Applying Learning Analytics in Designing for Professional Skills and Attributes in Tertiary Education

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Chapter 12
Applying Learning Analytics in Designing for Professional Skills and Attributes in Tertiary Education

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ABSTRACT

In this chapter the authors explore the use of learning analytics (LA) to track skills acquisition in tertiary education environments, with a specific focus on group work skills. They discuss the importance of design for learning with regards to developing professional attributes and skills for collaborative group work projects, before considering the role of learning analytics in shaping educational experiences that relate to such skills and attributes. Finally, they outline a design process used to develop and implement an iterative learning analytics evaluation approach to the design for learning in collaborative team projects.

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1. INTRODUCTION

Professional skills and attributes are an important part of what universities promise their students they will have attained upon graduation. Graduate profiles include lists of such skills and attributes, for example communication skills, resilience, and ability to work in groups. Yet, in learning environments with a strong focus on disciplinary content, the development of professional skills and attributes is often unclear. Even if they are listed in the learning outcomes of individual courses, they are not necessarily assessed, and they are even less likely to be assessed at different levels in an overall degree. Part of the reason for this may lie in the challenge of assessing skills and attributes for which the development relies on incremental changes over time and the honing of skills through repetition, such as group work skills. This is quite different from assessing the achievement of self-contained bits of disciplinary knowledge, for example in the form of an exam. Similarly, when it comes to providing feedback, it is more challenging to provide feedback on a particular skill or attribute that can always be improved, than on a skill or a bit of knowledge that has demonstrably been achieved.

In this chapter we explore the use of learning analytics (LA) to track skills acquisition in tertiary education environments, with a specific focus on group work skills. In other words, what kind of data can we collect to provide meaningful feedback to individual students on the development of skills such as the ability to work in teams or communication skills. We discuss the importance of design for learning with regards to developing professional attributes and skills for collaborative group work projects, before considering the role of learning analytics in shaping educational experiences that relate to such skills and attributes. Finally, we outline a design process used to develop and implement an iterative learning analytics evaluation approach to the design for learning in collaborative team projects. In this context, the promise of learning analytics lies in its iterative potential, which means it can be used for both summative and formative assessment, but is especially useful in formative assessment *for* learning, rather than summative assessment *of* learning. The formative part is particularly important in the context of developing professional attributes and skills, as there is a formative and iterative element to the development of such skills. Using learning analytics data on a continuous basis, and visualising such data as part of the process, potentially allows us to track the development of professional attributes and skills as part of the learning process, meaning we can also adjust our learning design in a just-in-time manner.

The purpose of this chapter is to offer general concepts, principles, and methods for planning and implementing evaluation processes for collaborative team projects, with a specific focus on utilising the power of LA to enhance team and individual performance and learning outcomes at varying levels. We conclude by outlining the feasibility of the approaches we are proposing, as well as the resources needed, and the risks involved.

2. LITERATURE REVIEW

2.1. The Broader Context: Designing for Professional Skills and Attributes in Tertiary Education

There is a growing recognition of the importance of professional skills and characteristics, commonly known as graduate attributes, within curricular and pedagogical design in tertiary education. These graduate attributes, as Bowden et al. (2000) articulate, are "the qualities, skills, and understanding a university

community agrees its students should develop during their time with the institution." They encompass more than just the disciplinary expertise or technical knowledge that has typically been the mainstay of most university courses. Instead, these attributes extend further to prepare graduates as agents of social good, ready to face an unpredictable future.

This paradigm shift has been propelled by the understanding that disciplinary content knowledge, though crucial, is not the only factor determining graduates' success in an increasingly intricate and dynamic professional world (Oliver & Jorre de St Jorre, 2018). Today's professionals require a comprehensive skill set that includes problem-solving, critical thinking, communication, and teamwork (Oliver, 2011; Oliver & Jorre de St Jorre, 2018). These skills are not confined to a particular professional context but are broadly applicable and essential for navigating an evolving workplace environment. Consequently, those involved in tertiary education — from educators to curriculum designers — have been placing greater emphasis on integrating these skills into the learning experience, aiming to produce well-rounded graduates.

Collaborative group projects, integrated into the tertiary education curriculum, provide a practical platform for students to develop and refine these crucial professional skills and attributes (Fittipaldi, 2020). Such projects bridge theoretical knowledge and practical real-world problems, thus enriching students' understanding of the subject matter (Balasooriya et al., 2016; Hamer & O'Keefe, 2013; Michaelsen & Sweet, 2008). Beyond this, they necessitate students to work collectively towards a shared goal, cultivating skills such as collaboration, decision-making, communication, and conflict resolution. They also invite students to assume diverse roles and responsibilities within the group, enhancing their adaptability. Simultaneously, these collaborative projects simulate professional environments, presenting an invaluable opportunity for educators to assess the development of these skills and attributes.

Despite many tertiary institutions frequently listing expertise in groupwork as a desired outcome in their graduate profile statements, they often fail to effectively equip students with the necessary skills for successful collaboration. Thus, while institutions regularly employ groupwork activities throughout their courses and assess students based on both the process and outcomes, they generally provide minimal, if any, formal instruction regarding the strategies and practices that constitute effective groupwork (Fittipaldi, 2020). It is essentially assumed that students will autonomously recognise and define successful groupwork strategies, master their implementation through mere participation in group assignments, and gradually refine their groupwork skills throughout their academic journey, without significant guidance from the institution. The reality is of course rather different and as a result, students' perceptions of group work are often negative and characterised by frustration (Butt, 2018; Koh et al., 2009). However, well-designed group work projects and activities, with clear expectations and learning outcomes, as well as a clearly expressed rationale for their value, may address some of these negative perceptions. Part of well-designed group work is students feeling the project is meaningful, that they have a stake in it, as well as a sense of agency.

Understanding the significance of agency in groupwork is crucial, particularly in an academic environment. As students traverse their academic journey, it is logical to predict that their proficiency and agency in employing groupwork abilities will steadily grow, thus decreasing their dependency on instructors' assistance. Nevertheless, these proficiencies and strategies do not instantaneously appear; they mature along a continuum. At the outset of a course or program, this spectrum is typified by considerable faculty input. As students move forward, the scenario changes towards fostering more self-reliance and autonomy. This evolutionary path is reflective of expectations in the professional sphere, where graduates are expected to exhibit substantial individual agency, especially in team-oriented scenarios.

Consequently, it is pivotal for tertiary institutions to nurture this gradual enhancement of agency in groupwork, synchronizing academic experience with workforce preparedness.

2.2 Challenges of Assessing Skills and Attributes in Group Work

The challenge of assessing individual skills and attributes in the context of group activities in tertiary education is complex. In contrast to professional settings with predefined roles, the more fluid and evolving nature of group roles in tertiary education further complicates the task. This fluidity makes it difficult to clearly delineate and evaluate individual skills and contributions, especially those graduate attributes such as leadership, problem-solving, and adaptability, that might surface organically within group dynamics.

Current assessment methods often struggle to accurately appraise individual contributions, frequently focusing on the product rather than the process that led to its creation. As Nordberg (2008) explains, "the work of the individual is lost in the product of the group" (p. 481). This emphasis on the product often leaves the processes and efforts made by individual group members unacknowledged. Group-level assessments may not differentiate between the efforts of group members, inadvertently rewarding those contributing less and penalising those working hard. This can negatively impact motivation, trust, and the development of critical graduate attributes, reinforcing the need for a more process-oriented assessment approach.

However, it is not just the assessment of individual contributions that is fraught with difficulties. Forsell et al. (2020) highlight another under-explored aspect of groupwork assessment: the role of teachers as assessors. Their study found that while peer assessment is a significant focus in the research field, the role of teachers in this context has received less attention. This gap is surprising, given that teachers, as facilitators of learning, play a critical role in evaluating and guiding the development of graduate attributes. There may be several reasons for this, ranging from the complexity of group work assessment to a lack of established methodologies, and to a lack of visibility of what groups do outside of formal classes. The lack of focus on teachers as assessors in group work assessments underscores the multifaceted challenges in this field.

Peer evaluations, although designed for a more nuanced evaluation, can be influenced by social biases, fear of retaliation, or lack of clarity about evaluation criteria. Self-assessments, too, are often skewed due to inherent biases or students' inability to objectively evaluate their own skills and contributions. Recent research around the development of evaluative judgment can be seen as a response to this issue, as well as developing a case for evaluative judgment as an important graduate attribute in itself (Boud et al., 2018; Khosrav et al., 2021; Tai et al., 2018), which would fit logically into a group work-related skill set. Again, however, evaluative judgement is a skill that needs to be developed, and indeed *taught*, in a deliberative manner; students do not simply develop this ability by osmosis through group work assignments or peer assessment.

The challenge in doing this well underlines the need for innovative strategies and tools to make visible, and fairly evaluate and assess, each student's contributions and development of graduate attributes in group work. The task is to strike a balance between promoting collaborative learning and recognising individual skills that drive group success. Herein lies the potential of learning analytics, an emerging field that could offer valuable insights and tools for addressing these challenges. As we discuss in the next section, the application of learning analytics may help unravel the complexities of group work as-

sessments, including the role of teachers as assessors, thereby advancing our understanding and refining assessment practices in higher education.

2.3 The Evolution and Refocusing of Learning Analytics in Tertiary Education

Learning analytics, which consists of measuring, collecting, analysing and reporting on learner data, presents an opportunity to understand and support student assessment (Siemens et al., 2011). The theories and methodologies that learning analytics draws from have included machine learning and data science, education, cognitive psychology, statistics, computer science, neuroscience, and social and learning sciences (Joksimovic et al., 2019). Typically, log data or "digital traces" from learning management systems or Massive Open Online Courses (MOOC) platforms have been investigated to identify possible patterns of learner engagement (Gasevic et al., 2016).

However, maturation of the field highlights the need to align analytical approaches with learning theories for deriving meaningful insights and enabling better decision-making for *learning*, rather than being purely computationally driven (Gašević et al., 2015; Wise & Shaffer, 2015). Furthermore, the importance of adopting these approaches with clearly defined goals and utilising multiple qualitative and quantitative data sources has been recognised (Bartimote et al., 2019).

Much of the use of learning analytics tools has focused on disciplinary knowledge acquisition, engagement, and academic performance. This focus has somewhat overshadowed the potential of learning analytics in skills development, particularly the professional skills and attributes often referred to as graduate attributes.

The increasing emphasis in tertiary education on such professional skills and attributes signals a necessary paradigm shift in the use of learning analytics. Learning analytics is increasingly being seen as a tool for not just assessing and enhancing knowledge, but also for fostering the holistic development of crucial professional skills, particularly in the context of collaborative group work (Shum, 2022).

2.4 Applications of Learning Analytics in Assessment of Skills and Attributes

The area of skills analytics has focused on tracking and cataloguing professional skills, primarily focusing on identifying skills and potential gaps to suggest training (Shum, 2022). However, the existing emphasis on skills development misses a key element: understanding skills development and delivering assessment and feedback. Current analytics systems tend to overlook the processes involved in skills acquisition and progression, thereby failing to offer feedback. Kew and Tasir (2022) underscored this gap in learning analytics practice by observing that although learning analytics practice predominantly focuses on monitoring/analysis and prediction/intervention, it often neglects crucial aspects such as assessment/feedback, reflection, tutoring/mentoring, adaptation, and personalisation/recommendation. Feedback is particularly important in aiding learners to understand their developmental trajectory and to plan for improvement. To harness the potential of learning analytics in relation to skills, we must balance documentation, understanding of skills development, and assessment. Such a comprehensive approach could provide a more meaningful contribution to skills development.

Learning analytics could be instrumental in assessment of skills and attributes, and could play a significant role in shaping student learning outcomes. As learning analytics transcends the traditional focus on knowledge acquisition to encompass a broader spectrum of competencies, it may be crucial in assessing not only what learners know, but also what they can do, their attitudes, and their dispositions.

Learning analytics offers tremendous potential for enhancing professional skills development, especially in collaborative settings. Early identification and support of students struggling with key skills such as problem solving, critical thinking, communication, and teamwork can be made possible using learning analytics (Arnold & Pistilli, 2012. Existing learning analytics tools such as OnTask can provide personalised feedback and promote self-regulation (Lim et al., 2021), which are essential aspects of professional skill development. Similarly, the Student Relationship Engagement System (SRES) can enhance personalised communication and feedback between teachers and students (Arthars et al., 2019), further improving the development of professional skills. Initial work by Echeverria et al. (2019) around the use of multimodal group data to identify collaboration within group work shows considerable promise in this respect. However, to capitalise on the potential requires deliberative approaches to both learning design and teaching practice.

2.5. Design for Learning and Student Activity

It has become widely recognised that learning per se cannot be designed (Biggs, 2003; Smith & Ragan, 2005). This is because learning is a response to the circumstances that a student experiences at the time when it is anticipated that they will learn. What follows however is that learning can be designed *for*. Through preparation, educators can manipulate the circumstances for students at learn time to influence if/what/how they learn. This is the central premise behind design for learning; that there is a formal process of design—similar to other design disciplines (e.g., interaction design or product design)—where various facets that the learner will experience are devised, enacted, and refined.

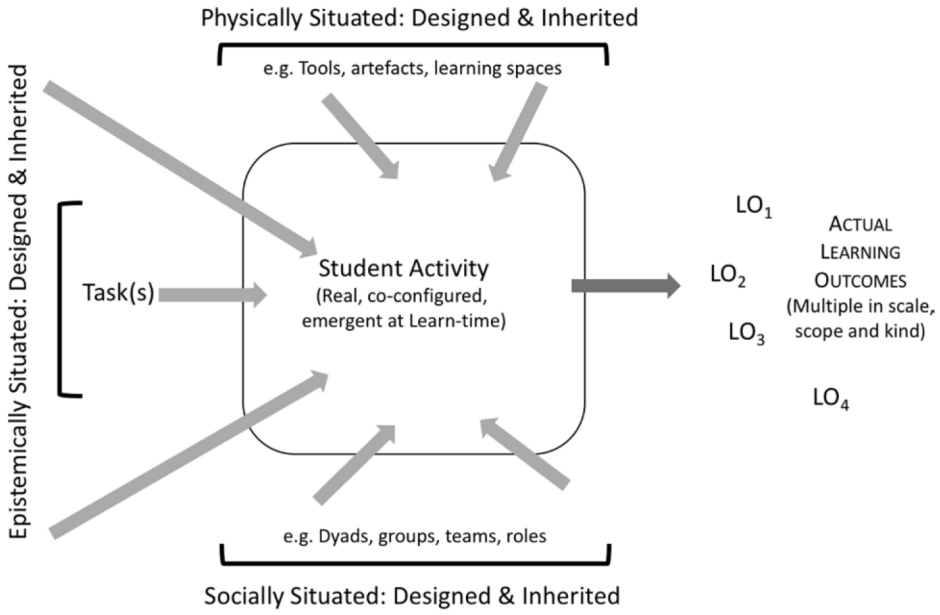
It has also long been understood that student activity at learn time is the primary driver behind student learning (Tyler, 1949). In other words, what a student actually does determines whether and/or what they learn. Similar to the understanding that learning itself cannot be designed is the reality that student activity cannot be designed because it too is a response to the circumstances within which a student is placed at learn time. These understandings are captured in Goodyear and Carvalho's (2014) Activity-Centred Analysis and Design (ACAD) framework.

2.6 Activity-Centred Analysis and Design (ACAD) Framework

Combining the notions that learning must be designed for and that learning is dependent on student activity, the Activity Centre Analysis and Design (ACAD) framework (Goodyear & Carvalho, 2014) proposes that educators are able to influence students' reactions and responses by carefully designing the circumstances of student learn time. The framework initially specified three distinct domains that influence student learning and that should be carefully designed, to which a fourth domain (co-configuration) was later added, as shown in Figure 1.

The fourth of co-configuration occurs at learn time—where a student's emergent activity in response to what has been design can be considered a re-interpretation, customisation or modification to the overall design (Goodyear et al., 2021). Orchestration can also be considered as a type of co-configuration of design. Orchestration refers to the teacher managing activities at learn time and manipulating or adjusting what has been designed as a real-time response to the students' interpretation (Dillenbourg, 2013). However, while important, orchestration is rarely influential in circumstances where students have little or no supervision, so it is reliant on teacher presence and activity, especially in the early stages of skills development where student agency may still be relatively limited.

Figure 1. ACAD Framework for Designing for Learning showing four domains of design; Environmental, Epistemic, Social and Co-configuration
(Goodyear et al., 2021)



2.7. The Application of the ACAD Framework in Assessment

According to Goodyear et al. (2021), each facet of the design of the environmental, social, and epistemic domains for student learning, should be accompanied by explicit and detailed rationales. They argue that sharing these rationales with students can establish detailed expectations of intended student activity for knowledge acquisition and skills development. For the development of group work skills, these rationales are derived from what is understood about individual and differentiated (for different group roles) activity that can lead to successful collaboration. Determination of specific desired student activity then allows their identification (or not) and analysis for either formative or summative assessment of individual students' skills within groupwork or collaborative situations.

3. CONCEPTUAL FRAMEWORK

As outlined above, we use the Activity-Centred Analysis and Design (ACAD) framework as a lens to focus on the students' individual and collaborative activity in team projects. In the process of designing for learning, particularly in the context of group work projects, the importance of understanding collaborative learning cannot be understated. Collaborative learning, a crucial component of modern educational practices, encompasses environments and methodologies in which learners collaborate on a shared task, with each individual responsible and accountable to their peers. This can manifest through both face-to-face discussions and digital interactions (either synchronous or asynchronous). The essence

of collaborative learning lies in mutual learning experiences, where learners can leverage each other's skills and resources, which can include requesting information from peers, appraising each other's ideas, or jointly monitoring work progress. Applying the ACAD framework to such collaborative activities creates opportunities for insightful data collection and analysis. This facilitates assessment and feedback not only on individual student contributions but also the collective learning process of the team. Insights can be used to adjust learning designs in a timely manner, enriching the collaborative learning experience and enhancing skills acquisition, both of which are pivotal in tertiary education environments. As noted, learning analytics can aid this process, offering iterative feedback and promoting effective group dynamics that augment both individual and group learning outcomes.

Within this section, we focus on learning analytics capability to track, analyse and respond to learning activity in an iterative way. This involves both individual and collective contributions to group projects, with the goal of improving formative group assessment for learning and learning outcomes, including the components that are assessed at an individual level. Leveraging learning analytics capability is the key focus here, which involves exploring the use value of existing data streams and adding potential new ones that may be specifically tailored to the design of a learning activity, in our case collaborative team projects. An associated focus is on the development of professional skills and attributes, as noted earlier.

The ACAD framework allows us to consider designing for, and understanding and improving, local and complex learning situations (Goodyear et al., 2021). Group work activities would qualify as 'complex learning situations', and with respect to learning outcomes, the aim is to develop both content knowledge *and* professional skills and attributes, even though the latter are often not explicitly assessed nor considered as part of the learning outcomes or marking rubrics. As Goodyear et al. (2021) note, "what students *actually* do may differ considerably from what their teachers *think* they are doing or what they *intend* them to do" (p. 446). In other words, the intention behind group work is often that students work together on a specific project, and that they produce a product at the end of it, which is then assessed. However, there is also a more hidden intention, which relates to professional skills and attributes, and which assumes that individual students acquire such skills (e.g., communication, problem solving, collaboration, resilience) in the process of doing group work. Yet, such skills are neither explicitly taught nor assessed, perhaps because it is considered too difficult to assess.

Professional skills and attributes are different from disciplinary content knowledge in that they require development that is iterative and ongoing. In other words, students get better at it over time if they are provided with enough opportunities to hone such skills. This honing of skills, however, does not just occur at learn-time, which is why Goodyear et al. (2021) draw attention to students' activity at learn-time as distinct from design-time. The notion of a learning ecology recognises that learning extends well beyond formal learn-time, and indeed occurs in a wide range of contexts (Kek & Huijser, 2017; Huijser et al., 2022). However, once we recognise this, what learn-time does allow for is formative assessment and teachers responding to learning activity within a specific learning context. In other words, this learning activity can be tracked over time, which is a crucial part of honing skills as mentioned. The question then ultimately becomes how best to measure how these skills are acquired (and demonstrated) during learn-time. Not only that, but how to measure improved proficiency in these skills over an extended timeframe, so that we can ensure development of professional skills and attributes over time, for example over the course of a degree.

Formative assessment is particularly important in this context because it allows for interventions and adjustments to the initial design for learning. In other words, it allows us to focus on what students *actually* do. In an ideal scenario, and over time, scaffolding is expected to gradually disappear, and student

agency in collaborative contexts is expected to increase. So, this is where learning analytics becomes very important, as it potentially allows us to formatively assess individual student activity during group work. Echeverria at al. (2019) have discussed the notion of 'collaboration translucence' in this respect. They explore a whole range of potential activity related to collaboration that they can collect data on, in their case in the context of training nurses. The data can potentially be used in formative assessment. Interestingly, they use the ACAD framework to conceptualise the different types of data they seek to gather: "A preliminary definition of collaboration translucence should include not only social aspects, but also making evidence of collaboration translucent according to the multiple, intertwined dimensions of group activity: 1) physical, 2) social, 3) epistemic, and 4) affective)" (Echeverria at al., 2019, p. 5). The latter is of course mapped to the 'design problem space' of the ACAD framework (Goodyear et al., 2021).

It is further useful to approach learning analytics through an ecological lens, as Tan and Koh (2017) have suggested in situating learning analytics pedagogically. More recently, Prinsloo et al. (2023) have similarly explored the benefits of considering learning analytics as being part of an overall data ecology or data eco system. In our case, this would allow us to explore potential linkages between short-term, immediate data collection that relates directly to specific learning activities (i.e., a collaborative group project) and broader available data in the larger data ecosystem of the university. In this way, learning analytics can become dynamic and provide immediate pedagogical value *in situ*, rather than being restricted to providing insights in hindsight, thus allowing teachers to potentially adjust their designs for learning in a dynamic way, particularly as it relates to the development of professional skills and attributes.

Overall then, overlaying the ACAD framework with an explicit learning analytics strategy provides opportunities to develop analytics for real-time tracking of skill acquisition, using learning analytics for personalised skill development plans, evaluating the effectiveness of learning analytics-driven skill and attributes interventions, and developing formative assessment related to professional skills and attributes development in dynamic ways.

4. PRACTICAL APPLICATIONS

4.1 Designing Collaborative Group Projects

In this chapter, we are developing an approach to the assessment of skills using learning analytics in a tertiary education setting. Alhadad and Thompson (2017) have suggested drawing on multiple frameworks to design for evidence-informed approaches to assessment in higher education settings. In order to design for learning in collaborative group projects in higher education, we have drawn on the ACAD framework (Goodyear & Carvalho, 2014), taken an ecological perspective (Tan & Koh, 2017), and used conjecture mapping (Sandoval, 2014) to guide the application of learning analytics. For the purposes of the chapter, we are focusing on collaboration skills.

Collaboration involves the joint participation of individuals in the completion of tasks through communication and joint action (Goodyear, Jones & Thompson, 2014). In much of the research about collaboration in relation to learning situations, the focus has been on assessing the impact of collaboration on the learning outcomes, rather than collaboration skills. As collaboration is one of the graduate attributes, our focus is on collecting evidence of productive collaboration.

Another challenge involved in the assessment of collaboration skills is that these skills are often not explicitly taught. Productive collaboration includes several phases including orientation and planning,

idea development, social interactions, overcoming challenges and reflection (Gosselin et al., 2020). In each phase, the development of collaboration skills leads to a kind of collaboration literacy (Worsley & Ochoa, 2020) in which students are able to identify effective collaboration and, in real-time, make decisions and act in ways that support this. As there are no plans to expect students to undertake any training in collaboration in this context, the collection of data about their collaboration must also scaffold their collaboration activity. Worsley et al. (2021) discuss the following factors for which data can be collected: climate, communication, compatibility, conflict, context, contribution, and constructive.

4.2 Collecting Data to Track Collaborative Group Projects and Individual Contributions

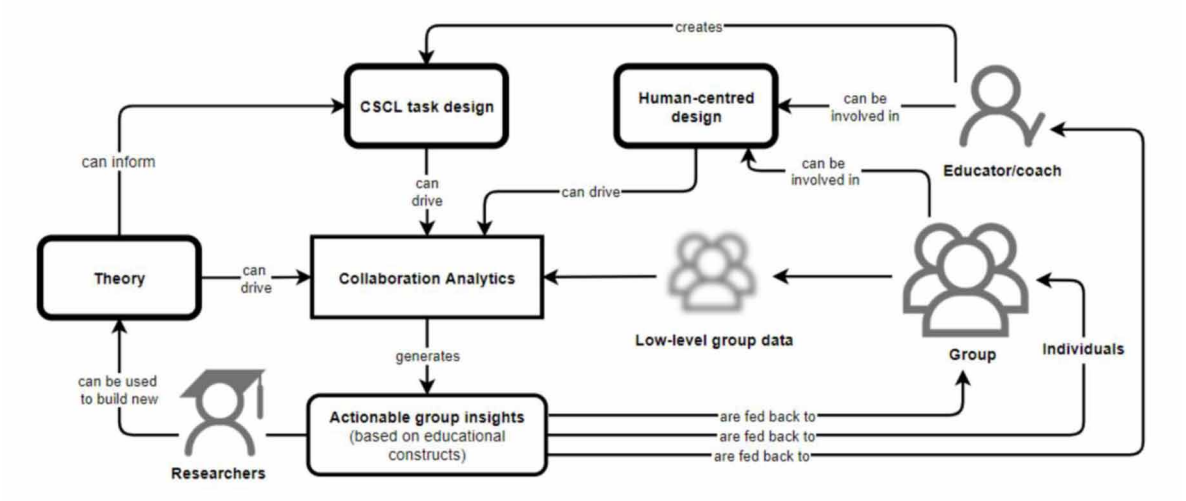
The types of data to be collected will be focused on the activity of learners in relation to collaboration and the co-creation of knowledge. This occurs before collaboration (in preparation for the workshops), during collaboration (productive collaboration) and post collaboration (reflection).

In 2013, multimodal learning analytics was introduced (Blikstein, 2013). The focus of many of the studies that identified with the use of multiple sources of data, was the analysis of face-to-face learning situations (e.g., Oviatt & Cohen, 2014; Thompson et al., 2013). With an overlap between these types of studies and conceptions of classroom practice such as orchestration (Dillenbourg, 2013), the application of learning analytics was directly applied to answer problems of practice. More recently, the term classroom analytics has been used (e.g., Howard et al., 2018) and applied to both higher education (e.g., Martinez-Maldonado et al., 2018) as well as schools (e.g., Alhadad & Thompson, 2017).

Schneider et al. (2021) describe the defining component of collaboration analytics as supporting "collaboration using data in ecological settings". This work can be found in many communities, including learning analytics, as well as computer-supported collaborative learning (CSCL) in which computers support the collaboration. The CSCL community discusses the capture of meaningful traces of learning, mapped to learning constructs and presented to teachers, students and educational stakeholders. Wise et al. (2023) outline nine elements of robust collaborative learning analytics: overall orientation to mobilise data traces to inform learning; careful clicks-to-constructs mappings that attend to the learning task; theorisation about group and/or individual level; theorisation and modelling of learning as a temporal process; multi-channel and/or physical space data; careful attention to what information to provide to whom and how; human-centred approach to LA design; examination of how LA are used in the world; and attention to systems level and ethical concerns. Martinez-Maldonado et al. (2021) have presented the following conceptual model of collaboration analytics.

Sensors are commonly used to capture data about movement, noise levels, or the position of students and teachers when collaborating (see Schneider et al., 2021). Some studies connect the sensor data to educational or learning constructs (e.g., Echeverria et al., 2019; Worsley et al., 2016) and suggest analytic techniques such as prosodic analysis or hidden Markov models (Worsley et al., 2016). Platforms such as BLINC (Worsley et al., 2021) allow students to select the elements of collaboration they wish to record before a meeting or class and then visualise these data in real-time or afterwards. Han et al. (2021) stress the importance of context in collaboration analytics, asserting that the selection of collaboration analytics must align with the needs of learners, instructors and the specific questions posed, given the unique nature of each learning context.

Figure 2. A conceptual modal of collaboration analytics



4.3 From Conceptualisation Into Practice

In this chapter we have considered using learning analytics to guide design decisions about collaborative tasks for graduate students. Using an inquiry approach to our practice (Alhadad & Thompson, 2017), we have identified design and research questions about the task. Learning analytics techniques are described that will enable the capture and visualisation of data during the enactment of the task, allowing the research and design questions to be answered. We describe the epistemic, social and set design (Goodyear & Carvalho, 2014), the teacher-content, teacher-student, student-content and student-student interactions (Tan & Koh, 2017) and the design and research questions that the data and analytics will help to answer (Sandoval, 2014; Alhadad & Thompson, 2017). Students at a university in Australia will be provided with the opportunity to undertake a 6-week course/unit with both individual and group components to it. The topic and disciplinary content students will be learning about is the use of artificial intelligence (AI) in everyday life. Every week during the six weeks, students will have the opportunity to engage in tasks that include lectures and readings that students access in their own time, as well as scheduled, hands-on workshops during which they work in groups of between three and five students to analyse an AI context. The assessment to be submitted will be individual work and comprise an analysis of one of the AI contexts addressed in their groups. In the submitted analysis they must include a description of the way in which they were informed by the way the group worked, including roles of group members, and tools used to collaborate, and they must identify at least one moment when the group work inspired a new idea. After each week, students will be asked to complete a brief reflection questionnaire that will be available to the instructors. Each week, students can choose to reflect on the task, the topic, the collaboration, or the learning tools available to them. The instructor will use this as a prompt for discussion with students and provide feedback. Individual students can use this as part of the documentation of their learning for the final assessment task.

The primary assumption about learning that informed this design are that knowledge is socially constructed through interactions between peers and between students and instructors. The epistemic design involves weekly lectures and workshops that allow students to explore contexts of AI in order

to understand its impact in their lives, and they produce evidence of their understanding in their final assessment. The social arrangements include individual connection to instructors and content through watching the lectures and regular reflections shared with instructors. The workshops are done in groups, online or face-to-face, during the timetabled session or a time organised by the students in the group. Every two weeks the students participate in a different group (three groups in total). The university provides the students with tools to support their collaboration including physical spaces on campus with recording devices, online tools for meetings, shared folders and tools for communication. The lectures are provided by video and their unit/course site provides links to these as well as appropriate readings and a submission portal for the assignment and the weekly reflection quizzes. The learning outcomes are related to how AI is used in everyday life as well as collaboration literacy (Marcello, 2006).

4.4 Developing Analytics for Real-Time Tracking of Skill Acquisition

Following Sandoval's (2014) work on design conjectures and Alhadad & Thompson's (2017) work on combining these with the ACAD framework, the following design (DQ) and research questions (RQ) have been identified:

DQ1: How do the collaboration tools help to document the process of collaboration?
DQ2: How do the different groups impact the process of collaboration?
DQ3: How does the teacher-student connection and feedback impact the process of collaboration?
RQ1: How does documentation of collaboration impact collaboration literacy and learning outcomes?
RQ2: How do the different groups impact collaboration literacy and learning outcomes?
RQ3: How does the teacher-student connection and feedback impact collaboration literacy and learning outcomes?

Many of the tasks that are done in preparation for collaboration can be classified as coordination (Schneider et al., 2021) such as making times for meetings, creating shared digital spaces (e.g., One Drive or Google Drive), or creating shared project planning. In preparation for collaboration, students may access online resources, completing tasks that are necessary for intentional participation in collaborative tasks. The data could be partly drawn from the creation of a space to share files (such as One Drive or Google Drive), and ascertain whether the files are accessed and/or whether new files are added.

Collaboration can occur synchronously or asynchronously. For those tasks in which students engage asynchronously, for example in the case we discuss in this paper, the students could do this is in shared documents in One Drive or Google Drive, and in chats, for example in MS Teams. Chat environments are not currently supported by QUT infrastructure and would most commonly occur using platforms such as WhatsApp, Messenger or MS Teams. When contributing to a document asynchronously, it is important for students to be able to document and provide evidence for their contribution. The system should provide these analytics in terms of both the creation of new text and the editing of others' text. Group email is another process through which students can collaborate asynchronously. If we assume that knowledge creation is situated, embodied, and co-constructed, then in synchronous collaboration, collaboration activity could include audio recordings of discussion, motion analytics of movement in the physical location, and the co-creation of digital and physical artefacts.

After any moment of collaboration, reflection on the collaboration activity is an important part of being a productive member of the group. Creating a way for students to share these reflections with facilitators is a key part of a formative assessment plan for collaboration. This would allow students to identify moments where collaboration is productive as well as moments that have not been, based on evidence, which they could then submit for feedback on alternative approaches to collaboration practice.

5. CONCLUSION

We commenced this chapter with an acknowledgement of the challenges inherent in assessing the progressive development of professional skills and attributes that are promised by education institutions to graduate students. A key attribute among these is the ability to work in groups, demonstrating effective collaboration towards group goals. Despite its complexities, we have identified substantial potential for LA to recognise, measure, scrutinise, and evaluate specific student actions that indicative of the incremental acquisition of such skills.

We have proposed the ACAD framework for designing for learning as a tangible determinant of the measurable elements that suggest effective groupwork and collaborative practice. Across the physical, social, and epistemic domains, the ACAD framework provides the foundation for an explicit learning analytics strategy. This then provides opportunities to determine markers, or specific indicators of skill acquisition and allows for real-time tracking and provision of feedback to both students and educators.

We recognise that there is a contextual element to identifying the types of analytics that need to be collected. This is challenging due to the desired state that students are expected to achieve, which is somewhat intangible. We also recognise that the types of analytics we use may need to be differentiated across a temporal plane—where analytics may differ across different stages of group work activity, for example planning, face-to-face interaction between group members, interaction with teachers, individual work toward a group goal, or reflection. Other examples of differentiated analytics may be needed for learner-created documentation, physical space location data, or dialogic discourse.

We further recognise that tertiary institutions are unlikely to be in a position to provide students with access to the infrastructure that would support their collaborative activity in one location. Consequently, students may be forced to use an assemblage of tools. Yet, while this may be a challenge, it is also authentic in the sense that it reflects the likely reality of a workplace context. Moreover, deciding on the composition of this assemblage is unique to each team and must be done in the first instance. The risk in this case is that students do not choose options that are equitably accessible to all students, which would then require an intervention from the instructor, which could be framed as a learning moment.

Despite the challenges, we have outlined the strong potential of learning analytics for assessing and guiding the development of group work skills and potentially other desired graduate attributes. This potential can help refine existing educational processes, where data-driven insights contribute to improving both students' learning experience and their learning outcomes.

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