tr>
<td><strong>Phase 2</strong></td>
<td></td>
</tr>
<tr>
<td>• Site document review</td>
<td></td>
</tr>
<tr>
<td>o Airline training organisation manual</td>
<td></td>
</tr>
<tr>
<td>o Student and instructor training reference documents</td>
<td></td>
</tr>
<tr>
<td>o Procedure manuals</td>
<td></td>
</tr>
<tr>
<td>• Individual semi-structured interviews</td>
<td></td>
</tr>
<tr>
<td>o Introductory interview at the beginning of training</td>
<td></td>
</tr>
<tr>
<td>o Reflective interviews across simulation/line training</td>
<td></td>
</tr>
<tr>
<td>• End of type rating</td>
<td></td>
</tr>
<tr>
<td>• Early stages of line training</td>
<td></td>
</tr>
<tr>
<td>• End of line training</td>
<td></td>
</tr>
<tr>
<td>o Follow-up interviews at the end of each training day</td>
<td></td>
</tr>
<tr>
<td>• Observation (field notes and video recordings) from beginning of training program to end of simulator training</td>
<td></td>
</tr>
<tr>
<td>o Everyday practice of ground training days</td>
<td></td>
</tr>
<tr>
<td>o Daily classroom-based learning</td>
<td></td>
</tr>
<tr>
<td>o Simulation-based sessions (briefing, simulator sessions, and debriefing)</td>
<td></td>
</tr>
</tbody>
</table>

Important to note in Figure 3.2 is the ongoing processes of the researcher’s independent reflections and the researcher–supervisor cross-checking activities during data collection and data analysis in order to develop understandings of pilot learning. The principal supervisor, a subject matter expert with extensive domain-specific knowledge as an airline captain, instructor and flight examiner, played an important role in this study to facilitate the researcher in data collection and analysis to produce domain-specific findings through this researcher–expertise interaction (Kikkawa & Bryer, 2013).

In order to conduct the study, extensive resource planning and management was required. Accordingly, the number of participants, the location of participants, data points for data collection, travel costs and materials had a major influence on how the study was conducted (Wiggins & Stevens, 2016). These issues are discussed in the next few sections.
3.3. **Phase 1: Research preparation**

To ensure that the research protocols, methods, and tools were functional and able to collect quality data, two research preparation activities were conducted (Mason & Zuercher, 1995; van Teijlingen & Hundley, 2001). The first activity was the process of negotiating access to the research site and key personnel, which included discussing the planned research schedule; and the second activity, the pilot study, was conducted to test the usefulness of planned research methods.

3.3.1. **Negotiating access to the research site and key personnel**

As mentioned in Chapter 1, this study was part of a larger ARC-Linkage Project with two airlines, therefore providing access to the airlines’ training systems (Wiggins & Stevens, 2016). The negotiation process involved determining the nature of the study, how data is recorded, analysed and used, and logistical matters of the researcher while on-site. Additional negotiations were done with Airline A to conduct a pilot study to test the utility of data collection tools and methods. Prior to the study, the researcher was introduced to other key personnel within the airlines. These people set the training schedule for pilot trainees and instructors, and manage changes to training schedules (e.g., trainee/instructor falling ill, additional training, training equipment failure), the simulator engineers who can help the researcher with simulator related issues (e.g., extraction of simulator recordings and solve any issues relates to simulator video recordings), and the internal travel manager of the airline (e.g., travel arrangements between research sites).

It was also necessary to confirm if the planned research tools (e.g., set up of video recording equipment) at different research locations would be accepted by the airlines and able to capture pilot activities during training. For example, recording of part task training sessions required cameras to be set up at strategic locations in the least obstructive manner, but still able to capture the lesson in detail. Therefore, with approval from the airline, it was decided that the camera would be mounted on the part task trainer (see Figure 3.3).
These types of activities were negotiated during on-site meetings after surveying the different training locations, and off-site meetings via emails and phone calls.

### 3.3.2. Pilot study

A pilot study was conducted to ensure that planned research methods and instruments would be able to collect quality data and provide the opportunity to refine them before the main study (van Teijlingen & Hundley, 2001). To test the interview protocol, trial interviews were conducted remotely (i.e., from Brisbane) via Skype with five volunteer pilots in Airline A who were going through the same initial first officer training program. Skype interviews were used because the researcher was based in a different country and the additional travelling expenses for a pilot study were not feasible. This also meant that conducting a full pilot study (i.e., conducting the full study on a smaller sample) was not possible (van Teijlingen & Hundley, 2001). A pilot study was not done at Airline B due to time constraints on the part of the airline.

After emailing the information and consent form (see Appendix A, p. 257) to each pilot, an initial Skype meeting was conducted with pilots where they were briefed about the
purpose of the pilot study and that interviews would be recorded to allow for later reflections by the researcher. After receiving their signed consent forms, pilots were interviewed at different intervals during their training, where they described their learning experiences according to the questions asked. They were asked whether they understood the questions and also to comment on the wordings of the questions. Based on their comments, no amendments were made to the type of questions asked, but some changes were made to the answer prompts. For example, alternative phrasing of questions was added (e.g., pilots were asked to identify training issues by indicating what was “hard,” “difficult,” “challenging,” and “still working on”). Prompts for further explanations were also added (e.g., “Describe more about [...]”, “Explain what do you mean by [...]”, “How did you carry out [...]”, “What were you thinking about when you were doing [...]?”) (see Appendix B, p. 261). The Skype interview format was also found to be a feasible alternative to face-to-face interviews especially during busy periods of training and when in different locations.

3.4. Phase 2: Main study

This section details the data collection procedures of the main study (see Figure 3.2). Table 3.3 shows the timeline of data collection in the two airlines. The main study commenced on December 2015 with Airline A and August 2016 with Airline B and continued until pilots were checked to line (final assessment). The timing for checked to line assessments were individually based, hence the timeline indicated in Table 3.3 shows the first day of each Phase and the last date where the last activity was conducted (final reflective interview with last pilot).

<table>
<thead>
<tr>
<th>Table 3.3 Timeline for this study at Airline A and Airline B</th>
</tr>
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<tr>
<td></td>
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</tbody>
</table>

The following sections outline the airline research sites and demographics of pilot trainees, the ethical considerations for conducting this case study and reported how issues of informed consent and anonymity were managed in this study, and the methods and procedures of the study.
3.4.1. Site and trainees

This study investigated initial first officer training offered by two regional airlines in the Tasman region (see Table 3.4). Airline A is in New Zealand, and their training sites are in both Christchurch and Auckland. They operated the ATR72-500 and ATR72-600 aircraft, and at the time of the study had approximately 280 pilots. Airline B is in Australia, and their training site is in Sydney. Airline B flew three variants, DHC8-200/300/400, and at the time of the study had 450 pilots. In line with current aviation trends, the training managers of both sites had informed the researcher that the pilot numbers would be increasing in the coming months.

For this study, the training programs investigated were on both ATR aircraft types in Airline A and only the DHC8-400 variant in Airline B. Both airlines have ownership of the training resources used in their training programs, meaning that they did not have to rent equipment or training spaces when carrying out training.

Table 3.4 The two research sites

<table>
<thead>
<tr>
<th>Airline</th>
<th>Regulatory body</th>
<th>Program/s</th>
<th>Location of training</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CAANZ</td>
<td>ATR72-500/ATR72-600</td>
<td>Christchurch/Auckland</td>
</tr>
<tr>
<td>B</td>
<td>CASA</td>
<td>DHC8-400</td>
<td>Sydney</td>
</tr>
</tbody>
</table>

The amount of data gathered varied among the airlines due to their different recruitment structure. Table 3.5 shows the differences in data collection periods during field research at the two airlines. Airline A had conducted the entire initial training in house, while Airline B had conducted most of the ground courses at a university. Data collection from ground training until the end of simulator training was conducted on-site, and remotely after pilot trainees had begun line training.

Table 3.5 Data collection period during field research

<table>
<thead>
<tr>
<th></th>
<th>Ground training</th>
<th>Simulator training</th>
<th>Line training</th>
<th>Checked to line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airline A</td>
<td>On-site</td>
<td>On-site</td>
<td>Remote</td>
<td>Remote</td>
</tr>
<tr>
<td>Airline B</td>
<td></td>
<td>On-site</td>
<td>Remote</td>
<td>Remote</td>
</tr>
</tbody>
</table>

Note. Shaded region represents time of data collection.

A total of ten pilot trainees (n = 6 in Airline A; n = 4 in Airline B) were involved in this study through convenience sampling (Marshall, 1996). The study sampling design may qualify for what is defined as theory-based or operational construct sampling (Patton,
1990) as the aim was to sample incidents of learning or learning blocks that occur during their time in training in an operational (i.e., real-world examples) context. However, the strategy to recruit participants was based on convenience. While convenience sampling is considered the least rigorous non-probability sampling strategy (Marshall, 1996), it was necessary due to the nature of airline training programs and monetary constraints (Wiggins & Stevens, 2016). In airlines, pilots are recruited and placed into training programs based on available training slots and conduct training only when required (i.e., depending on the need for more pilots). Due to how training programs are rostered, and the uncertainty of whether there would be other first officer training programs, the researcher had followed the first group of pilot trainee cohorts that agreed to participate in the study. Therefore, the findings of this study should be viewed with the understanding that there were no criteria for selecting the types of pilots in the study other than being part of the first officer training program.

For this study, ten pilot trainees were recruited because those were the number of pilots undergoing training at that point in time, hence it was not possible to recruit more pilots. There are no rules to determine the appropriate sample size of a qualitative study, rather, sample sizes are informed by contextual and pragmatic considerations, such as the purpose of the study and what can be done with the available time and resource (Patton, 1990). As the study was also conducted in a longitudinal manner, where trainees were followed and interviewed from the start to the end of training, this study meets the pragmatic “rule of thumb” suggested by Braun and Clarke (2013) for number of interviews for a study in a large project which should be around 10 to 20 interviews.

All pilots remained in the study until completion except for one pilot from Airline A, who had failed the training early during simulator training. Because the aim of this study was to develop a holistic understanding of the learning experiences of pilots during the program, individual uniqueness including failure an advantaged to this study. Therefore, the data collected from this pilot from start to cessation of training was included in this study.

3.4.2. Ensuring ethical research

This study was reviewed and fully approved by the Griffith University Human Research Ethics Committee (EDN/12/15/HREC). The committee reviewed information packages
for trainees (i.e., information sheet and consent form) and research instruments (i.e.,
original interview questions). Prior to commencement of the study, the researcher met
with potential trainees and outlined the study’s aims, methods and parameters in detail.
Specifically, trainees were informed that:

1. The purpose of the study was to understand the effectiveness of current training
methods.
2. Lessons would be video recorded and interviews audio recorded and retained for
subsequent analysis.
3. All personal information would remain private unless additional consent was
given, or the information was required by government, legal, or regulatory
authorities
4. Collected data would be used for publication and report writing.
5. A de-identified copy of the data may be used for other research purposes, but
their anonymity would be maintained unless they had formally agreed otherwise.

Consent was requested from the training managers of the two airlines, flight examiners,
flight instructors, ground instructor and pilot trainees. They were provided with an
information sheet and consent form (see Appendix A, p. 257) describing the above points.
Once participants agreed to be involved in the study, participants signed and returned the
consent form to the researcher. All participants were reminded that their participation was
fully voluntary and that they could choose to withdraw at any time without facing any
repercussions from the research team or the airline. As the study was conducted over a
prolonged period of time, the researcher worked with the understanding that pilot trainees
needed to focus first and foremost on their training, so their participation in the study
should not hinder their learning. Therefore, extensive planning with each trainee was done
to determine how interviews would be conducted. At the end of the data collection phase,
pilot trainees were reminded and assured of the confidentiality of their data.

To maintain anonymity of trainees during this study and after its completion, the
researcher had paid special attention to the storage and use of data (Wiggins & Stevens,
2016). All collected data (video and audio), field notes, and subsequent transcripts were
stored within secured cabinets on university grounds. Data collected in digital formats
were stored within the University’s online storage systems under university security
protocols. In all transcripts, the names of individuals and airlines were changed so that they were not identifiable, and all reports of this study’s findings will contain only de-identified information.

3.4.3. **Ongoing reflections**

Two types of reflections were conducted during the entire course of this study: the researcher’s independent reflections and researcher-supervisor discussions. First, recording of personal impressions of field experiences were considered as a way to inform what kind of data the researcher obtained on that day, and add contextual understanding to case reporting (Kikkawa & Bryer, 2013). The researcher used note-taking techniques during data collection and analysis to record her methodological concerns and decision-making. For example, the researcher recorded how long it took to travel between locations, especially when flights between states were involved (see Appendix C, p. 262, for example of time schedule).

In addition, the researcher actively discussed her thoughts and preliminary findings with a subject-matter expert. This interrogation with a person with aviation expertise provided the researcher with relevant domain-specific information which was essential to extract findings meaningful to the airline and pilots. The process ran from the start of the study design to the end of case reporting. For example, flight procedure or manoeuvre was explained by the subject matter expert so that the researcher could understand what the procedure/manoeuvre entailed and contrast it with the description of trainees, which allowed for better understanding of the core issue. Cross-checking activities were also conducted with the subject matter expert to refine the themes and findings of the study. The alternative views offered, and challenges made regarding the findings, led to deeper interpretation of the data.

3.4.4. **Site document review**

The main purpose of collecting and analysing site documents was to obtain contextual information on the intended curriculum (Mulhall, 2003). Table 3.6 lists the copies of relevant training documents were obtained from training managers and instructors from both airlines for analysis.
Table 3.6 List of collected documents and use during data analysis

<table>
<thead>
<tr>
<th>Document</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airline training organisation manual</td>
<td>Basic structure of training and assessment criteria</td>
</tr>
<tr>
<td>Instructor reference document</td>
<td>Training topics and objectives</td>
</tr>
<tr>
<td>Trainee reference document</td>
<td>Training topics and objectives</td>
</tr>
<tr>
<td>Procedures manual</td>
<td>Additional information</td>
</tr>
<tr>
<td>Trainee’s training records</td>
<td>Trainee information</td>
</tr>
<tr>
<td>Other training manuals</td>
<td>Additional information</td>
</tr>
</tbody>
</table>

These documents outlined the training topics covered in each program, which contained the assessment criteria and objectives for each lesson. Out of all documents, the ATO manual, the instructor reference document, and the trainee reference document were the main documents used for consultation with pilots during the field research. Other documents, such as standard operating procedure manuals, training records or other training manuals, were also collected so that the researcher could reference them if trainees discussed them during interviews.

3.4.5. Observations

Observations were designed to gather primary evidence for identifying the enacted curriculum (SQ2) and supplementary evidence for interpreting experienced curriculum (SQ3). In this type of method, targeted subjects (i.e., pilot trainees) are directly observed participating in activities occurring in the field (Stake, 1995; Yin, 1994) which allows researchers to be where the action is (Bernard, 2006). Though observations can be time-consuming and, in some cases, heavily restricted by a company or training organisation (Wiggins & Stevens, 2016), they allow the researcher to observe trainees engaging in goal-directed actions and object-oriented activities that need to be identified for analytical purposes (Yin, 1994).

Two types of observations were conducted: direct observation via field notes and indirect observation via video recordings. Observation topics focused on (a) what happens during a lesson/learning activity, (b) topics and objectives that are covered during a lesson/learning activity, and (c) interactions between the instructor and pilot trainees—and between pilot trainees—including questions, instructions, and conversations.
Direct observation via field notes
In this study, unstructured observation method, as opposed to systematic observation, was used for direct observations (McKechnie, 2008; Mulhall, 2003). Unstructured observation is characterised by entering the field knowing, to some extent, what to observe but having no set notions as to exact behaviours that might be observed (Mulhall, 2003). Observations were conducted throughout each day and recorded using field notes. Field notes were used to record the setting, people, and activities that take place in the observed context (Mulhall, 2003) as well as to record the introspective account of the researcher’s experience in the field (see examples in Appendix D, p. 263), including any methodological changes and why they were made (Merriam, 1998).

While observations allowed the researcher to gain an understanding of the training context and content, direct observations were reduced and eventually stopped as the study progressed. This was because, on too many occasions, the researcher had to leave the classroom to discuss logistical matters such as travel plans, pilot rostering, and meetings with training managers or instructors. Hence, to avoid distracting trainees, the researcher stopped taking part in direct observation and relied on video data.

Instead, the focus of field notes became more on pilot behaviours and other training activities that occurred outside of official training segments. The purpose of the notes was to identify possible learning activities that took place in addition to what was required by the intended curriculum. The notes also served as a reminder to clarify the reasons for those additional activities with the pilots during interviews.

Indirect observation via video recordings
In this study, video recordings allowed the researcher to record the phenomenon being studied (pilots’ learning) without being physically present. Video recordings were used in a similar manner as unstructured observation (Mulhall, 2003) to provide additional information to help the researcher to understand scenarios described by pilot trainees and to identify the enacted curriculum.

Observations were conducted during classroom-based and simulation-based learning activities. Opportunity for direct observation was limited when trainees began simulator training as training schedules became tighter and involved multiple locations. Furthermore, simulator training is considered highly stressful for trainees (as noted in
field notes, “pilots look tired and stressed, [so I left them alone to] let them rest” [notes_150119] and also from video data from debriefing sessions); therefore, the researcher opted not to conduct direct observations in the event of causing any form of distraction, even when offered by instructors to sit in the lessons. By further removing the researcher’s presence from the actual training context, it was anticipated that Hawthorne effects, where participants modify behaviour in response to their awareness of being observed (Wiggins & Stevens, 2016) could be reduced. Accordingly, video recordings were collected for classroom, briefing, simulator sessions (via company recording devices) and debriefing. Due to logistical difficulty and company restrictions, line-training was neither observed nor recorded.

Video recording procedures varied according to the training location. The main locations were: engineering course classroom; normal classroom; PTT; and simulator sessions including briefing rooms, simulator recording, debriefing rooms. All recordings were transferred into a password locked hard drive at the end of each day.

Engineering and classroom lessons
A Canon HD LEGRIA HFR26 camcorder was mounted on a small tripod and plugged in to direct power. The purpose was to record the actions of the instructor and record conversations happening in the classroom. The recording began about 5 to 10 minutes before class started (around 8.30am) and stopped at the end of the day, around 5 p.m., or after instructors and pilot trainees left. An example of classroom layout and camera position is presented in Figure 3.4, with further examples of footage are provided in Chapter 4.
Simulator sessions

Video and audio recordings of briefing and debriefing sessions were recorded using a Sony HDR-AS50 Action Camera. An additional audio recording device (a small Android tablet) was used in Airline B to capture improved sound quality of conversations between trainees and instructors. It was placed on the desk close enough to capture voices, though to the side to prevent obstruction during training.

During simulator sessions, personal recording devices were not allowed as this would have been disruptive (Dahlström & Nahlinder, 2009). Therefore, video data was extracted from the simulator recording device in the simulator centre with the help of simulator engineers. This data was transferred into a different password-locked hard drive that was kept within the simulator recording office until the end of the simulator training period. A backup copy of simulator recordings was saved on the password-protected hard drive. Note that all recordings within simulators required additional approval before recordings could be collected. Here an agreement, in addition to the ethical clearance was made between the university, chief investigator, the current researcher, airlines, and unions.

3.4.6. Series of individual semi-structured interviews

Interviewing is a useful qualitative research technique for obtaining rich accounts of situations or phenomena (Bernard, 2006; Cohen, Manion, & Morrison, 2007; Creswell,
A series of semi-structured interviews were conducted to obtain experiences from the pilot trainee’s perspective. Gathering multiple perspectives from different individuals (i.e., pilot trainees) contributes to an in-depth understanding of the topic of analysis (Patton, 1990; Stake, 1995). Table 3.7 shows that the interview schedule of these activities.

### Table 3.7 Interview schedule and topics of semi-structured interviews

<table>
<thead>
<tr>
<th>Interview Type</th>
<th>When</th>
<th>Topics</th>
</tr>
</thead>
</table>
| Introductory interview | Beginning of training program | • Introduction and building rapport  
|                        |                           | • Obtain background information                                    |
| Follow-up interview    | End of each training day  | • Obtain daily experiences of training  
|                        |                           | • Follow up issues of learning                                     |
|                        |                           | • Clarify researcher daily observations                             |
|                        |                           | • Lesson preparation plan                                             |
| Reflective interview   | End of type-rating        | • Overall experience of type rating training  
|                        |                           | • Major learning blocks                                               |
|                        |                           | • Techniques used to overcome learning issues                         |
|                        |                           | • Training methods that were useful/not useful for learning           |
| Early line training    |                           | • Effectiveness of type rating for preparing pilots for line training  |
|                        |                           | • Experience of line training (transition from simulator to aircraft) |
| Checked to line        |                           | • Current learning blocks                                             |
|                        |                           | • Experience of work (transition from supervised to normal operations) |

Semi-structured interviews were used as it gives the researcher more control over the direction and duration of the interview (Bernard, 2006). Three types of interviews were designed for different purposes of this study. Extensive planning with each pilot trainee was conducted to set up times for interviews.

First, the introductory interview was designed to provide an avenue for both researcher and trainee to simply get to know one another and explain the purpose of the study. This was an important process, as it established the expectations of both researcher and participant, which improved the ethics and reliability of the study (Cohen et al., 2007; Sandberg, 2005). The researcher then collected trainees’ demographic and background information in relation to their aviation career and motivations for joining the airline, contact information and preferred method of communication. Trainees also had the opportunity to ask any questions regarding the study.
Second, follow-up interviews, lasting 20 minutes on average, were conducted continuously from ground training to end of simulator training. Here each pilot trainee would focus on specific difficulties they encountered during lesson preparation, training, and techniques to overcome them for the particular day. The question about their perspectives on the enacted curriculum was also included for their suggestion for program improvement. As learning is a continuous process throughout training, the topics discussed during an earlier interview session would be followed up during the next interview session. The aim was to continuously track what pilot trainees were experiencing through these short interviews, and eventually follow up on key issues during reflective interviews.

Third, three reflective interviews, lasting between 30 to 120 minutes, were conducted at the end of type rating training, during line training, and after the pilot was checked to line. They were designed to ask the trainees to reflect on their experiences of all training lessons at the point of each reflective interview time. The questions of the sessions were somewhat parallel to the follow-up interviews and designed to ask trainees to describe the type-rating or line-training experiences that they had undergone during training and discuss their experiences of those lessons. As pilot trainees from Airline B had joined the study only from simulator training onwards, pilot trainees were asked to reflect on their university training and describe their learning experiences there in relation to the airline training.

In the introductory interview, a number of follow-up interviews, and all of the reflection interviews, the principal supervisor (subject matter expert) was present and assisted in some of the questions and provided feedback to the researcher on interview techniques (see Figure 3.5).
An interview protocol was used to provide direction for each interview (see Appendix B, p. 261) and focused on obtaining experiences of what pilot trainees found simple or difficult and their reasons for them. The interview protocol reminded the researcher to ask key questions regarding pilot learning experiences. It also summarised interview techniques including prompts and setting times for the next follow-up interview. Stake (1995) suggested that interviewers should prepare a list of issue-oriented questions—in the case of this study, questions about learning experiences during each lesson of training—and give them to participants in advance to indicate that there is an agenda for each interview. These questions should be able to elicit descriptions of episodes, linkages, and explanations (Stake, 1995). Therefore, pilot trainees were given a list of questions, which were the same initial questions asked during every interview, to look at prior to the interview. However, it was only done for the first few interviews as trainees soon learned the type of questions that would be asked and did not need further reminders.

All sessions were audio-recorded using QuickTime on an Apple laptop as the primary recording instrument, with the researcher’s phone as back-up. While the main method for interviews was face-to-face, busy scheduling required the researcher to use alternative format to maintain the ongoing implementation of these interviews. In the end, three interview formats were used for this study: on-site face-to-face interview, Skype interview, and email survey. Decisions on what formats were used at different times of the study is described below:
1. *On-site interviews.* Interviews conducted on-site usually occurred before or after a training lesson. This reduced interruption to the learning process during training. However, the limitation of this format was time and resource constraints. For example, one researcher interviewing up to six trainees and instructors while also performing other data collection activities was difficult.

2. *Skype interviews.* As trainees were based in different locations than the researcher, the most convenient method for interviews was Skype. The decision about whether or not to use the video option when interviewing trainees via Skype was left to the discretion of trainees. Most trainees in Airline A chose to leave the video function off, while Airline B pilots preferred the video function on. However, only audio recordings were transcribed. Interestingly, this interview format was found to be more suitable than on-site interviews during the ground training phase, as trainees sounded more relaxed and were more willing to describe their experiences. Interviews conducted via Skype also allowed the researcher to take more detailed notes compared to face-to-face interviews. During line training, Skype was the only format used. The main limitation for online interviews was the unstable internet connection issues, therefore, phone calls were made when the internet connection was too unstable.

3. *Emails.* This format was only used as a supplement for other interviews when required. During very busy training periods or when trainees were unable to participate in interviews, the researcher emailed them open-ended questions—worded the same way as face to face interview questions—enquiring about their training experiences. Their replies were followed up on during scheduled interviews.

### 3.5. Analysis through curriculum lenses

The various forms of data collected were analysed for each sub-question: intended, enacted, and experienced (see Table 3.8). Note that each question had a main source of data while other sources were supplementary, as opposed to all sources as equally important when addressing each research question (i.e., triangulation of data). For SQ3, supplementary resources were only referred to when explicitly mentioned by trainees to ensure that the trainee perspective remained the focus of the study.
Table 3.8  Data sources and research focus

<table>
<thead>
<tr>
<th>SQs</th>
<th>Interviews</th>
<th>Documents</th>
<th>Field notes</th>
<th>Video recordings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Intended curriculum</td>
<td>—</td>
<td>Main</td>
<td>Supplementary</td>
<td>—</td>
</tr>
<tr>
<td>2 – Enacted curriculum</td>
<td>—</td>
<td>Supplementary</td>
<td>Main</td>
<td>Main</td>
</tr>
<tr>
<td>3 – Experienced curriculum</td>
<td>Main</td>
<td>Supplementary</td>
<td>Supplementary</td>
<td>Supplementary</td>
</tr>
</tbody>
</table>

The researcher used both manual coding techniques and computer-assisted qualitative data analysis tool, NVivo software (QSR International, 2015a, 2015b, 2016), to manage the collected data. Unlike quantitative data analysis software (e.g., SPSS) that can instantly produce results through a selection of statistical process and variables/data points, this type of software provides only systematic assistance with decision-making during the coding or interpretation process (Bryman, 2016). The use of NVivo in this study had simplified the coding and retrieval processes of various quotes and enabled different ways of analysing the data when used with some of its functions such as queries or comparison of coded nodes (Bryman, 2016).

3.5.1.  Data preparation

Data preparation involved multiple steps including organising collected data, transcribing interviews, making digital copies of documents, ensuring videos were in a format that could be read by the analytical tool, and typing up field notes. All data was organised chronologically and according to participant, training program, and airline. Electronic copies were made for key documents for ease of accessibility, security reasons (as hard-copies are bulky and can be misplaced), and for analysis through NVivo. Table 3.9 shows the number of interviews conducted and follow-up emails for each pilot trainee.

Audio recordings of all interviews were transcribed verbatim (including utterances such as “erm,” “uh huh,” and “you know”). Pauses were noted via ellipses (“…”), and long pauses were noted via long ellipses (“……”). As this study did not require a deep analysis of utterances (i.e., conversation analysis), these techniques were deemed sufficient in capturing the nuances of each participant’s intended meaning (Braun & Clarke, 2006). As some pilot trainees were less available for interviews than other’s the number of interviews and emails between trainees varied. Note that content in emails was followed up during the next interview.
Table 3.9 Number of data points collected through interviews and emails

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
<th>P9</th>
<th>P10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>22 (I)</td>
<td>25 (I)</td>
<td>25 (I)</td>
<td>17 (I)</td>
<td>16 (I)</td>
<td>16 (I)</td>
<td>7 (I)</td>
<td>9 (I)</td>
<td>9 (I)</td>
<td>9 (I)</td>
</tr>
<tr>
<td>points (N)</td>
<td>3 (E)</td>
<td></td>
<td></td>
<td></td>
<td>9 (E)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Note. | I = Interview; E = Email

All transcripts were cross-checked with audio recordings again and corrected for errors including checking the accuracy of aviation terminology and abbreviations (e.g., GNSS, familiarisation flight). During interviews, trainees openly discussed their airline work and training experiences, including the names of airlines, instructors, peers, travel routes, and airports. Therefore, while preparing transcripts for analysis, identifying information of participants, airlines and flight operations were de-identified by being replaced them with generic titles in square brackets (e.g., names of people were replaced with [instructor] or [partner]).

During this part of the process, the researcher had started to conduct the preliminary analysis and plan how the main analysis of these data could be conducted. For example, reviewing transcription data alongside audio recordings allowed the researcher to reflect on the conversations with individual pilots and refamiliarise herself with the collected data.

### 3.5.2. Document review for intended curriculum

The analysis of training documents involved extracting information about the different courses and lesson plans for different phases of the initial first officer training program, including the objective of the training and checking/assessment activities (Bowen, 2009). Information regarding the courses of each airline was compiled into one document to form the training pathway of the program. Once the training pathway for all three programs was made, the researcher compared between each program to determine the similarities and differences of the intended curriculum of each training program (SQ1). This was done by categorising the type of activity being conducted (e.g., teaching aircraft knowledge, non-normal procedures training) and the required outcome for each lesson (e.g., assessment method and required scores).

The analysis revealed that each training program shared similar structural features in their training objectives, assessment and methods of training. Therefore, the three programs
were synthesised into one common framework for subsequent analysis of training curriculums. Five shared categories were identified—namely ground training (GT), procedures training (PT), simulator training (SIM), line training (LT), and checked to line (CTL)—among three training programs that were used by the airlines, forming eight *structures* in total (see Table 4.3, p. 100). These structures formed a timeframe for the program, which reflected the series of training courses that pilots completed from the beginning to end of their initial training and became an important structure with which the researcher was able to analyse different datasets of all pilots systematically. The outcome of this analysis is presented in Chapter 4.

### 3.5.3. Video review and field notes for describing enacted curriculum

Field notes and video-recordings were examined to provide evidence for the enacted curriculum and was also used to find concrete examples of each theme identified through thematic analysis (see next section) and to determine if what pilots had discussed was consistent in observation data (Heath, 2011; Sandberg, 2005). It should be noted that the purpose of video analysis was to describe the enacted curriculum and verify what was discussed by trainees. No deeper analysis (e.g., in-depth analysis of actual interactions between pilot and environment) was conducted on videos as it was not the focus of the study (i.e., to identify learning from pilots’ perspective).

The procedure for video analysis was conducted differently depending on the phase of training. For GT1, video recordings ran for the entire day in the classroom, regardless of whether trainees or instructors were present, resulting in an average of 8 hours of daily video recordings. Therefore, analysis for this phase was done by watching the recording of the first day in double speed, slowing down when there was trainee-instructor interaction to identify the content of interaction. The same technique was used for the other classroom courses. From GT2 to Sim-C, video analysis involved analysing the first and last 15-minutes of each video to identify the enacted curriculum.

Where trainees had provided specific examples involving the training program during interviews, the particular segment in the video was located and reviewed to verify what was mentioned. Notes were taken on the actions done by trainee and instructor, while conversations or instructions were transcribed.
3.5.4. **Thematic analysis for experienced curriculum**

The study employed thematic analysis (Braun & Clarke, 2006) to prepare and analyse the collected data as it is a flexible method of analysis that can “provide a rich and detailed, yet complex, account of data” and is not bounded by theoretical restrictions such as grounded theory (Braun & Clarke, 2006, p. 78). This type of analysis is widely used and considered to be a foundational method of qualitative analysis though is a method of analysis in its own right (Braun & Clarke, 2006).

The analysis was conducted via an inductive approach, whereby the findings of the study were allowed to emerge from the data collected through themes and categories (Braun & Clarke, 2006). The following section describes the thematic analysis process, which were (1) becoming familiar with the data, (2) developing case profiles, (3) generating initial codes, (4) searching for themes, (5) reviewing themes, (6) defining and naming themes, and (7) report writing. Steps 1 to 6 are described in this section, while step 7 is described in the next section.

3.5.4.1. **Becoming familiar with the data**

The process of becoming familiar with the interview data had begun during the data preparation stage while going through the process of transcribing, correcting transcripts with audio recordings and later with the subject matter expert. The next step involved the compilation and reading of all transcripts of each pilot trainee to become familiar with their experiences as reported over the course of the study. This process was done on hardcopy as it was easier to cross-reference across physical pages as opposed to digital copies. The researcher focused on understanding each pilot’s experiences and noting down potential themes arising from the data. No cross-checking between pilots was done at this stage to understand individual pilots’ perspectives before trying to analyse the differences between pilots.

3.5.4.2. **Case profile**

Using memos generated from each pilot trainee, the researcher wrote a narrative of each pilot’s experiences from her reflections and field notes. These narratives were summarised to become the short narrative and profile of each pilot, which are presented as case profiles in Chapter 4 Findings (see Section 4.4.2, p. 105). Through this process of
case profiling, the researcher further identified shared features throughout the training course and between cases. These shared features contributed to the generation of initial codes for subsequent interview analysis.

3.5.4.3. Generating initial codes

After case profiling and becoming familiar with the data, the formal coding process in NVivo was conducted. At this stage, the individual cases were combined into a single data set to enable cross-case analysis. Transcripts were coded according to the nodes in NVivo that were based on the preliminary themes identified during the process of data familiarisation. As coding progressed, new nodes were created as more ideas were generated. Some excerpts being cross-coded with other nodes. For example, excerpts were cross-coded across the “perception” node (positive, negative, neutral) and “automation” node. When coding, attention was given to being inclusive with transcript extracts, for example, by retaining some of the surrounding data to provide context for the code (Braun & Clarke, 2006). This coding and creation of new nodes continued until all transcripts were coded. In addition, data sources were also coded to the five timeline categories identified.

3.5.4.4. Searching for themes

The process of identifying themes involved compiling codes and memos from the previous step into a single document for sorting and categorisation. Newly categorised codes became preliminary themes and sub-themes. From this stage, cross-checking activities with the subject-matter expert was conducted to determine if the naming and organisation of themes and sub-themes were representative of the processes involved in pilot work and training. This iterative process was conducted by reviewing and recategorising the arrangement of themes and sub-themes until both researcher and subject-matter expert were in agreement with identified themes (see Table 3.10).
Table 3.10 Initially Developed Themes (left) and Modified Themes (Right) After Consulting Subject Matter Expert

<table>
<thead>
<tr>
<th>Competence theme (original)</th>
<th>Competence theme (modified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft type-specific knowledge</td>
<td>Aircraft type-specific knowledge</td>
</tr>
<tr>
<td>- System</td>
<td>- System</td>
</tr>
<tr>
<td>- Performance</td>
<td>- Performance</td>
</tr>
<tr>
<td>Procedures</td>
<td>Procedures</td>
</tr>
<tr>
<td>- Task</td>
<td>- Task</td>
</tr>
<tr>
<td>- Sequence</td>
<td>- Sequence</td>
</tr>
<tr>
<td>- Temporality</td>
<td>- Temporality</td>
</tr>
<tr>
<td>Aircraft controls</td>
<td>Flight manoeuvres</td>
</tr>
<tr>
<td>Manual flight</td>
<td>- Aircraft controls</td>
</tr>
<tr>
<td>Automation</td>
<td>- Manual flight</td>
</tr>
<tr>
<td>Multi-crew</td>
<td>- Automation</td>
</tr>
<tr>
<td>Multi-crew</td>
<td></td>
</tr>
</tbody>
</table>

Note. Discussions with subject-matter expert led to the formation of a more encompassing Flight manoeuvres theme and sub-themes of aircraft controls, manual flight and automation.

As shown in the table above, the initial arrangement of the competence theme, which was the over-arching theme describing pilot skills developed during the study, consisted of multiple sub-themes that were categorised as different. However, cross-check activities with the subject-matter expert led to a correction of the arrangement to create themes and sub-themes that were representative of pilot activities. For example, aircraft control, manual flight, automation were initially separate. After multiple discussions with the subject-matter expert, they were re-categorised as “flight manoeuvres” that could be conducted using different methods (i.e., aircraft control, manual flight, automation).

3.5.4.5. Reviewing themes

Once the preliminary themes were set, transcripts were recoded according to the new themes. Upon completing the coding process, coded extracts according to themes collated and read to determine if they had both “external heterogeneity” and “internal homogeneity,” meaning that there were clear distinctions between each theme and the extracts within each theme cohered meaningfully (Braun & Clarke, 2006, p. 91). During this step, “matrix coding query” was performed in NVivo, allowing the grouping of themes and sub-themes across time (i.e., the eight structures identified through document analysis, see Table 4.5, p. 121) to show the progression of coded experiences from the beginning until the end of training and the number of pilots who had commented about each theme.
During this process, cross-checking activities were done to ensure that excerpts cohered with the themes they had been arranged under. In this study, the theme that was found to be problematic was the “multi-crew” theme. During the analysis, the “multi-crew” theme had significant overlap with the “procedure” theme. This violated the external heterogeneity condition when developing the final set of themes. In reflection, the term “multi-crew” was used as a category during coding because it (1) replicated common practices and (2) was a term used by the trainees during interviews. According to Braun and Clarke (2006), when there is disagreement between the extracts and coded themes, it suggests that either the theme is problematic or the extract simply does not fit.

In reassessing the use of the term as a theme for this study, the researcher turned to the phenomenological method of bracketing (Chan, Fung, & Chien, 2013). As Mavin (2010) writes about bracketing, a “researcher may ask individuals to describe roles, functions or job descriptions in their given profession. At some point, however, these meaning units need to be transformed into a language that is reflective of the researcher’s discipline” (p. 65). The researcher ascertained that the term multi-crew was being used by interviewees to describe procedures requiring crew coordination and the social aspects of working with another pilot. It was determined that the excerpts categorised under multi-crew could be recoded into two parts: (1) “procedures” (e.g., tasks, sequence, temporality, and triggers) and (2) the “social skills” needed to detect and respond to social cues from other pilots. To that end, the final themes of the study were: knowledge, automation, procedure (task, sequence, temporality, trigger), and social skills (see Table 3.11).

Table 3.11 Modified Themes (Left) and Finalised Themes (Right) After Deeper Analysis of Multi-crew

<table>
<thead>
<tr>
<th>Competence themes (modified)</th>
<th>Competence themes (finalised)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aircraft type-specific knowledge</strong></td>
<td><strong>Aircraft type-specific knowledge</strong></td>
</tr>
<tr>
<td>- System</td>
<td>- System</td>
</tr>
<tr>
<td>- Performance</td>
<td>- Performance</td>
</tr>
<tr>
<td><strong>Procedures</strong></td>
<td><strong>Procedures</strong></td>
</tr>
<tr>
<td>- Task</td>
<td>- Task</td>
</tr>
<tr>
<td>- Sequence</td>
<td>o Motor</td>
</tr>
<tr>
<td>- Temporality</td>
<td>o Verbal</td>
</tr>
<tr>
<td><strong>Flight manoeuvres</strong></td>
<td><strong>Flight manoeuvres</strong></td>
</tr>
<tr>
<td>- Aircraft controls</td>
<td>- Sequence</td>
</tr>
<tr>
<td>- Manual flight</td>
<td>- Temporality</td>
</tr>
<tr>
<td>- Automation</td>
<td>- Trigger</td>
</tr>
<tr>
<td><strong>Multi-crew</strong></td>
<td><strong>Automation</strong></td>
</tr>
<tr>
<td><strong>Social skills</strong></td>
<td><strong>Social skills</strong></td>
</tr>
</tbody>
</table>

*Note.* Reanalysis of Multi-crew theme led to a new theme of Social skills and sub-themes of Procedure, also leading to reanalysis of Flight manoeuvres theme, which led to the emergence of Automation theme, sub-theme of Task (Motor and Verbal).
Finally, the researcher tested or “consider(ed) the validity of individual themes in relation to the data set” (Braun & Clarke, 2006, p. 91). No further amendments were made and any additional data that was missed in earlier coding processes was coded.

3.5.4.6. **Defining and naming themes**

Each theme was distinctive in terms of pilot learning experiences. However, they were all crucial and interrelated aspects in order to become a competent first officer of an airline. The knowledge theme had two sub-themes: systems knowledge and performance knowledge. The procedure theme was the largest theme in the study, consisting of four sub-themes, which were task, sequence, trigger, and timing. Both the automation theme and social skill theme had no sub-themes. The relationship between each theme and sub-theme is illustrated and described in Chapter 4, Figure 4.2, p. 123.

3.5.5. **Report writing**

Report writing is the final stage of thematic analysis. Chapter 4 addresses the three sub-questions of the study in three sections. Multiple tables and figures were used to illustrate the training program of each airline and the context of which pilot trainees had undergone training. Reporting of pilot trainee experiences involved the careful selection of data extracts to provide an account of the cases and themes of the study.

The first section describes the intended curriculum for new first officers within the two airlines by illustrating the training pathway. The training pathways were grouped and analysed into phases and structures for cross analysis for subsequent sections. The second section provides an overview of the enacted curriculum at different phases of the initial first officer training program. The third section reports the experienced curriculum of the ten cases in the study. The key themes of the study and trainee experiences across different phases of training were illustrated through a heuristic model developed from the findings of the study.

3.6. **Credibility for the Study**

The credibility of data depends upon whether trainees’ constructions of reality have been accurately understood and represented by the researcher (Lincoln & Guba, 1985). Sandberg (2005) states that ensuring that validation criteria are consistent with a study’s assumptions allows researcher/s to make “truth claims” about the study’s findings. He
proposed that researchers check the validity of their interpretations by combining other assessment criteria with what he called a “truth constellation”, which was based on the “theories of truth” from interpretivist philosophers such as Husserl, Heidegger, and Derrida (Sandberg, 2005, p. 52). The three criteria for validity according to Sandberg’s “truth constellation” are: communicative validity, pragmatic validity, and transgressive validity. An important aspect of this set of criteria is that each form of validity has strengths and weaknesses, but the weaknesses are supplemented or corrected by the other forms of validity.

3.6.1. Communicative validity

Communicative validity is the validation of knowledge acquired from trainees (Kvale, 1995) with three criteria to be justified: a community of interpretation, coherence of interpretation, and member checking (Sandberg, 2005). First, a community of interpretation was achieved in this study through a mutual understanding of the study purpose being shared by the researcher and trainees including trainees, training managers, instructors, others who were involved in the planning of training. Through this process, all stakeholders were aware of the reasons why the researcher was on-site and offered additional assistance when the researcher was inquiring about the pilot training system. Moreover, the purpose of the study was restated at the beginning of each interview or email exchange with pilot trainees. Using series of semi-structured interviews across the course of the initial training enables the trainees to focus on their learning experience but, at the same time, to make the form of dialogue centring on pilot trainees’ learning experiences during various stages of training.

Second, coherence of interpretation, whereby the process of interpretation involves the “circular relation between parts and whole” (Sandberg, 2005, p.55), was achieved through the systematic process of analysing data described above. That is, constant cross-referencing between categories and shifting analysis within categories and between trainees allowed for further refinement of categories of interpretations. Through this ongoing process of analysing interpretations individually and collectively, coherence of interpretation was achieved. Moreover, discussing findings with other researchers and practitioners in the field being studied contributed to coherence of interpretation (Sandberg, 2005). For example, the researcher ensured that the methods used for data collection provided avenues for pilots’ perceptions to be obtained and that the interpretive
methods used maintained the coherence of findings (Sandberg, 2005). More specifically, in this study, both participant and researcher fully understood the aim of the study (i.e., “community of interpretation” Apel, 1972, as cited in Sandberg, 2005, p. 54), and the researcher identified themes that fit within the whole data set (Kvale, 1995). In addition, domain expert knowledge was required for many corrections in interpretations of the data, which contributed to the communicative validity from the domain perspectives.

Third, member checking was achieved by discussing findings with other researchers and professionals in the field being investigated (Sandberg, 2005). In this study, the researcher presented findings to partner airlines, training managers, and instructors during multiple meetings organised for that purpose. On all occasions, interpretations of the findings were agreed upon, and this prompted further discussion about how training could be improved.

3.6.2. Pragmatic validity

While communicative validity ensures the credibility of researcher interpretation, it does little to ensure the credibility of data provided by trainees. Pragmatic validity of data aims to identify potential discrepancies between what is said, what is done in practice, and how it is interpreted for the purposes of a study (Sandberg, 2005). In this study, pragmatic validity is achieved by interrogating the accuracy of trainees’ accounts; for example, asking follow-up questions embedded with specific and concrete situations (Sandberg, 2005) or repeating an intentionally inaccurate version of a participant’s version of events to see if the participant will correct the errors (Sandberg, 2000, 2005).

The main methods used to improve the pragmatic validity of information given in interviews were participant observation and video recordings. The researcher reviewed videos and field notes taken during training sessions and compared them with what trainees had reported about the training sessions during interviews. Furthermore, pragmatic validity of findings was also achieved as some of the findings from this study had been already put into practice following meetings held with the airlines (see Chapter 5), and feedback from training managers was that some improvements were being observed as a result (Sandberg, 2005; Mavin, 2010).
3.6.3. **Transgressive validity**

Transgressive validity, which correlates with Derrida’s notion of “indeterminate fulfillment,” resolves the weaknesses of communicative and pragmatic validity, both of which focus on achieving consistent and truthful interpretations (Sandberg, 2005, p. 51). In this study, multiple sessions of coding, defining and refining of themes were applied to each pilot’s lived experiences (Braun & Clarke, 2006). This process was often repeated after preliminary themes had been cross-checked with a subject matter expert who provided different explanations of flight manoeuvres (e.g., steep turns) and specific flight procedures (e.g., circling approach), leading to refinement of categories and reinterpretation of trainee experiences. This cross-checking process was repeated until no alternative explanations could be offered.

3.6.4. **Reliability**

To achieve and/or establish the validity of data, in this study, the researcher sought to achieve reliability by practising “interpretive awareness,” meaning not only acknowledging personal subjectivity during the research process but also engaging in efforts to mitigate its effects (Sandberg, 2005, p. 59). The aim of these efforts was to avoid “biased subjectivity” (favouring statements that support the researcher’s agenda by being selective in interpretation and ignoring counterevidence) and instead practising “perspectival subjectivity”, meaning being aware of and acknowledging the fact that interpretations are influenced by the researcher’s personal perspectives as well as the qualitative methodology of the study (Sandberg, 2005, p. 59).

To ensure reliability, this study also involved clear and precise procedures used for attaining valid interpretations of the study (Sandberg, 2005). More specifically, the researcher discloses how the research question was formulated, how sampling of cases and trainees was conducted, how data was collected and analysed, reporting the results, and providing sufficient evidence or paper trail for others who wish to confirm the findings (Sandberg, 2005). With the exception of the latter two, this study’s satisfaction of the above criteria was covered in detail in Chapter 2 and this chapter, and related examples are provided in the Appendices. A detailed analysis and reporting of findings are shown in Chapter 4. The evidence requirement is satisfied primarily by the interview statement reference table in the appendices (see Appendix F, p. 267), as it would have
been impossible to present a paper trail of the full process of data analysis. However, records of all stages of analysis have been retained by the researcher.

3.7. Summary
This study adopted an interpretive approach to research. The qualitative case study approach was used to conduct an inquiry into pilot learning within the first officer training in two airlines. This approach was chosen as the most effective method for exploring how pilots learn within the initial first officer training curricula while taking into account the pervasiveness of contextual factors on pilots’ learning (Merriam, 1998; Stake, 1995). However, as the study was not experimental, it was not designed to establish any form of cause and effect, instead to provide a description of training from the perspective of the trainees. Nonetheless, these results may provide further information for more controlled experiments in the future (Wiggins & Stevens, 2016) which is also the intention of this exploratory study.

The next chapter first reports case profiling to give readers understandings of background information, learning processes during the course of the program, and learning experiences of the individual pilots. The findings from cross-case analysis were then reported to highlight overarching themes of important learning aspects for pilots who undertake their initial training.
Chapter 4. Findings

4.1. Introduction

This study investigated the effectiveness of current airline training systems at preparing new pilot trainees to work as first officers. Overall, little research has been conducted on aviation training programs. Within this limited research space, Chapters 1 and 2 also argued that, to date, the ICAO, regulators, and researchers have placed more emphasis on research related to SQ1 and SQ2. That is, there has been more focus on developing standards, training systems, and instructional methods for pilot training, while little attention has been given to how pilot trainees interact with and experience training programs. Accordingly, this study set out to focus on SQ3: how pilot trainees engage with current methods of pilot training.

Using Billett’s (1996) curriculum theory as a conceptual tool, the researcher investigated three main aspects of the initial first officer airline training: (SQ1) the structure of training set by training managers, referred to as the intended curriculum; (SQ2) how these training programs were carried out by airline training staff, referred to as the enacted curriculum; and (SQ3) individual pilot trainees’ (or “cases”) perspectives on their learning throughout the programs, referred to as the experienced curriculum, and was the focus of this study (see Table 4.1). A qualitative case study approach was used to better understand the experienced curriculum, with the intended and enacted curriculums providing context for cases to be examined.

Table 4.1 Research questions and related focus of inquiry

<table>
<thead>
<tr>
<th>Focus</th>
<th>Sub-Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ1</td>
<td>Intended curriculum: What is the nature of current training programs for training new first officers?</td>
</tr>
<tr>
<td>SQ2</td>
<td>Enacted curriculum: How is the training program implemented during the course of training?</td>
</tr>
<tr>
<td>SQ3</td>
<td>Experienced curriculum: How do pilots engage in the current provisions for training and development?</td>
</tr>
</tbody>
</table>

This chapter is divided into six sections (see Figure 4.1, p. 97). Section 1 outlines the three initial first officer training programs from the two airlines of the study. The intended curriculum (SQ1) for the three programs were identified and compared to determine the differences between the structure of programs. The shared structural features of the three
programs were grouped to form eight training structures to develop a common framework for subsequent data analysis (see Table 4.3, p. 100). Section 2 addresses SQ2 of the study by providing an overview of the enacted curriculum in alignment to the training phases and structures. Each section provides a description of the training objectives and assessments, as well as the structure and tools used during training.

Section 3 provides the background information of the ten pilot trainees of the study. This section contains the demographic information of each pilot trainee followed by their case profiles, which detailed their aviation background, learning experiences during training from the time they participated in the study (GT1 or Sim-A) until they officially joined the workforce of their airline (CTL). One pilot trainee was not able to complete his training with the airline and was eventually removed from the initial first officer training for specialised training. Unfortunately, he was dismissed after failing to meet the standards set for training.
Section 1

SQ1  Structure

Section 2

SQ2  Means

Section 3

SQ3  Experience

Thematic Analysis

Section 4

Key themes

Section 5

First Officer Development Model

Section 6

First Officer Development Model

Structure (SQ1)
Training Phases
- Ground training 1 (GT1)
- Ground training 2 (GT2)
- Procedure training (PT)
- Simulator training Block A (Sim-A)
- Simulator training Block B (Sim-B)
- Simulator training Block C (Sim-C)
- Line training (LT)
- Checked to line (CTL)

Means (SQ2)

Experience (SQ3)

Figure 4.1  Structure of Chapter 4.

Note. Sections 1 and 2 addresses sub-research question 1 and 2 of the study, while Sections 3 to 6 addresses sub-question 3 of the study, which was the main focus of the thesis. Each section builds upon the findings of the previous section and synthesised in Sections 4, 5 and 6.

Section 4 and 5 report the key themes identified in the study. These themes were developed from the learning experiences of the ten pilot trainees of the study and what they had discussed as difficult during the process of training. Section 4 defines each theme and the main issues encountered by pilot trainees. Deeper analysis of each theme was conducted, by cross analysing between themes during different segments of training, resulting in the formation of a heuristic model pilot trainee development during training. Section 5 introduces the First Officer Development Model (FODM) that was created based on these key themes and illustrates how the themes evolved over the course of a
training program. The final Section provides the rationale for the structure by exploring it within the contexts of (1) each phase of training, (2) what was taught in each phase, and (3) pilot experiences of training.

4.2. Section 1: Intended curriculums for new first officers

The initial first officer training for both airlines consisted of multiple training phases. These phases were designed around particular training method and tool/s, which included traditional classroom-based learning, computer-based training, procedures training on part task trainers or flight training devices, full-flight simulation, and aircraft training (i.e., on-the-job training). The training pathways for all three programs are detailed in Table 4.2.

Table 4.2 Training pathway for training programs

<table>
<thead>
<tr>
<th>Phase</th>
<th>ATR72-500 (A)</th>
<th>ATR72-600 (A)</th>
<th>DASH8-400 (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground training</td>
<td>Induction</td>
<td>Induction</td>
<td>Induction</td>
</tr>
<tr>
<td></td>
<td>Aircraft systems</td>
<td>Aircraft systems</td>
<td>Aircraft systems a</td>
</tr>
<tr>
<td></td>
<td>EP course</td>
<td>EP course</td>
<td>EP course</td>
</tr>
<tr>
<td></td>
<td>WB course</td>
<td>WB course</td>
<td>WB course</td>
</tr>
<tr>
<td></td>
<td>Performance course</td>
<td>Performance course</td>
<td>Performance course a</td>
</tr>
<tr>
<td></td>
<td>CRM</td>
<td>CRM</td>
<td>CRM</td>
</tr>
<tr>
<td></td>
<td>GPS/GNSS theory</td>
<td>GPS/GNSS theory</td>
<td>GPS/GNSS theory</td>
</tr>
<tr>
<td></td>
<td>HT1000 course</td>
<td>FMS course</td>
<td>FMS course a</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td></td>
<td>Familiarisation flight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(8 sectors)</td>
</tr>
<tr>
<td>Procedures training</td>
<td>Procedures course</td>
<td>Procedures course</td>
<td>Procedures course a</td>
</tr>
<tr>
<td></td>
<td>(3 sessions)</td>
<td>(6 sessions)</td>
<td>(5 sessions)</td>
</tr>
<tr>
<td>Simulator training</td>
<td>Conversion course</td>
<td>Conversion course</td>
<td>Conversion course</td>
</tr>
<tr>
<td></td>
<td>(11 sessions)</td>
<td>(11 sessions)</td>
<td>(12 sessions)</td>
</tr>
<tr>
<td>Line training</td>
<td>Familiarisation flight</td>
<td>Familiarisation flight</td>
<td>Ground training day 1</td>
</tr>
<tr>
<td></td>
<td>(6 sectors)</td>
<td>(6 sectors)</td>
<td>Phase 1</td>
</tr>
<tr>
<td></td>
<td>Introduction segment</td>
<td>Introduction segment</td>
<td>Phase 2</td>
</tr>
<tr>
<td></td>
<td>Initial route flying</td>
<td>Initial route flying</td>
<td>Ground training day 2</td>
</tr>
<tr>
<td></td>
<td>Progressive assessment</td>
<td>Progressive assessment</td>
<td>Phase 3</td>
</tr>
<tr>
<td></td>
<td>Line training</td>
<td>Line training</td>
<td>Phase 4</td>
</tr>
<tr>
<td>Probation period</td>
<td>3 months</td>
<td>3 months</td>
<td>3 months</td>
</tr>
</tbody>
</table>

Note. Type rating training involves ground training, procedures training, and simulator training. a represent courses completed external to airline (i.e., university pathway). The university pathway consisted of 12 weeks of training. First 6 weeks was multi-crew coordination course, followed by 2 weeks for aircraft systems course, next four week consisted of performance (1 week), FMS (1 week), and procedures (2 weeks).

Even though the training programs for all three pathways were similar, there were minor differences between them—specifically, tools used for training and the number and
sequencing of training sessions. For example, in Airline A, the ATR72-600 program had a part task trainer (flat panel trainer) that could be used for both ground courses and the procedures course. However, the ATR72-500 program had no flat panel trainer, and instead, the airline used a high-fidelity flight training device. Another difference between the programs was the scheduling of familiarisation flights. In Airline A, pilot trainees were scheduled to undergo familiarisation flights upon completion of type rating training, whereas Airline B required a set number of familiarisation flights to be completed before the final type-rating simulator assessment.

An important aspect to note was the availability of pilot trainees during early training differed between the airlines, which impacted on the field research process. Airline A conducted all training in-house; therefore, all pilot trainees were available to the researcher throughout their training (on-site and remotely). In contrast, Airline B’s ground training phase (specifically courses on aircraft systems, performance, FMS, and procedures) was conducted externally as part of the airline-university partnership. While Airline B oversaw the university program, the pilot trainees were not available for data collection until they had commenced the simulator-training block.

Despite some of the differences discussed above, the analysis of the intended curriculum revealed key structural features shared between the three programs in training objectives and methods of training. These common features were then grouped and categorised as training structures during data analysis, thus affording a common framework for analysis. This approach gave two important benefits. First, it allowed the intended and enacted curriculum to be compared across all three programs more systematically. Second, this overarching structure was used to organise the report of pilot experiences at different stages of training. Table 4.3 illustrates the three training programs according to structure and training content.
Despite wanting to finish training with as little additional training as possible (i.e., more simulator sessions), training managers were inclined to provide extra sessions if a concerned instructor had requested them. This was the case in Airline A, where one instructor had requested and was granted two more simulator sessions with a trainee pair. Instructors were not required to go through lengthy and difficult processes to request for such additions.

For Airline B, an extra optional simulator session had already been rostered or planned by the organisation to provide leeway in case more practice was required. As mentioned previously, two additional sessions that were not part of the actual type rating was planned by the company in anticipation for the need to provide extra practice.

Table 4.3 Training phases and structure of the study

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of training</th>
<th>Training method</th>
<th>Assessment</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground training</td>
<td>Aircraft systems knowledge</td>
<td>CBT, PTT, F2F, Classroom</td>
<td>Multiple choice assessment</td>
<td>GT1</td>
</tr>
<tr>
<td></td>
<td>Weight and balance</td>
<td>F2F, Classroom</td>
<td>Short answer assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRM Performance</td>
<td></td>
<td>Short answer assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GPS</td>
<td>F2F, Classroom</td>
<td>No assessment</td>
<td>GT2</td>
</tr>
<tr>
<td></td>
<td>GNSS/FMS</td>
<td>PTT/FTD</td>
<td>No assessment</td>
<td></td>
</tr>
<tr>
<td>Procedures training</td>
<td>Simulate training preparation</td>
<td>PTT/FTD, F2F, Classroom</td>
<td>No assessment</td>
<td>PT</td>
</tr>
<tr>
<td>Simulator training block</td>
<td>Exercises involving aircraft handling and normal procedures</td>
<td>FFS, F2F, Classroom, PTT</td>
<td>Training performance assessment</td>
<td>Sim-A</td>
</tr>
<tr>
<td></td>
<td>Exercises involving non-normal and emergency procedures</td>
<td>FFS, F2F, Classroom, PTT</td>
<td>Training performance assessment</td>
<td>Sim-B</td>
</tr>
<tr>
<td></td>
<td>Line oriented flight training</td>
<td>FFS, F2F, Classroom, PTT</td>
<td>Training performance assessment</td>
<td>Sim-C</td>
</tr>
<tr>
<td></td>
<td>Operational competency</td>
<td>FFS, F2F, Classroom, PTT</td>
<td>Type rating assessment</td>
<td></td>
</tr>
<tr>
<td>Line training block</td>
<td>Completion of flight training with FE</td>
<td>OJT, F2F, Classroom</td>
<td>Training performance assessment</td>
<td>LT</td>
</tr>
<tr>
<td></td>
<td>Completion of flight training with FI</td>
<td>PTT</td>
<td>Training performance assessment</td>
<td></td>
</tr>
<tr>
<td>Checked to line</td>
<td>Line check</td>
<td>N/A (Normal work)</td>
<td>Performance assessment by FE, Simulator check</td>
<td>CTL</td>
</tr>
<tr>
<td></td>
<td>Probation period</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. CBT – computer-based training, PTT – part task trainer, F2F – face-to-face, FTD – flight training device, FFS – full-flight simulator, OJT – on-the-job training, FE – flight examiner, FI – flight instructor.
4.3. Section 2: Overview of enacted curriculums for new first officers

The following provides an overview of each of the training phases for the study, including ground training phases 1 and 2; procedures training; simulator block A, B, and C; line training; and checked to line. The details of each training segment are described.

4.3.1. Ground training phases (GT1 & GT2)

Ground courses are conducted to satisfy regulatory requirements and provide pilot trainees with the knowledge necessary to perform their duties. For this study, ground training was split into two separate phases, namely *ground training 1* (GT1) and *ground training 2* (GT2). GT1 consisted of all classroom-based courses that focused on teaching factual and conceptual knowledge. The main mode of delivery for GT1 was computer-based desktop e-learning or face-to-face instruction. The assessments for this training segment were done through paper-based examinations testing the declarative knowledge of pilot trainees.

GT2 was a combination of classroom-based and simulator-based methods to teach pilot trainees how to operate the aircraft flight management computer (FMC). Pilot trainees were instructed in pairs from this phase onwards. The focus of training in GT2 was on transferring factual and conceptual knowledge of FMC from the classroom into procedural skills on the simulator. Delivery modes were primarily flat-panel training (flight training device for ATR72-500) with the assessment involving both an exam and a practical examination (see Table 4.3).

4.3.2. Procedures training phase (PT)

Procedures training (PT) included training conducted in a flight deck mock-up, flat panel trainer, and/or training in the FTD. The focus of PT was on procedural knowledge and motor skill development, with emphasis on developing specific company standard operating procedures, crew coordination, and automation use. The training methods used during this segment were a combination of face-to-face classroom-based instruction and simulator training. As a transitional phase of training, no assessments were conducted (see Table 4.3).
4.3.3. Simulator training phases (Sim-A, Sim-B & Sim-C)

Simulator training was conducted in accordance with lesson plans defined by each airline. Training took place in a full flight simulator, which provides a high-fidelity environment for pilot trainees to learn and practice aircraft handling, procedures, crew coordination, and management. Both airlines conducted these training phases in six-hour training blocks. Each block consisted of a one-hour briefing followed by a four-hour simulator session and, immediately afterwards, a one-hour debrief. As it was not possible for instructors to teach everything that might be encountered in the four-hour training session within the one-hour pre-flight briefing, pilot trainees were expected to prepare for each session by referring to the lesson overview and other appropriate company manuals and briefing materials to ensure that they were prepared. Thus, the main purpose of the briefing was to review the content and flow of the session, explain and reinforce key points, cover areas of known difficulty, address any questions from pilot trainees, and resolve misunderstandings so that pilot trainees could extract the maximum benefit from each simulator session.

Both Airline A and Airline B divided simulator training into three training blocks: simulator training block A (Sim-A), simulator training block B (Sim-B), and simulator training block C (Sim-C). Sim-A covered handling skills and normal procedures, Sim-B covered non-normal and emergency procedures, and Sim-C covered normal flight operation and type rating assessment (see Table 4.3).

Sim-A—As continuation of PT, this training block focused on normal procedures and basic aircraft handling techniques. The aim was for pilot trainees to learn aircraft handling techniques and become familiar with normal procedures for all phases of flight. It was during this phase of training that pilot trainees from Airline B joined the study.

Sim-B—The focus of Simulator Block B was to familiarise pilot trainees with non-normal and emergency procedures. Airline A also rostered additional classroom-based instruction (called admin days) for ATR72-500, and flat panel trainer sessions for ATR72-600.

Sim-C—The focus of Simulator Block C was to introduce pilot trainees to real-time flight operations through line-orientated flight training (LOFT) exercises.
LOFT scenarios are designed to be relevant and authentic and facilitate development of pilot trainees’ non-technical skills. As with Sim-B, further admin days were rostered for Airline A. Completion of Sim-C was a type-rating assessment.

4.3.4. Line training phase (LT)

Line training was conducted in aircraft during normal revenue service in accordance with the line-training syllabus of the airlines. All preceding training phases had to be completed before line training could commence. During line training, the priority was operating the aircraft normally, and line training tasks were not in any way to interfere with normal flying duties or priorities. During training, abnormal operations of the aircraft systems for demonstrations are prohibited and in-flight discussions had to be managed carefully by the flight instructor to ensure that such deviations did not divert the crew from the primary task of operating the aircraft.

The final assessment at the end of LT was a proficiency test conducted in the aircraft during normal revenue service. The assessment was intended to ensure that candidates had achieved the operational standards required for line operations, including knowledge in accordance with the standards specified in the operations manuals and correct application of company, route and AIP procedures, aircraft handling, crew management, and passenger awareness. Pilot trainees were required to complete and pass a check to line (CTL) before being cleared for unsupervised line operations with airline captains.

The first stage of LT was conducted under the supervision of a more experienced flight examiner for the purpose of consolidating standard operating procedures and developing route familiarity and operational skills. Following this, pilot trainees were supervised by flight instructors before completing their final assessments with a flight examiner, called check to line (CTL), where they were assessed while flying in normal airline operations.

4.3.5. Checked to line phase (CTL)

At this stage, pilot trainees were no longer under supervision. However, the normal six-monthly assessments were deemed too long and not effective for their learning since they were considered as newly trained. Therefore, pilot trainees returned after three months for simulator consolidation assessments. Upon completion of these assessments, pilot
trainees entered the general pool of pilot trainees in the airline. That means that no further assessments or supervision were required outside of the normal six-monthly assessments that all pilot trainees were required to undergo.

4.4. Section 3: overview of training experience of each case in the study

This section provides a brief description of each case study. Emphasis was placed on evoking descriptions of both “easy” and “difficult” learning experiences and, where possible, how pilot trainee pilot trainees prepared for lessons. These vignettes do not aim to represent the entirety of their training experiences but, rather, to highlight key experiences of pilot trainees during training.

4.4.1. Demographic summary of cases

In total, ten case studies were conducted: 6 from Airline A and 4 from Airline B (9 males and 1 female). To maintain the anonymity of the female pilot, all pilot trainees will be referred to as “he.” The average age of pilot trainees from both airlines was 28.2 ($SD = 6.96$), and their average total flight hours was 2211.7 ($SD = 1,861.30$) at the time of commencing the field research. Further breakdown of demographic information according to airline is pertinent, as it illustrates the differences in experience levels between airlines and pilot samples (see Table 4.4). For example, the average age of pilot trainees from Airline A was 31.67 ($SD = 6.98$), while Airline B’s pilot trainees had an average age of 23 ($SD = 2$). The combined total flight hours of Airline A’s pilot trainees were 3,476 ($SD = 1197.50$), while Airline B’s was 315.25 ($SD = 104.84$). All but one pilot trainee (Pilot 6) had passed all training exercises and was checked to line.
Table 4.4 Demographic information of cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Total flight hours</th>
<th>Background</th>
<th>Pathways</th>
<th>Airline</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot 1</td>
<td>25</td>
<td>2200</td>
<td>GA (I)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-500</td>
</tr>
<tr>
<td>Pilot 2</td>
<td>43</td>
<td>5700</td>
<td>GA (Cap)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-500</td>
</tr>
<tr>
<td>Pilot 3</td>
<td>25</td>
<td>3200</td>
<td>GA (SP)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-600</td>
</tr>
<tr>
<td>Pilot 4</td>
<td>32</td>
<td>2756</td>
<td>GA (I)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-600</td>
</tr>
<tr>
<td>Pilot 5a</td>
<td>29</td>
<td>3500</td>
<td>Airline (FO)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-600</td>
</tr>
<tr>
<td>Pilot 6b</td>
<td>36</td>
<td>3500</td>
<td>GA (SP)</td>
<td>DE</td>
<td>A</td>
<td>ATR72-600</td>
</tr>
<tr>
<td>Pilot 7</td>
<td>22</td>
<td>470</td>
<td>U</td>
<td>C</td>
<td>B</td>
<td>DHC8-400</td>
</tr>
<tr>
<td>Pilot 8</td>
<td>26</td>
<td>290</td>
<td>U</td>
<td>C</td>
<td>B</td>
<td>DHC8-400</td>
</tr>
<tr>
<td>Pilot 9</td>
<td>22</td>
<td>249</td>
<td>U</td>
<td>C</td>
<td>B</td>
<td>DHC8-400</td>
</tr>
<tr>
<td>Pilot 10</td>
<td>22</td>
<td>252</td>
<td>U</td>
<td>C</td>
<td>B</td>
<td>DHC8-400</td>
</tr>
</tbody>
</table>

Note: GA – General aviation, I – Instructor, Cap – Captain, SP – Single-pilot charter, FO – First officer, U – University, DE – Direct entry, C – Cadet. aPilot 5 was paired with a captain from Airline A due to failure of Pilot 6 during Sim-A. bRemoved from training program During Sim-A for special training by Airline A.

In Airline A, each case underwent initial first officer training, consisting of the ATR72-500 program and the ATR72-600 program. Airline B’s pilot trainees (Pilot trainees 7 through 10) had completed a Bachelor of Aviation at an Australian university prior to being selected for further training by Airline B. The final course for the university program was a multi-crew training course on a Boeing 737-flight simulator. Upon being selected by Airline B, each pilot underwent GT1, GT2, and PT at the university prior to transferring to the airline for Sim-A. Consequently, GT1, GT2, and PT data were only collected through pilot reflections during Sim-A, Sim-B, and Sim-C interviews.

4.4.2. Case profiles

Thematic analysis of pilot trainees’ interviews resulted in the ten case profiles presented below. Furthermore, the analysis revealed some differences in the issues encountered during training and how they tried to overcome them.

4.4.2.1. Pilot 1 (P1)

P1 was working as a general aviation (GA) flight instructor before he moved from Australia to New Zealand to seek employment. Prior to training, P1 had only flown small GA aircraft and had mostly flown as a single pilot. His experience with crew operations was limited to flight instruction with student pilots in ab initio as an instructor. He had
never flown an aircraft with automation, although he had gained some knowledge of automation and glass-cockpits through conversations with other pilot trainees and experiences with flight simulators, including one installed in his home computer.

P1 found that GT1 contained a lot of information, particularly the aircraft systems taught on CBT. The difficulties he had during that segment of training were determining the depth of aircraft systems knowledge he needed to have for his role as a first officer and understanding the links within and between aircraft systems. To overcome these issues, P1 used available training resources as well as other strategies, such as consulting a ground instructor and typing personal notes of the aircraft systems modules he was learning in order to better understand the content and links between systems. He also purchased a desktop flight simulator program to review aircraft systems, and as training progressed from GT1 to GT2, he used his desktop flight simulator to connect the various systems he was learning about in order to understand the links within and between them.

P1 found both PT and simulator block phases of training were challenging. Specifically, he had difficulty learning to work as part of a multi-crew environment, as this required not only learning new tasks and sequences for procedures but also carrying them out with another pilot. Like the other pilot trainees in the study, his flying experience as a single pilot made this aspect of training difficult. “I had to find that balance . . . between being a supporting guy and also not being an instructor” (P1_Sim-C). For him, it was difficult to stop playing the role of an instructor in the flight deck, but as an equal working together to complete tasks.

During PT, P1 used his personal desktop flight simulator to assist with his learning; however, he did not continue to use it after PT. He recalls, “when you’ve got to respond to certain checklists and you’ve got to do other things, there’s just a limit on what the simulator on my computer can do” (P1_PT). When he found that his simulator did not have the capabilities he required, P1 developed other learning strategies to supplement his formal training. When unable to study with his simulator partner during PT and Sim-A, he used voice memos on his mobile phone to practice company procedures. For example, he would record the “challenges” of the Pilot Monitoring (PM) role and then respond as the Pilot Flying (PF) role, and vice versa. “I played it back to me, and just talk it through the little voice memo that I had” (P1_Sim-C).
In Sim-B, P1 encountered difficulties using procedures manuals, as he found that they did not always represent procedures well. Each procedure is made up of multiple tasks, and pilot trainees are trained to carry out those tasks (e.g., flying the aircraft, voice commands, turning on a switch) in a set sequence and within a certain amount of time, and requires coordinating with the other pilot. After learning a procedure from the manual, P1 was able to visualise the page in the manual during the simulated exercise, which helped him to recall the tasks and their sequence. However, if the diagrams were not presented appropriately, this interfered with P1’s recall of procedures and, therefore, his learning process. For example, P1 noted in his manual that “single-engine go-around” diagram and the “normal go-around diagram” were identical, but in practice, they led to very different aircraft performance. When completing a simulated exercise using the normal go-around procedure, the similarity between the diagrams led P1 to become confused during recall and carry out part of his task using the wrong procedure and therefore the wrong timing. He reflected on his mistake, “I was thinking of single-engine probably in terms of the quickness of my checks… And so effectively, I did it [wrong]” (P1_Sim-C). This example highlights the importance of clear and precise visual presentation of procedures in materials from the learning process of this pilot trainee. P1 had also brought up the issue of the lack of guidance when learning procedures, where he stated that “we’re just kind of told [by instructors], “all right so go out and learn this and repetition, repetition.” That was the big thing they were pushing at times” (P1_Sim-C).

Of the transition from Sim-C to LT, P1 said that it was, “definitely overwhelming at first” as the simulator focused on different procedural aspects than LT. “It’s all different... the simulation focused on all the emergency stuff... There’s only a little focus on the normal procedures, and so far all I’ve done [in LT] is pretty much normal procedures” (P1_LT). To overcome this difficulty, P1 made a deliberate effort to develop his capacity to carry out normal procedures in LT. He said, “my main focus is on all the procedural stuff behind the plane” (P1_LT).

4.4.2.2. Pilot 2 (P2)

P2 was the oldest pilot of the group. Previously, he had worked as a captain with a small general aviation company; therefore, he was familiar with working in multi-crew and commercial environments. However, the aircraft he had flown in the past had limited automation.
Initially, P2 was apprehensive about the workload during GT1 and concerned about whether he would be able to keep up with the other pilot trainees. He was also concerned about being separated from his family during training, as he had to travel weekly from his homeport to the main ground-training base during GT1, GT2, and PT. He often expressed his tiredness due to early-morning travels or spending nights in hotels.

During GT1, similar to P1, thematic analysis of interview texts with P2 highlighted his difficulty in using automation. While P2 did not specifically discuss aircraft automation in GT1, he did express concerns about the practice of CDU in GT2. Even at the end of the type rating (the end of Sim-C), he was still not a stage where he fully understood the automation system. This example confirmed P2’s persistent issue in using automation throughout training. He stated his understanding of automation improved significantly during line training from using it often as part of work, at his CTL interview, he reported that he was still “not 100% with it, but much, much better” (P2_CTL).

Another issue highlighted during thematic analysis was difficulty learning procedures. Unlike P1, who had not worked in a commercial airline before this training, P2 had cross-institutional issues in learning procedures specific to Airline A and adapting his prior knowledge to Airline A’s practices. In various of his follow-up interviews, P2 stated that he had difficulties in carrying procedures due frequent incorrect calls (e.g., During Sim-A: “Instead of saying, ‘Positive climb’ I keep saying ‘Positive break’”), difficulty remembering procedures with many tasks (Sim-B: “the procedure that we do after an engine failure after take off or engine fire, it’s like three pages long.”), and confusion leading to incorrect task continuation of procedure (e.g., Sim-C: “a couple of times... I just jumped into the wrong procedure for the next step”).

P2 had also felt overwhelmed by the demands of training and sometimes suffered under the pressure from both himself and his instructor, which he said affected his performance. He said, “I was just quite annoyed that I wasn’t getting those flows [procedures] going. I think [it] just additional pressure on myself. Plus, I found that I was getting pressure from the instructor about it, too. I just bogged myself down” (P2_Sim-C). This comment also implies the importance of teaching style of instructors for P2’s learning process. P2 also reported that his confidence in his performance depended upon instructor feedback, and he felt that instructors focused on what went wrong in sessions and rarely commented on what was done well or correctly. The instructor’s focus on negative aspects made him
feel that he was being assessed rather than being trained. It added to the pressure he was already experiencing from his workload and prevented his constructive learning.

When discussing his transition from simulator training to line training P2 stated that the type rating had prepared him for LT, although he reported that type rating scenarios were not necessarily accurate representations of real-life environments. “... out there in real-life situations... [work] does happen a lot quicker. Things change” (P2_LT). He also found working and communicating with captains when having difficulties non-problematic, as he “was not new to the whole two crew game” (P2_CTL). Therefore, apart from the challenge of becoming more accustomed to using automation, he found line training relatively unproblematic.

4.4.2.3. Pilot 3 (P3)

P3 was born in a South American country and had lived in Australia for seven years at the time when the field research was conducted. After completing high school, he went straight to flight training to obtain his CPL, and he was able to secure an aviation job immediately thereafter. Prior to training with Airline A, he had mainly flown light aircraft doing surveying work and aerial photography. He had also worked as a Boeing 737-simulator operator at a flight simulator experience centre.

P3’s first impression of Airline A was positive, although he was sceptical about whether this would last. He stated that he was surprised by the friendly and relaxed environment, as he had expected airline training to be intense, and by the end of simulator training, he reported wishing for a faster pace of in the course progress. “It would have been good to have a bit more pressure here and there,” he said. “It was a very, very relaxed course” (P3_CTL). English was his third language; however, he did not find that this affected his learning process much during training.

Flying the ATR72-600 aircraft was not problematic for P3, even at the early Sim-A phase: “Flying the aircraft...is not hard... The systems are not hard. Yeah, I don’t find it a hard plane to fly” (P3_Sim-A). However, the multi-crew environment did pose challenges for him: “The multi-crew environment is something really new to me... I’m always used to just doing everything myself. Waiting to be prompted by someone to say something or to do something is something that is really new” (P3_Sim-C). These comments imply that his past experience affected his process of learning for this particular aircraft type.
P3 reported that carrying out procedures was difficult because the sequence of tasks was often interrupted different aspects when carrying out a procedure, such as pauses during flight sequences and even when coordinating with the other pilot. For him, during the early stages of learning a procedure, application of the procedure must be exactly how he had learned it: “you got this model in your head, and you’ve got to stick to it, and as soon as something else comes in there you’re just completely unbalanced” (P3_Sim-C).

Another issue that P3 identified was the timing of procedures. He stated that when preparing for lessons, using the full ATR72-600 flight deck poster, while useful for practising scans, did nothing to teach timing. He gave the example of a take-off sequence. “On a poster, [your partner] will call “take-off,” and I’ll be straight away, “timing, power set seventy knots”, we’d be one after the other . . . . In the plane you’ve obviously got to wait until you get the event” (P3_Sim-C). While P3 felt that using posters and working together helped pilot trainees to learn task and sequence, it did not prepare them to account for temporal factors when carrying out procedures. This meant that when they practised procedures in the simulator, they were not always equipped to handle the scenarios they were given. “Just that delay can sometimes throw you out a bit” (P3_Sim-C).

In the early stages of training, P3 focused on the procedural aspects of work, such as memorising specific tasks and sequences of procedures and enacting procedures with the other pilot in the cockpit. However, in LT and CTL he emphasised the importance of understanding the social aspects of working with the other pilot to ensure optimal crew coordination. He gave the example that a captain may interpret procedures differently than he did. “They all have a very different way of doing it,” he said. “At the end of the day, it’s a little bit confusing, but you just end up doing your own thing” (P3_CTL). Even after he had been checked to line, he still found the social aspects of a multi-crew flight deck non-intuitive. “I sometimes still have a hard time in just passing on to the captain what my intentions are or why am I doing something” (P3_CTL).

4.4.2.4.  Pilot 4 (P4)

After completing his CPL training, P4 went on to become a flight instructor. During the study, P4 was very busy and needed time to focus on his studies. Therefore, while he participated in some interviews, they were limited in numbers.
P4 found GT1 hard. “There’s a lot of new topics, new things that I don’t understand. I was expecting lots of numbers, lots of procedures, lots of things like that. I wasn’t expecting to learn new concepts . . . . computer systems, to me, are new concepts” (P4_GT1). P4 also talked about the difficulty he was having with automation in GT1, “There’s a huge automation … I’ve got a whole subject chapter that’s automation” (P4_GT1). Here P4 is referring to the fact that the ATR72-600 training program includes a great deal of information relating to automation, and he had little experience to fall back on. “I don’t even have any autopilot in my current aircraft. It doesn’t exist, not fitted” (P4_GT1). He further explained that his previous ATPL studies did not help him when it came to the automation training he encountered in the training program.

When reflecting on the type rating training, P4 said that he found it difficult to learn and remember aircraft-specific acronyms: “The hardest thing I found initially was the acronyms. Including all the speeds. They’ve got an acronym for every single piece on the panel ... I still wouldn’t be able to tell you what the acronym means” (P4_Sim-C).

P4 also noted that certain manoeuvres taught in Sim-A and Sim-B were difficult, not only because they consisted of many tasks, but also because they relied a lot on the coordination of tasks with the other pilot. This was especially the case with the go-around procedure: “Go-arounds are crazy. There’s just so much work to do . . . and in multi-crew . . . you’re really relying on the other person to get it right . . . . there’s just so many actions and things going on” (P4_CTL).

Like P1, P4 he felt that there was a significant difference between simulation training and line training, stating that “it’s a completely different skill set” (P4_CTL). He did find that automation had become easier to use and understand during line training as there was opportunity to practice more and that some of the instructors provided additional explanations with diagrams.

4.4.2.5. Pilot 5 (P5)

P5 started flying straight out of high school and had worked in various fields, some related to aviation. As he could not find any aviation-related jobs in New Zealand, P5 worked overseas and was trained as a first officer on a large multi-crew turbo-propeller aircraft similar to the ATR72-600. This made P5 the only pilot in the study who had experience
with type rating training. P5’s employment with Airline A was ideal for him and his family.

P5’s previous experience was very beneficial to him during training, and he did not bring up many issues associated with training during interviews. As the aircraft he had previously been trained to fly had many similarities with the aircraft he was being trained to fly in the program, he already had a basic understanding of what he needed to learn. Therefore, for him, training was a matter of adapting his existing knowledge to fit with Airline A’s practices. Unlike P2 who also had previous commercial work, P5 did not report having issues with procedures during training. When asked about challenges he had faced during training, he said, “Can’t really think about anything that jumped out, to be honest. Pretty much turn up, flitter about a little bit, nothing is taken too seriously, and sort of go home kind of thing” (P5_CTL).

4.4.2.6. Pilot 6 (P6)

P6 moved to Australia to obtain his CPL. He became a flight instructor and worked in a corporate company as a charter pilot. He went on to obtain an ATPL, which became one of his motivations for seeking employment in airlines. Compared to the other pilot trainees in the study who had come from overseas, he found the move to New Zealand challenging and mentioned wishing that he had a guide for pilot trainees moving to the country. “I would have suggested for the overseas pilot to have kind of an overseas checklist to go through, even if it was [only used at the end], but I would have [anticipated] and [prioritised] some of the [duties] differently” (P6_GT1).

During GT1, P6 had similar issues reported by other pilot trainees in the study. In particular, he highlighted automation as something he hoped to gain a better understanding of in later stages of training. However, as training progressed into GT2, PT, and Sim-A, he felt that the training workload was increasing, and therefore he had little time for interviews. During GT2, P6 found programming the FMC difficult, and he struggled to understand how to enter and extract data from the FMC.

From PT onwards, P6 continued to have problems using the FMC and also reported having difficulty remembering the sequence of procedures. P6 was aware that he was struggling with training, but he did not seem to know how to improve his performance. His training partner tried to help him to prepare for training lessons, but he was not able
to perform adequately during training sessions. By Sim-A, P6’s performance was assessed as not up to standard, and P6 was dismissed from the airline.

4.4.2.7. Pilot 7 (P7)

After graduating with a Bachelor of Aviation, P7 obtained an instructor rating and worked for two years in that role prior to being employed with Airline B. When reflecting on his university training, P7 reported finding multi-crew operations difficult to learn, echoing comments made by pilot trainees in Airline A. For P7, the difficulties of working in a multi-crew setting were remembering tasks, remembering task order, and remembering who was to accomplish each task. For instance, “you might know something that needs to be done, but you can’t remember exactly whose job it was” (P7_GT1).

One aspect of training that P7 emphasised during interviews—which was not discussed in detail by any of the pilot trainees in Airline A—was aircraft handling. Specifically, P7 reported difficulty putting into practice what was written in the airline’s flight crew operations manual (FCOM). For example, when preparing for the lesson on the high angle of attack recovery procedure, “the only thing that wasn’t clear was just how much to reduce the pitch attitude. It wasn’t in the training module. It wasn’t in the FCOM. It just says ‘pitch attitude reduce’” (P7_Sim-A).

Like many of the pilot trainees in Airline A, P7 had trouble remembering and sequencing procedures. For him, the way manuals presented information affected how he and his partner interpreted procedure sequences:

> When you have an engine failure, it’s got two things that need to be done, but it doesn’t really specify which happens first. In the FCOM, they were both aligned with each other, so if you read it, you may have thought that they both happened at the same time, not that you’re waiting for one, and then the other one, and then sequential steps. (P7_Sim-C)

P7 also reported finding automation difficult in the early stages of training, “[until] you had the knowledge, and you could pre-empt what hitting that button was going to make autopilot do” (P7_Sim-C). During LT, he shared:

> Unless you’re really exposed to all these random little mode changes or having to just disengage the autopilot completely and just hand fly it, not because of
the handling, because of it doing a mode that you don’t necessarily want. None of that was covered too much in the type rating. (P7_LT)

For P7, mastering of aircraft automation was through self-practice during line training, rather than through formal instructional methods during the different courses done in type rating.

### 4.4.2.8. Pilot 8 (P8)

P8 had obtained most of his flight hours through the university program during his training for his CPL, although he had logged additional hours flying with friends and family. P8 was optimistic when starting the airline training program, though he was worried instructors may have overly high expectations of his performance given his limited experience.

Reflecting on his university training, P8 reported that transitioning from the Boeing 737 to the Dash8-400 was both easy and difficult. Automation was not an issue for P8, and he said he never became confused between the Boeing 737 and the Dash8 because their buttons and FMC were so dissimilar. “They’re so completely different …it was like learning a brand new airplane, that I rarely confused in between” (P8_Sim-C). However, P8 mentioned that the initial learning of the Dash8-400 FMC was “very counter-intuitive … you have to be taught how to use it, you cannot just work it out” (P8_GT1).

What P8 did find difficult were procedures, as he had to relearn sequences and verbal calls for the Dash8-400 that he had already learned on the Boeing 737. P8 gave the example of the difference in flaps procedures between these aircraft. He explained that in the 737,

> “You go to flap 1, then you go flap 5, and in one call, you say together, ‘flap 15 gear down . . . . [however], if you do that in the Dash 8, you get the gear horn because you can’t take it to flap 15 with the gears still up . . . . that took me a while to retrain myself to go gear down with flap 5 instead of with the flap 15” (P8_Sim-C).

Another example P8 gave of a procedure-related challenge during training was the difficulty he had transitioning from flat panel trainer to full flight simulator (PT to Sim-A). When practising procedures on the flat panel trainer, the actions of carrying out tasks
do not always replicate what is done in the full flight simulator, even when the switches and dials are the same.

On flat panel training . . . you go “flaps 10” and touch it, and it automatically goes to flaps 10, whereas actually in the plane you have to lift this way and pull it this way and twist it . . . . That was a big learning curve the first time we got in the simulator. (P8_Sim-B)

When P8 began Airline B’s training program, the main issue he encountered was manual handling of the aircraft, and this issue continued to come up throughout his training. For example, in Sim-A and Sim-B, he had difficulty with manual flying intensive simulator sessions, especially with the landing technique. Throughout training, he tried to understand why he could not land the aircraft despite applying the techniques his instructors had taught him. “I can do the procedures,” he said. “I can do the calls, I can do the PM stuff perfectly fine, and then I try and manipulate the controls, and it all goes crazy and it doesn’t work” (P8_Sim-B).

Throughout his simulator training with Airline B, P8 had no trouble with crew coordination or memorising procedures. However, he did report having difficulty carrying out procedures when limited guidance was provided. For example, the manuals for some procedures (e.g., engine failure at take-off) are highly prescriptive, while others (e.g., engine failure during cruise) are not. P8 reported finding it difficult to carry out procedures if their associated tasks were not explicitly prescribed in manuals.

During LT, P8 reported that some captains expected him to know the radio calls for the airline, as if this were “presumed knowledge” (P8_LT). However, P8 explained that most cadets have not flown out of large airports and have never practised radio calls during training. Therefore he required guidance from the flight instructor in order to make the correct calls. P8 later expressed the opinion that more guidance should be given to “people who have very low hours or don’t have the experience of flying with [instrument flight rules] procedures and [instrument flight rules] radio calls and stuff like that. It’ll be useful” (P8_LT). After being checked to line, P8 shared that he was still learning new things, such as conducting circuits in different locations and dealing with different types of terrain and weather.
4.4.2.9.  Pilot 9 (P9)

P9 had gone on to university from high school to further his studies and complete his CPL. P9 had no further flying experience than that required to complete his CPL.

Like P8, when P9 reflected on his university training, he reported having to relearn some procedural habits that he had developed during his time flying the Boeing 737. For him, “it took a while geographically to know where things were in the flight deck because there were definitely habits of reaching up for something that was in a different position” (P9_Sim-C). P9, like P7, also discussed the trouble he had in learning to work in a multi-crew environment. However, these issues seemed to have been resolved before he started with Airline B.

One of the early issues P9 encountered during Sim-A was the transition from flat panel trainer to the full flight simulator. He noted that: “everything [instruments in the full flight simulator] was curved rather than being flat [touchscreen on the flat panel trainer]” (P9_Sim-A). Like P7, P9 also reported facing challenges with aircraft handling, especially during the transition from flat panel trainer to full flight simulator. Here he spoke of the difference between, “going from touching buttons to not ever having to trim the aircraft to [now] having to physically control an aircraft with [a] fair bit of movement to get the results that you wanted” (P9_Sim-A). During Sim-A and Sim-B, the majority of P9’s difficulties related to getting used to transferring the theory of flying an aircraft into practice, where he described needing to apply what he practiced in a real scenario before he truly understood how the aircraft would perform.

Apart from wanting more practice, P9 said that he had no problems with automation training prior to Sim-C. During Sim-C, P9 reported feeling a need to have a better understanding of the FMC—to know, “what the box was saying, what it’s displaying, and how to set up certain things” (P9_Sim-C). As he said, “We understood what we learned about it, but … we didn’t really understand what the FMS was trying to tell us, because we’ve never seen it before” (P9_Sim-C).

Like all of the pilot trainees in this study, P9 found the first few flights of LT overwhelming due to the amount of tasks that needed to be done in a short span of time. He found it especially challenging to manage interruptions when carrying out procedures as he had not encountered them during type rating (Sim-A, B, and C). He reported
struggling to deal with “interruptions . . . in the real-world, [where] things are happening all at once . . . having to multi-task and do one thing and then come back and still be on the same wavelength of where you were when you left” (P9_LT). However, his ability to manage interruptions had improved by the time he was CTL.

Flying the aircraft in different weather conditions was also challenging for P9. He found that aircraft handling in the simulator did not prepare him for the different weather conditions he encountered during LT. “Handling [weather] in the sim is sort of similar, but it’s not [the same],” he said. “In the conditions we’ve been flying in recently, the sim didn’t really replicate it that well” (P9_LT).

By CTL, P9 reported that he had become accustomed to flight operations, although he was surprised that he was still encountering new things toward the end of training; for example, doing visual approaches in new locations and dealing with weather conditions that he had not faced before. However, he felt confident with what he had learned by the end of training.

4.4.2.10. Pilot 10 (P10)

Like the other cadet pilot trainees in this study, at the beginning of training, P10 only had the flight hours he had accumulated while training for his CPL. Unlike all of the other pilot trainees in this study, his transition from single-pilot to multi-crew operations was straightforward. For him, success in the Boeing 737 training and subsequent transition to the Dash-8 was a matter of being strict and following procedures. “The university trains pilot trainees pretty strictly in terms of procedures and stuff,” he said. “You know you can’t slack off. This is how it’s done. This is how you should do it” (P10_Sim-B).

Like the other cadet pilot trainees in this study, P10 found aircraft handling difficult when he first began Airline B’s training program. In particular, he had problems with landing throughout Sim-A and Sim-B. He found it difficult to apply the appropriate “flare” and “touchdown” technique when landing that he is used to in the simulator.

P10’s biggest frustration during training was the lack of accuracy in the resources provided by Airline B, something that he discussed in interviews from Sim-A onwards. P10 relied heavily on manuals throughout his training in order to learn procedures and flight manoeuvres during the simulator training block, and even during LT. For instance,
in the following example, P10 wanted explicit instruction on when to trim the aircraft and when to use autopilot to reduce workload.

… there’s nothing on asymmetric landings or asymmetric approaches. ‘Cause they tell you, when you hear from people that when you do asymmetric you want to trim it out, apply the autopilot, but there’s no guide to how you should do that, what phase, what area you should use the autopilot to relieve your loads …there’s no procedure or guideline to when you should untrim the aircraft before landing. (P10_Sim-A)

Similar to P8, P10 reported that in LT instructors expected him to know certain procedures but offered little guidance. As during simulator training, he wanted more written guidance or clarity in manuals when learning something new. This was also an area of frustration for P10 when it came to appropriate triggers required to commence a procedure. He found this relatively easy in the simulator, where the triggers and prompts for procedures were explicitly listed in the manual or training resources, but during LT, the triggers or prompts were not specified. For example, he understood that he was required to get a “push back clearance” from air traffic control prior to commencing a push back, but this was not explicitly stated in the manual, rather a task that he was expected to know when it needed to be carried out based on some “unspoken rule” (P10_LT).

One specific task that P10 reported difficulty with was circuits, which were also a concern for P8. P10 felt that he needed more training in order to become proficient in flying circuits. Specifically, he struggled to be prepared to carry out required tasks at different points during the visual circuit. The key issue he encountered was combining and appropriately sequencing tasks such as hand flying the aircraft, speed control, flap extension, and checklists. In the following quote, he describes how he has just disconnected the autopilot prior to conducting a visual circuit to land.

As soon as you start to roll out, you disconnect the autopilot so it’s all hand flown. So you’re trying to hand fly an aircraft that you may not be familiar with, then you got to keep the speed under control, keep the descent going, get the flaps out, get the checklist done. So it’s just that sequence of items.” (P10_CTL)

After being CTL, P10 reported some challenges in working with normal airline captains. He stated that he learned, “not to rely too heavily, like when I was training,” as he realised
that normal captains were less vigilant and may miss certain calls (P10_CTL). He was also starting to encounter captains who did not follow procedures exactly, and he had developed ways of dealing with such situations.

4.5. **Section 4: Key themes in pilot learning**

Case profiling helped the researcher understand the holistic overview of individual learning processes and considered individual differences. The narrative description above highlighted key aspects of pilot learning during their initial training through thematic analysis of interview texts and other supporting data. These key aspects included four core themes: (1) knowledge, (2) procedures, (3) automation, and (4) social skills.

4.5.1. **Knowledge**

This theme refers to aircraft-specific knowledge, especially aircraft systems and performance. At the beginning of training, pilot trainees were generally overwhelmed by the amount of information they needed to learn in these areas and had difficulty prioritising what they needed to learn and the depth of knowledge required. As they progressed through the training program, pilot trainees reported fewer issues with aircraft systems, although they did continue to mention occasional issues with aircraft performance.

4.5.2. **Procedures**

This theme refers to company standard operating procedures (standard operating procedure) within each airline. This was one of the main focuses of pilot trainees as they progressed through training. Learning procedures required pilot trainees to first memorise and/or understand procedures as recorded in company manuals before carrying those procedures out appropriately in simulator and/or real-world settings.

Analysis of the data suggested four distinct aspects involved in performing procedures: the procedural tasks themselves, sequencing of tasks, prompting of sequences, and timing of all of the above. The tasks involved in a procedure can require both fine and gross motor skills (e.g., selecting buttons or conducting a flight manoeuvre such as landing) or voice commands. These tasks must be carried out in a set order, or in some cases simultaneously (e.g., flying an aircraft whilst also completing a checklist). Task sequences are prompted by triggers, which can be written into standard operating
procedures (e.g., missed approach procedure) or dependent upon circumstances (i.e., variable flight scenarios). While enacting all of these aspects of a procedure (tasks, sequence, triggers), pilot trainees must be aware of how long each action will take and when each action needs to take place. For example, this may involve waiting for the aircraft to reach a specific speed before the next task can be carried out or having to “make time” by increasing the speed of a sequence or reducing thrust to slow down the aircraft in order to ensure that all tasks are completed at the appropriate time.

Pilot trainees discussed these topics often throughout the study; however, different pilot trainees emphasised different aspects of procedures, with some having more issues with remembering sequences and triggers and others having more difficulty carrying out tasks. Timing was difficult for all of the pilot trainees interviewed, especially during the LT phase of training.

4.5.3. Automation

All pilot trainees interviewed for this study reported challenges with learning aircraft automation systems, including the Mode Control Panel (MCP), Control Display Unit (CDU) and Flight Management Computer (FMC). The topic of automation was first introduced in training during GT1 and was presented as part of the aircraft systems training modules. The nature of the automation-related issues reported by pilot trainees changed from GT2 onwards. During GT2, pilot trainees’ focus turned to how to use automation to replicate manual flight and better understand its functionality. Analysis revealed that even on completion of training, pilot trainees still had only a surface-level understanding of how automation functions.

4.5.4. Social skills

This theme refers to knowing when and how to communicate with other pilot trainees on the flight deck, including how to communicate with pilot trainees of different temperaments. This theme emerged when the researcher was trying to understand why pilot trainees were having difficulty working in the multi-crew environment.

4.6. Section 5: Classifying Key Themes

Once the above themes had been identified, the researcher classified pilot trainees’ comments relating to these themes as negative, positive, or neutral. Negative comments
were comments about difficulties in learning or critiques of the training process. *Positive* comments were comments about improvements in learning or ease of learning and approval of the training process. *Neutral* comments were generic comments relating to the themes. This category was added in order to ensure that all transcripts were fully coded to a specific category.

Table 4.6 represents the number of pilots who made comments during training. These comments were categorised by theme and by whether they were deemed positive, negative, or neutral. It is important to note that a lack of comments (positive, neutral or negative) in specific themes does not indicate that those themes were irrelevant to that segment of training. It only shows that pilot trainees had not shared experiences in relation to these themes, suggesting that it was not the main focus for them during that particular segments of training. Furthermore, positive comments do not indicate exceptional instructional methods, nor do negative comments about training necessarily indicate that training was inadequate. The numbers in the table also do not reflect the quality of the comments made; coded content does not mean that an in-depth explanation was provided by the trainee in relation to the issue.

### Table 4.5 Pilot perceptions regarding the learning of core themes across training structure

<table>
<thead>
<tr>
<th>Theme</th>
<th>GT1 N</th>
<th>GT2 N</th>
<th>PT N</th>
<th>Sim-A N</th>
<th>Sim-B N</th>
<th>Sim-C N</th>
<th>LT N</th>
<th>CTL N</th>
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<tr>
<td>Knowledge</td>
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<td>-</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note.** aAirline A (n = 5) due to one pilot trainee failure; bAirline B data collection commenced (N = 9). The numbers in the table reflect coded content in terms of total pilots, not the total number of comments.

It is important to understand that this table was only used to help the researcher identify when these issues emerged during training and to track how long various challenges lasted. For example, pilot trainees were discussing issues with knowledge of systems very early in GT1, while there was only one issue relating to procedures mentioned during this phase of training. On the other hand, issues related to procedures were consistently discussed from GT2 onwards, but knowledge of systems was rarely mentioned after GT1.
Automation emerges from GT2 onwards and continues to be problematic for pilot trainees even after they were checked to line (CTL). An interesting theme that emerged from PT onwards were issues related to social skills. Negative comments in Sim-A, Sim-B and Sim-C were mostly from Airline A pilots, however, LT and CTL onwards, Airline B pilots had also started to comment about social skills. The table provided a different mode of presentation to understand findings across time. In the next section, the key themes of the study are described next.

4.6.1. **Linking themes into a conceptual model of learning**

By detailing individual pilot experiences during training, exploring key themes, and categorising themes over time, Table 4.6 enabled the researcher to examine pilot learning over the course of a training program and classify key areas of learning at differing phases of training (i.e., GT1 through to CTL).

The First Officer Development Model (FODM), seen in Figure 4.2, is the model for training first officers up to completion of CTL. That is to say, the FODM depicts what pilot trainees have achieved on completion of training. The model depicts the captain, first officer, and automation as a joint cognitive system, each interacting with and influencing one another. The structure of this model was organised based on the theory of joint cognitive systems (Hollnagel & Woods, 2005; Hutchins, 1995; Soo et al., 2016) and indigenous models of practice (Kearns et al., 2016). This structure is discussed further in Chapter 5.
Figure 4.2 Final iteration (6th) of the First officer development model.

The model was based on pilot trainee learning experiences and arranged using a joint cognitive systems framework. It shows a new first officer who has, after the entire initial airline training, has become a competent component of the functional system after developing the required airline type-specific knowledge, ability to carry out procedures which consists of: tasks that include motor and verbal skills, sequencing of tasks and procedures, triggers to carry out tasks and procedures, and temporality (timing) of carrying out procedures. Social skills were required to work effectively with the other pilot. Automation is viewed as a significant component within the functional system instead of just an aircraft system. The joint cognitive system (depicted by dotted lines) must be able to handle the disturbances of external, but normal, work environments.

During training, pilot trainees learned aircraft-specific knowledge, including aircraft systems and performance. They learned to operate and interface with the aircraft automation system. They learned about company standard operating procedures and developed their understanding and performance of those procedures, including associated tasks (motor and verbal), task sequences, triggers for commencing sequences (as generated by self, captain, aircraft or external factors), and timing of procedures. As all airline flight operations involve at least two pilot trainees, the ability to detect and react
to social cues was also something that pilot trainees needed to develop during training. Following simulator training (represented by the dotted lines), pilot trainees had to learn about and adapt to new, dynamic, and complex real-world scenarios.

4.7. **Section 6: Exploration of the Initial Training Experience by outlining the development of the FODM**

This section will reveal specific details about the enacted and experienced curriculum by outlining the development of the FODM. It will also provide evidence to support the model’s design and explain links between the model’s various elements. The FODM provides an illustration of the skills of pilot trainees that should be developed when training by CTL. It illustrates the pilot trainees within a larger functional system and the interactions between the main elements of the system.

In the following sub-sections, the different iterations of the model reflect the different phases of training (GT1 through to CTL) and what pilot trainees had focused on during the study. It also illustrates the timing when pilot trainees started to interact with different elements of the system. Within each subsection, the intended and enacted curriculum is outlined, followed by a detailed description of each case’s experience.

**4.7.1. First Officer Development Model at GT1**

The focus of GT1 was to develop pilot trainees’ factual and conceptual knowledge of the aircraft’s systems and performance. Pilot trainees learned the aircraft’s systems through various media, primarily CBT. At this stage of training, aircraft were learned sequentially, and pilot trainees struggled to understand how they linked with one another. Thus the FODM model (see Figure 4.3) shows knowledge as the focus of pilot trainees, while aircraft systems are depicted as individual modules represented by separate boxes, with automation presented in the same manner as other systems.
4.7.1.1. Enacted curriculum for GT1

![Diagram showing systems and automation]

**Figure 4.3** GT1 – Pilot trainees learning about aircraft systems and performance knowledge.

*Note.* During early stages of GT1, pilot trainees view aircraft systems in silos as opposed to being part of a holistic aircraft system.

Each aircraft system is learned in isolation and links between systems are less understood. Automation is viewed with the same importance as other aircraft systems (e.g., hydraulics). GT1 consisted of four separate areas of instruction, including aircraft systems, weight and balance, performance, and crew resource management (see Table 4.6).

**Table 4.6** GT1 overview

<table>
<thead>
<tr>
<th>Training course</th>
<th>Class mix</th>
<th>Delivery methods</th>
<th>Training tools used</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft systems</td>
<td>Type-specific</td>
<td>Computer-based/Classroom-based</td>
<td>Computer Presentation slides Whiteboard Card board cutout Flat-panel trainer</td>
<td>Multiple-choice</td>
</tr>
<tr>
<td>Weight and balance</td>
<td>Combined</td>
<td>Classroom-based</td>
<td>Whiteboard Materials</td>
<td>Worked problems/Multiple-choice</td>
</tr>
<tr>
<td>Performance</td>
<td>Combined</td>
<td>Classroom-based</td>
<td>Whiteboard Presentation slides Manuals Materials</td>
<td>Multiple-choice and Open-ended questions</td>
</tr>
<tr>
<td>Crew resource management</td>
<td>Combined</td>
<td>Classroom-based</td>
<td>Whiteboard Presentation slides Materials</td>
<td>None</td>
</tr>
</tbody>
</table>
Aircraft systems course

The aircraft systems course was taught as a type-specific program where pilot trainees were separated according to aircraft training program. Each pilot trainee was provided with a personal computer and desk to complete the computer-based training (CBT) program (see Figure 4.4).

Pilot trainees must complete a list of topics on different aircraft systems that have been developed by the manufacturers who supplied the computer program. Pilot trainees were given eight days to complete 16 system modules on the computer trainers. While pilot trainees were able to choose their own pace for much of the course, they were given a guide that suggested order and completion times for the modules. Each classroom had at least one instructor present to assist pilot trainees when required (see Figure 4.5).

Instructors used presentations, whiteboards, and cardboard cut-outs to aid with instruction. These training methods were mostly conducted to review important aspects of each aircraft system, with specific focus on some of the larger and more difficult modules (e.g., the electrical system). These presentations were more interactive than the computer-based training program, as instructors asked pilot trainees questions about systems to test their knowledge and promote discussion.
The aircraft systems course for the ATR72-600 included three additional flat-panel trainer lessons to demonstrate certain aircraft systems (see Figure 4.6). Pilot trainees received these lessons in pairs and were brought in by instructors when the flat panel trainer was available to be used. Topics to be covered on flat panel trainer were provided in the reference manual.

![Figure 4.6](image)

**Figure 4.6** Flat-panel training sessions during GT1. Instructor explaining and showing how different systems operate in the aircraft through the flat-panel trainer. Sessions were conducted based on flat panel trainer availability and according to lesson plan.

The last two days of the aircraft systems course were revision. Instructors gave several presentations about specific systems modules, such as the electrical systems and hydraulic systems (see Figure 4.7). Presentations were designed by company pilots though each instructor can modify the slides to reflect what they felt required more information.

The assessment for this course was knowledge-based. Pilot trainees completed a multiple-choice assessment testing their aircraft systems knowledge at the end of the course.

![Figure 4.7](image)

**Figure 4.7** Summary presentations conducted towards the end of allocated time for trainees to complete the engineering courses. Example of the ATR72-500 instructor
presenting and explaining the ATR72-500 hydraulic system using presentation and direct instruction.

**Weight and balance**
As the ATR72-500 and ATR72-600 shared the same airframe, engines, and performance, pilot trainees training to fly these aircraft was combined in one classroom for this one-day course. The course was run through a combination of lectures and activities where pilot trainees practised answering questions (see Figure 4.8a). At the end of the day, pilot trainees completed a multiple-choice and worked-problems assessment. Their grades are provided to them on the spot.

**Performance**
As with the weight and balance course, pilot trainees were combined for this two-day course (see Figure 4.8b). Two instructors, both retired ATR72-500 pilot trainees, used presentations and manuals to instruct pilot trainees. Pilot trainees completed a short-answer assessment at the end of the second day.

![Figure 4.8 Other courses during GT1](image)

*Note.* (a) Weight and balance course, (b) performance course, and (c) crew resource management course. All three courses were attended by all Airline A pilot trainees. The main format of instruction was lecture format with some written exercises, reference material, and whiteboard use. Except for weight and balance course, other courses also used presentations.
Crew resource management
The one-day resource management course also combined pilot trainees training to fly both the ATR72-500 and the ATR72-600 (see Figure 4.8c). Pilot trainees were instructed on company culture, first officer communication calls, the company assessment model, and the company non-normal management model. The instructor used presentations and the whiteboard during the course. This course had no assessments.

4.7.1.2. Pilot experience of GT1
The main concern that pilot trainees reported experiencing during GT1 was knowledge development; thus, the primary theme for this segment of training was knowledge. The following sections present pilot trainees’ experiences in GT1. Areas of discussion include volume of information, prioritisation of information, linking and relating information, and sequencing of training.

Volume of information
One issue that many pilot trainees reported struggling with was the sheer amount of information presented during training. In some cases, pilot trainees simply needed more time to learn and absorb the information. For instance, “Electrical is a bit more difficult. It’s just a lot of parts. There’s nothing particularly hard about it, just time-consuming” (P5_GT1).

In other cases, however, having too much information left pilot trainees feeling confused. In the following example, P1 describes a course where he experienced information overload as tedious, irrelevant, and confusing.

The icing and rain protection system was extremely just tedious. It wasn’t difficult, but just the amount of information they presented was just massive. When it starts getting into the technological computer processes, and they put up a schematic of the computer and the[computer’s] thought processes, and what it thinks about and how it connects the dots in the system. That gets very confusing. (P1_GT1)

Though they often commented on the large volume of information involved in training, pilot trainees with previous experience (e.g., P1, P3, and P6) did not report finding the information difficult to understand, and several adapted what they already knew in ways that helped them with new learning. For example, P3 had flown turbo-propeller type
aircraft and found the power plant topic (one of the aircraft systems modules), “not really that hard, as it’s always just another [turbo-propeller] engine” (P3_GT1). P1 reported that his experience with flight simulators on his computer helped him to understand aircraft automation systems.

The autopilot stuff. I’ve always been involved with the flight simulator on my computer in the past. All the autopilot stuff is very easily transferable, the knowledge it’s all pretty standard across the board. (P1_GT1)

Even though P3 had only flown aircraft with analogue flight instruments, he had also worked as a “flight experience” Boeing 737-simulator operator. “It’s all glass cockpit,” he said. “So I sort of knew exactly how the screen . . . it’s all very similar stuff” (P3_GT1).

In his previous job, P5 had flown a similar type of aircraft with a comparable automation system to the one he was learning to operate in training. He did, however, report issues with learning the layout of the MCP:

So the [MCP] is the same, same logic, [but] different layout. I struggle with the [MCP]’s, because it’s a bit hard to get your head around the [MCP] until you play with it. Especially the autopilot functions. (P5_GT1)

Another common challenge, which was mentioned by all of the pilot trainees from Airline A, was memorising the large number of aircraft specific acronyms included in training.

As you get through the modules, we get into more advanced avionic systems or computerised systems, and so you’re starting to use your mental capacity a lot more. There’s a lot of abbreviations as well in modules that you’ve got to go back to the books and look to see what it means. (P3_GT1)

As all pilot trainees in the study were unfamiliar with the acronyms used in the various system modules and had not memorised what they represented, they had to refer to their manuals or personal notes before they could fully comprehend what was presented in the CBT module.

Prioritisation of information

Another problem that pilot trainees mentioned, which is related to the volume of information included in training, was how to prioritise which information was crucial to adequate performance and which was of secondary importance. For example, P2 said that
he struggled to, “decipher how much of this do I need to really understand, or how much of it’s just, this is the nice-to-know stuff” (P2_GT1). P1 described not knowing, “what do I need to know, in terms of my role. What can I just kind of push to the side … just separating what was essential information as opposed to just background knowledge” (P1, GT1).

One strategy that pilot trainees employed when faced with these questions was to ask instructors which information was necessary, and which was not. “[Instructor] said don’t worry about this too much” (P1_GT1). Another strategy that pilot trainees from Airline A employed was to refer to the sample exam booklet supplied by Airline A, using the sample questions to determine the importance of information:

[CBT has] a lot of information because it’s produced by the manufacturer, and as far as [Airline A] wants us to actually learn, I use the questions from the question book as a really good reference. Things that they deem as important to know, they’re always going to test us on. (P5_GT1)

However, using the booklet sometimes resulted in pilot trainees focusing on answering questions rather than fully understanding the systems. “You just limit yourself to what’s in the questions most of the time,” said P3. “We wouldn’t really go outside from that” (P3_GT1).

*Linking and relating information*

Trying to understand how different components within and between systems relate to one another was another area where pilot trainees reported difficulties. For example, P1 described the difficulty of understanding the connections between systems and how one affects the other:

Power plant was a massive module. There’s so many different levels. Like you got electrical components within the power plant system, how each of them talks to the engine, and so on. Just things like that were quite a bit to fit your head around. (P1_GT1)

To overcome this issue, all pilot trainees used the cardboard cut-outs (P1 and P2) and part task trainer (P3, P4, P5, P6) to facilitate visualisation. The utility of the cut-out tended to be limited to a single check for clarification; for example, P1 said, “I’ve been studying the overhead panel for a bit, just on the screen. But I kind of wanted to go over there [to
the cardboard cut-out] and visualise it a bit more” (P1_GT1). The flat panel trainer helped pilot trainees in two ways. In the first place, it helped them to better understand how systems function, even when the same system was presented in a manual and the CBT. For example, P3 reported finding the flat panel trainer helpful, “when you’ve played with it and you’ve visually seen that the generator has been disconnected, then you’re losing the screen. And then you’re like ‘okay, I see what’s happening’” (P3_GT1). Secondly, the flat panel trainer assisted pilot trainees with the geographical layout of the flight deck:

You’ve got the diagram. You’ve got the overhead panel. You’ve got the screen in front of you. It’s all on one page. You’re only looking here [at the computer screen]. Whereas when you’re in the flat panel trainer, you’ve got the screen, you’ve got the panel, so you’re looking at different places and just knowing where to look and looking and remembering what to look for as well. (P3_GT1)

As P1 and P2 were from the ATR72-500 program, they did not have the advantage of using the flat panel trainer to understand links between systems. Instead, they had to wait until the revision period, which was at the end of the aircraft systems course, when GIs carried out presentations on certain flight systems. P2 found the presentations useful, as there were simple animations and diagrams that showed the connections between systems:

Particularly the presentation … it actually had a diagram that showed where the power started to run all through the circuit. And that was good because then we could actually understand, ‘okay, so that’s what happens and oh, that’s how that one gets powered’ … you can see that switching of that particular thing might go up and feed that. (P2_GT1)

Pilot trainees also reported difficulty in understanding procedural knowledge represented in written form.

A lot of the things they’re trying to put through on the computer, they’re almost practical skills as well … I’ve just done a segment on setting up the autopilot from A to B, and it’s trying to tell you in words and in writing. But if somebody was like, “Okay. Sit down, physically do it,” it would probably be a little easier. (P4_GT1)

P1 had a similar issue when going through the power plant system. However, he was able to use videos to facilitate his understanding.
I was going through power plant, there was a thing that they were trying to explain to you how you do a test on the system. They just give you this massive paragraph of how you do the test. I’m just reading through this, this made no sense. All they had at the end there was a little video, two-second video, and they showed it, exactly what they had in the paragraph, and it made perfect sense. (P1_GT1)

The video had provided P1 with a different form of presentation that illustrated the process, allowing him to understand the training content through a different method.

**Sequencing of training**

While ATR72-600 pilot trainees generally found receiving flat panel trainer in conjunction with CBT useful, this was not always the case. In some cases, pilot trainees found that flat panel trainer lessons interrupted their CBT study time because they were not aligned with what pilot trainees were learning in CBT. P5 reported finding that the flat panel trainer was not aligned with what he was studying:

> I didn’t really get that much out of it, to be honest … It was just quite mixed up, just out of sequence … It’s all stuff we’ve already done on [CBT] . . . . probably could’ve used that time on the computer. (P5_GT1)

Interviews with pilot trainees also revealed that while they found reviews by the ground instructor helpful, it was important that reviews took place appropriate times. For example, P3 found the review on electrical systems, though a difficult module, “a good review, but it was a bit late into the whole session, because we finished electrics … We were reviewing electrics when electrics was long gone” (P3_GT1). P2 commented that if some of the presentations for the harder modules, such as electrics, had taken place earlier in training, it would have facilitated his understanding.
4.7.2. First Officer Development Model at GT2

Figure 4.9 GT2—Learning about automation.

Note. Pilot trainees start to better understand links between aircraft systems that form the aircraft. They also start to view automation as a system that was different than others, requiring other skills and knowledge to be able to operate effectively, leading to emergence of automation and procedure issues. Automation now involved understanding function and functionality of the Flight Management Computer (FMC), Computer Display Unit (CDU), MCP (Mode Control Panel) and the autopilot, and the procedures to use automation.

The topics covered during GT2 were aircraft automation and GPS theory. The increasing familiarity that pilot trainees reported relating to aircraft systems over the course of the training is represented by the system’s boxes in the FODM diagram beginning to merge as depicted by dotted lines (see Figure 4.9). Over the course of training, pilot trainees also began to view systems as part of the aircraft rather than discreet silos. However, many pilot trainees had started to view manipulation of the aircraft through automation as separate from other aircraft systems. For this reason, automation, which was taught as one of the many aircraft systems, was moved to its own area in the model. The dotted line around the automation box illustrates that pilot trainees were still developing their knowledge of aircraft systems and performance.
The arrow between pilot trainee and automation denotes direct manipulation with the CDU. During training, the pilot trainee learns the procedures for programming (motor skill, sequence, and triggers) and company standard operating procedure (verbal calls) for automation use. Results of the study indicated that pilot trainees had difficulty remembering the process of programming the CDU. This process also has a physical aspect requiring the motor skill of entering commands. Even though pilot trainees were taught this segment of training in pairs, findings do not suggest that pilot trainees started to learn about crew coordination at this stage of training. Instead, pilot trainees were observed to refer to their partners as another source of information rather the formation of a crew; therefore, these pilot trainees are not depicted in the model.

4.7.2.1. Enacted curriculum for GT2

Although it was delivered as one course, GT2 consisted of two areas of instruction: automation training (FMC and CDU), and GPS theory (see Table 4.7, p. 135).

<table>
<thead>
<tr>
<th>Table 4.7</th>
<th>GT2 overview</th>
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</thead>
<tbody>
<tr>
<td>Training course</td>
<td>Class mix</td>
</tr>
<tr>
<td>Automation (FMC and CDU)</td>
<td>Type-specific</td>
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<td></td>
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<td></td>
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<tr>
<td>GPS theory</td>
<td>Combined</td>
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</table>

Automation training

Automation training was a two-day, version-specific program where pilot trainees were separated according to whether they were learning to fly the ATR72-500 or the ATR72-600. The course had both theoretical and practical components. Pilot trainees learnt the theory of the FMS system and practised programming the FMC via the CDU. They also learnt to use the automation system. Instruction took place through direct instruction with presentation slides, whiteboard, and course material as training aids (see Figure 4.10a). The practical component was delivered on the flat panel trainer for the ATR72-600 (see Figure 4.10b) and FTD for the ATR72-500 (see Figure 4.10c).
Figure 4.10 GT2 course structure.

Note. (a) Classroom-based instruction using presentation and manuals to teach the function and functionalities of the automation system, (b) Part task trainer used for automation training by ATR72-600 pilot trainees, (c) Flight training device used to teach automation by ATR72-500 pilot trainees.

GPS theory

The GPS theory was a one-day combined classroom course reviewing general GPS theory (see Figure 4.11). The instructor taught the class using presentations and referred to specific manuals and charts as part of the lecture.

This course provided basic GPS theories before pilot trainees got aircraft specific GPS theory as part of the automation course. This was done before automation instruction began, where pilot trainees also completed the required GPS assessment.
4.7.2.2. Pilot trainee experience of GT2

Although automation (specifically FMC) was the primary topic of instruction during this segment of training, the main theme that emerged in participant interviews related to procedures; specifically, the task of operating the aircraft FMC through CDU.

Operating the aircraft FMC through CDU.
All of the pilot trainees reported that they did not have trouble understanding the automation system during classroom-based training, but some reported issues with programming the FMC during simulator-based training. Pilot trainees with previous automation experience in particular reported finding it easy to adapt their prior knowledge to the FMC systems training. “It was fairly easy to understand. I’ve already played with FMC in the past when I was working my second job in [country], so it’s all pretty easy” (P3_GT2). Some of the pilot trainees with previous automation experience reported finding the FMC course “slow and [a] bit boring” (P5_GT2), however, still reported facing challenges when programming the CDU. For example, P3, who had previous FMS experience, said:

When there’s no routes stored in the systems and you want to create a new one, you put in your departure point and your arrival point and then you can put in any waypoints in between. But if you wanted to put in an airway that’s already stored in the [FMC], you have to press a certain key [on the CDU]. There is nothing that prompts you to press that key. Usually every page would have something on the side telling you to press this key… to add this. But on that page, there is really nothing. Then just out of the blue, you press this other key,
and then put into one of the points, and it will give you a whole lot of options.

(P3_GT2)

Not surprisingly, pilot trainees with no previous FMC experience also reported struggling to program the CDU. For example, P2 had difficulty applying what was taught in the classroom to the simulator.

I understood it in the classroom, what he was talking about and how you got there. But when you actually sit in front of the machine and you start doing the process, you sort of get much like, “Where do I go from here again?” He might need to prompt us, and it’s like, “Ah, that’s right.” Then it sort of flows.

(P2_GT2)

Based on the excerpt, it was not clear how well P2 had understood what was taught in the classroom, as he was not able to transfer the information learned into practice.

4.7.3. **First Officer Development Model at PT**

By the time pilot trainees reached PT, their understanding of aircraft systems had improved, although some pilot trainees still expressed doubts about their knowledge, and pilot trainees were still getting accustomed to using automation in conjunction with carrying out procedures. Therefore, while most lines between systems in the FODM are removed at this stage of training, some remain to represent these residual concerns.

Training at PT was focussed on learning company standard operating procedures (see Figure 4.12). While pilot trainees were paired during systems review, they had been relatively disconnected from one another; however, pilot trainees begin to work as a crew during PT in order to comply with standard operating procedures, which is why the second pilot is depicted in the model at this stage. Furthermore, a dotted line appears between the two pilot trainees because crew coordination between pilot trainees developed over the course of PT but was still problematic. Both pilot trainees were now actively engaging with automation based on their roles (pilot monitoring and pilot flying), as depicted by the line linking the pilot trainees to the automation. However, a first officer would normally be on the right, and focus was given to the trainee in that position.
Figure 4.12 PT – Starting to learn about company standard operating procedures.

Note. Trainees are now actively engaging with the other pilot trainee. Procedures involve both motor tasks and verbal tasks and the coordination between pilot trainees. The emphasis on learning a procedure included accurately remembering the tasks, sequence and trigger for a procedure. Pilots start thinking about working with another pilot.

As pilot trainees started to practice procedures, they were required to memorise and carry out specific task sequences involving prescribed actions (motor tasks) and call outs (verbal tasks). To do this appropriately, they had to remember triggers for task and sequence commencement. At this stage of training was not time critical, so pilot trainees could learn procedures in their own time. Thus, the focus was on learning correct triggers, tasks, and sequences, and timing was not emphasised.

As pilot trainees started to work together, they reported encountering problems relating to maintaining good teamwork (social skills), although they said that these challenges were mild. Pilot trainees were focusing on developing their capacity to perform procedures while giving little consideration to developing proper crew coordination. This is depicted by the dotted line between pilot trainees.

4.7.3.1 Enacted curriculum for PT

Like GT2, PT was aircraft type-specific and taught in pairs. Instructors met and briefed pilot trainees before each lesson, outlining the lesson content prior to moving to the flat panel trainer or flight training device. Figure 4.13 illustrates the simulator session of the PT course. Some instructors carry out a full briefing in a classroom before moving into
the simulator session while some conduct the briefing within the simulator room itself. Debriefing for each session followed a similar format, ending with instructors providing revision and lesson preparation points to be completed before the next session, which is the next day. The training tools and documents used were procedure manuals, student reference document, whiteboard and simulator device (FTD or FPT).

Figure 4.13  Instructors carrying out PT course.

Note. (a) ATR72-600 course on the FPT with instructor bring trainees’ attention to a specific flight system; (b) ATR72-500 course on the FTD with instructor briefing a procedure before asking trainees to carry out the procedure.

To develop first officer procedural skills, once each procedure had been completed, pilot trainees swapped seats and repeated the lesson.

4.7.3.2. Pilot trainee experience of PT

The main theme that came up in interviews during this phase of training was procedures; in particular, pilot trainees discussed the difficulties they experienced learning tasks, sequences, and triggers for procedures.

Difficulty learning procedures.

Pilot trainees reported three issues relating to learning procedures: tasks, sequences, and triggers. A task is either a single motor (e.g., selecting a switch) or verbal action (e.g., checklist delivery) or a consistent application of actions (e.g., maintaining straight and level in manual flight) embedded within a procedure. P2, for example, described having difficulty remembering to perform the task of setting his airspeed selector prior to checking power levers were set to a specific position (or “in the notch”):

I keep missing the first thing. So that sort of frustrated me a little bit. When it comes to the acceleration altitude checks, the pilot flying puts his hand on the power levers and checks it’s there in the notch. … but before you do that you
Multiple tasks can be done by an individual in sequence, concurrently by one pilot, in sequence with another pilot, or concurrently with another pilot. Pilot trainees reported that their recall of the correct sequencing for tasks was sometimes guided by “flows,” or patterns taught by the airline. However, even with these guides, pilot trainees found it difficult to remember all of the tasks in a sequence:

… the most challenging thing for me was to…remembering all the pre-cockpit set up flows. There’s no way you can sort of remember it all, but trying our best to remember once we go through it, what we’re actually looking for. That was probably the most challenging [aspect of procedures training]. (P2_PT)

One pilot trainee reported the difficulty of learning carrying out tasks and procedure sequences when practicing with a poster. He describes the lack of realism makes rehearsal difficult, “on the poster it's not as easy as with the flat panel because you can’t use the FMS. You can't set the autopilot. You can't do much. You're just pretending.” (P3_PT). The final issue that came up in terms of procedures was learning triggers to commence sequences. A flight consists of multiple procedures, and even when pilot trainees had learned the sequences of those procedures, some of them reported difficulties remembering triggers to prompt procedure sequences. P1, for example, said that he struggled with, “determining which sequence would follow the last, as there is no specific flow that we are used to yet, unlike a checklist which involves a pattern usually.” (P1_PT). This example highlights that there are different types of procedures that pilot trainees must learn, and some are more difficult than others.

First Officer Development Model at simulator blocks (Sim-A, B and C)

Pilot trainees from Airline B participated in the study from this point onwards. During simulator training, pilot trainees practised procedures in a high-fidelity full flight simulator. While the simulator environment offers high levels of realism in terms of factors such as time and motion, it remains a controlled and artificial environment; hence the simulator blocks are depicted with solid boundaries.
Pilot trainees made few if any comments about aircraft systems and performance, suggesting that they had sufficiently understood the systems as part of the aircraft; hence, no lines separate the aircraft systems at this stage of the FODM development.

As pilot trainees began to carry out procedures that required crew coordination, the line between the two pilot trainees in the diagram became solid (see Figure 4.14). In interviews conducted at this stage in the training, pilot trainees talked about the importance of being aware—from a social perspective—of the tasks and, to some extent, workload of the other pilot on the flight deck. Pilot trainees said that sharing the flight deck with pilot trainees who had this awareness improved their performance while working with pilot trainees who did not have this awareness created added difficulties. For this reason, social cues were added as a category under Pilot trainee in the diagram, although this was never part of the indented or enacted curriculum.

Figure 4.14  Simulator block (Sim-A, Sim-B, and Sim-C) – working with another pilot and automation.

*Note.* Pilot trainees are starting to work as a joint cognitive system. Note that temporality emerged as an issue during these stages of training as procedures are now carried out in full flight simulators with motion. Timing for carrying out a procedure is now affected by aircraft performance on top of partner triggers or actions. Social skills become more crucial as trainees start to support or manage each other to complete a procedure.

At this point in the development of the diagram, pilot trainees and the automation system formed a functional system to perform flight planning, navigation and flight path control (Soo et al., 2016). However, even at the end of simulator training, some pilot trainees
reported that they did not feel adequately familiar with the automation system. For this reason, automation is depicted within a dotted line.

4.7.4.1. Enacted curriculum for simulator training blocks

The training structure for all simulator block sessions was essentially the same. Each session was conducted in a company-owned facility according to a set syllabus. In Airline A, simulator exercises were intentionally rostered back-to-back, forming several training blocks. For instance, Monday through Thursday pilot trainees completed training exercises 1 to 4. Simulator training session times were within the morning to evening session, with the earliest session at 7 a.m. and the latest at 10 p.m. For continuity of training, the same instructor was rostered to teach the pilot-pair in each simulator training block. Different instructors were used only if the original instructor was unavailable.

Airline B was a larger airline than Airline A, with multiple bases around the country. As the simulator was near capacity, simulator training slots were rostered throughout each 24-hour period through the company’s pilot rostering system. In the case of Airline B, back-to-back exercises were coincidental rather than planned, and instructors varied for each session, although some back-to-back sessions occurred.

Simulator training

Training objectives (see Table 4.3, p. 100) were carried out through a six-hour training block consisting of a one-hour briefing, a four-hour simulator training session, and a one-hour debriefing. Briefing sessions were usually one-hour long, with some provisions made for longer or shorter sessions. They were usually conducted in a briefing room that had various resources and tools available; for example, a whiteboard, company operational manuals, posters, desks and chairs, and a computer to access company resources (see Figure 4.15).
Figure 4.15 Briefing room consisting of a whiteboard, briefing computer, manuals, flight deck poster. Whiteboard contains a diagram drawn by the instructor during a briefing about aircraft flaps.

The purpose of briefing was to ensure that pilot trainees were aware of the training activities that would be conducted in the full flight simulator. Instructors went through each lesson’s objectives in detail and discussed how different tasks and procedures should be carried out. Instructors used various techniques during briefing to cover topics related to the lesson and ensure that pilot trainees understood the intentions of the exercises they were going to complete. For example, as instructors introduced procedures, they would draw a model of those procedures on the whiteboard and enact the steps required to complete each procedure (see Figure 4.16a). Pilot trainees took notes of information that they considered important and had opportunities to clarify any questions they had regarding the lesson plan with their instructors (see Figure 4.16b).

Figure 4.16 (a) Instructor demonstrating action of carrying a task (b) Instructor writing and drawing key points of a procedure

Simulator exercises were four-hours long and conducted in a full flight simulator. Each lesson had a specific training focus, objectives, and minimum performance standards, all of which were listed in the lesson plan (see Appendix D, p. 263 for an example). The exercises were carried out according to a set syllabus determined by the airline. Airline A provided pilot trainees with lesson plans for each exercise via printed reference
documents, whereas Airline B made lesson plans available for pilot trainees to download via the company website. Pilot trainees were required to prepare for each lesson prior to each exercise using all available resources.

During each session, instructors played multiple roles apart from teaching, including programming the simulator to meet the requirements of the lesson plan and playing the part of other staff members, such as cabin crew or air traffic controllers. Pilot trainees were trained in pairs. However, the instructor’s focus was mainly on the pilot sitting in the right-hand seat, who played the “pilot flying” (PF) role. Meanwhile, pilot trainees sitting in the left-hand seat carried out captain procedures and the “pilot monitoring” (PM) role. Midway through each four-hour session, pilot trainees switched seats and roles, and the training exercises were repeated. Some of the techniques employed by instructors in the simulator included direct instruction and guidance, directly correcting mistakes, and pausing the simulation to provide advice on improving performance.

After the simulation exercises were completed, pilot trainees were debriefed on their training performances in a debriefing room. The purpose of this post-exercise debriefing was to assess and discuss pilot trainee performance during the simulator session. Generally, instructors asked pilot trainees to try and recall each training exercise and self-reflect on their own performance. Following this, instructors discussed with each pilot trainee any performance issues that the instructor felt were significant.

Instructors used various tools during the debriefing process, including the debriefing tool, a custom-made computer program that records simulator exercises and allows playback with specific features, whiteboard, training manuals, and posters. Figure 4.17 shows an instructor using the debriefing tool to review a procedure that the pilot trainee had performed during the simulator exercise.
Figure 4.17  Debriefing session using a debriefing tool.

Note. The instructor uses the whiteboard to list down what trainees had recalled during the simulator session. The debriefing tool was used to show what trainees were doing in the simulator at the time of a scenario to facilitate recall and reflection of actions.

At the end of each simulator session—apart from the operational competency assessment exercise at the end of Sim-C—pilot trainees received training performance assessments, and their grades indicated whether they were progressing as expected and had met the minimum criteria set for the lesson or whether they required further training or needed to repeat the lesson. The assessment was repeated for every training objective; for example, the landing exercise was graded separately from the circuit exercise.

Towards the end of the debriefing session, instructors informed pilot trainees of their scores and filled in pilot trainee records in a record of training book (Airline A) or online database (Airline B). Instructors also left comments to remind pilot trainees of key points or as notes for future instructors alerting them to aspects of training that the pilot trainee had not completed or needed to repeat. Pilot trainees signed off on their scores to indicate that they had agreed on their grades following discussions with their instructors.

Between simulator block preparations

Upon completing each training block (four simulator sessions), ATR72-500 pilot trainees from Airline A returned to the classroom to reflect on training and discuss the next training block (see Figure 4.18). During reflection, instructors discussed in detail aspects of pilot trainee performance that could be improved upon. This was done in a style similar to a briefing, although it concluded with suggestions for what pilot trainees should focus on in the next Sim-Block.
The ATR72-600 pilot trainees also had part task trainer sessions to prepare them for the next simulator training block (see Figure 4.19). Pilot trainees met instructors in pairs and generally followed the same format used during simulator training: briefing, simulator session, and debrief session. However, depending on instructor style, briefing and debriefing could be conducted in the flat panel trainer room or in a normal classroom. Each flat panel trainer session had a set training syllabus that instructors followed. Although flat panel trainer sessions were considered to be preparatory exercises, pilot trainees still had to meet minimum training standards before they could continue on to the following training block.

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**Figure 4.18** Classroom-based course after simulator-training block to reflect on previous sessions and plan for future simulator sessions.

*Note.* Instructor uses this opportunity to revise training aspects that trainees can improve on (Only ATR72-500 training).

**Figure 4.19** Mid-simulator part task trainer sessions in preparation for coming simulator sessions.
Structure of training

There was a total of ten training exercises for Airline A pilot trainees and 11 for Airline B pilot trainees. As described above in Section 4.3.3, p. 102, the sessions were Sim-A, Sim-B, and Sim-C. The final session for both airlines was the competency assessment. All training was conducted in pilot pairs.

4.7.4.2. Pilot trainee experience of Sim-A

The following is an overview of pilot trainee experiences reported during Sim-A training. The areas of discussion include: transiting from lower-fidelity simulation to full flight simulator; aircraft manual handling skills; learning tasks within procedures; carrying out procedures; learning timing of procedures; dealing with interruptions to normal sequences; importance of triggers when learning procedure; and automation.

Transitioning from lower-fidelity simulation to full flight simulator

With the exception of P1 and P2 who received PT on a high-fidelity flight training device (e.g., full flight simulator with no motion), all pilot trainees discussed issues transitioning from low-fidelity simulators to full flight simulator when they began Sim-A. For P1 and P2, the transition to Sim-A was simple: “the [flight training device] was quite a good representation of what we’ve got here in the full flight simulator. Everything you saw sitting in front of you was identical, really. That whole transition from going…sitting in [a] [flight training device] to sitting in the full flight simulator, it’s not too significant at all” (P2_Sim-A).

For other pilot trainees, it took time to become accustomed to the new location and feel of instruments, switches, and controls in the full flight simulator. For example, P4 reported having to move differently than he was used to when selecting instruments and control:

“There are obviously some differences when you get into the thing. They talk about pushing the buttons or whatever, but I think it’s a relatively minor issue. The main difference for me was having all these consoles and things where you have to kind of go underneath it. As in the throttle quadrant sticks out [having to physically move or move around an instrument when manipulating consoles]. It’s not just a flat screen” (P4_Sim-A).
Aircraft manual handling skills

During Sim-A, pilot trainees from Airline B often discussed aircraft-handling techniques as an area of difficulty, whereas this topic was only mentioned once by one Airline A pilot. Airline B pilot trainees’ comments related to basic aircraft handling skills such as turning, speed control, trim changes with flaps, and landing. For instance, during one of the simulator lessons that focused explicitly on manual flying techniques, but one Airline B pilot trainee noted the difficulty he experienced when applying these techniques in the full flight simulator:

In the airplanes that we were flying, you actually have to put in a fair bit of movement to get the results that you wanted, and that was different. You only have to make really small changes to get the outcome that you want. Probably the biggest thing was actually just having the controls and getting used to like “adding power, got to put in a bit more right rudder, taking off power, got to put in a little more left rudder.” (P9_Sim-A)

When it came to more challenging manual flying tasks, P7 reported that applying previous techniques sometimes resulted in further difficulties:

[In the] high angle of attack recovery procedure . . . one of the initial . . . actions is [that] you have to reduce the pitch, but it doesn’t say how much to reduce the pitch by. So I was just going back to what I done in [general aviation], and I reduced it by 5 to 10 degrees. Which was a bit too much for the [DHC8-400]. The instructor [explained] afterwards that you can usually just lower it 2 or 3 degrees. (P7_Sim-A)

Pilot trainees said that having explicit guidelines helped reduce their confusion about how to carry out tasks. In the following excerpt, P7 uses the example of selecting flaps 35:

The instructor taught us a few intricacies that weren’t mentioned in the training modules or [flight crew operations manual]. For example, selecting flap 35, a little sequence to remember, to push forward, to trim then set the power. For example, going from flap 0 to flap 5, as the flaps are running, just trim for 3 seconds and that sets it up. Just little things like that just takes your mind off having to anticipate it and think ‘how much do I need to trim by’ it just like an automatic “flaps are down to 5, trim for 3 seconds,” and that’s a good ballpark figure. Just little things like that. (P7_Sim-A)
Some pilot trainees continued to have issues with topics covered in the lessons even after completing several simulator sessions. P8 describes how he still needed explicit instruction to improve his flying skills:

In our previous sim, we were just given an altitude and a power setting. This time, the instructor was like, “if you increase power a little bit, and then keep your speed the same, and then pitch up to keep the speed the same, increase a little bit, pitch up to keep the speed the same, glance at vertical speed, and then just keep going ‘til you have the correct vertical speed.” And I found that way of setting up the climb to get like 190 knots at 1,000 feet per minute was a lot easier than just going, “hit 60%, 6 degrees, nose up.” And then it’s all wrong. Because when you do that, it’s hard to fix it because there’s two variables that you’re trying to get. Whereas if you keep one of the variables the same and then you’re just adjusting for the second, to the second variable it will be easier.

(P8_Sim-A)

Pilot trainees from Airline B discussed applying some form of theory to manual handling techniques—something that none of Airline A’s pilot trainees mentioned. For example, P10 describes his initial learning of flap settings as follows:

You understand the differences between doing a flaps 15 and a flaps 35 landing, but sometimes you need to put it into action a lot more before it comes naturally. So at the moment you’ve got to go, “I’m doing flaps 15. It’s going to be pitch up first and then use power to control sink. When you’re in GA, when you do a landing, it’s the same technique regardless of what type of flaps you use. In the Dash8, for flaps 35, you’ve got to do the opposite. You’ve got to power back and pitch as required. So it’s kind of a practice just to get it.

(P10_Sim-A)

Only one manual handling issue was mentioned by an Airline A participant. P3 commented on initially finding it difficult to make a crosswind landing in the ATR72-600 aircraft. “It is a challenging [aircraft] to land on crosswinds, and I do like that. I’m not used to applying so much rudder on a crosswind landing, but eventually I got it the second sim session” (P3_Sim-A).

Learning tasks within procedures

As mentioned in PT, procedures include various tasks that must be carried out in sequence from memory. Even after PT training, pilot trainees continued to report difficulty
memorising and recalling the tasks within procedures. In the following example, P2 was still finding it difficult to remember call outs for the after take-off procedure:

It’s quite a long-winded procedure. To get that right, get all of those calls right, and then get them out at the right time, it’s like, “Ah.” I was getting annoyed, because I’d always miss one thing. You’d get it next time, but then you’d miss something else. (P2_Sim-A)

P2 reported having an additional problem with certain verbal tasks due to past experience combining those same calls with different motor tasks. In these cases, he said he often reverted to previous company practices:

… I still have to mentally “check” myself. Sometimes, I guess, when you’re going through a missed approach procedure and it’s a busy time, instead of saying, “Positive Climb,” I keep saying, “Positive Break.” Which is what I called in my previous company. (P2_Sim-A)

P4 also discussed having difficulty memorising procedures, although he found working with another pilot helpful:

I think I’m finding it a bit harder to remember things? Like checks and flows and call outs and things like that, and making associations. Probably would have liked to have that done a little bit faster. And I don’t know a better way to train in that regard. Because when you do it on your own, it doesn’t really work. You really need a partner. (P4_Sim-A)

As most procedures in the flight deck are designed to be carried out by both crew members, P4 felt that the only way to learn those procedures was with another pilot who acts out the required calls.

Carrying out a procedure

Some procedures required pilot trainees to multi-task. The excerpt below describes P9’s experience performing a circuit involving multiple tasks that had to be conducted concurrently and in sequence:

The most difficult thing to grasp is the big transition that happens with flap 35, so going from flap 15 to flap 35. You really got to hold the nose down, trim it, and really hold the pressure down, otherwise you’d balloon and you gain height. And in circuit pattern, when you’re coming around and you’re on base-leg, you want to keep this from happening…the management of taking flap 35,
bringing the power back in, condition levers as well, and then doing the turn at
the same time. There’s just a lot happening. A few times we either took the
flap and we remembered to hold the pressure off to trim it, but we forgot to
bring the power back in, so we fell below profile a little bit. And then there
were other times where if you didn’t hold enough pressure, the aircraft didn’t
descend enough, so when you rolled out final, we were above profile. (P9_ Sim-A)

Learning timing of procedures
Another issue that came up with several pilot trainees was being able to perform
procedures within a set amount of time. P3 reported that when he was unable to perform
procedures within the available time, his solution was to rush:

The one thing where we’re getting a bit messy was on a take-off . . . and also
the go arounds sometimes. Just rushing a bit. The instructor told us to just slow
down and make sure we did everything properly. We got [enough] time [to
complete each task], so that’s what we did, and we got it right. We used to rush
in the go around procedure and forget things like pushing the go around button.
We both did it. I did it. He did it. It all turns to crap when you forget things like
that. (P3_ Sim-A)

P10 reported having to do an additional action during an instrument approach called an
ILS (for instrument landing system) in order to ensure that he had time to complete a
procedure:

I think the biggest one would have been knowing that when you fly the ILS,
especially when you’re coming in from below 3,000 feet, that you really need
to have to power back to flight idle to configure quickly, ‘cause you only have
that window, whereas in all the . . . I don’t think it’s written in any of the
resources that below a certain altitude you’ve got this much time. (P10_ Sim-
A)

When learning procedures, several pilot trainees mentioned that procedure manuals or
other provided resources were sometimes inaccurate. In the following example, P10
described having problems understanding the timing of tasks when learning the tasks and
sequences of a procedure from the procedures manual or other written training resources.

You know that you need to do it, but some of the things, like on downwind,
you’re supposed to go flap 15 landing checklist. [The flight crew operations
manual] It’s just got “configure” and a “landing checklist.” It makes it sound
like there’s a break [bold added] in between, where in reality you should be going “Flap 15 landing checklist.” (P10_Sim-A)

Dealing with interruptions to normal sequences. During Sim-A, P1 reported struggling to handle interruptions to normal sequences, whether they came from his partner, the environment, or himself:

The tough one is when somebody, the other person, says something incorrect, or if you just say one thing out of order, you don’t, it just kind of screws with your rhythm a little bit. You have to figure out a way to find your way back. (P1_Sim-A)

Importance of proper triggers when learning procedure. Another issue discussed by some pilot trainees was the difficulty in developing the triggers for carrying out procedures. Some procedures required pilot trainees to work together to complete tasks. In these cases, pilot trainees relied on each other to trigger tasks in sequence by enacting specific actions or verbal calls. This led to difficulties when one of the pilot trainees missed a cue. Pilot trainees brought this issue up during PT, and it continued to be a problem for some pilot trainees in Sim-A. Interestingly, pilot trainees from Airline B did not discuss this issue of missed procedural triggers. In the following excerpt, P3 outlines the difficulty he had flying with a partner who was not familiar with procedures:

The one thing that was throwing me off a bit the first couple of [simulator exercises] was the captain calls and the first officer calls. My partner wasn’t really familiar with the captain stuff, so yeah, he wasn’t 100% on the captain stuff. The thing is … because I know the flows, but, I need his input. He needs to trigger me, otherwise I’m not going to just come out of nowhere and say, “Hey, this is what I’m doing next.” I need him to tell me something so I can do the next move. (P3_Sim-A)

Being able to work and communicate well with other pilot trainees on the flight deck and “making sure we’re on the same page” (P1_Sim-A) was not something that came easily to all of the pilot trainees. In the following example, P1 discussed a situation when he and his partner had a different interpretation of what was wrong during an approach to land:

I interpreted it as one thing and my partner interpreted it as another. We didn’t clash or anything, it was just more of a case of we weren’t quite sure of what was the right thing to do. I was flying, so I just followed what I thought was right. But when it comes to the debrief, the instructor was like, “Oh no, your
partner was probably more right in that instance.” Just things like that where you’ve got to get used to taking into account what they’re saying as well. That’s kind of, that’s kind of interesting to get used to. (P1_Sim-A)

In contrast, pilot trainees who had multi-crew experience prior to training found it “quite simple” to work with others on the flight deck (P2_Sim-A). However, for these pilot trainees, previous experience sometimes interfered when they were enacting procedures that were new to them. “When it comes to the two crew and the standard operating procedure calls, it’s changing from the ones that I was doing in my previous company to the ones here, so occasionally, I’ll end up saying the wrong thing” (P2_Sim-A).

Automation
During GT2, pilot trainees did not report many difficulties with understanding the functionality of automation; instead, the issues they raised related to remembering how to program the FMC through the CDU. However, during Sim-A one pilot trainee discussed having difficulty understanding some of the functionality of the system:

The biggest thing for me personally is the automation stuff, getting my head around that. I’m still at times not understanding it. I’m making silly mistakes because I’m not understanding what mode I need to be in . . . . This is like, “Okay, the change then, I’ve got to go to this page, and then I’ve got to be in this mode,” and so it’s just a lot longer process, rather than just being able to physically make the change. For me, it’d be far easier to just turn the autopilot off. (P2_Sim-A)

At this stage of training, P2 felt that it would have been better to manually fly the aircraft than try and program the automation, which requires multiple steps and remembering the different functions, to fly it for him.

4.7.4.3. Pilot trainee experience of Sim-B

The following presents pilot trainee experiences in Sim-B. The areas of discussion include: manual handling tasks; learning procedures from manuals; learning procedures and getting consistent triggers; timing of procedures; remembering automation programming and functionality; and developing social skills required for working as crew.
Manual handling tasks

As mentioned previously, pilot trainees in Airline B (P7, P8, P9, and P10) reported having difficulty with aircraft handling, especially as sequences became more difficult; for example, when pilot trainees were required to fly the aircraft single-engine. As P9 said:

…the theory of doing it all was one thing, and executing it and flying it is another thing all together… I knew the theory with different flap settings. For smaller flap settings, you tend to not need as much role input as you lift off. So one of the first things that took me a little by surprise, because I’ve never had a feel of how the airplane was going to react… the engine fails, the plane yaws to the side of the runway. So you have to straighten yourself back up again … as it lifts off, the airplane actually rolls quite a lot. So the idea was that you had to straighten up the airplane and roll at the same time so that you keep the plane on the centre line. It took me one attempt for me to realise that you actually have to do it all at the same time. (P9_Sim-B)

Sometimes pilot trainees needed to fly the aircraft manually while preparing to use automation. For example, the aircraft had to be finely trimmed prior to engaging the autopilot, and each time this happened pilot trainees had to fly the plane manually during the trimming process. In these cases, what seemed to be an automation issue was actually the pilot having difficulty hand flying the aircraft using primary and secondary controls. Here P8 reported lacking the procedural skills to manually fly the aircraft while preparing it for automation:

Just the trimming, because when you’re hand flying, you don’t touch anything, right? You just have your feet on the pedals, your hands on the controls, you’re not touching any other buttons. You have two hands to move the aircraft and your feet and you can just manoeuvre. But when you have to trim before you turn the autopilot on, I find it very difficult to trim the rudder while I’m flying. It’s a very funny switch. It’s like flick, flick, flick. It’s not like you turn the wheel until it’s set . . . You’re kind of just touching a button until you see it line up. You’re not feeling the trim … I had the same problem when I first started using electric trim, because I was so used to feeling, not looking anywhere, just feeling it. I think that the rudder trim system doesn’t allow you to feel the trim. I find it difficult to trim. Plus, when I’m trying to hold the control column in a roll, it’s quite difficult to take one hand off, because it’s just heavy. (P8_Sim-B)
Another crucial manual task that pilot trainees talked about in interviews was landing. Landing was problematic for several pilot trainees in Sim-A and continued to be problematic in Sim-B, especially for P8 and P10.

[The] hardest part of the landing was the flare and just the touchdown, because depending on how you fly, you might look down the runway and look at the horizon and judge how much you’re sinking by, and that judges how much to pull back by. Or some people use peripheral vision to see how much you’re sinking. It’s a bit different in the simulator. It’s a bit harder, and you’ve got to re-program yourself into going, “This is where I need to start to round out and flare,” and “This is how much power you need to reduce by.” So I think that was the part that took me the longest to get correct. (P10_Sim-B)

While P10 had some sense of why he was having issues with landing (i.e., simulator depth perception) and took steps to improve, P8 only became more confused as the training progressed. By Sim-B, he had tried everything he could think of and followed the advice of his instructors, but he was still unable to land properly. The following excerpt conveys his frustration:

My landings were like, the first one was, say, a hard landing or something. So [the ground instructor] would be like, “Okay, what you could have done to correct that would be to, I don’t know, flare later,” or whatever it was. And then on my next flight I was like, “Must flare later, must flare later, must flare later,” and so when I was ... But the situation was different, right. It wasn’t in the same situation. So I would follow what [the ground instructor] was saying like it was the law… I was extremely ... I don’t know what’s going on, like, every landing was bad. But I was trying, I was doing what he was saying, so I was like, I don’t understand why this is all bad if I’m doing what he’s trying to tell me to do then. Like, why isn’t it working? Because obviously I’m trying ...

(P8_Sim-B)

P8 explained why trying to apply the theory of landing too strictly was problematic:

I had the procedure in my head. Flap 15 landing, crosswind, you do this, and then this and then this, and this.” And from what I was told in the debrief or the [flight crew operations manual] or whatever, and I did that, and it just didn’t work. [What the instructor] was trying to get at is, “Yes, it’s all nice and good to have this procedure written down in the flight crew training manual, but when it’s a like an aircraft handling thing, there isn’t really a way that they can
write down exactly this power setting and exactly this and exactly ... Like you just have to kind of, like this is [just] a guide (P8_Sim-B)

P8 reported that when instructors gave him advice or corrected him, he had, “no idea that, that’s why I had a hard landing or something like that. Like, I don’t have the knowledge in order to self-correct” (P8_Sim-B). These excerpts the confusion of P8 when trying to learn the manual flying task, and how the various resources used (i.e., instructor or manuals) were not effective in teaching him.

**Learning procedures from manuals**

Several pilot trainees shared that learning procedures from manuals was easy when those procedures had clearly listed tasks and each task was clearly specified.

I think the [engine failure procedures] was very clearly written in the manual. Very, very clear. If this happens, you do this. If this happens, you do this. It’s something you can really learn. (P8_Sim-B)

However, when tasks were not clearly defined, this caused confusion for some pilot trainees.

…sometimes you read it incorrectly, or you understand it incorrectly from a manual. Manuals are good, but they’re not like ... sometimes they’re a bit ambiguous, and you’re not quite sure what it is … in the training procedure it says to make this call, but it doesn’t quite say where to look at to make that call or what you’re actually calling for. I was a bit confused when I read it. (P8_Sim-B)

Sometimes certain aspects of procedures were not clearly stated in the manual. In these cases, some pilot trainees reported finding it difficult to carry out the procedure. P8 explained that one reason for this issue was because they never had to think about it previously. In the following excerpt, P8 describes the evacuation training scenario. Previous training sessions had only practised carrying out specific procedures, rather than carrying out full scenarios of which the procedure forms one part of the simulation. In this case, the evacuation procedure on ground was clearly listed in the manual, however, the manual did not include detailed instructions of what needed to be done when the flight warning occurs to trigger the need for landing and evacuation.
We had learnt the evacuation procedure from once we’re on the ground, but I didn’t feel like from the ping to landing was managed very well. We didn’t quite know what to do in what order … we knew exactly what we were going to do [after landing], because it’s written down in the manual, and we’d learnt the manual. So there was not very high workload. (P8_Sim-B)

When asked why he didn’t bring up this issue prior to attempting the exercise, P8 explained that “we didn’t realise that we didn’t know what to do” (P8_Sim-B).

Learning procedures and getting consistent trigger

Pilot trainees in Airline A continue to report a need for accurate triggers when carrying out procedures, especially when they were first learning those procedures.

… there were times when I knew the procedure, I knew it was coming, I knew how to do it, but then my partner would have a brain fart … It kind of throws me off … That sort of stuff kind of [throws] you off that flow that you got going on, because you’re not getting the triggers that you’re used to getting, especially at the early [stages of learning a procedure] where you rely on those triggers to help you. (P1_Sim-B)

Timing of procedures

As covered in the discussion of Sim-A, pilot trainees reported issues with timing when they were putting procedures into practice in the full flight simulator. Even when a pilot has learned the sequence of a procedure, incorrect timing can result in sequences being disrupted. P2 recalled an experience when he knew the flow but got confused, “because I didn’t appreciate what stage the aircraft was at” (P2-Sim-B):

When you sit down and study the sequence: one step, next step, next step. When you’re actually in the airplane, you do a couple of steps and then it’s like, “Ah ok…wait for it to accelerate” … And then sometimes when you sit there [and] all of a sudden your flow would be disrupted. (P2_Sim-B)

Several pilot trainees also talked about the difficulty of learning or creating an awareness of timing of procedures from manuals. P9 shared how his experience of the difference between learning about control jams from manuals and actually carrying out the procedure:

You read the crew coordination and the recall items, but then until it actually happens you don’t really know how quickly things happen. And it did happen
very quickly … we knew that we were going to get the jam at some point, but…we didn’t think about it too much. And then it just happened, and all of a sudden. I was really shocked, and we had to do the recalls, and by the time we did the recalls it was probably a tad too late. It was…yeah, as soon as you recognise there is a roll jam, just dive straight into the recalls. That’s why they’re called recalls. That gave us an appreciation for timing. (P9_Sim-B)

P9 found that certain procedures require quick actions, while some procedures can be done at a slower pace. Here, it is described that he was not able to develop a sense of time based on reading manuals, but only when he carried out the procedure in an actual scenario in the full flight simulator.

**Remembering automation programming and functionality**
Pilot trainees reported having difficulty remembering how to program the FMC and recalling its functionality after not practising for prolonged periods. P7 and P9 both struggled to remember how to program the FMC during the training exercise, as the last time they had used the FMC was during GT2 at university.

We did it when we were at [university], so that would have been a good three weeks before we even started here … The FMS programming … I was really scratching my head thinking, “How do I do that again?” … Because all the sims up to now—no FMS. (P7_Sim-B)

P9 said of programming the FMC via the CDU that it, “wasn’t as if it was difficult,” but it was something he, “wanted more practice [at],” especially when it came to the more advanced programming skills, “…like the different functions and how to set up different parameters …what happens if you want to manually change a leg somewhere within it or set up a holding pattern?” (P9_Sim-B)

P8 found that he had forgotten about the functions of the FMC and how it presented itself on the MCP during non-normal situations. The last time he had learned about this was during GT1, and he had, “forgotten all these obscure little rules that kind of, don’t make logical sense [at that time]” (P8_Sim-B). In the following excerpt, he described being surprised by the aircraft automation modes:

… I’d want to engage the autopilot [via the MCP], obviously, so I would push buttons that would normally work, under normal situations. But under these [abnormal] situations, because it was in a different funny mode, the airplane
went into other funny modes … I didn’t understand why it was doing it … I thought I was pushing this button to get this certain mode, but actually under these circumstances it creates a different mode. (P8_Sim-B)

P8 further explained that he had learned about various types of automation modes for the FMC during GT1 on the computer-based program, but he had only had the opportunity to practice in normal modes.

…we didn’t really do any abnormal things though. We never did anything abnormal. It was all like normal modes … [The automation is] in this weird dark corner and it just does weird things … We had learnt about those modes in the ground school. But that’s like three months ago. (P8_Sim-B)

*Developing social skills required for working as a crew*

During this phase of training, pilot trainees were still trying to develop the appropriate social skills (e.g., how and when to communicate with other pilot trainees) to work effectively as a crew. P3 explained that effectively carrying out procedures requires more than just completing tasks, sequences and triggers. It is also necessary to know how to work and communicate with the other pilot:

It’s not handling the flows, it’s just applying the right technique to, or just working with [your partner] really. We got the right calls now. We got the right flows, and it’s just making sure that we are working in a good team. (P3_Sim-B)

Some pilot trainees reported that they found teamwork more challenging when they were working within tight time constraints.

The hard part is still trying to get good synchronisation of good teamwork going, because me and [my partner] get along and all that, but sometimes…that showed quite a bit in [training exercise 5], where we have a rejected take-off. [My partner] was just rushing through the procedures, and I feel like I’m being rushed as well. We skip some steps here and there and make mistakes, and when you do that obviously it doesn’t end up too well. I’m trying to slow down, but he just starts trying to go faster, and it’s hard. (P3_Sim-B)

P3 further reported finding it difficult to maintain awareness of what his partner was saying while completing the tasks set within procedures:
...I made all these mistakes as well. We had a bleed leak on the ground, and [partner] started diagnosing the problem and he mentioned a leak, and I didn’t listen to that. I was focused on something else on the screen. Then I told him, “I’ll just pull out the checklist,” which was on the flight warning system, and it was actually the wrong checklist that was being showed by the system, and if I had listened to what [my partner] said then I would have told him to apply the right checklist, but he just followed my orders and just pulled out the wrong checklist.

How much information can you take at once? You are listening to someone. You know he’d said something, but you are trying to fly the plane. 90% of your attention is focused on one thing, and then the other 10% is listening to something, but it’s not absorbing that information and applying. It’s really hard. (P3_Sim-B)

On the other hand, P3 gave an example of a scenario where listening to his partner had resulted in an error. Below he describes conducting an instrument approach using a non-direction beacon (NDB) in poor weather from overhead the airport.

I was doing an NDB approach from overhead and then doing a tear drop. Just as I was turning my heading bug for the inbound leg, [my partner] was doing some other stuff, and I was trying to listen to him, and I didn’t turn my course bug… I tracked inbound instead [of] outbound, and I was bang on to the track, but I was on the wrong track. (P3_Sim-B)

Reflecting on this error, P3 said that in a multi-crew environment, “It’s pretty easy to get distracted” [Sim-B].

4.7.4.4. Pilot trainee experience of Sim-C

The following presents pilot trainee experiences during Sim-C. The majority of the interviews with pilot trainees at this phase were about the entire type rating rather than one part in isolation. The main areas of discussion included: difficulty carrying out procedures, social interruptions, managing tasks within procedures, and difficulty learning and understanding automation.

Difficulty carrying out procedures

P2 talked about the difference between learning a procedure (in this case the engine flame out procedure) in theory and performing it in the simulator:
The engine flame out. The engine fire after take-off sequences. I was having big trouble with that … I could sit down right in front of the poster, and I could run through it. I’d get it all correct. I could write it down on a piece of paper. When I got in the sim, I don’t know, I’d always stumble or I’d get it mixed up. (P2_Sim-C)

P4 talked about issues with correctly timing procedures:

The other thing is if you don’t get it done in time, and you do level off, that’s going to stuff your flow. That’s going to make it even harder. When the bloody thing levels off and then, you know, it accelerates and then it over speeds, and you still haven’t pulled the power back yet. You’ve kind of got to take your own initiative to pull the power back, but you’re so difficult and you’re so caught up in the flow that you kind of miss it, then the thing’s quacking at you. (P4_Sim-C)

Another issue that came up in interviews was the confusion that could arise when two procedures were similar to each other. In the following example, P2 reported struggling to correctly recall the engine flame out procedure because of its similarity to other single-engine procedures:

There was the engine flame out, the engine fire, or the single-engine go around were all very similar but slightly different. So I’d trip up on the three of them. Sometimes at different points … At some point you might get to the end of the acceleration point. It’s like “power levers notch, climb procedure.” I’d just go blank. What’s next? I can’t remember. A couple of times I went blank or a couple of times I just jumped into the wrong procedure for the next step. (P2_Sim-C)

Other pilot trainees reported similar scenarios. In the following excerpt, P3 recalled that during his assessment he called for the automation to be engaged at the wrong time, and upon reflection, he realised that he may have confused two similar procedures.

… I may have got it mixed up with my single-engine or engine flame out procedures as soon as we set the VFTO. Then we just engaged the autopilot, I mean the engine flame out. That’s what I did during the engine fire. The problem is two engines you’re blasting out and we’ve set it in to [maximum continuous thrust power], so we’ve got even more power. We’re still on two engines, and the flight director is pointing out 17 degrees pitch up. As soon as you engage the autopilot you start to pitch up 17 degrees nose up. When it’s not what you’re supposed to do, you’re supposed to maintain 9 or 10 degrees,
not up, until you cut the engine and then just drop back down to a lower attitude on the flight director. Then you can engage the autopilot. (P3_Sim-C)

These examples show that even after having learned procedures, carrying them out during practice can result in errors.

**Social interruptions**

P3 talked about the importance of each pilot on the flight deck being able to interpret where the other pilot was in a procedure. Specifically, he explained that if his partner was unaware of his flow, he or she might perform tasks correctly but at the wrong time, thereby interrupting the flow of a procedure in progress.

The other thing that really got us was we do an engine flame out exercise and we’ve got it in our head this is how it’s going to go. Then all of a sudden me or my partner will call for the autopilot, right in the middle of the sequence, while he’s just about to say something or activate something. Then it just stops, the sequence just stops there, and we have to think about it again and say, “Hang on, what was I going to do next? Where am I right now?” (P3_Sim-C)

P3 also explained that some necessary tasks were included in the company’s standard operating procedure but not written into the crew-coordination sequences presented in the manual. For example, turning on the autopilot was included in the standard operating procedure, but the exact timing of the task was left to the discretion of the pilot:

It is in the standard operating procedures that you have to do it. But, it’s not in the actual sequence. It doesn’t say … if I call for gear up, he puts the gear up. It doesn’t say pilot flying, autopilot engage. You have to call out whenever you’re ready to cue on the autopilot. These extra little phrases come here and there, and they do throw you off. (P3_Sim-C)

P3 stressed that when learning a procedure, “[the newly learned procedure is] very, very fragile. You got this model in your head and you’ve got to stick to it, and as soon as something else comes in [and interrupts the process] you’re just completely unbalanced” (P3_Sim-C).

**Managing tasks within procedures**

P8 spoke about the difficulty he had with procedures that could be performed at variable times but required both pilot trainees to work in tandem. Although P8, like other pilot
trainees from Airline B, did not specifically mention the issue of crew coordination, he discussed the problem of his partner failing to perform actions at the appropriate times:

P8: I handled the busyness and the management of the flight quite well. Like the instructor was saying I managed it quite well when I was pilot flying because my partner was doing random stuff. I was like, “stop that, do this, stop that, do this.” Trying to get it how I wanted it. He said that I managed that well.

R: That busyness, is that … what you’re talking about now, is that actually in the manuals or is it something that you just need to come up with yourself?

P8: I think it’s a coming up with it yourself thing. It’s like an outline of the things you need to get done in cruise, in the manual, but not necessarily what order to do them in, or when it’s appropriate to do them. So like, we were coming in on the STAR and my partner was fiddling with his speed bugs, and I was like, “Can you just stop that. I need to brief the STAR,” because I’m halfway through the STAR and things like that. We were coming up into the holding pattern, he was fiddling with the VNAV, and I was like, “No can we just enter the HOLD now?” Certain things you have to do when you enter the HOLD, like pilot monitoring has to turn on the lights, and he has to call certain things and stuff like that. I think he was just distracted and things like that. But it wasn’t … it’s not really written anywhere.

(P8_Sim-C)

Difficulty learning and understanding automation

P2 said that automation was the hardest aspect of training for him, and even at the end of training, he had not fully understood it. “That was a learning curve, and I still haven’t got it down pat” (P2_Sim-C).

When discussing automation, P7 shared his confusion about MCP modes and the difficulty he was having recalling their functionality in flight. For instance, when the pilot puts the aircraft into a descent via the autopilot using vertical mode on the MCP, the autopilot requires the aircraft to have a lateral mode, such as maintain heading. If the pilot selects vertical mode first, the autopilot will automatically engage a lateral mode. However, this can vary depending on angle of bank:
P7: If you stand by the MCP, and then you put the MCP ... If you hit the vertical mode, it will just choose a basic lateral mode, and it depends what angle of bank you have on that point in time. You can get roll hold, and then if you have less than six degrees angle of bank . . . It goes to wings level, and then after being in wings level for six seconds it goes for heading hold? That’s not the same as heading select. Knowing all of these different modes, what the airplane, what the computer was going to do was a little bit tricky.

R: Was this taught?

P7: Yeah, it was in [GT1], but when you think about when we were learning with [GT1], we had two weeks to learn the entire airplane. (P7_Sim-C)

P7 stated that the different types of functionality of automation were taught during GT1 on CBT, however, at that time, it was one module amongst the many that he needed to learn during that phase of training. As shown in the excerpt, he was not able to recall what was learned during GT1 and apply it effectively during simulator training.

4.7.5. First Officer Development Model at LT

The transition from simulator to line training was not straightforward for pilot trainees in this study, and some pilot trainees described line training as a new type of training. Rather than training with another pilot trainee, in line training pilot trainees sat next to flight instructors and learned material that was different from what they had practised and what had been normalised during simulator training. Carrying out procedures became more difficult in this phase of training due to the volume of information involved, the pace of work required, and interruptions from the environment (e.g., air traffic controller, cabin crew, weather).

While pilot trainees generally spoke in positive terms about having flight instructors as partners (mostly because the flight instructors did not require monitoring in the way that partners had), pilot trainees did report having difficulties with this new arrangement. As flight instructors had different opinions and methods when approaching procedures, pilot trainees were often required to adapt their own behaviours, which often meant performing procedures differently than they had during simulator training. For this reason, the
diagram depicts both the boundary around the pilot trainee and the connection between the pilot trainee and the flight instructor with a dotted line at this stage (see Figure 4.20).

Figure 4.20 LT–Transition from simulator to line training.

Note. Pilot trainees are type rated and can fly the real aircraft. There is a change in flying partner to an experienced captain during early stages of LT. The relationship between trainee and captain is different compared to working with another trainee. Social skills required to work effectively with the other pilot becomes more crucial. Dotted arrows between pilots depicts the relationship between the trainee and the other pilot which now more complex than when flying with another trainee. The trainees are now exposed to the real-world which is much more complex compared to the sterile simulator environment. Trainees also learn new tasks, linking procedures within a flight operation, and handle variations in normal procedures. Trainees learn to adapt knowledge gained during simulator training to the real-world. Automation use became more rampant and easier through practice, though gaps in automation functionality were still present.

During line training, pilot trainees began to fly in real-world settings. They worked with professional air traffic controllers and cabin crew, faced real-life environmental factors such as weather and terrain, and learned the characteristics of various airports. This complex socio-technical environment is depicted with a green outline in the diagram.

Pilot trainees (P2, P4) who previously reported that they had difficulty with automation became comfortable with it over the course of line training as a result of the practice they gained during normal flight operations. For this reason, the line around automation became solid at this stage in the development of the FODM.
4.7.5.1. **Enacted curriculum for LT**

Both Airline A and Airline B had theoretical knowledge and practical components embedded into their line training syllabi and assessments; however, Airline B had a fixed schedule for topics to be reviewed, while Airline A had no fixed schedule.

Airline A’s line training involved:

- **Familiarisation flight.** For this activity, pilot trainees sat in the “jump-seat” in the flight deck as observers. Pilot trainees were rostered to go on at least six familiarisation flights. There were no assessments for this phase of training.

- **Introduction segment.** This segment of line training required pilot trainees to conduct at least 20 flight hours with highly-experienced instructors, in this case, flight examiners. During their 20 hours, pilot trainees had to perform at least ten take-offs and ten landings, with pilot trainees acting as pilot flying in at least six of each.

- **Initial route flying.** In this phase of line training, pilot trainees conducted flight operations with flight instructors. Pilot trainees were required to complete at least 100 hours, or 75 operating sectors, of introduction and initial route flying. Training included discussing specific topics (e.g., knowledge of standard operating procedures at different phases of flight, FMS, and general operational topics), operating in particular aerodromes, conducting instrument approaches and departures, and developing route familiarity.

- **Progressive assessment.** The progressive assessment was conducted midway through line training to determine if pilot trainees were progressing as expected and provide them with feedback on their performance. The assessment was conducted by a flight examiner, who was rostered by the airline to fly with the pilot trainee. This assessment had to be completed prior to the LT check to line assessment.

- **Check to line (CTL) assessment.** Once a pilot trainee had completed all required syllabus items and the minimum required flight hours, an flight examiner assessed their performance during normal flight. Before CTL, pilot trainees were briefed about the assessment, including the aim of the check, exercises to be covered,
standards to be achieved, procedures in the event of real emergencies, and how emergencies and weather would be simulated. The assessment tested the pilot trainee’s abilities as both pilot flying and pilot monitoring.

Airline B’s line training involved:

- **Ground training day 1.** Ground training day introduced the pilot trainees to pre-flight preparation, flight planning, and what they should expect for day one of line training. Ground training day was effectively a detailed briefing for the first day of flight. It involved pilot trainees meeting their flight instructors one-on-one before the first day of line training. Flight instructors decided how they would approach training.

- **Ground training day 2.** This aspect of training was listed in the training document; however, no further information was provided. Pilot trainees also did not know the purpose of this training segment, although P8 stated that it was mainly used to “catch up” on the knowledge components of line training.

- **Phase 1.** This phase was conducted with a highly-experienced instructor (flight examiner) or flight instructor and required a safety pilot (third pilot) to be sitting in the jump seat. The syllabus included a walk-around check, before start sequence and drills, take-off, stable approach criteria, and landing. Safety pilot trainees remained until all of the items in the syllabus were checked.

- **Phase 2.** In this phase, pilot trainees were still paired with flight examiners and followed a specific syllabus focused on flight planning, fuel policy, understanding and using the aircraft maintenance document, performance and loading, pre-departure, start and taxi, take-off and climb, cruise, descent and approach, landing and shutdown. Pilot trainees had to complete all items, and instructors had to sign off on the training assessment form according to company standards.

- **Phase 3.** In this phase, pilot trainees were supervised by normal training captains. The training syllabus included practical demonstrations and discussions of maintenance procedures, take-off and climb, cruise, descent and approach, landing, taxi, shutdown, communications, Jeppesen knowledge, altimetry, and
FMC/CDU use. Pilot trainees had to complete all items to a proficient standard, and instructors had to sign off on the training assessment form.

- **Phase 4.** Training at this phase included several theoretical and practical topics listed in the training manual and concluded with a check assessment form. The CTL took place over at least four sectors with the aim of ensuring that candidates had achieved the operational standards required for line operations, including: knowledge in accordance with the standards specified in the operations manuals and correct application of company, route, and AIP procedures, aircraft handling, crew management and passenger awareness.

4.7.5.2. **Pilot trainee experience of LT**

The following presents pilot experiences in LT. The areas of discussion include: learning normal operating procedures, developing aircraft handling skills, dealing with time pressures, learning new tasks, managing interruptions/changes to sequence, working with captains, use of automation, and flying in different types of environments.

**Learning normal operating procedures**

The main issue pilot trainees reported relating to the transition from simulator to real-world environment was determining if what they had learned during Sim A, B, and C could be applied in the context of real-world flight operations.

Most pilot trainees reported that as simulator training emphasised non-normal procedures, which meant that they rarely practised normal, day-to-day operations, little of what they had learned in simulator training could be applied in line training. P4 said, “There’s a big difference between type rating and line training. Probably because the simulator is there to characterise all the emergency and things. Whereas the line training is much more line orientated, so it’s a completely different skill set” (P4_CTL).

P10 said that simulator and line training were, “quite a bit different” in terms of actual work practices (P10_LT):

Ground training in the simulator prepares you for a lot of things, but it doesn’t give you much of an idea of how things are going to run on line. You know what I mean? There’s a lot of things that you don’t really do in a particular order when you’re doing your simulator training. Like when you get push back
clearance. When the captain takes the parking break off, then you get push back clearance, like a prompt, but it’s not written anywhere. (P10_LT)

Familiarisation flights were one of the methods used by the airlines to ease the transition from ground to line training. During familiarisation flights, pilot trainees reported focusing on how procedures were carried out and comparing this with what they had practised in the simulator. “I had just finished the type rating, so I was just kind of watching what they would be doing, kind of anticipating it to confirm what I’d just been doing in the sim” (P1_LT). P2 also described observing how pilot trainees applied procedures in the real-world:

I was focusing on the standard operating procedures and how the guys were using in a real-life situation. Just how it flowed really, I guess. In the sim it’s very structured with all the approaches…essentially you’re all set up nice and early and you’re just concentrating on flying the approach. When you get on line, it’s not nearly that ideal situation. (P2_LT)

Familiarisation flights were also an opportunity for pilot trainees to develop their sequencing of tasks. For example, P1 used familiarisation flights to test his own knowledge against how a normal flight crew performed sequences:

I was just trying to follow the normal procedures. Just trying to think about what was coming next in terms of what I know now … trying to anticipate it before it happened so that it was all kind of coming together a bit more without me having to do anything. If we were in a flight coming in for an approach to land, I’d just be thinking about when I would do something and comparing it to when they would do it and seeing if it matched up. Just to confirm what I was preparing for. (P1_LT)

Familiarisation flights also helped pilot trainees to develop their awareness of unfamiliar airports.

… I hadn’t been to those places before. I didn’t really know what the approaches looked like. The airfield itself, even the small details like where the parking bays are and just seeing different approaches and how the crews set it all up and get ready for it. (P9_LT)

During LT, pilot trainees reported having difficulty developing step-by-step routines for carrying out normal operating procedures and proceeding through a day’s work. Incorporating time management into this process was an additional challenge: “None of
it was really new. We all knew what needed to be done, but we didn’t really know how to do it” (P7_LT).

P8 described how inefficiently he carried out procedures during early LT. “In the beginning, I didn’t entirely know exactly what to do in what order … stumbling through it … I wouldn’t say not correctly … but maybe not necessarily doing it in the most efficient order” (P8_LT).

Some pilot trainees also found that some of the practices they had learned during simulator training could be modified for use on line. For example, P2 reported that although he already knew how to carry out briefings during flight, during line training he learned a more practical method from his flight instructor. “Just being brought aware that there is a much better way of doing [it] so that’s practical” (P2_LT).

Even during the later stages of LT, some pilot trainees reported having difficulty carrying out sequences for normal procedures. In interviews, pilot trainees attributed this difficulty to the fact that normal procedures were not often practised during simulator training, and when they were practised, they were practised individually, so pilot trainees did not have opportunities to enact sequences over the course of several stages of flight. This came up when P10 was asked if there was something about his training that he felt could be improved:

Flying from A to B. They expect you to know it, but you haven’t ever done it in the sim . . . . You may know the procedures, but you don’t know all the finer details of what to do . . . . You’ve got all the different pieces, but you haven’t ever put it into a big picture. And there’s no guide, there’s no map, there’s not really any formal manual that puts every little bit of piece together to build this big picture of how you line fly. (P10_CTL)

**Developing aircraft handling skills**

Several pilot trainees, mainly those from Airline B, described the challenge of becoming accustomed to certain handling techniques when flying real aircraft. Their comments were related to performing in the real-world context techniques they had learned in the simulator. In normal flight, they found, some techniques could be applied exactly while others needed to be adapted or replaced. For example, P9 discussed needing to modify
his control of the aircraft during increased turbulence, something the simulator had not fully replicated:

… I need to work a little bit on the last few hundred feet of the approach, especially because it’s been so gusty. Being a little more assertive with the airplane. In the sim, I suppose, we had a bit of turbulence knocking us about, but especially now in the real-world, when some of the conditions … have been pretty challenging, and flying the approach looks different from what it would be in the sim … Power settings, they’re a little bit different to what you could expect because [of] the conditions. (P9_LT)

Landing the aircraft was an area where pilot trainees reported having particular trouble translating their learning from the simulator into performance in normal flight. This was especially the case for pilot trainees with less or no flight experience prior to training. The simulator was not always able to accurately replicate the conditions of real-world landing scenarios, which meant that pilot trainees had to adjust the techniques they had learned in the simulator when they were learning to land real aircraft. P7 reported that during one landing, following the techniques used during simulator training would not work in the real-world, he stated “following the technique I used in the sim, and then [the flight examiner] said no, the sim is all a bit different, try this technique” (P7_LT).

While flying was not normally an issue for more experienced pilot trainees, there were some manual flying techniques that required practice. P3 reported having issues during take-off with aileron inputs in crosswind scenarios. Normally, pilot trainees turn the control wheel into the wind during take-off to stop the aircraft from rolling. As the aircraft accelerates during take-off, and gains speed, ailerons become increasingly effective, requiring the pilot to reduce the roll input. However, in the scenario described below, P3 reduced the aileron too much and the aircraft began to roll while still on the runway:

… I was keeping it straight on the runway [for take-off], and then we’ll run into wind, but I just relaxed my aileron a little bit too much as we were gaining speed, which is what you’d expect to do. But probably went a bit too quick on that, and the wing started tipping and we were rolling [while still on the ground]. So I just put the aileron straight back into the wind and it corrected it. (P3_LT)
Dealing with time pressures
In LT, pilot trainees had to work within time constraints imposed by their surroundings, which was initially overwhelming for many of them. Several pilot trainees reported having difficulty getting accustomed to the speed at which work had to be completed. For example, P2 said,

Once you’re actually out there on line, everything is happening at a pace…I suppose you’ve got to keep up with that pace. Talking to the controllers and so forth… I suppose more on the ground, actually. Pre-flight, when you’re doing all your set ups, and you’re getting your clearances, load sheet, weights…and everything moves at a pace… I certainly felt…not pressured, but certainly, it was on from one thing to the next. You sort of move quite quickly. (P2_LT)

P9 used radio calls as an example of one of the many adjustments pilot trainees had to make to keep up with the pace of commercial flight operations. “In the sim, you just make the radio call whenever you’re ready, but in the real-world, obviously, there’s other airplanes trying to contact the control tower … you have to, if there’s an opportunity, you jump in” (P9_LT). This statement was echoed by P7, who said of on line flight that, “you don’t always have as much time as you think” (P7_LT).

Learning new tasks
Pilot trainees from Airline B described having difficulty learning tasks required for LT that they had not practised or even discussed during any of the previous training phases. One example of this, given by several pilot trainees from Airline B, was radio calls. “In general, the whole of line flying training, radios is something that I think I’m not 100% certain of. What radio calls to make, when to make them, what to say on the radio calls” (P8_LT). While some pilot trainees said that they had received support from their flight instructor when learning these new skills, others said that they did not feel adequately supported. For example, when P8 asked his flight instructor for help learning radio calls, he was told that this was “presumed knowledge”:

… I was talking to my training captain on the ground training day. I was like, “Can we go through all the radio calls?” He’s like, “Oh no, that’s presumed knowledge.” . . . I had to kind of ask, “Please help me,” so he eventually went through them. But he was like, “That was meant to be presumed knowledge. We don’t go through any of that.” (P8_LT)
In the end, P8 asked his previous partner for his notes on radio calls whose flight instructor had discussed on radio calls. As P7 recalled, “I think I wrote notes with all the radio calls, and [P8] actually asked me for a copy of them later that day.” (P7, LT)

Some tasks had to be done differently in LT due to varying conditions. This was surprising to P10:

> When you start out, you don’t know … you don’t know that you’ve got to give [air traffic control] bay numbers. So you give them … the bay number for taxi clearance. It’s knowing which fork in the road to take, but when you first started, you thought there was only one fork for everything. (P10_LT)

P10 explained that having to learn new company-specific procedures during the early stages of line training was sometimes difficult, as pilot trainees were already under pressure and concentrating on flying aircraft or performing other tasks. “The first few days that you’re really absorbed into doing something, you won’t pick that stuff up. Even though they might tell you it, it even goes in one ear and out the other” (P10_LT).

*Managing with interruptions/changes to sequence*

In addition to applying task sequences in a real-world context, during LT pilot trainees also had to learn to prioritise and complete task sequences in the face of real-world interruptions. In normal flight, procedures pilot trainees had learned during simulator training were constantly interrupted, and pilot trainees had to learn to overcome these interruptions to complete the required tasks. When asked about his experiences with interruptions, P9 said:

> From the sim it was like, okay, now we’ve got to do this, and you go through the drill. Nowadays it’s like, you can just start the drill, and while you’re midway through it, something else will happen, and you go from one thing to another. Yeah, I’d say probably from the first one or two flights, having to multi-task, do one thing and then come back, and still be on the same wavelength of where you were when you left. (P9_LT)

Some pilot trainees developed processes to ensure that they completed standard operating procedures as required despite interruptions. For example, P1 used a mnemonic to ensure that he did not miss crucial steps when completing tasks in an order that was different from the manual:
The standard operating procedures say … Okay at this point you have to do this, when the load sheet turns up, but, sometimes you have to go kind of outside of that. … I’m developing a way of, when things go away from that normal process, to remember. You’ve skipped a step here, but just remembering that you’ve got to come back to the previous step. (P1_LT)

Carrying out procedures in the real-world requires adaptations to sequences of tasks depending on the environment, which interrupts the learned sequence developed during simulator training. Based on this excerpt, the method of managing interruptions to sequence is left to pilot trainees themselves, in this case P1, to develop.

*Working with captains*

In LT, flight instructors acted both as instructors and as part of the multi-crew flight deck. In general, pilot trainees reported that working with captains was easier than working with other pilot trainees as partners. For example, P3 said,

I actually don’t mind it. I like sitting there and just having someone with a lot more experience, someone who knows his role really well. It just makes it easier . . . Everything flows a lot quicker, and there is a bit of a gradient, obviously, but I don’t really find it hard to adapt” (P3_LT).

This sentiment was echoed by P8, who stated that captains were more proactive than other pilot trainees; specifically, P8 ascribed the captain’s proactivity to social skills, as he described the captain “reading [his] mind”:

I think the captain is very proactive, whereas in the sim, both of us was training and learning. But in the real-world, the captain reads my mind most of the time, and he just does things without me even asking for it. (P8_LT)

Another pilot trainee described taking advantage of having a more experienced flight instructor as the supervising pilot:

During LT, I was asking to do the harder stuff. So if it was a bit windy in Wellington, or if it was chilly low cloud in Dunedin or something, I was asking to do those sectors. Because I’d rather sit there and do it knowing that if anything got too hairy, I could just let the other guy do it, but then I start building a foundation. I know that flying with training captains is a better place to exert myself a little bit, and maybe put myself in a position where I’m a little bit out of my depth, but still being very supervised. (P5_CTL)
Several pilot trainees said that they expected flight instructors to accurately assess whether they, the pilot trainees, were capable of managing issues that came up during flight.

It’s much easier because the captain, they’ve been there for so many years, and they know what they’re doing. That gives you a bit more confidence in yourself, as well, because if they’re not saying anything to you, that means you’re not doing anything wrong as well. You do feel much more comfortable with the captain sitting next to you and you kind of just do your things … like if you screw up the drill or something, the captain might just point out you missed something. (P7_LT)

However, some pilot trainees reported needing additional support or help accomplishing tasks. In the following scenario, a pilot appeared to be reluctant about receiving a radio call and then placing the new clear waypoint into the FMC via the CDU:

On my first flight I was pilot monitoring, and the captain who was pilot flying wanted to give a PA. So he handed over controls to me. [As] he is making his PA, ATC called us with a track direct to a point. I replied to the radio call, but then I just did nothing. I just waited, because I was waiting for him to stop making his PA so that he could put it in the CDU, because I thought that was what you’re meant to do. And the safety pilot was nudging on my shoulders going, “put it in the CDU!” (P8_LT)

P8 shared that scenarios like this were something that he had to get accustomed to, as all his prior training had taught him to strictly follow rules. In LT he learned that “it’s not necessarily like, ‘This is your role and this is my role.’ It’s more of a ‘We’re going to do this somehow together’” (P8_LT). Learning this required P8 to shift his understanding of what multi-crew means; specifically, he learned that while procedures are important, the social aspect is just as crucial to multi-crew flight operations. “In the Simulator I thought multi-crew was pilot monitoring and pilot flying, doing their roles to complement each other. Now multi-crew is just you both doing things to help each other to get the outcome done” (P8_LT).

As pilot trainees were taught and observed by more than one instructor, it was inevitable that they received a variety of opinions, which some pilot trainees found confusing.
Dealing with different captains’ opinions, taking them on board but not getting too confused about all the information that’s being thrown at me, kind of catches me out a little bit. (P1_LT)

P1 stated that it would be good to be rostered with the same captain for a few flights, as this reduced the number of opinions that he was exposed to and gave him a chance to develop his own methods:

That will be quite nice to actually just be flying with one person for extended periods rather than flicking between a few who might have a little bit different views on certain things. One might have this tip for landing. The other one might have this tip for landing. You know, you kind of just want to develop that groove without having to worry about what the captain’s saying too much, I guess. (P1_LT)

Use of automation
Most pilot trainees said that line training afforded them an opportunity to practice automation. For example, P7 felt that his CDU skills had improved as a result of practice during line training.

It’s much easier now. In the sim I feel like they didn’t really use the … FMC much. Now in the airplane, I’m really starting to get to know the FMC. In the sim, you had to think about what you had to press before you pressed it, like thinking, “How do I get to the fuel page?” and stuff like that … But now it’s just like you know exactly what to press almost before the screen has even refreshed. It’s becoming much more second nature. (P7_LT)

However, even after several flights, there were still some pilot trainees who said that they needed more practice to feel comfortable with automation. “The standard stuff [i.e., setting up the flight plan] I’m reasonably happy [with] now. But when air traffic control starts throwing odd stuff at you, I’m not 100% on that yet, still getting my head around” (P2_LT).

By the end of LT, most pilot trainees stated that they were comfortable with automation and reported that having the opportunity to practice using it in various situations during line operations had been beneficial. “I think it’s just using the equipment more, that thing was probably the biggest thing along the way was getting used to the automation, getting my head around it” (P2_CTL).
P7 and P9 shared this sentiment, although neither of them had commented on automation while they were completing the simulator blocks. During LT, P7 stated that in simulator training automation was covered at a basic level, but he did not discover the more complex aspects of automation until he began line training. In the following example, P7 even suggested that when automation became too confusing during LT he disconnected autopilot and flew the aircraft manually.

I think it is, well for me, being exposed to it more has been helpful. In the sim it was a lot about manual handling of the aeroplane, that was really what a lot of it was. There was a little bit on the automation. And the automation you just kind of picked up as you went. Unless you’re really exposed to all these random little mode changes or having to just disengage the autopilot completely and just hand fly it. (P7_LT)

*Flying in different types of environments*

In addition to the procedural challenges that pilot trainees encountered during LT, they also faced environmental complications, such as weather, which they had not encountered in the simulator. For example, all pilot trainees in Airline B noted their initial surprise when encountering turbulence for the first time:

We didn’t do a sim with turbulence. In September and for a couple of months in Sydney, it’s actually pretty windy and turbulent. It would have been helpful to have a bit of experience for turbulence in the sim … They just didn’t program it into any of the lessons, or maybe they did, but it was only a very light level. I saw in one of the lessons plans it was like 10% turbulence, but that’s probably not enough to really feel it. (P7_LT)

**4.7.6. First Officer Development Model at CTL**

The final stage of the FODM illustrates pilot trainees—now new first officers—working with a normal captain in the flight deck (see Figure 4.21). The main shift when pilot trainees are CTL is that they are no longer under the supervision of another pilot. This means that to a certain extent they no longer have a safety net.
Trainees are checked to line as official first officers and can work with any captain. Social skills remain important when having to communicate with other captains and maintaining functional joint cognitive system. Trainees continue to learn and develop their knowledge on flight operations and procedures.

At this stage, the working system (pilot trainees and automation) was drawn within a wispy boundary to depict the pilot becoming accustomed to reduced support and supervision of captains during normal flight operations and when communicating with air traffic controllers, working with cabin crew, dealing with weather, and learning and managing the characteristics of various airports.

4.7.6.1. Enacted curriculum for CTL

The enacted curriculum for this stage of training was highly individual, as pilot trainees were primarily learning on-the-job. Therefore, the aspects of enacted curriculum will be discussed together with pilot experience in the following section.

4.7.6.2. Pilot trainee experience of CTL

The following presents pilot trainee experiences after pilot trainees were checked to line. The areas of discussion include: dealing with interruptions, exposure to various
environmental conditions, loss of training support, working with different captains, automation, and difficulty conducting manual flying.

**Dealing with interruptions.**

By the time pilot trainees were checked to line, they were much more capable of dealing with interruptions during flight, which had become part of their normal practice:

> You probably know you get interrupted all the time… The process is a lot stronger. It just seems to flow better. It doesn’t really matter if there’s interruption. It just seems to flow. (P9_CTL)

By CTL, pilot trainees had also become more accustomed to slight changes in task sequences:

**P3:** All the times in the sim, you would always start “Hotel” [mode] before we do the weight and balance and put the numbers into the FMS and all that. In real-life, we don’t always start in “Hotel” [mode] first. Sometimes we do all the numbers first because you have passengers boarding from the right-hand side, and they can’t walk behind the exhaust of engine number 2. So we can’t start until everyone is on board. So we do all the paperwork first, the weight and balance and all that.

**R:** And that sort of throws your flow off a bit?

**P3:** Initially, yes. But after doing it quite often, you get used to it. (P3_CTL)

As some procedures are captain-led, how they were timed and sequenced during flight depended on the captain. In the following example, P3 spoke about his difficulty with different captains having different interpretations of standard operating procedures:

In the standard operating procedures, they’ve outlay the way they want it done, but it’s not really that specific. People just interpret it the way they want it. For example, in the pre-descent checks … Everyone just gives it at a different time, so…some guys will give it to you straight away, some guys are really keen like you’re still climbing after taking off from [airport] and they’re already giving you some landing data, and others just do it at the last minute. They all have a very different way of doing it. (P3_CTL)
Exposure to various environmental conditions.

Even at the end of training, some pilot trainees reported being surprised by new procedures. For example, P8 talked about weather avoidance, which he had not practised during training:

… I never had weather during any of my training, and then all of a sudden it’s now pouring rain every day. There’s thunderstorms everywhere, and I think I somehow find that quite difficult, that decision-making process … I don’t think I ever did during training. (P8_CTL)

P9 was surprised by a landmark-based navigation technique used by ATC. “Air traffic controller told us to fly to certain landmarks up here in Cairns. And because I was new, I had absolutely no idea what they were talking about. I was just really surprised. (P9_CTL)

Loss of training support.

This theme emerged when pilot trainees discussed the difference between flying with a flight instructor and flying with a normal captain. P8 discussed having mixed support from captains, with some offering little to no support. “Some captains have been very good, like on the line … ‘If I was you I’d go this way’ and explain the reasons why, and be very helpful … Other guys are like, ‘You’re flying, you’re in charge, you decide’” (P8_CTL). P8 further explained that a lack of support from a captain sometimes led to situations where he chose the “wrong decision and [got] into a sticky [situation]” (P8_CTL).

P10 said that when he started flying on line he assumed that within a multi-crew environment his flying partner would be vigilant and provide basic PM support. However, he, after CTL, found that was not the case. “You don’t have that person sitting next to you watching you the whole time” (P10_CTL). After flying with a captain who did not monitor him at all, he learned that he needed to be vigilant. “You’ve really got to be careful” (P10_CTL).

Working with different captains.

The main issues pilot trainees identified in this area related to inconsistencies in the way captains carried out procedures. When procedures were not clearly defined in airline standard operating procedures, it was more likely that captains would develop their own unique ways of carrying them out. As P3 said, “In the standard operating procedures
they’ve outlay[ed] the way they want it done, but it’s not really that specific. People just interpret it the way they want” (P3_CTL). P3 gave the example of the briefing that occurs during the descent phase:

When it comes to the descent phase, they all seem to have their own little technique, don’t seem to have a standard. That took a while to get used to, because you get used to doing one thing the way the captain wants it done. You fly with a different captain and he shows you another way … They all have a very different way of doing it. But at the end of the day, it’s a little bit confusing but you just end up doing your own thing. (P3_CTL)

Pilot trainees from Airline B shared similar experiences to those described by P3. One pilot found it difficult to “get used to” different captains after working with the same person for some time:

The standard procedures are normal, but [the captains] do little things that are different to the person that I did my training with. So I guess for the first couple of weeks it was just trying to find my feet and meeting new people, and just getting comfortable with knowing what people were going to be like, I guess. (P9_CTL)

There were also cases where captains abused their authority. In the following excerpt, P10 shared his experience of a captain who, “didn’t follow procedure” (P10_CTL). In this example, the pilot trainees were supposed to change the traffic collision avoidance system (TCAS) from “resolution advisory” (RA) mode to “traffic advisory” (TA) mode. The RA mode gives pilot trainees guidance on how to avoid other aircraft if there is a collision risk, while the TA mode only advises pilot trainees of nearby aircraft without the avoidance function. TA is often used at airports where the procedures and radar are very accurate, so it is deemed unnecessary for pilot trainees to engage RA. However, some airlines require their pilot trainees to use RA at all times.

Our procedure used to be you put the TCAS on TA only so you wouldn’t get RAs from the aircraft on the adjacent runway. We changed procedure. I was coming into [major airport] one day, and the captain was like “TA only. I’m putting it on.” I was trying to say to him like, “What do you mean? That’s not procedure any more.” The first thing he said to me was, “I don’t care. I’m the pilot in command. I want TA only.” (P10_CTL)
In the following example, P3 remembered being in an uncomfortable situation with a
captain who did not adhere to the airline’s rules about maintaining a sterile cockpit below
set altitudes.

P3: I flew with a line captain, and he just kept on talking all the time, I
actually find it quite frustrating. He was talking from take-off all the
way to transition, through transition, all the way up till we levelled
out. That’s too much.

R: What did you do there?

P3: I just said let’s wait until we level out. And I just kept interrupting
him, making the calls for him because he wasn’t making a few calls
here and there. I was like “come on…”

R: How does that make you feel? Because we know what we’re
supposed to do and you’re wanting to do the right thing, and you’ve
got someone not wanting to do the right thing. How do you approach
it?

P3: Well, I didn’t tell him to shut up, but I just said… I just kept reminding
him of the checks. (P3_CTL)

This case highlights the importance of social skills in the flight deck, especially when
procedures are not properly followed. The need for pilot trainees to have effective social
skills is even greater after training. P5, one of the more experienced pilot trainees,
reflected on the importance of teaching first officers how to communicate with other
captains and crew:

You should be able to fly with a guy you’ve never met and you know in theory
what he’s going to say and what he’s going to do. That part of it doesn’t change.
All of the stuff about philosophy with checklist and stuff, that’s all exactly the
same. It’s things like conflict resolution, how to bring up a problem in a
constructive way … Learning how to actually communicate in a cockpit
environment … with the gradient and the authority levels, you have to be able
to tell somebody who’s senior to you what to do in certain situations.
(P5_CTL)

P5 highlighted that conflict resolution and assertiveness to communicate confidently with
someone of higher rank was crucial when working in a multi-crew environment. This
sentiment was shared by P7 who was shared his experience of working with a captain who was not carrying out his role properly.

P7: There have just been some captains that have been ... very sloppy and they’re just not very, not very switched on or not very attentive anymore.

R: How do you deal with that being in the flight deck with said captain?

P7: You’ve just got to be watching everything they do, how they fly. If it looks like they’re going to exceed anything or anything’s going to go wrong, you bring it to their attention. Standard phraseology ... I’ve had to learn how to manage upward ... I won’t tell them like, ‘Oh, I don’t think that’s a good idea.’ I’ll say like, “Oh, do you think that’s the best thing to do? Or is there another way we could do it?” Or “I reckon we might be a bit high here.” Then kind of let them say, “Oh yeah, we are high” instead of me telling them in blunt words. (P7_CTL)

P7 adopted his own method of communicating with a captain in order to maintain peace in the multi-crew environment. However, his method of communication may not be appropriate or effective during non-normal situations when decisions must be made quickly.

Automation use

After CTL, pilot trainees reflected on their learning of automation. For example, P7 remembered the initial shock he felt in a situation when the autopilot disengaged during turbulence:

The Dash8 doesn’t handle [turbulence] that well, and the autopilot will just disengage … The first time that happened, I was like, “Oh, shit,” like I didn’t know what happened, and it was so bumpy that that’s [what’s] happening. But now it happens relatively regularly, and it’s almost like a non-event now. You accept it. It’s like, “Okay, it’s really bumpy, the autopilot may disengage.” If it does, you just hand fly it for a bit, get it back under control, and just reengage it. (P7_CTL)

In general, pilot trainees said that when it came to learning about automation, practice was key. However, there were still times when functionality was an issue.
When you put it back into the CDU and say, “I want to track direct to the field rather than going out and around,” the plane wants to nosedive. It goes into a mind of its own. The FMC goes, “Oh, if I want to get to the field at this height I really need to put the nose down and descend at a really high descent rate, right?” So everything’s happening. [The aircraft is] maintaining straight and level flight. And then the FMC changes, and then all of a sudden, the aeroplane just goes into a turn and just nosedives. (P9_CTL)

P9 further went on to describe the need to better understand the VNAV function and how to properly use it in different scenarios to prevent the above situation from happening.

**Difficulty conducting manual flying**

Some pilot trainees had difficulty manually flying when having to rely only on their own judgement. Some manoeuvres are highly prescriptive and guided by the FMC. For example, descent is a complex manoeuvre that varies depending on weights, wind, air traffic control boundaries, terrain, and weather. When aided by the FMC, descent can be very straightforward, but without the support of the FMC, the pilot must mentally calculate the flight path, which increases workload. P10 described his difficulty in manually carrying out certain manoeuvres, especially when carrying out circuits.

[With an] RVAV or an ILS, everything is set up for you. You know what you’re gonna do, when, and where. The path is set for you. Whereas in a circuit, there is no guidance. There’s not electronic guidance, per se … Even if you [know the correct procedure for carrying out circuits], you got to be able to do it correctly, like that turn on the base. How you do it, how you manage everything … It’s more about getting everything under control. The speeds correct. You get out to 45 seconds, turn around the corner, disconnect the autopilot, start a slow descent. It’s about getting that combination correct. (P10_CTL)

When discussing carrying out circuits, P10 emphasised that the difficulty he experienced was not about determining which task needed to be done, as this was prescribed by the procedure. What he struggled with was being prepared to perform the task when required. This suggests that his issue arose from his lacking fundamental flying skills, since he was highly reliant on the FMC to guide him on the flight path.

P7 talked about how much they rely on the FMC when determining a target vertical speed in the circuit. To some extent, the FMC provides calculated vertical speed, and unless
required pilot trainees are unlikely to use raw data to calculate rate of descent. “We do place a lot of faith in the FMC, but it does help out a lot,” P7 said. “It does lower the workload to working out either if we’re high or low.” (P7_CTL)

Usually vertical profile is calculated and presented by the FMC, but during visual approaches, that guidance is taken away. P8 said that in these situations he determined flight paths through “trial and error,” (P8_CTL) but trying to manually work out if the aircraft was high or low took so much of his attention that his entire performance was affected.

4.8. Summary
This chapter reported findings from a qualitative case study involving ten cases. The focus of the study was on the pilot trainees’ experiences at the various stages of their companies’ first officer training programs, which involved a type rating and line training. This chapter provided an overview of the three training programs included in the study before categorising them according to the training phases and structure that were used to understand and illustrate pilot learning throughout the training process. Through thematic analysis of interview texts and other supporting data, learning experiences of the pilot trainees were examined individually and holistically. The results of individual case studies were summarised as each case’s profile, which outlined the pilot trainees’ most significant experiences related to their learning processes. Cross-case results from the thematic analysis with all ten cases highlighted four primary themes of knowledge, procedures, automation, and social skills. These themes represent the key information and skills that pilot trainees must learn and improve upon to become competent first officers for their airlines. These themes were explored through the development of the First Officer Development Model (FODM), which acts as a heuristic to understand what pilot trainees learned during training. The final section of this chapter explored the formation of the model through a detailed report of the process of each training program (enacted curriculum) and pilot learning process (experienced curriculum) across time. The key themes identified in the study are discussed further in the following chapter.
Chapter 5.  Discussion

5.1.  Introduction
This thesis explored the learning experience of pilot trainees as they went through their airlines’ initial first officer training program. The purpose was to better understand, from the pilot trainee’s perspective, how effective current training methods are at preparing new pilots to fly for airlines. A study of this kind is timely given the current sector-wide pilot shortage and expected future demand for pilots. This study was undertaken based on the premise that improving the effectiveness and efficiency of pilot training programs has the potential to improve pilot learning, thereby limiting pilot failures, reducing the cost of retraining, and potentially increasing the supply of trained pilots while maintaining existing safety standards. The results illustrate what pilots focused on during each phase of training—specifically what they learned and what they found challenging. Four main themes emerged during the process of analysis: aircraft type-specific knowledge, automation, procedures, and social skills.

This chapter presents a discussion on the study’s findings in four sections. The first section provides a summary of pilot trainee learning processes that occur through a training program. Within that section is also a discussion about the demographics of the pilot trainees, specifically flight hours, and their implication on pilot performances. The following section discusses the key themes found during the study. What follows next is an examination of the contributions the study makes to both theoretical and methodological literature. The final section considers the limitations of this study and suggestions for future research.

5.2.  Summary of pilot trainee experiences
The aviation industry often uses flight experience in terms of hours as one of the minimum standards of training to be met, suggesting that having more flight hours would be an indicator for better and safer performance (Kearns et al., 2017; Todd & Thomas, 2013b). However, the findings of the study revealed that having more flight hours does not necessarily result in better performance. All but one pilot trainee had successfully completed ground and line training within their allocated training resource. The one pilot who was unable to complete training had more or equal flight experience (in hours).
compared to the other three trainees undergoing the same training program. As the study had a small sample, no statistical analysis was conducted. Nonetheless, these findings provide support for the work of Todd and Thomas (2013b) where experience, as measured by flight hours, is not predictive of safe flight performance.

The structure of training for both airlines followed a linear model, where each segment of training is meant to provide the required knowledge for the next segment of training in a sequential manner (MacLeod, 2001). Trainee experiences, therefore, reflected the issues related to linear models of instructions (MacLeod, 2001). As pilot trainees were being trained to operate large and sophisticated aircraft, they had to learn a great deal of information during training, and initially many of them reported finding this overwhelming. Previous experience in related aircraft systems helped reduce the burden of understanding some of the systems. For one pilot, having gone through a similar training program in the past prepared him for the coming training process. Trainees (P2, P3 and P5) with turbo-propeller experience expressed having little problems understanding the related aircraft systems and lesser issues with handling the aircraft. Automation, which was initially taught as one of the aircraft systems, became an increasingly difficult skill for them to master as they progressed through training. Challenges with automation included how to use automation to replicate manual flying via the MCP, programming the FMC via the CDU, understanding the functionality (underlying computer system logic) of the FMC, and coordinating the use of automation through other pilots.

When pilot trainees begin transitioning from classroom to simulated environments, some struggled to learn procedures, which in this context means flight-related tasks varying in type and complexity. Enacting procedures required pilots to recall and repeat tasks involving motor skills (e.g., hand flying an aircraft or manipulating a switch) and/or verbal commands and responses. Pilots found procedures particularly challenging when they had to put into practice what they had learned from manuals, which involved tasks performed in a specific sequence or timeframe, with some tasks performed simultaneously. Trainees had also described carrying out memorised procedures difficult when tasks had to be performed in coordination with other crewmembers. In addition, some pilot trainees found it difficult to recognise or remember triggers for commencing procedures which can come from themselves, the aircraft or the other pilot.
Multi-crew coordination became an increasingly complex issue when pilot trainees began training with other pilots—either their peers during type rating or training captains or flight examiners during line training. While multi-crew as a concept is ubiquitous in airline training literature and regulation (e.g., multi-crew cooperation training, multi-crew pilot license), this study’s findings indicated that successful multi-crew coordination, at least at the level of a new first officer, requires a basic combination of procedural and social skills. Analysing pilots’ multi-crew experiences according to these two skill sets, allowed the researcher to better understand the problems faced by trainees in multi-crew environments.

These findings suggest that the process of becoming a first officer of an airline involve two main aspects, first is the acquisition of domain-specific knowledge which occurred during the type rating training (i.e., declarative and procedural knowledge development), and the process of embedding themselves in the socio-technical context of the workplace. This process is described in relation to the four themes of the study.

5.3. **Key themes of the study**

The four key themes identified in the study were: aircraft type-specific knowledge, automation, procedures, and social skills. These themes emerged and evolved at differing times during the course of training, and to aid ease of understanding where and how they emerged were represented as a heuristic developmental model and supplemented with examples in Chapter 4. It was interesting to note that across time, themes such as “procedures”, “social cues”, and “automation” had become increasing problematic, while other themes such as “knowledge” faded away (see Table 4.6). The model shows the specific skills that trainees were focusing on learning, as deduced by topics shared during interviews, during training. Each theme is discussed in terms of their implications for aviation training and potential training recommendations

5.3.1. **Aircraft type-specific knowledge**

All pilot trainees reported finding it challenging to learn new aircraft systems because of the large amount of information they had to absorb. Alongside such difficulty was determining what needed to be learned and developing an understanding of how different systems were integrated. During the early stages of training, trainees developed their domain-specific factual and conceptual knowledge about the aircraft, such as the
electrical and hydraulics systems. These are forms of declarative knowledge (Billett, 2016; Krathwohl, 2002), as they mainly involve concepts and facts and can be described verbally. In general, pilot trainees were satisfied with the computer-based training format that was the primary mode of instruction during ground training. They especially found the self-pacing format afforded by computer-based training useful as it provided the trainees with the opportunity to use their own methods to learn the required content. The main critique they had regarding this mode of instruction was in terms of the design of the program, which were at time repetitive and slow in pace. This was, unfortunately, a manufacturing issue (Kearns, 2010) that trainees had to endure until they completed the course.

In addition to computer-based training, pilot trainees had additional face-to-face instruction, which was helpful because trainees could clarify any factual or conceptual confusion with the instructor and also seek different explanations of aircraft systems and their links between one another. They were also able to clarify if the content presented in the computer-based program was information that they needed to know in detail. This provides some support for Kearns’s (2010) claim about the limitations of purely technologically-based courses in teaching and that there are advantages to hybrid courses using both face-to-face instruction and e-learning.

In GT1, ATR72-600 trainees had a further benefit of an additional mode of presentation available in the form of part task trainer lessons, which was useful when trainees observed what occurred when aircraft systems changes were turned on, how they functioned normally, or failed in real time. They could also see which systems were connected and how one system affected the other. ATR72-500 trainees, on the other hand, had to wait for this opportunity until GT2, when they began to use high-fidelity, flight training device. During GT1, ATR72-500 trainees relied heavily on instructors to clarify their understandings of the different aircraft systems. Instructor presentations and videos also help to develop their understanding of the links between systems.

A majority of pilot trainees in Airline A said that they would have preferred to have these additional modes of presentation more integrated with their computer-based training, as this would have prevented confusion and helped them to consolidate what they had learned in the computer-based modules. Trainees’ difficulty at this stage was mainly around forming a deeper conceptual understanding of the links between aircraft systems.
and aircraft performance. Trainees used various strategies to overcome this issue, such as referring to posters to visualise different aircraft systems, watching videos, clarifying with instructors, writing notes, and in one case even purchasing a personal computer simulator. All these techniques demonstrate that trainees were personally motivated to improve performance (Billett, 2016). However, one trainee had described the assessment as requiring only surface level understanding which made him feel like his knowledge was not being tested. This suggests that potentially some trainees may not have sufficient understanding of underlying systems or able to apply their knowledge to handle complex problems in the aircraft if the need arises (Sousa, 2016).

The findings showed that learning large amounts of information, specifically knowledge of aircraft systems and performance, was difficult for pilots during early stages of training; however, this improved as pilot training progressed. This suggests that the airlines’ training methods, which included desktop e-learning (computer-based training) coupled with instructor-guided presentations and the integration of flat-panel and/or high-fidelity flight training devices, were considered effective means of teaching by pilots for the knowledge components of aircraft systems and performance. However, comments during GT1 highlight areas where training can be improved with more considerations given to the design and use of e-learning during training (Kearns, 2010) and learner-centered instructional principals (MacLeod, 2001; Karp, 2000) to improve consolidation/deep understanding of learned materials.

One potential method that may help trainees overcome the “need-to-know” and “nice-to-know” paradox (Pariès & Amalberti, 2000), was by providing the opportunity for trainees to apply what they have learned in the classroom/CBT in a practical scenario either through questioning by the instructor (mental rehearsal) or in a simulated environment. Krathwohl (2002) provides a taxonomy of terms that can be used to invoke specific structures of knowledge (e.g., remember, understand) for the objective of learning (e.g., factual knowledge, conceptual knowledge). The aim is to promote elaborative type rehearsal (Sousa, 2016) so that trainees can better understand and apply what they learned.

One significant finding that came up was in relation to the automation system, which was taught as part of GT1 with other aircraft systems. Findings suggest some pilot trainees
had limited understanding of automation and were not satisfied with how it was taught. This issue is explored in the next section.

5.3.2. Automation

Automation in large commercial aircraft is a complex system of computers, sensors, multiple screens for pilot interaction, and input controls (Billings, 1997). Chapter 2 outlined that automation consists of three components: the mode control panel (MCP) on the dashboard, which engages the autopilot into specific modes; the computer display unit (CDU) in the centre column—a keyboard and screen which provides an interface between pilot and automation; and the flight management computer (FMC), the underlying computer logic system. The issues with automation that pilots in the study identified were related to: (1) programming the FMC via the CDU, (2) flying the aircraft with the automatic pilot from inputs on the MCP, (3) giving commands (to another pilot) to fly through automation, and (4) gaps in knowledge of functionality of automation.

As discussed in Chapter 4, trainees learned about the aircraft automation systems during GT1 and gained practical experience with it in GT2 and PT. In GT1, automation was taught through computer-based training, which was the same mode of instruction used to teach other aircraft systems such as the electrical and hydraulics systems. During GT2 pilots learned how to operate the FMC through the CDU, however, findings suggest that some trainees who had limited experience with automation before training did not receive enough practice and/or instruction during GT2 to fully understand automation. Conversely, pilot trainees with previous experience using automation did not have many issues with the use of automation during training.

In addition to pilot trainees with previous automation experience, pilots from Airline B—low time university pilots—did not report finding automation especially difficult. This may have been a result of their early exposure to automation on the university’s Boeing 737 aircrafts’ automation system, during their multi-crew training course prior to transitioning to the DHC8-400. This is a plausible conclusion based on previous studies that investigated the utility of conducting *ab initio* training with technologically advanced aircraft which found that automation training in small airplanes can be transferred to larger aircraft (Casner, 2003b; Dahlström, Dekker, & Nahlinder, 2006). However, Airline
B pilots did comment on gaps in their knowledge of functionality of automation during training due to lack of practice or lack of understanding of the automated system.

The findings of the study suggest that most trainees only had a basic understanding of the automation system before they operated it in the real-world environment. This corresponds with Wood and Huddlestone (2006) article about the state of current pilot training programs where there is a gap between the procedural knowledge required to operate highly automated aircraft and current training practices. However, it is difficult to identify gaps in trainee knowledge when it comes to the understanding of aircraft functionality, as this is not usually observable until a non-normal situation occur, when trainees ask relevant questions, or when issues are explicitly questioned by trainer. If these gaps are identified only during line training, or worse, after training, the overall resilience of the working system is affected, which can be highly problematic during non-normal situations.

When asked about their experience of learning automation functionalities, some pilot trainees stated that this information was taught during the engineering course (i.e., GT1), but it was not put into context during FMC training (i.e., GT2). This meant that the link between declarative knowledge and its corresponding procedural knowledge was not made explicit enough for trainees, and therefore they were not able to conceptualise the connections between information and systems (Anderson, 1976). These findings are aligned with other research stating that pilots have inadequate knowledge of systems functionality and training for automation needs to be improved (FAA, 2013b; Holder & Hutchins, 2001; Strauch, 2017a; Wood & Huddlestone, 2006).

Pilots had trouble determining what was required to command the aircraft via autopilot to replicate manual flying, or as one pilot put it, “understanding what you want it to do and how would you get it to do that” (P2_CTL). For example, making a turn while manually flying is a simple matter of turning the control column and looking at the PFD and ND. However, performing this task using the automated system requires the pilot to engage autopilot, engage the “heading” dial, and turn the “heading dial to the required heading. In cases such as this, using automation increased, rather than decreased a pilots’ workload, which is why some pilots in early stages of simulation (e.g., Sim-A) found it easier to fly the aircraft manually. These issues were further complicated when the pilot
was required to make inputs via the MCP or CDU but had to command the other pilot to make these actions, making it a compounded issue of automation and crew coordination.

In this study, three pilot trainees (all from Airline A) were experiencing advanced automation for the first time, with one having no experience on aircraft automation at all. Research has found that pilots with no experience on automation could be proficient if training curriculums adequately explain the functionality of automation in addition to button pushing procedures (Casner, 2003a). If teaching focuses only on procedures (e.g., actions to program/use automation), then brittle skills are learned, and trainees will find it difficult to cope with situations different to what was taught during training (Casner, 2003a).

Learning automation is a complex process because it requires a combination of declarative knowledge and procedural skill. In order to understand and use automation, pilot trainees must be able to grasp the functionality, or logic, behind the automation system, and be skilled at interfacing with automation via both CDU or MCP inputs and receive and understand information (Soo et al., 2016). As illustrated in the final stage of FODM, the automation system forms part of the joint cognitive system along with the captain and first officer (Degani et al., 2017). Both pilots can make decisions and communicate with each other, and the automation can also make decisions and relay them to the pilots via the CDU or MCP (and in many cases the PFD). Automation is part of the joint cognitive system because it is capable of acting independently of pilot input, making it a third agent of control in the flight deck (Christoffersen & Woods, 2002; Klein, Feltovich, Bradshaw, & Woods, 2005; Klein, Woods, Bradshaw, Hoffman, & Feltovich, 2004). In its most advanced form, automation can completely replace human decision making (Parasuraman & Manzey, 2010; Parasuraman et al., 2008). Despite these changes, the training of automation (as a system) does not reflect how it should be used or understood during work (as another member).

One method to improve human performance in the flight deck is through teamwork amongst components. Adopting the idea that automation is another team-member implies that CRM training, therefore, should include automation use in its objectives (Taylor, 2018). However, the design of automated systems in the flight deck makes collaborative communication difficult (Taylor, 2018). Until automation systems are designed to become more human-centred and considerate of team play capacities (Christoffersen &
Woods, 2002; Sarter & Woods, 1997), pilots will continue to need a deep understanding of the various automation functions and functionalities, and the modes of communication afforded by automation.

During training, many airlines allow pilot trainees to determine when and how to use automation (Barshi, Mauro, Degani, & Luokopoulou, 2016). This is problematic during the early stages of training, because most pilots do not yet have sufficient experience to use automation appropriately or maintain a balance between practising automation and learning to hand fly the aircraft (Casner et al., 2014; Ebbatson et al., 2010; Haslbeck & Hoermann, 2016; Haslbeck et al., 2014). Therefore, pilot trainees should be provided with ongoing guidance and advice as they practice using automation (and/or refrain from using it) in diverse situations that highlight a variety of tasks and operational constraints (Durso et al., 2015; Mosier et al., 2013).

The findings of the study support the suggestions of Rigner and Dekker (1999) about how automation should not be taught as equivalent to other aircraft sub-systems but in a way that is representative of pilot work. As most actions taken by pilots would involve automation in some form or other, their interactions and role as a third pilot (Sarter & Woods, 1994) should be emphasised during training.

An important point that is made in this thesis is that the true nature of automation, from an engineering and ergonomic perspective, may not reflect what is illustrated on the FODM. The FODM describes the perspective of pilot trainees understanding of automation as they progress through their training. Teaching pilot trainees the function and functionality of automation, as well as its use during flight operations, is important; however, the findings suggest automation mastery takes time. According to Casner (2003b), automation proficiency is a “unique set of skills that must be learned in addition to basic airmanship” (p.11), therefore, it cannot be assumed that more time in line operations would lead to the proper and deep understanding of automation. Given the skills and knowledge needed to effectively operate automation (FAA, 2013b), and the added complexity occurring when the other pilot is integrated, it is suggested that a training syllabus for automation should: (1) present the automation system as an active agent in the flight deck, where the automation is able to make decisions without pilot awareness; (2) ensure pilots regularly practice skills (daily in early stages) and revisit theory related to automation use throughout ground training, and even during simulation
stages; and (3) have instructors make explicit links between automation theory, practice, and expected use, rather than leaving it up to pilots to determine these connections themselves.

5.3.3. **Procedures**

Difficulty in learning and carrying out procedures was one of the main issues reported by pilots in the study. Procedures are meant to govern the interaction between human beings, technology, and the operational environment (Mauro, Degani, Loukopoulos, & Barshi, 2012). Deeper analysis of procedure-related issues showed that procedures consist of various tasks. A complex task (e.g., manual flying) is where performance is reliant on the integration of both implicit and conceptual knowledge (van Merriënboer, Clark, & de Croock, 2002). A simple task, on the other hand, requires little cognitive effort (e.g., turning on a switch). Furthermore, tasks difficulty varied according to how they must be carried out—if they must be carried out singularly, concurrently (e.g., manual flying and verbal calls), in unison with another pilot, in a set sequence, at the appropriate moment (trigger), across time, where timing can be influenced by environment (e.g., delaying aircraft acceleration and flap retraction due to high terrain) or the other pilot (e.g., a pilot delaying a command due to the co-pilot’s high workload). During training, pilot trainees practice company procedures during PT and Sim-A, B, and C, though most pilots reported continuing to struggle with procedures through LT and even after CTL.

The initial learning of a procedure was through manuals, which most trainees described as having to rote learn and use rote rehearsal strategies such as repetition of content through verbal or written formats (Sousa, 2016). While rote learning allows for immediate recall of information, in this case procedures, it occurs in a specific sequence and, in the case of learning, does not require understanding (Sousa, 2016). The other form of rehearsal is elaborative rehearsal, where information is not stored exactly as how it was provided, but to associate new ways of thinking about the information in relation to previously learned information (Sousa, 2016). While it is not possible to ascertain the level of understanding trainees had regarding the procedures, the issues described by trainees reflect rote learning strategies. Deeper understandings of procedures would require trainees to link what they have learned during GT1 to why certain actions are performed within a procedure, especially during non-normal scenarios.
The following is a discussion of how pilot trainees learned procedures during training and associated issues under four headings: tasks, sequence, timing, and triggers.

5.3.3.1. Tasks

Company procedures consist of either motor or verbal tasks (discussed below), each varying in terms of complexity.

Motor tasks

Manual tasks can be single actions, such as changing a flap setting or pressing a button to engage the autopilot, or multiple actions, known as “stick and rudder” skills, which involve the “technical execution of manoeuvres and procedures needed for safe flight” (Helmreich & Foushee, 2010, p. 21). Some pilot trainees, mainly those from Airline B, struggled to carry out more complex manual tasks during training. Initially, this was due to them being unfamiliar with larger aircraft, though they continued to comment on challenges relating to manual flying throughout the simulator training blocks, with the main areas of difficulty being landing and conducting circuits. Interestingly, there were few comments about manual flying from trainees in Airline A.

The manner in which trainees in Airline B discussed their performance of procedures reflects the early (cognitive) or novice stage of motor skill learning (Slater, Castanelli, & Barrington, 2014). This corresponds with findings from Wikander and Dahlström’s (2016) large study outlining hand flying issues of low-time pilots as one aspect that all pilots in their study agreed upon:

One aspect that most target groups agreed on was the need for more manual flying practice and as well as increased exposure to real flight experience during the initial training. More consideration and effort should be aimed at finding an appropriate balance between aircraft and simulator time, while adapting the training syllabus in regards to calibration and balance in the competency performance (p. 178).

This study’s findings on comments from low-time pilot trainees reporting difficulty understanding aircraft performance parameters reflect Wood and Huddlestone’s (2006) critique of training programmes that dedicate little time to developing and practising students’ psychomotor skills or provide instructions on “basic performance parameters” (p.366). Motor skill acquisition begins with learning declarative knowledge (the
conceptual understanding/factual understanding) about specific steps required to carry out complex tasks (Clark, Feldon, van Merriënboer, Yates, & Early, 2008). Once this is established, procedural knowledge (physical actions in relation to appropriate environmental cues) can be developed, but it must be actively engaged through practice before motor learning can be improved and automatized (Rhein & Vakil, 2017; Slater et al., 2014). Because there is a distinction between “know that” (techniques) and “know how” (skills); unless training draws explicit links between theory and practice, inexperienced individuals can struggle to make these connections on their own (Ryle, as cited in Brown & Duguid, 2001, p. 203).

In this study, during engine failure training in Sim-B, some pilots from Airline B reported that they referred to training resources to develop their own “know that” as a way of improving their flying. However, this sometimes led to them misunderstanding how the tasks should be carried out, or even incorrectly applying what they have learned during practice. Even the more experienced trainees in Airline A commented on needing time to get used to handling the aircraft, which they did during the LT phase. As low-time pilot trainees continued to struggle through training, this reflects a failure on part of the program to dedicate enough time and instruction for them to properly develop these skills.

Ebbatson et al. (2010) found that manually flying large jet transport in asymmetric conditions uses different control strategy to either flying a light aircraft or heavy aircraft, making the learning of basic manual control a more complicated ordeal than expected. Therefore, it is crucial that enough time for practice is provided for trainees to become proficient and confident in handling the aircraft during these conditions. However, practice needs to be correct. The assumption that skill improvements just require additional practice is inaccurate. A review by Hambrick, Macnamara, Campitelli, Ullen & Mosing (2016) revealed that deliberate practice only accounted for a 12% of performance variance, leaving the other aspects unaccounted for. Evidently, there are multiple factors other than practice that leads to performance increments. Therefore, pilots require ongoing, appropriate guidance in order to become proficient at flying aircraft and prevent the learning of incorrect skills (Sousa, 2016). This is why training should be calibrated to learners’ familiarity with content, with relevant strategies or approaches provided by the training organisation (Kearns et al., 2017). Smith and Ragan (2005) suggested that supplaned strategies (i.e., direct guidance and structured
approaches) be used for learners with little prior knowledge of the content, while generative approaches (e.g., facilitative) should be used for trainees with some prior knowledge.

The consequence of not providing sufficient time for pilot trainees to learn complex tasks such as hand flying is that other lesson objectives later in the training program are not learned due to trainees being overloaded. Thus, a lack of progress in later stages of training may not be related to the content of lessons but rather the additional workload required for trainees to refine previously learned tasks. The current recommendation in the aviation literature is for low time pilots to increase either flight hours or simulation time in order to make up for their lack of experience (Wikander & Dahlström, 2016), and to some extent this approach was employed by Airline B, which rostered pilot trainees extra simulator sessions; however, the findings of this study suggest that the airline may have underestimated the amount of additional exposure trainees require to sufficiently refine their manual flying skills.

It is also necessary to consider the broader implications of pilots not developing sound hand flying skills and instead becoming reliant on automation, as described in Chapter 2. Billings (1997) discussed potential issues that can arise when new pilots fly highly-automated aircraft. His concerns centre around the possibility that pilots who have never acquired the finely-tuned manual skills that older pilots take for granted may not be able to demonstrate such skills if they transition to other aircraft or if the aircraft they are flying is degraded due to a systems malfunction, such as an automation failure. The findings of this study suggest that airlines may need to account for the reduced “stick and rudder” skills of low time pilots and make allowances for this during training, as they can no longer assume that pilots enter training “with a firm foundation of manual skills” (Orlady, 2010).

**Verbal tasks**
Communication is a core competency that is assessed as part of training and assessment and viewed as a vital management tool for crew coordination and aviation safety (Flin et al., 2003; Flin et al., 2008). Most airlines standardise much of the communication required in the flight deck through their standard operating procedures. While communication can involve both verbal and non-verbal behaviours (Flin et al., 2008), this part of the
discussion is specifically related to verbal tasks contained within standard operating procedures (Gontar, Fischer & Bengler, 2017).

As a way of improving many aspects of the multi-crew environment in response to past accidents (Edkins, 2005; Foushee & Helmreich, 1988), airlines have made almost all work-related communication that happens within the flight deck, with air traffic controllers, and cabin crew, standardised (Hawkins, as cited in Mavin, 2010, p. 26). This standardisation is established through the use of standard operating procedures, listed in company manuals. The verbal aspects of procedures involve standardised calls between pilots, air traffic controllers, and cabin crew. Standard operating procedures provide set verbal tasks that enable pilots to give commands to other pilots (e.g., “gear up”), indicate that tasks have been completed (e.g., “altitude set”), or provide feedback or information to other pilots (e.g., “1,000 feet till altitude”).

Verbal tasks also call for further actions to be carried out during procedures and have varying levels of complexity depending on how much input is required from the speaker. The findings of this study revealed that when pilot trainees made incorrect standardised calls, or no calls when there should be, it led to confusion for their partners and/or missed or mistimed “triggers” for further tasks (discussed in later sub-sections). Even though most verbal tasks are standardised, some require the wording or command to be determined by the pilot. For example, when pilot trainees are flying the aircraft or acting as pilot flying, they are not allowed to carry out other tasks, such as adjusting the flight director bars for flight path guidance. Here, the pilot flying must command the other pilot who is the pilot monitoring, to adjust the bars with specific instructions (for example, “turn Heading [knob] 20 degrees left”). They can also ask the pilot monitoring to action a pre-programmed flight plan in the CDU or configure the autopilot, or to adjust the aircraft heading. Furthermore, if the pilot is having difficulty determining current automation system status, having to command the other pilot to program the CDU or make MCP changes adds another layer of complexity. While trainees eventually become accustomed to calls related to routine tasks, some trainees found it difficult to commit those procedural calls into memory.

One verbal task that trainees from Airline B described as being difficult was radio calls or radio communication, an issue that was brought up during LT. One pilot had expressed difficulty keeping up with radio communication at different airports, or even knowing
how to contact air traffic control at different airports. A study by Lee (as cited in Kanki, 2010, p. 138) found pilots took longer to execute a go-around exercise in the simulator when they were given realistic radio communication as compared to non-realistic radio communications. These findings highlight that radio communication is much more complex than what is practised during simulators. Burki-Cohen, Kendra, Kanki, and Lee (2000) conducted a review to determine the importance of realistic radio communication during simulator exercises and found that developing radio communications skills are important as it not only crucial in developing coordination with air traffic controllers, but also to become accustomed to communicating under stressful circumstances.

5.3.3.2. Sequencing of tasks

Some pilot trainees in this study reported finding it difficult to sequence tasks within procedures—to remember what happens next. During PT, when pilots started to learn about company standard operating procedures, some trainees shared that they were receiving little guidance about how to learn and memorise procedures. One pilot’s reflection was: “We’re just kind of told, all right so go out and learn this and repetition, repetition. That was the big thing they were pushing at times” (P1_Sim-C). Because of this, pilots from both airlines relied heavily on the standard operating procedures manual to learn the sequences of tasks. Some pilot trainees were able to develop their own methods for learning procedural task sequencing, but others found this highly challenging. For example, P2 said that remembering the sequence (or flows) associated with procedures, “was probably the most challenging [aspect of procedure learning]” (P2_PT).

Another area where pilot trainees reported having difficulty was linking multiple procedures sequentially for a full flight operation. Some pilot trainees felt that this difficulty arose from a lack of coherence in how procedures were taught. During training at both airlines, the majority of procedures were taught and practised in isolation (e.g., non-normal procedures); however, in practice procedures are carried out in a linked manner within flight phases, between phases, and from the beginning to the end of flight. Because procedures were not taught in this way during training, pilots expressed having difficulty “putting it together” (P8_Sim-C). These findings suggest a need for clearer depictions and explanations of the connections between procedures, and more practice during training, especially for less experienced, low time pilots.
The study found that there is a need for additional resources to be presented in multiple formats to provide trainees with the opportunity to understand how a procedure is carried out, as opposed to just referring to the manual. This multiple format approach allows pilot trainees to understand the nuances of procedures (Barshi et al., 2016). While Airline B had additional resources that pilot trainees could refer to—and very often did—the resources were sometimes inaccurate. They commented this led to them developing an incorrect understanding on sequencing of tasks, requiring clarification with instructors during briefings, or required relearning after being corrected when in the simulator. Having to relearn a skill that has been practised, even if done in preparation for the class, is a difficult and demotivating process (Sousa, 2016).

Airline A used several strategies—manuals and videos—to help pilot participants to remember how to sequence procedures throughout the course of flight. Further, Airline A also works and educates instructors on the concept of “flow,” or kinetic melody (Roth et al., 2015), when it comes to teaching procedures to pilot trainees. Here they are taught to remember task sequencing, as a kinetic flow. Here manuals present a sequence of tasks as diagrams and videos, that are very detailed, to assist the learning of procedures, that are eventually embodied and appear as “sequences of movements, actions and perceptions” (p. 284). However, these resources (perhaps due to their importance or how they can help learning) was not stressed by instructor and was not used by some trainees in Airline A. Therefore, having resources available does not mean that trainees will engage with them as expected (Billett, 2009).

Many pilot training programs also use acronyms to guide pilots’ thought processes when they are managing non-normal or emergency situations. For example, FDODAR stands for Fly aircraft, Diagnose the problem, determine Options, Decide on course of action, Assign duties to crew, and Review (Munro & Mavin, 2012). However, even when pilots reach this stage of procedural learning, one aspect is often not accounted for—timing. This is discussed next.

5.3.3.3. Learning timing

One issue that pilot trainees in this study brought up frequently was the timing of procedures. Timing, which in the literature can be referred to as temporality (Reddy, Dourish, & Pratt, 2006), relates to knowing how long it should take for a task to be
completed, which is determined primarily by the pilot and aircraft (i.e., components of the functional system). For example, a pilot may need to hasten, slow or even delay a task due to different circumstances such as the other pilot being busy completing their own tasks, or having to wait for other crew members to complete their tasks before the pilot can carry out a task; or the aircraft may need extra time to accelerate to a certain speed, thus delaying the task of flap retraction, for example. Other factors that can influence the timing of procedures include cabin crew and air traffic control. For example, a pilot busy with a radio call may delay the next task in a procedure, which would, in turn, require both pilots to recognise the need for a delay in the next task.

As stated in Section 4.6, p. 120, the functional system, includes both pilots and automation, working together as a team; therefore, both human and automation elements should be considered by instructors when training timing of procedures. Furthermore, temporal control is an element of complexity in a joint cognitive system (Cellier, Eyrolle, & Marine, 1997). In a joint cognitive system, various subsystems (e.g., other pilot, automation, external crew members, aircraft) may adhere to different time scales based on their respective goals (Woods & Roth, 1988) and feedback times may vary according to the circumstances (Brehmer, 1992). For example, a pilot may want to relay a message to the cabin crew during a busy flight sequence, but this may be slightly delayed due to cabin crew being preoccupied with a cabin emergency.

The results of this study suggest that timing is not taught effectively during the initial first officer training programs. Neither airline in this study included prescriptions for the timing of tasks, procedures, and sequences in its standard operating procedures and the only way that pilot trainees were taught timing during training was by watching video recordings of flight. Mauro et al. (2012) stated that procedures that do not account for sequence and timing, or the time “required for machine or human process to operate or for an environmental condition to change” (p. 759), could lead to unsafe outcomes even if each task was correctly executed and sequenced. Therefore, timing must be explicitly taught in pilot training programs.

5.3.3.4. Learning triggers

Pilots must know how to recognise triggers for tasks in order to ensure that procedures are carried out appropriately, but findings from this study revealed that some pilot trainees
struggled with learning triggers for commencing procedures, receiving incorrect triggers from the other pilot, recognising incorrect triggers in the environment, and learning new triggers in new contexts (during LT onwards).

Almost all triggers are standardised and defined in company standard operating procedures. Verbal triggers, as with the case described Section 5.3.3.1, p.197, generally follow a sequential structure of checklist and involves callouts at specific points in time during flight. Gontar, Fischer & Benglar (2017) describe these kinds of standardised communication as being important to guide crews through complex tasks as it promotes a shared situation understanding and allow pilots to better anticipate anticipating each other’s behaviour.

Clark et al. (2008) describe learning triggers or cues as a form of “if-then production.” A standard operating procedure is a complex set of tasks consisting of multiple if-then productions with sub-goals (tasks) that are sequenced together to achieve an overall goal (completing a procedure). In terms of this study’s findings, pilots reported issues with triggers on two levels: recognising and responding to multiple triggers within a single procedure and recognising and responding to triggers for consecutive sequences of procedures. Clark et al. (2008) state that novices find achieving sub-goals effortful, as conscious effort is required for each decision.

The concept of triggers is also related to the decision-making literature, such as naturalistic and recognition-primed decision making (Flin et al., 2008). Naturalistic decision making was developed from a series of investigations that looked into how experts made decisions in their normal working environment, such as flight decks (Flin et al., 2008; Klein, Orasanu, Calderwood, & Zsambok, 1993). For example, a trigger may be associated with a pilot deciding (decision) to divert around a thunderstorm. Prior to the diversion (decision) the pilot, in consultation with the other pilot, triggers the actioning of a number of tasks, such as slow aircraft up to turbulence penetration speed, advise cabin crew, turn on ‘fasten seat belt’ sign, turn on anti-ice equipment. Some pilot trainees in the study stated that these decision-making processes were taught by their flight instructors during LT, though was instructor dependent as some may choose to not teach at all (as was the case in this study).
5.3.3.5. Implication to practise for procedures

As one pilot said, “procedures are fragile” (P3_Sim-C), and if sequences are broken, pilots can fail to recall which tasks should come next. It is therefore important for airlines to determine the best ways in which procedures can be taught. Trainees in the study were required to learn procedures from company documents. Some trainees had difficulty learning at the first step, which is memorising the sequence of task as listed, some had issues with the translation of memorised procedures into action especially when crew coordination was required, and some had difficulty adapting the different ways procedures are applied in the real-world.

The accuracy of procedures is crucial when it comes to learning. In the study, pilots, especially those from Airline B, found that having to relearn procedures or other skills difficult. It was counter-productive when what was provided in training resources to supplement their revisions or lesson preparation were inaccurate, leading to confusion during training. Though these types of issues were easily rectified as the lesson progressed, such problems should not occur in the first place. As described by Sousa (2016), practice does not make perfect, but makes permanent. Therefore, it would be worthwhile in investing time during training to ensure trainees are practising correctly. Airlines must ensure that training documents are consistent and contain accurate information and instructors can provide guidance at the end of each session to prevent trainees from learning the procedure in an incorrect manner.

Aircraft manufacturers provide procedures to airlines as part of the aircraft purchasing process and airlines modify them to fit their own company style of operation (Degani & Wiener, 1997). According to Degani and Wiener (1997), procedures are meant to unambiguously specify: what the task is; when the task is conducted (time and sequence); how the task is performed (actions); by whom it is conducted; and what type of feedback is provided to other crew members (p. 305). Barshi et al. (2016) also stressed the multifaceted nature of procedures from a design perspective, which is meant to govern and account for technology and human and environmental (THE) factors. Using a THE Model to assess the complexity of a flight operation involves understanding interactions between Technology, Humans, and the operational Environment, all embedded in the context of a flight mission (Mauro et al., 2012). Timing involves understanding each components individually and their multiple ways of interactions (e.g., human-
environment, human-technology, technology-environment, and all three simultaneously) as it depends upon how long it takes for the pilot(s) or automation (technology) to notice that a change is needed and how long the environment (aircraft) needs to react to a change (e.g., increase aircraft power) (Mauro et al., 2012). Barshi et al. (2016) further outline that a properly designed procedure adheres to what they call the “4Ps”: philosophy (i.e., values of airline), policy (i.e., broad specification of how things should be done), procedure (i.e., specific specification of how operations should be carried out), and practice (i.e., what the pilot actually does). The first three are related to procedural development, while the final aspect is related to the practitioners themselves and whether they conform to or deviate from procedures (Degani & Wiener, 1997).

This study shows that pilot trainees had difficulty learning procedures from manuals. This supports the assertions made by Barshi et al. (2016) about the importance of proper procedural design, especially when it comes to clarifying the specific steps and sequences that must be completed when performing a procedure (see Barshi et al., 2016, p. 27-28). However, Barshi et al. (2016) do not sufficiently address the social aspects of flying in their models of procedure, specifically in the areas of “timing” and “humans”. While pilots may be individuals with particular capabilities and limitations (Dismukes, 2006), during flight both pilots must work together as a team. The findings of this study suggest that pilot trainees’ difficulty carrying out procedures was largely related to their being interrupted by other pilots in the flight deck, indicating the importance of flight deck communication and coordination. However, these aspects are not taught during training.

One method to assist developing procedural skills was discussed between the researcher, primary investigator of the project, and Airline A, specifically regarding the use of a captain during simulator training as opposed to another student pilot. The group discussed that the captain, sitting in the left-hand seat throughout training, along with guided instruction by an instructor, provides a model for understanding triggers, demonstrate correct task accomplishment, sequencing of tasks and timing of procedures (Sousa, 2016). This would also provide pilots with a model of how a professional pilot works and help them to develop accurate expectations of how procedures are carried out. However, this practice is not realistic simply due to cost but was considered as an option. The idea was adapted to potentially have a captain involved at strategic intervals during training. For example, even during one such session in the Sim-B and/or Sim-C phases of training,
could provide significant improvements to pilot learning. Alternatively, the flight
examiner or simulator instructor could play the role of the captain; however, logistical
issues of simulator operation and radio calls between air traffic control and cabin crew
(which is carried out by the flight examiner or simulator instructor as part of training
scenarios) would need to be considered. A “spiralling curriculum” or circular model may
be used by airline training programs to organise their courses, which exposes pilots to the
entire process of work, so that they are aware of what is expected of them, in a full flight
operation and also how to sequence and link procedures during the various stages of flight
(Bruner, 1960; Morgan, 2017). Gibbs (2014) states that delivering a spiralling curriculum
involves setting up instructor support for task learning (i.e., scaffolding) and revisiting
the same task multiple times (i.e., in a spiral) throughout the course of study with less
support offered each time the task is revisited (i.e., faded support), thus making the
activity more complex. MacLeod (2001) suggested that sequences can be learned in
scenarios that increase in complexity as procedures become more difficult. When learning
through this type of instruction, pilot trainees must have enough time to practice the same
task multiple times. In the case of the initial first officer training, pilots could be instructed
through an entire flight with instructors scaffolding specific tasks (e.g., radio calls,
passenger announcements) and slowly fading support (unless continued support is
required) with each exercise repetition (van Merriënboer et al., 2002).

Another issue that was discussed was in relation to radio-calls. In both airlines,
instructors, on top of the various other tasks they need to carry out during training, were
given the role of simulating radio, which a common practice is most training scenarios
(see Burki-Cohen, Go & Longridge, 2001). Burki-Cohen et al. (2001) called for more
realism in terms of radio calls during simulation training, with some suggestions like
cross-training with air traffic controllers or developing specific scenarios. However, these
recommendations are costly. Perhaps role-playing exercises can allow trainees to practice
how they might communicate with air traffic controller, followed by self-regulated
practice during familiarisation flights with an emphasis on observing how radio-calls are
conducted could improve trainee performance and confidence in radio communication.

5.3.4. Social skills

The last theme that emerged in the study was based on difficulties trainees discussed
having when training and learning with others in an interactive manner. The findings
show that the transition to working in a multi-crew environment was difficult for pilots who only had single-crew experience prior to training. During the early stages of training, the findings show that rather than working as a team, it was two individuals in the flight deck and the aircraft automation system (see figure 4.12). One pilot expressed trying to slow his partner down during non-normal procedures practice was difficult, and conversely, said partner expressed being thankful for his partner support but was only concentrating on completing the procedure.

This issue was initially identified as a multi-crew coordination issue. However, deeper analysis of the term multi-crew revealed that it was understood by pilot trainees to describe (1) procedures requiring crew coordination, and (2) the social aspect of working with another pilot. Specifically, multi-crew was conceived by pilot trainees as performing procedures (e.g., tasks, sequence, timing, and triggers) in a social context with other pilots and crew members. Therefore, while communication, or verbal tasks are one aspect of procedures, as discussed earlier, it is also fundamental to developing a shared understanding of the flight, resolving conflict, avoiding conflict, a means of maintaining good coordination amongst pilots, and determining when it is appropriate or not appropriate to speak (Flin et al., 2003; Gontar, Fischer & Benglar (2017)). This aspect of communication seems to be neglected during training.

As a means of improving the effectiveness of crew coordination, airlines continue to encourage and teach CRM skills. Here CRM is considered a key aspect of this training, as it is supposed to teach crew coordination and flight deck management, with additional focus on interpersonal, communication, and other non-technical (i.e., social) skills (Kearns et al., 2017). According to the NOTECHS model (see Section 2.3.2.2, p. 36), the categories of CRM social skills are cooperation, leadership and management. According to this model, to determine if “social skills” are being carried out appropriately, communication is fundamental (Flin et al., 2003). Here communication between pilots should manifest in such a way that each pilot’s “mental models and thinking processes” are apparent to the other pilot (Flin et al., 2003, p. 98).

Previous research has identified that tasks in dynamic operational environments are commonly characterised by distractions and interruptions from internal or external sources (Latorella, 1996; Loukopoulos, Dismukes, & Barshi, 2001). Such environments feature many interdependent agents that have their shared and job specific tasks and
objectives, therefore frequent interruptions are more likely and is part of daily routine. However, the interplay of interruptions and time pressure can impact the pilots’ workflow. Research in other high-risk organisations such as the healthcare domain showed a correlation between interruptions and errors committed and perceived workload (Gontar, Schneider, Schmidt-Moll, Bollin, & Bengler, 2017).

Interruptions are ubiquitous in normal flight operations and have become a normalised practice (Gontar, Schneider et al., 2017). While common in normal flight operations, it was not initially intuitive, and trainees reported having difficulties handling them during early stages of line training. While trainees were eventually able to become accustomed to the pace and environment of work, it was mostly because the captain was able to support them during those early stages, with some providing personal techniques to help trainees in the learning process (e.g., P3, P5 and P8).

When analysing the time social skills were addressed during training, the CRM course was the main mode of instruction. In Airline A, CRM was taught in a classroom during GT1. As part of the course, pilot trainees were taught first officer communication language when dealing with an “unsafe captain” and being assertive with the captain, such as the “ultimatum” call that first officers can use to take over aircraft control from a captain behaving in manners they deem unsafe or what it means to be “assertive”. However, in practice in this study, pilot trainees rarely—or did not—use this call even when they felt the captain was not acting appropriately nor did they mention employing “assertive” techniques taught during the course. Rather, they reported using their own methods of communication, or just conforming, to prevent upsetting their captain and the collegial working environment. During simulator training, pilot trainees were required to demonstrate threat and error management skills following company standard operating procedure although were unsure how to manage parts of flight operations that were highly descriptive in company manuals (e.g., P8 states that management of flight is a “coming up with it yourself thing”).

What appears to be the case from the study, is that when it comes to social skills in general, and communication skills specifically, manuals are unable to encapsulate all forms of communication which includes not only verbal aspects, but also non-verbal aspects (Flin et al., 2008) required for effective crew coordination. Further, at no point during training were related social skills, such as basic conflict resolution techniques,
taught nor practised. These techniques depended on the inherent social skills of individual pilot trainees. For example, during a simulator assessment, P8 describes becoming more comfortable sequencing the many tasks required during a flight scenario, though had to learn ways (social skills) to redirect the other pilot’s current activities to align with his (e.g., “Can you just stop that. I need to brief the STAR”). However, later during line training P8 found it difficult to communicate effectively or seek help from his captain (e.g., some captains were like “You’re flying, you’re in charge, you decide”). This issue was found to become more complex when trainees transition from simulator training environments to line training environments as seen by the increase of discussion related to social skill issues.

The findings highlight some of the areas where there are theory-practice gaps between type rating training (GT1 to SIM3) and line operations (including LT and CTL) (Roth, Mavin, & Dekker, 2014). A theory-practice gap is said to occur when there is a mismatch in the experiences encountered within education or training and the workplace (Roth, Mavin, & Dekker, 2014). Roth, Mavin, & Dekker (2014) had conceptualised the “gap” as being the outcome of human praxis within two domains (i.e., training and workplace) that contain societal divisions of labour. An evident example from the findings of this thesis is the difficulty associated with social skills that trainees identified during simulator and line training, where the former involved partnering with another trainee, and the latter with a captain.

This gap still exists in current training systems despite utilising high fidelity simulators due to the mismatch between the functions of the two systems, such that training emphasises on specific aspects usually in compliance to regulatory requirements (e.g., procedure compliance, technical skills), while the workplace requires resilient joint cognitive systems that can handle disturbances that occur in the real-world (Branlat & Woods, 2010; Dahlström et al., 2009). Here, the standard operating procedures and theories taught in the classroom are not adequate, or effectively prepare pilots for work in the real-life environment. Therefore, it was not surprising that pilot trainees perceived that they were required to learn a lot during line training (i.e., on-job-training) or through their own means. While learning during LT was expected, the findings described trainees learning about new knowledge but, in the case of some trainees, they were not receiving as much guidance in the learning process. Self-discovery methods (MacLeod, 2001) were
used during LT, which begs the question of whether such self-learning was expected or intended by the airline, and what are the effects of the hidden curriculum (Billett, 2006a). Nonetheless, the question remains if, or how much, of this aspect is problematic to the safe performance of pilots.

It is important to remember that trainees have their own individual agency and presage (i.e., personality and character) that affect how they engage with training and others (Billett, 2006b; Telfer & Moore, 1997). Therefore, merely presenting and discussing the skills is unlikely to change behaviour of trainees and lead to only agreeing on the surface but not applying them during work (Owen, 2009). The findings of the study show that current CRM training addresses these issues to a certain extent, though seems falls short in instigating learning amongst trainees.

Barshi (2015) suggested that current pilot training programs, including the two airlines in the study, that employ a linear structure of training (i.e., engineering course, followed by simulator procedures training and finally a line oriented flight training session) provide little opportunities for trainees to apply what they have learned in an operational manner. For example, despite the emphasis on CRM, aviation training is still mainly divided into components instead of being an integrated process. “Technical” components and “human factors” components remain separated, with CRM training being one isolated course amongst the multiple operational training (Pariès & Amalberti, 2000, p266). To overcome this issue, Barshi (2015) suggested that the entire training program can be restructured through what is called a compressive line-operations flight training that follows a spiralling format. Central to this format of training is that trainees would be taught and trained based on topics that are mission focus training is structured to follow the profile of an entire flight operation. Through this method, trainees would be paired with their partner from the first day and will be presented with problems that can occur during flight operations, which allows pilots to practice not only the required systems knowledge in an operational manner, but also to promote discussion between two pilots which develops their communication and teamwork skills. More emphasis on social skills development should be conducted throughout the training program using facilitative skills (Dismukes et al., 2000) would likely be able to improve pilot social skills.
5.4. Potential contributions of this study

The findings of this study reveal areas of training that can be improved based on the perspective of pilot trainees who experienced the program. In particular, the study contributes to the theories of joint cognitive systems by understanding the process of becoming part of complex socio-technical environments. This section also provides a methodological reflection on the methods used in the study and their implications to research in the aviation domain. This study showed that more in-depth studies into pilot training and learning is required. Telfer and Moore (1997) and Billett (2006a) suggested that an ideal training curriculum (i.e., training effectiveness) would be when goals and interest of the workplace (i.e., intended) and the ideals of those who participate in such curriculums (i.e., experienced) align. The study found that there were still theory-practice gaps despite previous efforts to align the goals of training and work (Roth, Mavin, & Dekker, 2014). This study hopes to address this gap by highlighting the issues that trainees encountered during training to promote discussions amongst training managers about the gaps in their training and between work.

![Diagram](image)

**Figure 5.1** The First Officer Development Model (FODM) in its 6th iteration. This iteration presents the skills that pilot trainees have develop and the dynamics of the joint cognitive system after being checked to line.
Through the illustration of the First Officer Development Model (FODM) in its various stages, training managers can have a heuristic understanding of what trainees were learning and how a particular component (e.g., the automation system or the other pilot) of the joint cognitive system were viewed by trainees throughout the process of training. From here, targeted interventions can be planned and areas requiring further investigation can be identified.

5.4.1. **FODM, joint cognitive systems and pilot learning**

The FODM is an indigenous formal model of practice that was developed from the learning experiences of pilot trainees as described across the training process (Kearns et al., 2016). These types of models are sometimes called “folk models” or common-sense model that are based on descriptions rather than on explanatory reasons and are intuitively meaningful to those that can associate with them (Dekker & Hollnagel, 2004). While there are significant weaknesses inherent in them (see Dekker & Hollnagel, 2004 for further discussion on this topic), they are not necessarily incorrect as they have been developed based on the formalisations of practice by and for specific industries (Kearns et al., 2016).

This study adopted an expanded view of cognition and used the theory of joint cognitive systems to better understand issues identified by trainees during training. By conceptualising pilot learning as not only the acquisition of required knowledge and skills—or competencies—listed in the training manuals, but also the process of becoming part of the aircraft functional system as a competent first officer of an airline. The study was able to identify what trainees were learning about and when they had issues in developing those skills.

This study was premised on the understanding that pilots’ work within complex socio-technical systems with constant transactions between humans and highly automated components (Soo et al., 2016), and accordingly, a joint cognitive system perspective should be adopted (Hollnagel & Woods, 2005). Rather than the methodological perspective adopted, the theory of joint cognitive systems and functional systems shaped the way of thinking about learning and pilot performance. The contribution of this study to the theory of joint cognitive systems is in terms of the chronological description of the process that pilots go through to become a component of the functional system.
According to Weber and Dekker (2017), safety is an emergent property from the joint cognitive system which consists of the interplay of different components during work. Learning to become part of such a system as a reliable component, therefore, means looking at the learning process through similar lenses. By illustrating the FODM in a systems manner, those involved in training are constantly reminded that trainees are learning to become part of a system, and therefore instructional techniques and training content should be planned with that outcome in mind. In the context of training, while assessments are individually focused, pilot learning involves knowing how to become a competent component of such systems, which requires the training of both individual skills and teamwork skills (Flin et al., 2008). While traditional theories of learning and pilot performance offered explanations for the findings of the study, it was only by understanding that trainee experiences with the expectation that will become part of a system that the effects learning issues become clearer.

The use of automation is complex as it requires pilots to have procedural skills, declarative knowledge, and the ability to effectively interact within a joint cognitive system involving both humans and machines. Human-machine interaction literature suggests that in order for people to work effectively with automation/machines, they must consider themselves and the machines they are working with as a “team” (Degani et al., 2017, p. 212). Automation is understood to be a third agent of control in the joint cognitive system within the flight deck because of its ability to make changes independent of pilot input (Christoffersen & Woods, 2002; Klein et al., 2005; Klein et al., 2004). In order to achieve a safe flight operation, all three agents—captain, first officer, and automation—must work together to maintain system equilibrium or resilience during normal and non-normal situations.

As illustrated in the final stage of FODM, the flight deck is a joint cognitive system made up of the automation system and the pilot/s. In this system, the two pilots can make decisions and communicate with each other, while the automation, via its functionality, can also make decisions and relay them to the pilot via aural cues or through other flight instruments such as the CDU, MCP and PFD. The findings of the study also imply there are gaps regarding automation use. While programming issues were overcome through practice and exposure during line training, functionality understandings were still limited.
Along similar lines, the FODM provides an illustration of what trainees focused at different segments of training, which can be used as a tool to identify potential areas of disconnect between set training standards and expected amount of learning in the training curriculum. For example, airlines appear to apply specific assessment methods to assess pilot trainees, such as multiple-choice exams, on completion of engineering school in GT1, to assess competence of aircraft systems knowledge. However, pilot trainees were still unsure to what extent they needed to understand and memorise the different aircraft systems. Airlines also provide procedural training for areas such as automation, as in PT, but pilot trainees express becoming more confident in their understanding of using automation only during LT. If the purpose of ground training was to prepare pilots for real work environment, then clearly, there is a mismatch between assumed and real competence of airlines for pilot trainees. Even though all but one pilot trainee had been checked to line, trainee experiences reveal that trainees were still learning about pilot work during line operations. The findings suggest that the joint cognitive system remains resilient because the captain/instructor was reliable enough to support the first officer when required. This is not saying that new first officers were completely unreliable, but that they were still learning about new things that were never considered during ground training.

The FODM, at least to the airlines of which this study was conducted, provides an overview of the areas of focus for pilot trainees at different stages of training, and reflect on whether it matches the intentions of the training program or whether other training activities would benefit the trainee. Further, as can be viewed in the early stages of the FODM, learning at GT1 and GT2 was mainly focused on the learning of the individual trainee. Once computer-based classroom training was completed, simulator sessions began (PT onwards), and during this segment of training, the pilot trainees worked in pairs to reflect how they would work as pilots. At this stage, the unit of analysis for assessing performance, and therefore learning, involved understanding the interaction between pilots’ cognitive systems (including social aspects) and automation—their joint cognitive systems. For example, pilot trainees generally felt that their performance was better, or things were smoother, during line training than during ground training. The FODM shows that the structural difference in the system was the presence of a captain. The effects of the difference in components of the system should be investigated to
identify why trainees had these perspectives and what about these effects, if any, can be used to develop current training methods.

5.4.2. Methodological reflections

The methodological contributions of this study are presented in relation to conducting in-depth and prolonged qualitative studies within the aviation training context. This section includes a discussion of Billett’s (1996) three concepts of curriculum—intended, enacted, and experienced—the use of multiple methods, and the importance of flexibility when conducting research in dynamic and complex fields such as aviation.

This section also discusses the feasibility of using a qualitative case study approach when investigating pilot training programs and some of the key features required when conducting research in the aviation domain and subsequent analysis of collected data.

5.4.2.1. Curriculum lens

The study employed curriculum theory as a lens to categorise the training program according to the intended, enacted, and experienced curriculum (Billett, 1996, 2006a). The study shows that even with good intentions from the airline and regulatory body, and even the instructor, if the perspectives of those who experience the curriculum (i.e., pilot trainees) are not considered, then the effectiveness of training is not guaranteed or fully understood.

By focusing on the experienced curriculum, the study was able to provide a detailed, and rare perspective, of pilot learning during airline training programs. The study was able to reveal not only the main issues encountered by pilots undertaking initial first officer training, but also the nuances of those issues. This perspective of training has received little attention within research and offered a different way of reflecting on training issues. These experiences were considered when reflecting on the intended and enacted curriculum to develop training recommendations that targeted those issues identified in the study.

It should be noted that most of the learning that occurs is based on trainees’ actions, agency and intentions, which involved their active engagement with the training content (i.e., experienced curriculum). The training program itself has been structured to provide these opportunities to engage (e.g., availability if flat panel trainers, familiarisation
flights, instructor availability). Through their perspective, their decisions on how they choose to/or not to engage with the training system reveal areas that limit their learning.

It is recommended that aviation authorities and training managers focus more on identifying and understanding issues faced by pilots from their perspective before making changes to standards or training structure. The study showed that a bottom-up approach can reveal problems that were not considered previously (e.g., importance of social skills) and decide how training resources can better be used. Training managers can use these pieces of information to determine if current practices are inhibiting learning that they deem crucial for work, design or change current training activities that provide access activities that are crucial for skill development and also make aware such practices are available to trainees for their use.

5.4.2.2. Qualitative case study approach

This study was an in-depth investigation of pilot learning during initial airline training, which involved tracking trainee learning experiences for an entire training program (3-4 months). This allowed the charting of what and when pilot trainees were learning and the issues that occurred. It also allowed for the mapping of issues that had occurred at later times and determining which aspect of training needed to be improved. This was only possible through the day-to-day observations and interviews with pilot trainees. The depth and breadth of this study would not be possible through positivistic types of research where contextual factors are neglected (Wiggins & Stevens, 2016).

However, conducting research of this type within training programs that have tight training schedules was difficult. The procedures of data collection and analysis were effortful and time-consuming not only for the research team, but also of those who were involved in the study (i.e., pilot trainees, instructors, and company staff who were not part of the study but assisted in lodging, travel and rostering). Furthermore, this type of research requires the on-going consideration of maintaining good rapport with participants, which can be difficult when having to meet each other almost on a daily basis and during busy training schedules. On-going adjustments to travel and research plans were required for the study. Therefore, flexibility on the part of the researcher is crucial.
While interviews revealed the perspective of trainees, being physically on-site and observing practice was also required to develop appropriate prompts and follow-up topics to encourage rich descriptions of learning experiences by trainees.

5.4.2.3. **Support from all levels of training**

Partnerships between airline academic institutions are rare. However, these partnerships are highly beneficial as they form a platform where new knowledge about relevant issues faced by the industry can be created and access to knowledge provided from research (Dahlström, 2002). The study would not have been possible without first establishing trust with the stakeholders in the airline and the airline training managers. A key reason for this successful partnership was because the study was generated through an industry-university collaboration (via ARC-Linkage) that aimed at generating data on issues that airlines are having difficulties. This collaboration was driven by the practical need to overcome the pilot training issue faced by the partner airlines, which was the agenda of airlines and therefore, the agenda for research. The researchers designed studies that can address that agenda and provide empirically-based recommendations to address the issue of the airline (e.g., Mavin et al., 2015).

Ultimately, this study was only possible due to the joint effort of those directly or indirectly (e.g., other personnel in the airlines) involved in the study, and unwavering support of the company managers. The study also used video recordings in place of direct observation during major training sessions. This method not only allowed for more in-depth analysis of the situation but also, as much as possible, removed the presence of the researcher during training. This method was only possible due to the trust given by airlines and consent of instructors and pilot trainees involved.

5.4.2.4. **Requirements for domain-specific knowledge**

Due to the complexity and technical nature of pilots’ work, it was crucial that a subject matter expert was available for consultations and cross-checking activities during all phases of the study. As the study involved trying to understand the nuances of pilot learning experiences, it was vital that the technical aspects described by pilots were well understood and accounted for during the process of data collection and analysis. Thus, during the study, the researcher consulted her supervisor (subject-matter expert) to clarify
and cross-check her understanding of what pilot trainees had discussed about during interviews, and even to participate during the data collection phase of research.

This dilemma brings up the importance of considering the roles of the researcher not only in the field but also outside the field during the process of analysis. During field research, the insider or outsider status can result in two different realities being shared by a participant in the same study (Flick, 2009). In this study, the researcher who was not an aviation expert was not able, in some cases, to fully understand some of the nuances of what pilot trainees were discussing or privy to experiences that required domain-specific knowledge (e.g., procedures for conducting circuits). This supported the view that understanding of domain-specific activities may remain hidden outsiders (Flick, 2009) and richer data can be obtained when the researcher is also a member of the researched group (Mercer, 2007). However, collecting data as an outsider also led to the collection of data that insiders may not be privy to as the participants were more relaxed and willing to share their opinions and experiences to the outsider (Mercer, 2007).

Furthermore, during the analysis process, the development of a common framework (i.e., FODM) that synthesised the findings across the entire study was also only possible due to the supervisor’s expert knowledge. While the researcher may be able to generate preliminary plans on how to present the findings of the study, the final formation of the structure was through the efforts of both the researcher and subject-matter expert cross-checking activities and discussions.

Therefore, it is stressed that if studies of this nature do not include a highly experienced subject matter expert, who also has academic background knowledge, as part of the research team, studies of this nature are simply not possible. This process was also used in cross-cultural research when research teams consisted of members with different cultural backgrounds (Kikkawa & Bryer, 2013). This on-going process led to different ways of understanding problems, as was the case with interpreting the issue of “multi-crew” during the study and what it meant in the process of training and learning.

5.5. Final considerations for the thesis
This study was an exploratory study that conducted an in-depth investigation, both on and off the field, to understand how pilot trainees learn to become first officers of an airline
through the initial first officer training program. As few studies had conducted research in this manner, the limitations and areas for future research are discussed.

5.5.1. Limitations of the study

There are several methodological limitations inherent in this study. These limitations should be considered in line with the findings of the study.

It needs to be emphasised that the findings of this study, while informative, is in no way claiming exact truth. This qualitative case study was exploratory in nature as little was known about what occurs during a type rating and how trainees experience them. Being exploratory in nature, no initial claims were made during the data collection and analysis process. Findings were based on comments made by trainees that were formulated into themes, however, while quantifying of comments made understanding the issue sometimes easier, it did not dictate level of importance. In other words, frequency of comments was not used as an indicator for importance of issues. Fewer comments regarding a topic were no less important than something that all pilots had commented about.

This study was conducted within two regional airlines located in the Tasman region. Hence, the training foci were related to short-haul, domestic flights; as opposed to long-haul, international flights. The aircraft type of the study was a turbo-prop aircraft rather than jet aircraft. The sampling technique of this study was also necessarily through convenience sampling for reasons explained in Section 3.4.1, p. 71. Hence, the potential generalisability of the findings is limited to initial airline training pilot trainees within the Tasman region. Future research can use more purposeful sampling techniques (Marshall, 1996) to recruit pilot trainees with more diverse backgrounds and experiences to obtain a wider range of training experiences that can lead to better understanding of the nuances of learning within the initial aviation training context.

Another possible issue is the sample size of the study. This study was limited to ten pilots, which came from one cohort of each training program. Even though pilot trainees of this study were describing similar issues and, in some cases, providing similar explanations, it is possible that more trainee accounts may yield additional findings. There are also limitations in terms of generalisability of the findings to other airline training programs.
The FODM, though considered one of the contributions of the study, also has its limitations in the fact that it was developed explicitly on pilot experiences in relation to the first officer training in the two airlines. Although the model was developed based on the understanding that pilot performance emerges from a joint cognitive system, the study only focused on the experienced curriculum (i.e., one pilot, the trainee). While intended and enacted components of the curriculum provide context, only experiences related to the key themes (knowledge, procedure, social skills, and automation) were reviewed in this thesis. As aviation was argued in Chapter 2 to have focused almost entirely on standards, it was thought timely to provide a learner’s insight by exploring their perspective during training. It is acknowledged that contextual information is significant in cognitive systems theory and qualitative type research as it provides further insights into understanding the pilot training system as a whole and its effects on pilot learning.

Another limitation of this method is the assumption that trainees will be able to verbally recall their learning process and experiences, and lack of comments is understood as being not problematic or not what they were focusing on during a particular segment of training (see Section 4.6, p. 120). Therefore, there could have been more issues that they have not personally identified (lack of self-awareness) or, despite consistent follow-up interviews, have simply forgotten. Conversely, there were few comments about the positive aspects of training, which could be a result of the focus of the study being on the identification of problem areas. However, trainees had the opportunity to share aspects of training that they found highly useful (e.g., familiarisation flights, use of FPT during GT) though they lacked the detailed description provided when discussing their issues. Future research will need to address this limitation by comparing trainee narrative with the full observed curriculum obtain a holistic description of the training curriculum.

Despite these limitations, this study was able to provide insight to type rating training that, to this date, has not received any formal reviews. Hence, this study forms a stepping stone for future research into airline pilot training programs.

5.5.2. Future research

Other than the recommendation provided in the previous section, the findings of the study have provided further avenues for research. These are discussed next.
The findings suggest that there are differences in learning experiences for pilots with different backgrounds, such as low time pilot, pilots that had been instructors, pilots with only single pilot experience and even pilots with multi-crew airline exposure. Other aspects such as age, language proficiency, and gender were also found to affect pilot learning processes during training. In terms of age, brain development studies have shown that brain development continues into emerging adulthood, which implies that the brain fully matures only around mid-twenties (Dumontheil, 2016). What are the implications, if any, for training when it comes to age? Further, there were different problems associated with the number of flight hours, though it seems more to do with the type of flight background rather than flight hours. Future research should investigate how these differences affect the pilot’s learning experiences and how the training system can cater for such differences.

The aviation industry at times contains terms of words that are used often, but difficult to describe specifically. For example, airmanship, situational awareness, multi-crew; how are these concepts understood by pilots and how does one effectively teach these skills? While these words are useful to understand what was wanted by the airline, they do little to describe the essence of what needs to be achieved. Therefore, it is suggested that a phenomenological approach to research, while not common in aviation, but still occurring (e.g., Lempereur & Lauri, 2006; Mavin, 2010) could assist in uncovering the essence (Giorgi & Giorgi, 2003) of words and constructs used in aviation, before more detailed, or large scale, experimental/objective research should be conducted.

The findings of the study showed that pilot trainees continue to learn as they progress to line training and even after their check to line. Some pilot trainees in the study stated that they had learned a lot during line training and were still learning even after their check to line. Unfortunately, the only data source collected for those two segments of training (i.e., LT and CTL) was through interviews. Furthermore, as pilot trainees were very busy during those segments of training, it was difficult to schedule more consistent follow-up interviews. As trainees felt that they were learning more during line training, it would be useful to identify clearly what they were learning and if their learning was about new tasks, or whether it is where they consolidate what they have learned, or both. It was also at this stage of training where pilot trainees expressed having to manage their own behaviours when dealing with captains and flight instructors who had different
approaches to procedures. Future research should conduct in-depth investigations into pilot learning at these segments of training. Specifically, what aspects of training are applied directly when transitioning to line training, or required adaptations, or cannot be applied, or even never taught before? The theory of situated learning by Lave and Wenger (1991), alongside theories used in this thesis, may be useful in identifying these forms of learning when pilot trainees start conducting line operations.

Though only briefly discussed by two pilot trainees in Airline B during their CTL interview (see Section 4.7.6.2, p. 185), the findings of the study suggest that low hour pilots had problems flying the aircraft when they had to judge the height of aircraft during the approach without automation guidance, or with vertical awareness. This issue was in relation to conducting visual approaches during circuits. Here it was suggested that the removal of the VNAV function (i.e., switching to manual flight) which meant the need to self-calculate the vertical speed and still flying within tolerance was difficult. A quick follow-up interview with pilots from Airline A regarding this issue revealed mixed responses, with some suggesting that it was a non-issue because of constant use from previous work experience, while others agreeing that it involves some form of guessing when it comes to determining aircraft vertical profile. However, the question now is whether such skills were taught in the first place (i.e., during ab initio training), or is it a skill that was usually left to pilots to develop as they accrue more “flight experience” in general aviation prior to entering the airline. If so, the mandate of airlines to use automation more often means even lesser opportunities for pilots to practice such skills. Should such a skill be practised with passengers or in a simulator to ensure pilots can develop those skills appropriately? More research is required.
Chapter 6. Conclusion

This thesis began by discussing the forecast pilot shortage and training standards issue faced by the airline industry. While there have been changes to the required standards of pilots entering the airline, not much is known on how airlines enact such changes. While little is known about the training processes used by airlines, much less is known about trainee experiences during those processes.

The study focused on the perspective of trainees as they progressed through training, addressing a gap in the literature of pilot learning. By adopting a constructivist perspective and using a qualitative case study approach, this study focused on how ten trainees (cases), learned and developed during their initial first officer training. By following their journey, this study developed a heuristic model—First Officer Development Model (FODM)—that mapped the general development of pilots as they become first officers.

The study showed that considerations should be made in relation to manual flying skills and instruction of aircraft automated systems. As flight path management is a crucial aspect of safe flight operations, these two skills must be developed appropriately. Another aspect that was highlighted was the concept of timing when carrying out procedures. This factor was not well taught during training and was left to pilot to learn on his or her own. Furthermore, while crew resource management has been carried out in airlines, the findings showed that pilot social skills need further development/instruction. Finally, the findings of this study highlight important issues that training organisations should bear in mind when planning training programs, especially those tackling the issue of pilot shortages.

The case study research approach used in this study was appropriate when understanding the learning experiences of pilot trainees. The continuous engagement between researcher and pilot trainees throughout their entire initial training program provided insights into their learning processes that would be missed with other forms of research. However, several considerations must be made before other researchers adopt this research approach. Most importantly, the analysis showed the importance of having at least one
research member who has extensive domain-specific expertise to ensure that findings of performances reflect the realities of practitioners.

Future research should continue to focus on the learner’s perspective when investigating the effectiveness of training. The curriculum theory used as a lens to categorise training programs into the intended, enacted and experienced curriculum is useful in this study as it showed the different perspectives of pilot training. However, the emphasis of training effectiveness should focus on the experienced curriculum, as the student is the one subjected to the training practices. Through their perspectives, a bottom-up approach to improving training can be used. This thesis concludes by stating that to improve aviation training more attention needs to be given to the trainees learning processes.
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QSR International. (2015b). *Understand nodes and cases in NVivo for Windows*. Retrieved from https://www.youtube.com/watch?v=l5dJOKkJZxs&list=PLNjHMRgHS4Fc x3NfpKsaqXuGdcxI9y-Qa&index=4


Appendices
Appendix A  Information and consent form

Airline pilot training: An appraisal of current practice
Griffith University Ethical Approval: EDN/12/15/RREC

INFORMATION SHEET

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You are asked to consider participating in a collaborative research program between Griffith University and your airline. The research is entitled "Airline pilot training: An appraisal of current practice". This study is funded through a research grant from the Australian Research Council (LP140100057) and supported by Mount Cook Airlines (New Zealand), QantasLink (Australia) and the Royal Australian Air Force.

Why this research is being conducted.

In regards to airline pilot training, there have been limited reviews on the fundamental processes of how effective current training curriculums prepare pilots for work. For this study, we are investigating how pilots are trained at two critical stages of training: (1) initial first officer training, including type rating; and (2) command upgrade training. The study will review current training practices with a focus on how curriculums developed by senior pilots (curriculum planners), taught by instructors, and experienced by student (new first officers or command upgrade candidates) work in practice. This project addresses the limitations in our understanding of airline pilot training programs.

Who is involved and what you will be asked to do.

In order to develop a holistic understanding of the entire training process we will be investigating either initial first officer training programs or command upgrade training. You will be in either one of these groups and will also be a curriculum planner, instructor/examiner or student.

Curriculum planner: Pilots involved in developing previous and current training programs. They will be asked to answer questions regarding to the development of training curriculums, and how and/or why these changed occurred over time. In all cases, interviews will be recorded to assist with later data analyses.

Instructor and/or examiners: Those involved in teaching and/or assessing trainees. This group of participants will be a major focus of the study. We will ask to be involved in their lessons and when appropriate, and when time is available, ask questions during training. Longer interviews will be conducted after each training block to obtain their perspective of the entire training segment. In all cases, interviews and lessons will be video and recorded to assist with data analyses.

Pilot trainer: Pilots in this group – like instructors – will be the main focus of this study. They will be asked to complete a series of surveys at the commencement of their training and during simulator sessions. They will be briefly interviewed throughout their training, including ground school, simulator training and line training. Most contact will be face to face and will be informal. However, during line training, due to difficulties maintaining contact with pilots, discussions will more likely be via telephone or other means, such as Skype. As a way of conducting a thorough
analysis at a later date, we will be video and audio recording ground courses, interviews and simulator training sessions (briefing, simulator and debriefing).

All participants in this study will not be asked to do anything different from what has been planned by the airline or outlined here, but simply allow our research team to follow your progress. We will at all times, limit our intrusion as much as possible. This study has been sanctioned and supported by your company’s senior management: pilots, your company’s head and pilot union.

Note: Interviews and classroom lessons will be either video and/or audio-recorded when possible or convenient. Participants will be informed when recordings are being conducted. The researcher will not video- or audiotape simulator session, nor will we be present. However, we will retain a copy of the debriefing tool video data. All recording data from the study allows researchers to conduct analysis at a later date.

Is this voluntary?

Participation in this study is entirely voluntary and is no way connected to your employment. If any one pilot (student or instructor) involved in a particular training exercise does not wish to be involved, that training exercise will be excluded from the study. If you wish to be involved, we ask you to sign the attached consent form and return to the investigator.

If you wish to withdraw from the study at any time, you are free to do so. Your decision does not affect your employment (status). Once the audio and video recordings have been transcribed, participants are anonymized. Given the size of the data set, analysis may take a couple of years. However data will be destroyed after project completion or five years.

The expected benefits of the research

Benefits for this research include: advancing the literature of training in aviation; formulations of new models of learning in pilot training; advance of improved and/or new training methods that promotes effective learning and development in pilot training specifically and other professions broadly. You, as others, will be informed of the outcomes of the study without any possibility that your participation can be identified.

Risks to you

There are no known risks associated with this study that is not already apart of your normal job role as a pilot.

Your confidentiality

Your participation is known because of the simple fact of the social context of data collection. However, all information gathered is kept in the strictest confidentiality within the research team. No individual pilots will be revealed during the reporting of this research without their specific consent. All information will be kept in password-protected files known only to the researchers.

Should you wish to withdraw at any time during the research, you may do so without prejudice. Overall, all data collected throughout the study will, where possible, be de-identified to maintain confidentiality and anonymity and stored separately. Your privacy will be managed by the research team at all times.

Whilst the data will be kept in the strictest confidence, we would like to seek permission for a small sampling of the images to be used for academic publications and or conference presentations. It is assumed, that by signing this consent form you will not automatically agree to this. An additional signature will be required by yourself at the end of the consent form if you agree to this.
Further information

You may contact the Chief Investigator Associate Professor Tim Mavin by email t.mavin@griffith.edu.au, or call on +61 7 XXXX XXXX or +61 XXX XXX XXX. Alternatively if you would like to speak to an officer of the University not involved in the study, you may contact Griffith University Research Ethics on 373 54375 or research-ethics@griffith.edu.au. If significant new findings develop during the course of this study that may relate to your decision to continue participation, you will be informed.

The ethical conduct of this research

This study adheres to the guidelines of the ethical review process of Griffith University. The information sheet should indicate that Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on +61 7 373 54375 or research-ethics@griffith.edu.au.

Feedback to you

All participating pilots will receive general updates about the study through email. Pilots can also request a brief descriptive summary of their own performance following the completion of their initial training. On completion of the research, participants, via a companywide report, will be given appropriate and timely summary of the results of the overall research.

Privacy Statement

The conduct of this research involves the collection, access and/or use of your identified personal information. As outlined elsewhere in this information sheet, your identified personal information may appear in the publications/reports arising from this research. This is occurring with your consent. Any additional personal information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for further research purposes. However, your anonymity will at all times be safeguarded, except where you have consented otherwise. For further information consult the University’s Privacy Plan at http://www.griffith.edu.au/about-griffith/plans-publications/griffith-university-privacy-plan or telephone (07) 3735 4375
Airline pilot training: An appraisal of current practice
Griffith University Ethical Approval: EDN/12/15/RREC
CONSENT FORM

Associate Professor Tim Mavin  Griffith University  +61 XXX XXX XXX
Ms Cassandra Soo  Griffith University  +61 XXX XXX XXX

PROGRAM:  □ TYPE RATING  □ COMMAND UPGRADE

ROLE:  □ CURRICULUM PLANNER  □ INSTRUCTOR/EXAMINER  □ STUDENT

You are involved in a type rating program or command upgrade program. You are also a curriculum planner, instructor/examiner, or trainee. You will be involved in some or all of the following activities depending on program or role:

- Be interviewed about previous and current training program developments and implementations
- Complete a few short surveys at the beginning of the training program and throughout the training program.
- Be briefly interviewed after each lecture or when convenient.
- Be interviewed on completion of training blocks.
- Allow the interview to be recorded with a voice recorder.
- Allow the researchers to observe your ground courses.
- Allow the researchers to record your simulator detail, including briefing, simulator session and debriefing.
- Be contacted via Skype or emails to ask about line training until you are checked to line.

By signing below, I confirm that I have read and understood the information package and have noted that:
- I have had any questions answered to my satisfaction;
- I understand the risks involved;
- I understand that there will be no direct benefit to me from my participation in this research;
- I understand that my participation in this research is voluntary;
- I understand that if I have any additional questions I can contact the research team;
- I understand that I am free to withdraw at any time, without comment or penalty;
- I understand that I can contact the Manager, Research Ethics, at Griffith University Human Research Ethics Committee on (07) XXX XXXXX (or research-ethics@griffith.edu.au) if I have any concerns about the ethical conduct of the project; and
- I agree to participate in the project.

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
</tr>
<tr>
<td>Date</td>
</tr>
</tbody>
</table>

Sign below if you consent to the following:

□ I agree to still images (4) being used for academic publications
Appendix B  Interview protocols

Initial interview protocol
1. Explain purpose of research
2. Remind participants of their rights to: withdraw without repercussions, data is kept in strictest confidence, and all identity will be anonymised.
3. Remind participants that as per consent form, all interviews were recorded, though can be stopped when requested.
4. Set up recorder if approved
5. Ask questions about:
   a. Aviation background
   b. Expectation of self in training
   c. Future aspirations in aviation
   d. Company impression and training experience so far
6. Stop recording
7. Exchange contact details and negotiate preferred method of contact
8. Thank participant for their time
9. Set next interview session

Example questions:
• Briefly outline your personal history and working life to date.
• Could you explain briefly how you came to be doing your current work?
• What did you do to get here?
  o Where do you want to end up?
  o What are your aims/goals for entering this airline?
  • Would you move to another airline? Why? (larger airline or others)
• What motivates you to engage in paid employment?
• Why this employment?

Reflective and follow-up interview protocol:
1. Greet participant, remind them of their rights as participants and audio recording of interviews
2. Set up recorder if approved
3. Ask following questions:
   PERSONAL
   a. What was easy (why? Describe...)
   b. What was hard/difficult/challenging (why? Describe...)
   c. What did you do to prepare for the lesson (why? Describe...)
   d. What will you do to prepare for the next lesson (why? Describe...)
   e. Previously you mentioned ( ), how is it for you now?
   f. Any other things that you would like to talk about? Anything else about training you’re finding helpful or difficult?
   TRAINING RESOURCES
   a. Any specific training methods you found useful or not useful?
   b. How were the instructors? (like/dishlike, why?)
   LESSON PREPARATION
   a. Will you studying tonight?
   b. What will you be studying tonight?
   c. What will you be using?
4. Stop recording
5. Thank them for participating
6. If possible, plan next interview session

Prompts
• Talk me through...
• Tell me about today...
• Can you give me an example?
Appendix C  Example of time schedule

Week 2 simulator data collection schedule for Airline A

20 mins drive from hotel
Appendix D  Field notes example

[edited to remove identifying information and align context]

18/12/2015 (Airline A - GT1 day 4)

- P1 came in earlier (8am, normally 8.30am) to start studying as he needed to leave for medical around 11am.
  - Came back around 2pm, mentioned being distracted → follow up
- P2 and P6 arrived slightly late
  - P2: 9am (left hotel late)
  - P6: 9.30am → follow up
- Little conversation occurring in -600 room and -500 room. Everyone seems to be doing their own thing, including instructors
- P3 asked to use FPT, instructor agreed → follow up
- Instructors planned on taking pilots out to look at a real aircraft
  - Did not happen because no aircraft available
- -600 session received impromptu presentation on phase of flight → follow up
- Pilots and instructor starting to leave ~4
Appendix E  Lesson plan examples

Image removed
Image removed
## Appendix F  Statement summaries for each theme

This table provides the list of summarised statements for useful excerpts of each theme. Some coded excerpts excluded from list as they were too short or vague. Number of excerpts statements do not reflect total number of coded comments.

<table>
<thead>
<tr>
<th>GT1</th>
<th>GT2</th>
<th>PT</th>
<th>SIM1</th>
<th>SIM2</th>
<th>SIM3</th>
<th>LT</th>
<th>CTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>Subject not hard, just large Systems was difficult to learn sometimes not due to content but due to amount</td>
<td>lack of knowledge on aircraft performance/limitations</td>
<td>Lack of understanding of procedure (and performance) – wind shear</td>
<td>Lack of knowledge of procedure and performance</td>
<td></td>
<td></td>
<td>Difficulty remembering engineering knowledge (near cyclic)</td>
</tr>
<tr>
<td>Prioritisation of information</td>
<td>Large amount of potentially unnecessary information that goes into too much detail</td>
<td>Difficulty prioritising information: do I really need to know this?</td>
<td>Difficulty determining essential information from background information</td>
<td>Prioritise information through exam examples</td>
<td>Difficulty prioritising information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training material and actual work inconsistency</td>
<td>New information</td>
<td>Automation - Never used automation before, only manual flight, difficulty understanding what has been changed to automation from manual flight</td>
<td>Electrics - Used FPT to build visual/idea before studying</td>
<td>Electrics - Different button but same name</td>
<td>Engine Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(R) Training material and actual work inconsistency</td>
<td>Ice and rain</td>
<td>Oxygen instructor explain information when asked</td>
<td>Ventilation GPS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Past experience
  Past experience with automation did not transfer
  Past experience with automation, knowledge transferrable
  Previous job involve automation and glass cockpit, transferrable
  Previous job used similar automation system
  Past experience made understanding easy
  Past experience made understanding easy
  Past experience made understanding easy
  Past experience made understanding easy

Acronyms
Getting used to the abbreviations
Getting used to abbreviations in a sentence
Visualising information
Difficulty visualising links
Trying to understand links between systems difficult
difficulty working out how different systems are connected
Presentations show connections between different components
FPT provides practical aspects that link information together
FPT not useful if already have background knowledge
- Aircraft
Consolidate information from [CBT-SYSTEMS]
Visualise aircraft instruments
Famil: Transfer what was seen in flight to class
observe crew coordination and use of SOP
Watching interaction surprised by speed of procedure at different phases of flight
difficulty visualising information
Aircraft performance
Difficulty understanding aircraft speeds and application
Instructional technique
Class was not interactive, difficult to maintain focus

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Task: Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm existing knowledge on operating GNSS</td>
<td></td>
</tr>
<tr>
<td>Incorrect FMS manipulation</td>
<td></td>
</tr>
<tr>
<td>Programming FMC, have certain tricks</td>
<td></td>
</tr>
<tr>
<td>Theory to practice: remembering how to program</td>
<td></td>
</tr>
<tr>
<td>Transition to FBT, positive, able to develop motor skill</td>
<td></td>
</tr>
</tbody>
</table>

| Task: Different landing technique for different flap settings |
| Task: Motor |
| Learning how the aircraft handles |
| Landing techniques difficult |
| Getting used to aircraft speed |
| Manual flight also has temporal, need to pull power back instinctively |
| Crosswind landing initially challenging though learned by end of lesson |
| Learned handling tips from instructor (have expectation that information should be provided in materials) |
| GA to airline: initial action of high angle of attack recovery procedure |
| Landing: unable to land properly |
| Could not perform steep turns |
| Inaccurate information in document – learn wrong ‘thing’ |
| Getting used to aircraft handling (circuit) |
| Circuit was messy: instructor talked through vs briefed then self-perform |
| Task: Verbal |
| Learning procedure: memorising tasks (calls and checks) |

| Task: Motor |
| Workload of multiple actions |
| Trimming increases workload (required for automation use) |
| Engine failure - getting used to aircraft |
| Engine failure: flying technique (doing actions at same time rather than sequence) |
| Engine failure: flying technique (doing actions at same time rather than sequence) |
| Anticipating aircraft performance |
| Learning manual control input to get desired result |
| Depth perception in sim confusing |
| Difficulty learning flare and touchdown |
| Crosswind technique different from GA |
| Task: Verbal |
| PA task |
| Phraseology or PA task |
| GA and phraseology |

| Task: Motor |
| Using incorrect flying technique during circuit |
| Go-around: additional action of pulling back speed |
| Engine fire after take off – high workload (multiple memorised tasks) and high stress environment/time limited |
| Additional actions not in SOPs |
| Crosswind landing: challenging at start |
| Proximity of instrument |

| Task: Verbal |
| Workload associated with giving orders/calls |
| Difficult procedure: engine failure at take-off (multiple tasks) |

| Task: Motor |
| Cross-wind landing: getting used to aircraft |
| Landing: sim technique slightly different |
| Landing: sim technique incorrect |
| Landing: sim technique works |
| Landing: getting used to it, flare |
| Getting used to aircraft handling |
| Practice manual flying: learning technique |
| Other normal tasks not done during sim |
| Scan |
| Paperwork |
| Weather and radar |

| Task: Verbal |
| Instructor provide suggestion on briefing |
| Unsure on proper radio call phraseology at different locations |
| Contacting ATC |
| Radio calls – assumed knowledge by company |

<p>| Task: Motor |
| Manual flying (still learning) |
| Manual flying during circuits |
| Getting easier |
| Aircraft control improving |</p>
<table>
<thead>
<tr>
<th>Sequence</th>
<th>Seeing procedure in practice was good [MODEL]: offers prioritisation (sequence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence</td>
<td>difficulty remembering how to program FMC/FMS procedure</td>
</tr>
<tr>
<td>Sequence</td>
<td>Remember sequencing of tasks (carrying out series of tasks)</td>
</tr>
<tr>
<td>Sequence</td>
<td>Difficulty remembering flows (pre-cockpit set up)</td>
</tr>
<tr>
<td>Sequence</td>
<td>Learning SOP as FO and different roles (PF/PM); sequence and temporality</td>
</tr>
<tr>
<td>Sequence</td>
<td>Learning procedure easy once accustomed, crew coordination embedded within</td>
</tr>
<tr>
<td>Sequence</td>
<td>procedure difficult crew coordination and rules embedded with procedure</td>
</tr>
<tr>
<td>Sequence</td>
<td>Difficulty learning flows and calls, require partner</td>
</tr>
<tr>
<td>Sequence</td>
<td>Mistakes in crew coordination causes confusion</td>
</tr>
<tr>
<td>Sequence</td>
<td>Self or partner induced interruption affect flow</td>
</tr>
<tr>
<td>Sequence</td>
<td>Trying to stay ahead, crew coordination and sequence [MODEL]: theory alone is</td>
</tr>
<tr>
<td>Sequence</td>
<td>confusing</td>
</tr>
<tr>
<td>Sequence</td>
<td>Difficulty understanding [MODEL]</td>
</tr>
<tr>
<td>Sequence</td>
<td>Some procedures are long</td>
</tr>
<tr>
<td>Sequence</td>
<td>Engine flameout and engine fire sequence</td>
</tr>
<tr>
<td>Sequence</td>
<td>Making a plan and executing at appropriate time</td>
</tr>
<tr>
<td>Sequence</td>
<td>Evacuation procedure: planning beyond written procedure</td>
</tr>
<tr>
<td>Sequence</td>
<td>Never thought about sequencing</td>
</tr>
<tr>
<td>Sequence</td>
<td>Inconsistency in mistakes</td>
</tr>
<tr>
<td>Sequence</td>
<td>SOPs interpreted differently and conducted differently (timing and sequence</td>
</tr>
<tr>
<td>Sequence</td>
<td>wise), becomes confusing</td>
</tr>
<tr>
<td>Sequence</td>
<td>Dealing with interruptions has become easier</td>
</tr>
<tr>
<td>Sequence</td>
<td>Interruption to process not problematic</td>
</tr>
<tr>
<td>Sequence</td>
<td>Transition from single to multi-crew easy, just follow procedure</td>
</tr>
<tr>
<td>Sequence</td>
<td>Some procedures are more complicated than others, some require more crew</td>
</tr>
<tr>
<td>Sequence</td>
<td>coordination alone</td>
</tr>
<tr>
<td>Sequence</td>
<td>Captain role critique, affects flow of process, initiating certain processes</td>
</tr>
<tr>
<td>Sequence</td>
<td>captain role during training: missing important triggers</td>
</tr>
<tr>
<td>Sequence</td>
<td>Critique of having to play captain role, causes confusion with own role.</td>
</tr>
<tr>
<td>Sequence</td>
<td>Increase workload during an already steep learning curve</td>
</tr>
<tr>
<td>Sequence</td>
<td>Linking multiple procedures</td>
</tr>
<tr>
<td>Sequence</td>
<td>Go-around and developing beyond one sequence</td>
</tr>
<tr>
<td>Sequence</td>
<td>Different places have different problems, requiring adaptations</td>
</tr>
<tr>
<td>Sequence</td>
<td>Putting tasks in sequence, learned from safety officer forks in sequences</td>
</tr>
<tr>
<td>Sequence</td>
<td>Forks in procedures previously unknown</td>
</tr>
<tr>
<td>Sequence</td>
<td>Flows are fragile</td>
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<tr>
<td>Sequence</td>
<td>LOFT exercise</td>
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<tr>
<td>Sequence</td>
<td>One engine inoperative circuit</td>
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<tr>
<td>Sequence</td>
<td>Linking procedures in flight operation (management of flight)</td>
</tr>
<tr>
<td>Sequence</td>
<td>Remembering roles, rules and corresponding task</td>
</tr>
<tr>
<td>Sequence</td>
<td>Getting used to crew coordination</td>
</tr>
<tr>
<td>Sequence</td>
<td>[MODEL]: guides management sequence [MODEL] is good but requires a lot of</td>
</tr>
<tr>
<td>Sequence</td>
<td>understanding and practice</td>
</tr>
<tr>
<td>Sequence</td>
<td>Visual circuit</td>
</tr>
<tr>
<td>Sequence</td>
<td>Famil flight-triggers for action</td>
</tr>
<tr>
<td>Sequence</td>
<td>Speed of work</td>
</tr>
<tr>
<td>Sequence</td>
<td>Sim vs line (transfer)</td>
</tr>
<tr>
<td>Sequence</td>
<td>Sim vs line (different)</td>
</tr>
<tr>
<td>Sequence</td>
<td>Becoming more familiar</td>
</tr>
<tr>
<td>Sequence</td>
<td>Forks in procedures previously unknown</td>
</tr>
</tbody>
</table>

<p>| Trigger | Difficulty transferring knowledge from classroom to sim                        |
| Trigger | Difficulty remembering next sequence                                          |
| Trigger | Difficulty learning roles and triggers for next action                        |
| Trigger | Difficulty triggering next sequence                                           |
| Trigger | Limitations in trying to learn procedures with crew coordination alone        |
| Trigger | Captain role critique, affects flow of process, initiating certain processes |
| Trigger | captain role during training: missing important triggers                      |
| Trigger | Critique of having to play captain role, causes confusion with own role.      |
| Trigger | Increase workload during an already steep learning curve                      |
| Trigger | Crew coordination as trigger for action                                       |
| Trigger | Developing trying to learn cues, anticipating aircraft performance            |
| Trigger | Missed minima call (precision and non-precision approaches)                  |
| Trigger | Preparing for circuits                                                       |
| Trigger | Manuals: SOP detail                                                           |
| Trigger | How things are done: task and trigger                                        |
| Trigger | Carrying out procedure requires triggers                                     |
| Trigger | Learning from manual: remembering task, order and trigger                    |
| Trigger | Single vs double engine                                                      |
| Trigger | Learning triggers                                                             |
| Trigger | (SOP/FCOM)                                                                    |
| Trigger | Remembering procedures better                                                  |
| Trigger | Visual circuit                                                                |
| Trigger | Famil flight-triggers for action                                              |
| Trigger | Speed of work                                                                 |
| Trigger | Sim vs line (transfer)                                                         |
| Trigger | Sim vs line (different)                                                        |
| Trigger | Becoming more familiar                                                        |
| Trigger | Forks in procedures previously unknown                                        |
| Trigger | Circuits the problem with circuits insufficient training for circuits         |
| Trigger | Some procedures need to be reviewed                                           |
| Trigger | Sequencing of new tasks on line                                              |</p>
<table>
<thead>
<tr>
<th><strong>Timing</strong> learning limitations with working with a poster, no timing or actions (temporality or motor skill)</th>
<th><strong>Timing</strong> learning Learning from manual – presentation illustrate temporality Partner Difficulty slowing down for some procedures (rushing)</th>
<th><strong>Timing</strong> Aircraft Getting prepared earlier: Management of flight – approaches Pauses in sequences: corresponding to aircraft performance Control jam procedure – some procedure are more time constraint Control jam procedure – knowing when (cues) to prompt action Partner Sequencing and timing of procedure</th>
<th><strong>Timing</strong> Aircraft Difficulty developing temporality when revising with poster Remembering and actioning Aircraft performance and rushing Remembering procedures better Rushing during procedures</th>
<th><strong>Timing</strong> External Interruption to sequence: time pressure Making a logical sequence of procedures Dealing with changes Mnemonic Use card (tool) checklist Developing flows to try and manage workload or busy- ness Dealing with mistakes, lesson learned [MODEL] – dealing with non-normal, multi-crew Working with people outside the flightdeck Getting back after being interrupted</th>
<th><strong>Timing</strong> [reflection] timing of tasks in procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Video of pilot interaction and communication</strong> Video on crew performance show the importance of communication Company emphasis CRM showed what was expected of them during work (multi-crew)</td>
<td><strong>Learning to work together</strong> Supporting partner Overload by partner and instructor</td>
<td><strong>Communication</strong> Working together and workload Emergency/non-normal workload management Distracted by partner Trying to work effectively with partner Social aspect of multi-crew in addition to technical aspect difficulty slowing partner down/effect of partner</td>
<td><strong>Shared SA: multi-crew and speed of action</strong> Communication interruption (part of SOP) Difficulty learning ‘multi-crew’ Communication between partner Cruise Management is self-taught, some not written in SOP Slipping into old habits</td>
<td><strong>Working with captain:</strong> everything flows quicker Captain dependent captain offers support Captains are proactive Captain ‘know what they’re doing’ - easier and safety net Captain offers support Captain offers safety net Impression of multi-crew Changing impression of multi-crew Reliance on multi-crew to catch errors</td>
<td><strong>Dealing with emergencies:</strong> Reliance on captain Need to be comfortable with working with people you don’t like, or communicate with someone senior Be supportive, don’t be intimidated by seniority Past experience with multi-crew help understanding and dealing with different personalities better, even when disagreeing Learning to communicate with captains without offending them Sterile cockpit – everyone follows rules differently Communicating with (difficult) captains Captain not following SOP Need to learn to communicate intentions more Different captains, different ways of doing Not ready for next task No more safety net of training captain No training captain monitoring, no input from captain Discussion with captains when time permits Cockpit environment determined by captain Getting used to working with other people (captains)</td>
</tr>
<tr>
<td>Automation</td>
<td>GNSS simple to use Easy to understand, was not hard GNSS is new Theory should be provided before practical aspects</td>
<td>Past experience assist understanding autopilot, FMS needed practice Difficulty understanding functionality of automation Difficulty programming FMS</td>
<td>Difficulty understanding automation modes Difficulty understanding links between automation devices, lack of practice</td>
<td>Lack of continuity in FMS use (require more practice) lack of understanding increases work load—use of automation during engine failure Automation during non-normals sometimes surprising Previous training Difficulty understanding different functions and programming changes Use of automation during emergencies Unsure on how to use automation during engine failure Lack of information of automation use</td>
<td>Use of automation during emergency Need more practice Understanding functionality Use of VNAV - functionality Use of VNAV – understanding how it works Using automation as part of flight operation was hard Automated induced stalls Influence of past experience Assist in understanding functionality Difficulty getting used to automation (mostly manual)</td>
</tr>
</tbody>
</table>