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The role of soci(et)al relations in a technology-rich teaching | learning setting: the case of professional development of airline pilots

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Abstract Teaching and learning tend to be predominantly investigated in formal (school-like) settings; and many investigations focus on either teaching or on learning. In this study, a societal-historical activity theoretic approach is used to investigate teaching | learning (*obučenie*) in the context of aviation. Drawing on a large database from simulator-based pilot training and examination sessions that are followed by debriefing meetings, the analyses show when and how certain higher psychological functions exist as soci(et)al relations between instructor and instructed before appearing as a psychological characteristic of the instructed. Both immediate and relational dimensions of activity exist, making possible learning by means of active *imitation* (not blind copying) and articulation in conscious awareness.

Keywords soci(et)al relations; teaching | learning (*obučenie*); tools; societal-historical activity theory

1. Introduction

Every higher psychological function was external—i.e., it was social [social’noj]; before becoming function it was a social relation of two people. (Vygotskij, 2005, p. 1021)

Paraphrasing Marx: the *psychological* nature of man—the totality of societal [obščestvennyx] relations, *transposed to the inside and having become functions of the person and forms of its structure*. (p. 1023)

Most research on teaching and learning tends to be concerned with the activities in formal institutions (kindergartens, schools, colleges, or universities) where specially trained individuals implement curricula that they or someone else designed. Less frequently investigated are teaching and learning in informal settings, including science clubs, museums, home, or workplace. An even smaller number of studies focus on teaching and learning when individuals move back and forth between institutions and workplaces (e.g., Roth, 2014a). Whereas there is a considerable literature on work-based learning (e.g., Wearne, Dornan, Teunissen, & Skinner, 2012; Williams, 2010), studies and reviews tend to focus on either teaching or learning and few if any studies exist concerning formal learning situations involving instructors who are expert practitioners but not pedagogically trained (Hsu et al., 2009). This study was designed to investigate teaching | learning that occurs when organizations are required by some regulatory agency to provide instruction closely related to and in preparation for the actual work members are doing. The study is grounded in a societal-historical framework, according to which higher psychological functions, consciousness, and personality first exist *as* and

in society-specific¹ relations with others (Leont'ev, 1983b; Vygotskij, 2005). *Imitation* and *division of labor* are key aspects of the immediate and tool-facilitated nature of relations that bring about the transformation (learning, development) of participants (Vygotskij, 2005).

The particular setting investigated here is aviation, where a tool is used in the training: high-fidelity full motion simulators. In aviation, however, there is a second level of tool use in learning. After each 4-hour simulator session, the flight examiner—a captain with the same airline who has additional certification from the national aviation regulator to instruct and assess other pilots—and the pilots debrief what has happened for the purpose of improving future performance (e.g., Dismukes & Smith, 2000). Some airlines have a debriefing tool—computer driven assemblage of video, aspects of the cockpit such as instruments, and other representations of the events in the simulator—that can be used to replay, analyze, and evaluate the trainees' performances. Although there have been many studies of debriefing on professional development generally, recent literature reviews reveal that there is a surprising sparseness of theoretical and empirical work on (a) teaching and learning processes and (b) the role of tools and technologies (e.g., Fanning & Gaba, 2007; Tannenbaum & Cerasoli, 2013). One of the problems of the training and evaluation sessions in the simulator is that the pilots tend to forget many events and most of the detail because of the number and intensity of the tasks they have to accomplish, as shown in the database on which this study is built (Roth, 2015). The debriefing tool allows them to make present again events that the flight examiner (very rarely the pilots) deem as suitable for teaching/learning purposes.

2. Background: activity theory and societal relations

In this study, I investigate formally organized teaching/learning situations that are part of the actual workplace and, therefore, involve instructors who have not undergone college or university training. In the aviation context where this research takes place, many instructors and examiners began their careers as commercial pilots immediately after graduating from high school, some having started to fly much earlier. That is, this study focuses on what have been called *natural pedagogical settings* (Hsu et al., 2009). I investigate teaching and learning from an activity theoretic perspective that takes consciousness to be the product of human labor in a material world so that humans produce themselves while participating in the generalized satisfaction of human needs (Leont'ev, 1983b; Marx/Engels, 1978). Thus, while producing something, or while completing some task, humans produce themselves at the material-bodily and ideal levels (i.e., they learn). This is why—from the inherent practice perspective—participating in human practice makes learning inevitable and unproblematic, while at the same time rendering problematic the notion of knowledge (as some fixed state or essence) (Lave,

¹ Following K. Marx (sozial, gesellschaftlich), both Vygotsky and, more so, Leont'ev use the adjectives social [social'nij] and societal [obščestvennij], the latter also implying the political and economic situation of a society. The distinction is one between simple community and sociality (e.g., family), on the one hand, and society with its structure, on the other hand. Stetsenko (e.g., 2005), attuned to the fact that Vygotsky was working towards a “classless and just society” (p. 82), is one of the few scholars using the distinction between the two adjectives.

1993). This process can be represented in an expansion of the frequently used triangle characteristic of activity theory, which actually constitutes a shorthand depiction. The expanded version shows that the entire production process from the beginning to the end constitutes the unit of analysis (Figure 1); and this unit has everything characteristic of *society* as a whole. For this reason, I prefer using the English translation *societal-historical* [obščestvenno-istoričeskogo] to characterize activity theory, an alternative that Leont'ev (e.g., 1983a, p. 19) himself had used to denote the theory he was developing together with Vygotsky, and that is also used in the German literature (e.g., Holzkamp, 1983). This is exemplified in the context of my research in aviation.

The motive of transportation activities is getting the passengers and cargo from Point A to Point B. In cultural-historical activity theory, Point A is the initial state (object); and, at the very beginning of the process, Point B is the motive. At the end of the activity, Point B is the outcome. In the theory, this entire transformation from start to finished product constitutes the unit of analysis. Figure 1 makes apparent that not only the location of the aircraft is changed, but also the aircraft and the subjects (pilots). This is so because fuel is used up, the engines, the tires, and other parts of the aircraft are worn. Humans, too, change in the process of activity: pilots and cabin crew fatigue, use up energy, and become more competent practitioners in physical and intellectual (ideal) terms. Training in the simulator is premised on this idea of the transformation of the pilots—their physical and intellectual knowledgeability—while they accomplish the task, which simulates the process of getting an aircraft from some Point A (one of the airports that the airline serves) to some other Point B (another airport in the schedule of the airline).

Figure 1. In activity theory, the entire production, here the transport of passengers from point A to point B, is the unit of analysis.

Societal-historical activity theory approaches knowing and learning in terms of a multi-leveled unit (category): *activity* (Rus. dejatel'nost'; Ger. Tätigkeit). A societally motivated activity is realized by means of individual (conscious) actions, which themselves are composed of operations. Thus, a conscious action is realized by a sequence of unconscious operations, each of which triggers the next without requiring conscious reflection (Leont'ev, 1983b), a fact that has been made thematic by the term *kinetic melody* (Luria, 1973). A kinetic melody unfolds without requiring conscious awareness of the individual notes. In aviation, procedures exist in the form of kinetic melodies that unfold on their own once triggered. That is, once an experienced pilot recognizes the need for and announces some procedure, the entire procedure unfolds on its own as a coordinated event that requires no conscious awareness and effort because

one thing immediately (without the interference of cognition) leads to the next until everything is said and done (Roth et al., 2015). Pilots do not remember the individual steps on their own, but, as seen in experimental settings, go back to the beginning of the procedure and then play it as a whole until they get to the part that was to be remembered (Roth & Mavin, 2015). The final part of a sequence frequently is a call for a checklist, at which point the pilots go through the list to confirm that everything that was to be done actually had been done so that the aircraft is in the required configuration.

When pilots are trained to fly a specific aircraft type—a process referred to in the industry as *type rating*—or are assessed, the collective *subject* of activity (Figure 1) also includes the flight examiner/instructor, though the simulated flight still has the same object/motive. The activity now also is modulated by the institutional division of labor, where the flight examiner/instructor takes on the duty of teaching and the pilots are in the role of the taught. The Vygotskian position on teaching and learning taken here frequently is framed in terms of a “social construction” of knowledge that is subsequently internalized. Numerous commentators make clear, however, that the concept of internalization is not needed (e.g., Mikhailov, 2001; Travieso, 2007). In fact, in discussing writing and reading their own notes, persons relate to themselves as to others (Vygotskij, 2005), Vygotsky foregrounds the fact that the higher psychological functions still exist in the forms of social relations now directed towards the self rather than towards the other, the form in which these functions first appear. From a societal-historical perspective, communication, because of its collective nature, is the lynchpin of teaching and learning events: “speaking is the central function—social band + psychological means. Cf. immediate and mediated relations between people. *Hence* digression: imitation and social division of functions as a mechanism of the modification and transformation of functions” (Vygotskij, 2005, p. 1022). Here, imitation does not imply mindless copying. Instead, imitation already implies knowing and understanding (Chaiklin, 2003), a social psychological fact that has been confirmed in more recent neuroscientific studies (e.g., Iacoboni, 2009). The primacy of the societal *relation* in Vygotsky’s theory of the development of higher functions finds its expression in the notion of *obučenie*, which translates both as *teaching* and as *learning*, thereby referring to a single but double-sided process in the encounter of the learner and instructor (Chaiklin, 2003; Cole, 2009; Stetsenko, 2005). The notion emphasizes the irreducible unity of “teaching | learning as an unfolding relation” (Roth, 2014c, p. 290). Here, the Sheffer stroke “|” indicates that teaching and learning cannot be considered independently but mutually constitute each other just as Vygotsky implied with the notion of *obučenie*. This mutually constitutive process, teaching | learning (or *obučenie*), is articulated by the word, which, to play any role in the process, exists for (make sense to) both teacher/instructor and learner simultaneously—or, as Vygotskij (2005) notes, it is not a word at all.

3. Method

This study was designed to investigate teaching | learning (*obučenie*) in a technology rich working environment: aviation. There are two main tools that modulate the events under investigation. First, the training and assessment occurs in a full-motion high fidelity simulator prior to actual piloting of aircraft in regular line duty. Second, a 45–60-

minute debriefing meeting follows each simulator session. In two of the five airlines participating in the study of debriefing, a debriefing tool was used (Roth, 2015). This study focuses on debriefing sessions using a debriefing tool for learning from events that occurred in the simulator. In the sessions, participants subsequently describe, analyze, and evaluate what has happened for the purpose of professional development (learning).

3.1. *Participants*

3.1.1. Organizations

This research was conducted in the context of the type-rating and assessment activities of five airlines operating in two countries of the southern hemisphere. These airlines own or rent simulator facilities that also include offices for briefing and debriefing pilots. Two of the airlines use a debriefing tool (described below).

3.1.2. Individuals

A total of 42 pilots in training or under evaluation participated in the larger study (6 pilots in training, 16 first officers, 15 captains, and 6 captains with flight examiner status). There were 16 flight examiner/trainers, 6 of whom also had been examined as part of the pilot group. The participants, aged 27–62 years, had commercial flight experience ranging from 1,200 to 24,000 flight hours, having been employed as commercial pilots from 4 to 45 years.

3.1.3. Ethics

Ethics approval has been sought from the companies and labor unions in addition to the standard institutional review boards because of the confidential nature of the simulator sessions and debriefing meetings. Pilots were invited with the guarantee that non/participation would not affect their employment status. They could terminate participation with removal of their data at any point during the research. Separate to consenting to participation, pilots explicitly signed usage of still images and video offprints.

3.2. *Ethnographic context*

3.2.1. General description

This study draws on an extended ethnographic effort into teaching, assessment, and learning in the context of aviation at different stages in the careers of pilots flying a particular aircraft. New pilots with experience commercially flying other, generally smaller aircraft are trained (following some classroom teaching related to aircraft knowledge and procedures) for 11 sessions in the simulator. All other pilots undergo twice per year two days of training and assessment; and they must pass the examination to be able to continue flying (or are taken off the job and assigned to retraining). The simulator sessions are 4 hours long, preceded by a 1-hour briefing session and followed by a debriefing session for which a 1-hour slot is available. The seating and orientation in the debriefing meetings is invariable. Flight examiners always sit on one side, close to the

whiteboard behind them, facing the two pilots, who, in almost all cases observed, take the same relative seating as they have done in the cockpit (i.e., captain on the left, first officer on the right) (Figure 2). On the wall, perceptually accessible by a slight turn of the head of all participants, is the debriefing tool (Figure 2), which is controlled by the flight examiner (via mouse).

For the purpose of exemplifying the findings, a particular event was selected involving two new pilots who were under training at the time. Ike (40 years) has had 4 years of experience flying commercially with a total of 1,200 flight hours; Nina (29 years) had 7 years experience as commercial pilot and had accumulated 3,200 flight hours. The training captain Matt (37 years) had flown commercial aircraft for 19 years, accumulated 7,400 flight hours and had obtained flight examiner certification 8 months prior (pseudonyms are used throughout). This particular training session was chosen because my ethnography showed the flight examiner to be more oriented towards teaching, whereas with more experienced pilots they orient more towards assessment. However, both aspects—teaching and formative assessment—are integral to both types of participants. The event was selected because, according to Matt, Nina was “struggling” with flying a go-around procedure (missed approach), the issue raised during the debriefing meeting. Nina continued struggling with flying the procedure over the next two days when Matt still articulated major problems with Nina’s performance, which he characterized as thinking of nine things required in the go-around sequence but missing five of them and not knowing which five she was missing. However, five days after the present session, when Nina and Ike underwent their final examination, the go-around procedure no longer was an issue. Nina flew it successfully so that the flight examiner did not address it during the interviews or in the debriefing session. This suggests that in the meantime Nina had learned to correctly fly the go-around procedure following a missed approach call.

Figure 2. Typical seating during debriefing, with examiner to the right and the two pilots to the left.

3.2.2. An instructional episode from the type-rating training in aviation

The flight examiner (Matt) had marked the go-around for discussion at the mid-session break that divides the simulator sessions into two parts, often associated with a change of roles from pilot flying to pilot monitoring (both pilots have either access to the same instruments and actuators [e.g., power lever] or each have an identical copy [e.g., electronic attitude director indicator]). Matt had suggested that Nina had issues with go-around routines, including the combination of rudder, trim, flight director, and power. In his assessment, while she was improving, her performance was not quite at an acceptable standard level. The problem was particularly visible when the aircraft was flying only with one engine (after the second had failed), but also was present when both engines were operating in normal condition.

A *go-around* (alternatively *missed approach*) refers to a situation where the pilots decide during the final stages of an approach to an airport that they cannot actually land because of some problem (e.g., cannot see the landing runway because of poor visibility). Once the pilot flying announces a missed approach, a particular sequence of actions has to follow according to, and in the order specified by, the airline's standard operating procedures. The relevant part of the procedure, as shown and discussed by the participants during the debriefing meeting, includes the following steps. Simultaneously with announcing "Go around," the pilot flying (a) pushes the *go-around button* on the *power lever* (Figure 3b) pushing the button changes the autopilot mode that operates the *flight director* from "landing" to "climb" mode, Figure 3a), (b) rotates the aircraft to the required *pitch attitude*² assisted by the flight director on the *attitude indicator* (Figure 3a) by pulling on the steering column, and (c) pushes forward on both power levers from the *flight idle* across the *notch* to the *ramp* position (Figure 3b). Following this initiation, there are many more parts of the sequence until the pilot flying calls for an after-takeoff checklist, which terminates the go-around procedure. Nina failed in properly executing these steps and in their timing.

The go-around procedure is a difficult one, because it arises rarely in everyday flying practice (three to four times a year in the airline of the participants employing about 150 pilots and operating 20 aircraft). In one study, even third-party evaluators (pilots at all ranks) asked to analyze a taped go-around event failed to note that parts of the procedure (e.g., pushing the go-around button) are missing (Roth & Mavin, 2015).

a

b

² *Attitude* refers to the orientation of an aircraft with respect to the horizon. It is indicated by *pitch* (up-down angle) and *roll* (sideward angle.)

Figure 3. a. Key features of the electronic attitude director indicator; the (magenta) cross is the *flight director* indicating where the aircraft (currently at horizon level as indicated by “□ □”) should be pitched. b. The power lever, side perspective, with go-around button.

3.2.3. The debriefing tool

The *debriefing tool* is a software package that integrates a variety of representations of the entire 4-hour simulator session (Figure 4). The display of the debriefing tool includes the video taken in the simulator showing the two pilots from the perspective of the examiner who sits behind them, where he also has access to the controls for selecting the scenarios and failures to which the pilots are exposed in situ and without prior knowledge thereof. There are also many instruments, such as the attitude indicator and the engine gauges. Iconic representations of the steering column from frontal and side perspectives are provided as well as the power levers and flap lever (Figure 4).³ In the session analyzed here, the trainer included a visual representation of the aircraft from behind and the flight path. Finally, there is a panel where the flight examiner selects the episodes and another one in which various flight parameters (e.g., elevation, air speed, and vertical speed) are provided.

Figure 4. The debriefing tool interface includes a variety of representations of the 4-hour simulator session that precedes the debriefing meeting.

3.3. Data collection and preparation

³ The flaps are movable parts of the wings that passengers can see extending (on landing) and retracting (after takeoff) that give lift to the aircraft.

The episode used in this study derives from a database including 35 videotaped debriefing sessions. For 29 sessions, the pilots and flight examiners were interviewed briefly between the two halves of the simulator sessions, following the second half, and following the debriefing meeting. In each instance, the participants were asked what stood out for them, what they thought would be discussed during the debriefing meeting, whether the debriefing meeting had unfolded and covered as anticipated, and what they had learned (taken away) from the simulator session and debriefing meeting. All interviews were audiotaped. For six sessions, the briefs also were videotaped, as were the entire simulator session, the debriefing meeting, and interviews with all participants following the second-day debriefing meeting.

Verbatim transcriptions of all recordings were contracted to a commercial supplier, who hired an individual with aviation experience. I verified all transcriptions for accuracy. For the purpose of analysis, I prepared detailed transcriptions of many episodes following the conventions of conversation analysis modified to include information on prosody, gestures, and body movement (Selting et al., 1998). These fine transcriptions were used in the *data session* (see below).

3.4. Data analysis

The purpose of the present analysis was to develop an *ethnographically adequate account* (McDermott, Gospodinoff, & Aron, 1978) of teaching | learning in the context of the (continued) training of airline pilots. In this approach, researchers “*use the ways members have of making clear to each other and to themselves what is going on to locate [their] own satisfaction an account of what it is that they are doing with each other*” (p. 247, original emphasis). A standard approach to achieving an ethnographically adequate account in technology rich environments exists in the form of *interaction analysis* (Jordan & Henderson, 1995), sometimes also referred to as *data session* (Heath, Hindmarsh, & Luff, 2010). Researchers (“owners” of tapes) interact with others over and about the contents of videotapes featuring pilot interactions; often, as here, the contexts are technology-rich settings (e.g., computers, photocopiers, aircraft, or surveillance video). A tape is played until someone asks playing to be stopped, which is followed by a description or hypothesis of what is going on. This then is discussed until the topic is exhausted and play is continued. Sequences are frequently replayed, or the play head is returned to the beginning. In this manner, it is normal to spend 2–4 hours on no more than 60–90 seconds of videotape. The purpose of a session is to produce as many hypotheses as possible.

As the owner of the videotape, I prepared the fine transcription for the analysis session. I noted tentative hypotheses during the meeting, which I subsequently developed for the analyses. I tested all hypotheses in other parts of the database. Other participants were also invited to ascertain the accuracy of the fine transcriptions, especially where the soundtrack was not clean, thereby providing difficulties in hearing precisely what was said. The rule for a session is that any proposed description or hypothesis has to be testable in the materials provided. For example, it generally is not possible to state what a person feels or thinks. Thus, members of interaction analysis sessions focus on what semiotic resources the participants in some situation make available *to each other*, as evident in the way these resources are taken up by these others (recipients). As a result,

interaction analysis produces an account of the *endogenous* production of the social world, that is, it takes a view from the perspective of the participants who take up and act upon what others in the same situation make available to them.

4. Teaching | learning (*obučenie*) in a natural, formal-informal context: the case of type-rating in aviation

4.1. Ethnographic description of the episode: endogenous production of a teaching-learning event

The event presented here was an episode, with clear, participant-identified and initiated beginning and ending (on the part of the flight examiner/examiner). The episode is described by means of glosses and the full transcription is provided in the appendix, but in the main body of the text only those parts explicitly focused on in the analyses are presented. During the interview preceding the debriefing meeting, Matt had already identified the go-around as an issue that Nina was “not quite nailing yet.” Following the debriefing meeting, Matt described why he had selected the episode and what the issue was: “Nina was only going to the notch for the go-around, which she needs to go to the ramp. And she’s, before she does anything she looks down. You don’t need to look down because looking down makes the plane go down. You need to just feel it hit something and then give it another handful.” This information, however, was not available to Nina and Ike. In the debriefing room, the three relate in such a way that they mutually constitute the very conditions (including the relation) within which they talk about what has happened when the go-around is taking place. Mikhailov (2006) notes that the late, Spinozist Vygotsky thought about such situations in terms of an *intersubjective speech field*, which supplanted his earlier idea of “semiotic mediation.”⁴

The flight examiner Matt initiates the episode by naming the event (“go-around”) and starting its replay, which lasts until turn 11. At this point he stops the replay. During the replay, Matt specifies that this was the two-engine go-around thereby distinguishing it from the single-engine go-around procedure they also had flown. The video shows that while announcing the go-around, Nina moves forward the power lever to the first notch, which can be seen both in the video and in the representation of the power lever that appears on the right of the engine instruments. Matt is heard to say “to the ramp there” and “pitch up, Nina,” which, as can be seen on the instruments represented in the debriefing tool (Figure 4), is followed by the movement of the power levers from the notch to the ramp and the pitch of the aircraft to the 8° mark indicated by the (magenta-colored) flight director (Figure 3a).

Matt makes a move to begin talking (turn 09), but the video is still running. He stops talking, brings the video to a halt, and then makes another offer to start the discussion. Even before a grammatically complete statement is formulated, Nina begins a statement about what needs to be done during a go-around and, in the second part of the statement, moves her hand in simulation of moving the power lever forward. But rather than

⁴ Within an irreducible analytic unit, there cannot be mediation because any one part of the whole is connected to and presupposes all the other parts. No part, therefore, can stand *in the middle* (Lat. *mediare*, to be in the middle) between two other parts.

stopping at the notch during the actual flight simulation, which is revealed on the video and on the representation of the power lever, her arm moves to a fully stretched configuration (turn 13). The second part of the statement also falls together with the continuation of Matt's statement, articulating what Nina ought to be thinking of. After the formulation, there first is a longish pause, and then a description of "hitting something" while the arm/hand configuration moves forward for the first time. There is a pause, and then a forward movement of the hand as if pushing the power lever while describing the action as "push past" (turn 14). Here, the description "push past" makes salient the stopping that can be observed in the video and the representation of the power lever, which had stopped at the notch.

There is a first verbal description of how the power lever should be pushed associated with the hand movement (turns 12–14), which is then repeated (turns 16–21). Nina provides a description that constitutes her experience at the time when she actually had moved the lever to the ramp as required. There is a pause (turn 15), and then the flight examiner first formulates the upcoming instruction ("you got to go") (turn 16), followed by a verbal description that instructs Nina how she was to move the power levers: first "into the notch" and then "another handful forward" (turn 18). That is, the description again highlights that the movement has to be more than just to the notch in the way Nina had done in the simulator and before completing it following Matt's request to "pitch up again" (turn 05). This latter part is formulated as "not much it's sort of just like another half handful forward" (turn 17). Figure 3 shows the positions involved in moving the power lever from the flight idle position (where the lever was) to the notch, and then from the notch to the ramp (the required position in the go-around procedure).

Matt then provides an explanation that failing to produce the correct movement of the power levers from flight idle to the ramp is not so critical in the two-engine case they observed, but crucial in the single-engine situation, where the live engine has to operate at 100% power (at ramp) (turns 25–35). He then repeats the instruction once more, again providing a verbal description/instruction ("into the notch and a handful more") and produces the hand/arm movement that takes the power lever into the required position.

35 Ma: single engine its (.) MO:re important. so you=s just got think; (0.95)

[into the notch] [(1.11) <<p>and handful more.>]

[((turn 14, c–d))] (.) [((turn 14, d–e))]

36 (0.28) ((*all reorient to the monitor*))

37 N: <<p>yea.>

38 (1.09)

39 Ma: and=then (.) ye=know (.) jUST (0.28) see (0.57) you know

[you=re getting onto that flight [trajectory] after i said=t=you]

[((*pointer to attitude indicator*))]

[((*Nina nods*))]

40 which is great but you just need to (0.81) you=know (0.26) jes a=bit like
 <<dim>the OLD ways ye=know> (0.89) pOWer up pITch up
 (0.31) [clEAn up].

By means of the connective “and,” Matt marks that something else is to come in addition to what has been articulated before. Matt then initiates a move for turning to another aspect of the go-around procedure: pitching the aircraft up. He says that Nina had gotten onto the flight trajectory *after* he had instructed her to do so (turn 39). He furthermore marks what is to come as something that can be seen (“just see”), and then describes Nina as getting onto that flight path after he had told her (turn 35). At the same time, he moves the bold-faced cursor in pointer configuration towards the attitude indicator. The referent of what he had said (“after I said to you”) can be found in turn 05: “pitch up again.” In the written standard operating procedure, the go-around call is followed by the action of pitching the nose up to +8°, followed by pushing the lever to the ramp. As the transcription shows, Nina had stopped the power levers at the notch. Matt then provides, using rhythmic intonation, an expression pilots are taught as memory aid: power up, pitch up, clean up. It is a memory aid in the sense of Vygotskij (2005), where the words and intonation are signs used to stimulate a physical action. The first two parts addressed in this memory aid are precisely those that are highlighted as having been problematic in Nina’s performance. This aid is then reproduced twice, once identically (turn 51) and once in a transformed but to-be-taken-as-equivalent way (turn 48). After an extended pause, there is an assessment term (“so it’s cool”), which completes this episode of the debriefing meeting.

As assessment and instructional sequence, the episode presented differs from most formal educational settings in that the instructor not only provides verbal descriptions of actions but also produces himself, and thereby exhibits for instructional purposes, the relevant movements. These, thereby, constitute the referent for the assessment and for the instruction in a way that is directly accessible to the learner Nina, even though she does not yet (over the next two days) perform the movements in an acceptable way for a pass rating. Matt not only instructs, by providing a verbal *description*, but also acts out what the instruction describes so that the learner can perceive how what the words describe is to look like when physically executed. Given the high spatial accuracy of the flight-related movements that flight examiners display when assessing and instructing pilots (Roth & Mavin, 2015), Matt’s movements are available to Nina in the way they would have been while actually sitting in the cockpit (apart from the apparent difference in perspective, which necessarily would be from behind, as seen by the flight examiner, or from the side, as seen from the person in the captain’s seat, here Ike).

This sequence clearly was directed towards Nina rather than Ike, which is evident in the Matt’s bodily orientation towards her as recipient. However, as an instructional sequence, it was also intended for Ike towards whom Matt orients repeatedly. Reading the transcription, however, some readers might initially conclude that Ike was not engaged. Some viewers of this part of the debriefing meeting tape proposed this as a working hypothesis. Upon my closer inspection, however, this hypothesis was rejected based on clear evidence of his participation (e.g., turn 14); in addition, his engagement was apparent throughout the debriefing meeting generally, as well as in an extensive

verbal exchange and commentary in the episode immediately preceding the one presented here.

14 Ma: [what=ya=need to think of] (0.31) is (.) you need=te gO
 (0.85) [hIT something] [(0.48) [push past.]
 [((a-b))] [((b-c))] ((Matt))
 [((f-g))] ((Ike's movement))

Cursory evidence for non-involvement/ engagement included apparent lack in verbal contribution to description and analysis and the arms folded in front of the body, which are often understood to indicate removal from and direct involvement in the situation. However, closer inspection provides signs of his acute attention to the teaching sequence. Easily missed and initially unnoticed by other viewers in the data session, Ike's hand movements produced—simultaneously in the way required by the standard operation procedures—the pull on the steering column that pitches the aircraft up and the pushing forward that moves the power levers to the ramp. This occurred at the same point where Nina and Matt are also moving their arms/hands in simulation of moving the power lever and steering column. Noticeably, Ike does not produce in this instance the movements that would have been required in the seat where he had been sitting. Instead, he produces the movement from the perspective of a first officer, the position he was training for and the seat that Nina had taking in this rotation of their session: from the perspective of the right-hand seat. That is, his left arm/hand moved forward as he does when pushing the power levers forward, and his right hand, in the configuration that he was when holding the steering column, was pulling backward as it would be when pitching the nose of the aircraft up.

4.2. Looking forward (instructing) while looking backward (assessing)

By the end of the 1:10-minute episode, the observed performance and the associated movement of the power levers, as represented in the debriefing tool, come to be contrasted repeatedly by the flight examiner's verbal and gestural descriptions. Nina, too, moved her hand/arms four times in the required way rather than in the way she evidently had done during the actual simulator exercise. The episode shows that even before Matt comes to describe verbally (for the purpose of reflecting) and gesturally (to be imitated)

what should have been done, Nina articulates the required movement subsequently exhibited in Matt's movements. In contrast with what she had done in the simulator, the movements therefore show that she was aware of what should have been done: she had become aware of something that previously was hidden in the inchoate stream of experience while practicing to fly a new type of aircraft. The episode had been both an evaluation / critique of what Nina had done and an instruction of what she would have to do in the future.

4.2.1. Assessment

The fact that the flight examiner brings up the issue, marks the turn-around as salient, something worthy of being talked about. Matt completes the description with an assessment: When the movement has been completed by "another half handful forward," then "it's until what it needs to be" (turn 19).

- 16 Ma: [see] you godda go [↑into the nOTCH]
 [((N as in turn 13))
 [((Ma, turn 14, c-d))]
 17 (0.34)↓ and then you just needa (.) its nOT much its sort of jst like
 18 another [hALF hANDful fORward]
 [((Ma, turn 14, d-e))]
 19 and then its into what it needs to be.

In this situation, the turn produces a critique, as there are repeated demonstrations of how the hand/arm configuration has to be produced. However, the Matt does not explicitly describe what was wrong. It is Nina who actually articulates what is at stake: she has her hands there, thinking what she was doing, and that time is long (turn 24) before she had moved the power lever up to the ramp. While verbally orienting the flight examiner to the hand movement ("sort of kind of that," Nina reproduces the movement required to bring the power lever forward (turn 21). That is, the critique exists in and as the instructor-instructed relation, just as a societal historical approach suggests (Vygotskij, 2005).

- 21 N: [mm sort of kind of that.]
 [((a→b>, b→a, a→b))]

- 22 (0.75)
 23 Ma: y[eaa.]
 24 Ni: [m=hANds] there and i=m thINKing; what am I dOing (0.15) oh yea; ramp.
 (0.47) yea am i at the rAMP? (0.37) yea (0.18) ((hand as Ma in c-d)) and
 HHmy HHarm [(isnt?)] so long.

After a pause, Matt acknowledges and affirms the gesturally offered description of the movement, but Nina begins to speak offering a description of what she experienced during the event that they had just seen. She first reflects, questioning, “What am I doing?” Then there is the insight into what needs to be done, “ramp.” She acknowledges having to take the power levers into the ramp (“Yea, am I at the ramp?” and then confirms it (after having moved the levers), “Yea,” while moving the hand with the invisible power lever into the same position that Matt had earlier displayed. She describes herself as sitting, wondering about her actions while the power lever is at the ramp, and describing the time as having been long. This is in fact what can be observed, especially in the representation of the power lever, which is sitting for about 0.5 seconds at the notch prior to beginning the final, slow movement up to the ramp.

Nina had read and memorized the standard operating procedures describing a go-around. However, her situated actions did not conform to the written procedures. There is a close relationship between plans (instructions) and evaluations, a relationship hinged on their respective relation to situated actions (Suchman, 2007). This author showed that plans (instructions) do not causally relate to the situated actions they describe. Instead, plans are better considered as triggers of situated actions—much in the way Luria (1973) suggests thinking about kinetic melodies that are triggered and then unfold on their own. It is only after the fact that situated actions can be compared to, and evaluated in terms of, the plans that preceded them. When Matt enacts the movement required for pushing the power lever to the ramp, it can be seen as an actualization of what the procedures describe, and, in this way, serve as a referent for the evaluation in the way Suchman described.

Evaluation appears for a second time when the instructor noted that with two engines running, which the aircraft had in the event, the way Nina had flown was “not such a biggie,” followed by an explanation: “it’s a lot of power.” But with a single engine running, the power lever has to move forward to the ramp (in emergency situations even beyond the ramp) (Figure 3). But the failure moving the power levers to the ramp and simultaneously pulling on the steering column to pitch up the plan, thereby, is and becomes an issue. As all three participants know, Nina had had this same problem when Matt has failed one of the engines before (i.e., from his flight examiner controls, he stopped one of the engines of the simulator). While failing to get this double movement required by the standard operating procedures is not merely a more minor issue in *this* situation but in all situations when the go-around has to be flown with two intact engines. However, it was and will be a real issue in single-engine go-around situations. The way in which Nina acted in the simulator, here exhibited in the debriefing tool for all participants to see, would be a problem for her in future examinations because it would mean a 2 (*minimum standard*) rating in the *procedure* subcategory of the *knowledge* human factors. The associated word picture in the airline’s assessment form establishes a correspondence between “Displayed lack of familiarity with procedure; correct procedure selected but executed slowly or with errors” and the score of “2,” and three 2’s requiring being taken off the job and retraining. Immediately preceding the debriefing meeting, the flight examiner expressed the concern that Nina still does not satisfactorily perform the pilot flying’s actions during the single-engine go-around.

4.2.2. Instruction

In the episode, Matt produces the full hand/arm movement required for the go-around, thereby contrasting the two movements seen in the videotape, of which the second included a verbal description (“to the ramp”). The full movement produced in this debriefing meeting also serves as a plan (instruction) for future situations where Nina has to fly the go-around procedures. Similarly, the movement Matt produces with the cursor to the attitude indicator is an instruction (pointer) that tells Nina where to orient in future go-around situations to check the appropriate pitch of the aircraft. Each aspect of the procedure articulated as a referent for the analysis of the preceding performances also serves as a plan for future situations. Instruction here functions in two senses of the word: teaching and making known to a person what she has to do. Both these senses presuppose certain types of knowledgeability: that of (a) imparting knowledge or skill (e.g., flying the go-around procedure to satisfaction) and (b) doing what the statements “to the ramp” and “pitch up” or Matt’s hand/arm gesture in turn 14 describe.

5. A societal-historical account of teaching | learning (*obučenie*) in aviation

In this section I focus on two aspects of learning and development that stand out from Vygotsky’s program of a concrete human psychology and that are relevant to understand the instructional episode: soci(et)al relations and their affordance to learn in multiple ways ways (Vygotskij, 2005).

5.1. Soci(et)al relation

The episode exhibits a feature of double relation of learning that had been exhibited in the work with deaf-blind children in the USSR (Meshcheryakov, 1974). These children did not just eat with a spoon when given one. Instead, an educator placed the spoon in the hand of the children, guided it to their mouth. In addition, educators guided the children’s other hand so they would touch the spoon and the hand that was holding it. The children not only used a tool (rather than their hands) but also explored spoon use. Eating with a spoon emerged as a relation, which was reflected upon through the exploration of the tool and process. In the present study, an analogous process occurs. Rather than flying the real thing, and rather than memorizing facts and procedures, Nina and Ike learn to fly in a simulator. The simulator is a tool much in the same way that a school and university science laboratories are simulations of the full laboratory that some of them work in when taking up graduate studies or science careers. In the aviation case, the full motion simulator has high fidelity with the real situation: flying in the simulator gives the same feeling as flying the aircraft, involves the same hand and arm movements, and the same perceptual processes. In the video clip that the participants watch and analyze, Nina is flying a go-around procedure. But she is not just doing it on her own. Instead, part of the procedure exists *as* relation first, just as it has been predicted for all higher psychological functions. This is evident from the following considerations.

During the exercise, Nina makes the call for “flap 15” prior to actually having moved the power lever to the ramp or rotated the aircraft to the required pitch—although in both

instances, she had done part of the required movements.⁵ Matt then says “to the ramp there” and “pitch up,” which is followed by a beginning of the pitching up process and the movement of the power levers. The standard way of looking at the speaking turns is to say that Matt, to whom the words are attributed, gave the two instructions, and Nina followed them (turns 05–06).

A more appropriate way of considering verbal exchanges takes account of the fact that words do not only belong to the speaker, whose vocal organs produce the sound, but also to the recipient, in whose ears the sound resonates (Vološinov, 1930; Vygotskij, 1934). Nina’s response begins with the *active* reception (Roth, 2014b). Thus, “pitch up Nina” exists for both, and is integral part of Nina’s response, the second part of which is the movement that pitches up the aircraft. A division of labor is achieved of a movement that culturally is one but in the course of instruction becomes two: “The renewed division of what had been fused in one” (Vygotskij, 2005, p. 1023). This situation is depicted in the following alternative transcription that takes active reception into account:

-- Ma: [pitch up [Nina] ((*in Matt’s mouth*))
 06 -- N: [pitch up [Nina] ((*in Nina’s ears*))
 -- [((*Nina pitches up*))]

Because “pitch up Nina” belongs to both speaker and recipient, the response cannot be uniquely attributed to Nina. Pitching up, therefore, exists not only *in* the relation of instructor and pilot but *as* their relation. Similarly, the movement of the power levers from the notch to the ramp exists *as* the instructor-student relation. Five days later, during the examination, the independent examiner (i.e., not Matt) observed Nina making the required movements. At that point, what *was* a relation first (including Matt) now exists in a way that might be described to Nina as one of her higher psychological functions.

Here one clearly sees that teaching (instruction) and learning cannot be considered independently, an issue made thematic in the notion of *obuchenie* (Cole, 2009). The expanded transcription makes evident that there is not a simple cause and effect relationship between Matt’s (instructional) statement “pitch up, Nina” and Nina’s pulling on the steering column that pitches the nose of the aircraft up. Instead, the statement, to do anything, has to be actively received; and this active reception is the first step in the learning process, which becomes apparent as having occurred when Nina, five days later during the end-of-training examination, pitches the aircraft up at the appropriate instances when she has to fly the go-around procedure.

There is more to this episode than this relation of instructor and instructed. In the debriefing meeting, the participants talk about and enact the relevant movements. In dissecting the whole movement, which exists as a series of conditioned (non-conscious) operations, each part now is made an object of conscious awareness: an individual, goal-directed (conscious) action (Leont’ev, 1983b). The debriefing meeting, the video clip, and the verbal and gestural production of the hand/arm coordinated movement allow something to come to conscious awareness for the purpose of making it subsequently disappear as an operation in a much larger whole. This whole, for the experienced pilots, will be the entire go-around procedure (Roth et al., 2015); it will not require any more

⁵ “Flap 15” indicates that the wing flaps are extended to 15 degrees, which gives more lift to the aircraft when the speeds are lower.

conscious thought than driving a car, to which an experienced driver does not have to give a second thought. It is the debriefing tool, with its video clip and the visual representation of the power lever and steering column, that facilitates the participants' relation to the past event, allowing them to bring to Nina's conscious awareness something that she had not been conscious of, and, in the future, should no longer be conscious of.

The event by means of which a previous experience became the object of reflection, and, thereby, became available to individual and social consciousness, also *was* a relation. This relation is established by and reflected in those very words that are used to talk about and instruct the procedure. When Matt says "pitch up, Nina," then those words not only communicate something but more importantly establish their relation that the teaching | learning process presupposes (Vološinov, 1930; Vygotskij, 2005). Thus, it was not Nina alone, who was focusing on the recorded performance. Instead, Matt selected the fragment. It was made salient by the very fact of its selection, naming, and playing. That the power lever to ramp was at issue for Nina, too, was evident in her associated hand/arm movement even before Matt had completed his description of how to execute this movement, and, thereby, describing to and instructing what Nina was to do in future situations. As before, the solicitation Nina actively received and her actions that followed *together* constitute the response. The repetition and reflection on the hand/arm movement, therefore, existed *as* social relation first before it existed as a psychological function that can be ascribed to Nina. I do retain, however, Vygotsky's insistence that even when Nina does the sequence on her own, this function still exists as a social relation, which "means to relate to oneself as to another" (Vygotskij, 2005, p. 1022).

5.2. *From performance to actions to operations*

For the purpose of instruction, whole procedures come to be broken apart so that what normally are parts of an entire kinetic melody (i.e., operations) become separate conscious actions. The intent is to make pilots aware of problems for the purpose to compile these actions, once corrected, into whole operation sequences that unfold on their own without requiring conscious awareness. In the following I articulate how a small part of the go-around procedure comes to be dissected into even smaller parts, followed by the provision of a verbal device that is intended to allow the students to reconstitute the actions into the operations of a larger unit. Ike and Nina have already had 7 days of classroom instruction and have prepared themselves by reading the standard operating procedures for flying the particular aircraft type.

5.2.1. Dissecting a movement, imitation, and social division

Above I cited Vygotsky stating that imitation and social division are the main features in the production of psychological functions. Both aspects can be seen at work in this episode, here illustrated with the part where a whole movement is dissected for teaching | learning purposes. In this instructional sequence, what normally is one unit of coordinated movements—described in the standard operating procedures—comes to be dissected into elements. Two of the three parts in the "power up, pitch up, clean up" phrase are described, analyzed, and critiqued. First, the hand-arm movement required for

pushing the power levers is addressed separately from the simultaneous movement required for pitching up the aircraft; then this movement is dissected into two parts, the first taking the power lever from flight idle to notch position, then continuing until the ramp position is attained.

13 N: <<p>yea; need=ta=[do the go=around>]
 [((gesture Fig. a–b))]

14 Ma: [what=ya=need to think of] (0.31) is (.) you need=te go
 (0.85) [hIT something] [(0.48) [push past.]
 [((a–b))] [((b–c))] ((Matt))
 [((f–g))] ((Ike's movement))

The flight examiner's movement appears in two parts, just as Nina's movement seen on the debriefing tool. But if this two-part movement had been what was to be articulated, then it would not have been other than a description of the original movement that was negatively evaluated here. What Matt shows, instead, confirmed by the preceding movement Nina enacted when the critique began, was one extended movement of the power lever from where it is *through* the notch position and right up to the ramp (Figure 3). This extended movement rather than a two-part movement separated by some time (iconically represented in the time between its two parts in the repeated iterations) has its verbal description in "you need to go, hit something push past" (turn 14). The push *past* verbalizes the extension, thereby overriding any possible hearing and seeing of a movement consisting of two parts separated by some pause. The dissection is explicit in the difference between the movements Ike produced, on the one hand, and those that Matt and Nina exhibit, on the other hand. In the former instance, the hand on the steering

column also moves (turn 14, f–g), whereas it is at rest in the two other cases (turn 14, a–b, c–e).

Here, there is also a visual presentation in the form of the corresponding hand/arm movement (turns 16, 18) concurrent with part of the two parts of the verbal instruction. This presents an opportunity for a double strategy: the gestural depiction affords imitation, which, while it is (inherently) not influenced by cultural conceptions and verbal description that brings something to awareness, still requires experience-based understanding (Chaiklin, 2003; Iacoboni, 2009). The function of speech in this instance is *apophantic*, that is, to make something show itself from itself (Heidegger, 1977). What is to show itself is this: how a single movement can be thought as consisting of two parts, each associated with a physically sensible end point: notch and ramp.

Second, the pitch-up movement is addressed together with an orienting cursor movement to the attitude indicator where the aircraft pitch is represented (turn 39). In so doing, what is to be one (conscious) action, the “go-around” call together with the pitching up and power lever to the ramp, is articulated in terms of three (two plus one) actions: “to the notch” + “a handful more” and “pitch up.”

39 Ma: and=then (.) ye=know (.) jUST (0.28) see (0.57) you know
 [you=re getting onto that flight [trajectory] after i said=t=you]
 [((pointer to attitude indicator))]
 [[[Nina nods)]]

cursor in
the form of
a white arrow

40 which is great but you just need to (0.81) you=know (0.26) jes a=bit like
 <<dim>the OLD ways ye=know> (0.89) pOWER up pITch up
 (0.31) [clEAn up].

41 Mi: <<p>[.hh hhhh] [.h hh]

42 N: <<p>[hmm]> ((nods twice))

Matt initiates the talk about the issue by placing the pointer to the electronic attitude director indicator (Figure 4, close-up in Figure 3a), the pilots’ principal instrument for pitch (lateral axis) and roll (longitudinal axis). In fact, there are multiple indirect references to the pitch before it is actually named as the issue. First, the pointer moves to the instrument where the pilots may find the aircraft’s pitch; second, Matt notes getting onto the flight path, which presupposes a correct pitch.

5.2.2. Recombining the actions to make them (non-conscious) operations in a larger action

In explaining the relationship between goal-oriented, conscious actions and non-conscious operations, Leont’ev (1983b) uses shifting the gears of a car manually as a paradigmatic example. Something that is a conscious action with non-conscious parts for

an intermediate driver, shifting the gear up or down, is decomposed for instructional purposes: each operation is brought to consciousness and thereby turned into a conscious action. Through practice of executing the actions in sequence, the learner eventually comes to a point where the thought of shifting triggers the entire shifting process without that its components need to be brought to conscious awareness. This entire process constitutes a kinetic melody that unfolds on its own once it is set off (Luria, 1973). In this episode, one observes precisely this type of instructional processes at work. In this debriefing meeting, the different (unconscious) operations that constitute the first action in producing a go-around are presented as three conscious actions. In the meeting, what had been two movements in Nina's performance, two actions, are made to stand out so that their role in their fusion into one continuous movement, here highlighted. In this one action ("[Power levers] to the ramp" consists of two operations. The resulting action is to be combined with another action, "pitch up," so that these two come to be fused into a single coordinated movement that is but one of the operations of the action that initiates the go-around.

The orientation towards compiling larger sequences into single actions is made further apparent when the flight examiner adds another phrase well known to pilots: "aviate, navigate, communicate." It denotes a sequence of actions to be taken in the case of emergencies, beginning with taking control of the aircraft (aviate), followed by taking the aircraft into the appropriate direction (navigate), and finishing with communicating what is to come next to others in the cockpit. In fact, in emergencies the desired state is not to have a sequence of actions but to have a single movement in which these actions have been transformed to operations that unfold on their own once the sequence is triggered. Matt then articulates the sequence of actions again required for the go-around: power up, pitch up, clean up (turn 46).

For both issues articulated, power and pitch, the flight examiner provides multiple iterations of instructions for what to do. But this is not the point of the instruction, as shown by the fact that Matt then offers a way of remembering the required sequence of what here are explicit actions: power up, pitch up, clean up. He described it as "the old ways," that is, as a traditional way of soliciting junior pilots to constitute action sequences into a single movement, a kinetic melody (Luria, 1973), that can unfold without requiring conscious thought. This can be seen in the use of the memory aid—power up, pitch up, clean up—which is to constitute, for Nina eventually (e.g., during her exam 5 days later), one single movement rather than three or more separate actions executed when after she has thought of (made conscious) the next step. It is to constitute one of those cockpit melodies on which competent flying is based (Roth et al., 2015).

6. Discussion

6.1. Multiple functions of an instructional sequence

In formal learning contexts, formative assessment tends to be distinguished from (final, summative) assessment tout court. In the context of aviation, every assessment implicitly has both functions. This is so because of the special nature of the culture, where pilots are assessed on the levels of their performance in situations that they rarely,

if ever, encounter in the course of their work.⁶ The simulator sessions and associated debriefing meetings both assess the pilots as to their current competency levels and prepare them to fly under non-normal conditions. This double function of assessment is apparent in this investigation.

The playing, description, and analysis of the video has multiple functions. On a first level, it was a look at what Nina had actually done while flying *this* go-around procedure. But this performance is only a particular instance of Nina's general performance of the procedure, especially critical when she would be flying with only one live engine—as can be seen from the spectacular aviation tragedy in Taiwan with the same aircraft type (TransAsia Airways Flight GE235), where the captain had shut the one operating engine off rather than moving the lever to the ramp. Playing this part from the simulator session stood in for all situations in the simulator session where she was in the position of pilot flying this procedure. But making this performance the topic of the debriefing meeting is part of the *instructional* goal to allow Nina to learn from this (formative) assessment implicit in the critique. Matt's repeated display of the full movement required in pushing the power lever to the ramp is a referent against which Nina's preceding performance is judged; but it is also an instruction for how to perform this part of the go-around in future situations during her training, the assessment session that would occur a few days later, and on the job should she encounter a go-around while transporting passengers.

As instructional sequence, the debriefing fragment is more: it includes Ike in the intended audience. He responds in this sense when acknowledging Matt's instructional comments and by producing the (correct) double movement required according to the standard operating procedures. Ike not only acknowledged the instruction repeatedly, understanding it at a conceptual level, but also exhibited the correct hand/arm movements, and, thereby, the required embodied knowing.

6.2. Kinetic melodies: learning by (immediate) imitation and the social

This episode illustrates the double nature of knowing to operate an aircraft. It integrates bodily knowing how to fly an aircraft explicated and available for conscious awareness in descriptions such as those that appear in the standard operating procedures. There are recent suggestions that the events in a cockpit are best described in terms of the concept of *kinetic melody* (Roth et al., 2015). In the melody, each pilot has an integral part in the way an instrument has in a multi-instrument musical composition. In the way musicians coordinate their play by means of cues, pilots act when something else has happened in the cockpit as a whole. That is, the announcement (call) “go-around” is the trigger for a whole process that is an integral and integrated response on the part of the cockpit as a whole. If something does not happen, i.e., if an operation is missing such as pushing the go-around button, then the entire sequence falls apart, which observing pilots and flight examiners come to label an “untidy” or “messy” procedure (Roth & Mavin, 2015).

The kinetic melodies that describe the events in a cockpit consist of bodily physical movements, perceptions (instrument readings, oral signals), and words (“calls”) that

⁶ This is also what makes these examinations stressful even for experienced pilots, because they cannot ever know what they will be confronted with and how the crew as a whole will perform. It literally is a high-stakes examination, to which pilots are subjected twice each year.

together get the work done. These melodies become untidy when something is not said (or incorrectly said) or done at the appropriate instant, or missed altogether. There is a continuous flow where moving a switch, dial, or lever follows some sound-word or where gazing at a particular instrument leads to an announcement (e.g., the “positive climb” that follows after Nina has pitched the nose of the aircraft upward). It is during type-rating training that pilots are prepared to become part of such *collective* melodies. The purpose of the instruction in this specific episode is to assist these pilots new to the company and the aircraft it uses to compile what currently are conscious actions into larger, single units that constitute the response to a difficult situation. That is, the purpose of instruction is to evolve patterns that allow joint kinetic melodies to arise in practice as individuals learn to contribute their part to the whole.

In this episode, we observe the way in which the social relation including examiner/instructor and pilot *is* the form in which the hand-arm movement required to push the power lever all the way to the ramp first exists. The relation is the first appearance of the integration of the simultaneous movement that moves “[the power levers] to the ramp” and “pitch[es the aircraft] up,” just as predicted in the societal-historical approach (Leont’ev, 1983b; Vygotskij, 2005). In this framework, a second important part of teaching | learning consists in the opportunities to learn by means of imitation, an active process requiring understanding (*recognition*) of what is depicted in a hand/arm movement rather than a passive process of blind copying. Matt offers an opportunity for imitation by using the left hand and arm in the movement, which is what the pilot in the position of Nina (right seat) would have done. Previous research shows that the flight examiner would have used the other hand and arm had Nina be sitting in the left-hand seat (Roth & Mavin, 2015), the seat that Matt normally occupies because he is captain in this airline.

6.3. *The role of debriefing tool*

The debriefing tool therefore provided the group with a resource that offered multiple re/presentations of an event to be described, analyzed, and critiqued. Thus, the participants could see and hear themselves, as recorded by the camera mounted in the simulator. The video permitted viewing the grosser hand/arm movements, such as that concerning the power lever. But the position of the power lever is not clearly seen in the video. Matt pointed to the attitude indicator rather than making reference to Nina’s actions or to the steering column represented as seen from the pilot and as seen from the side. There is good reason for this: neither the video nor the steering column representation shows the minute movements by means of which Nina had brought the aircraft to the appropriate pitch. However, the movement is clearly visible through its representation on the monitor, especially in the side perspective relevant to the movement that pitches the aircraft up. The attitude indicator, though evidently a representation of the actual instrument, also is different from a mere representation. This is so because pilots can see in the same mode what previously had been perceptually available to them in the aircraft. That is, this part of the debriefing tool makes available an aspect of the flight in the same mode that it was available to the pilots during flight. The power lever is different, appearing only in the form of an iconic representation but not affording the equivalent identical sensory (haptic) modalities (pushing, feeling resistance) as the

attitude indicator. By means of the debriefing tool, some aspects are *self-present* in the meeting, and do not require representation. They can be referred to when and as needed.

In this debriefing episode, the participants orient to the debriefing tool, which as a whole or in its part becomes the object of perception. The participants then orient towards and address each other. While doing so, the debriefing tool still displays the instant when it had been stopped. It is this image that serves as the ground, synecdochically for the played event as a whole. The synecdochical nature can be seen in the pointing to the attitude indicator, which, at that time is still. The issue to be discussed is the delayed process of getting from 0° to 8° pitch. The image of the indicator stands for the entire issue critiqued, the delay and prompt-requiring action that brings the aircraft into its proper flight path.

In its entirety, the episode exemplifies one of the advantages of the debriefing tool over other means of making an event present again. When the video plays and the instruments display what had been displayed during the flight event, everything is literally present in the situation. This recorded account of the event literally is its own presentation. Participants may obtain certain information simply by looking at the appropriate place in the display. Verbal, gestural, or cursor referencing index an aspect much in the way speakers mark a particular location in space and, by subsequently pointing to it, make that past topic present again.

My research shows that the pilots tend to emerge from the simulator sessions having forgotten most of what had happened, what they had said, and what the flying conditions and instrument reading were for any given event (Roth, 2015). In this situation, the debriefing tool provides multiple re/presentations for a particular flight event. This is made present again in this way, unhampered by possible interferences that often plague personal accounts. There are irremediable states of affair that are the same whenever the event is replayed, whether hours, days, or months since it originally occurred. Both examiners and pilots are held to what appears on the debriefing tool, which is taken as indisputable. (Fight examiners revise assessments when they can see, or are challenged about, the precise nature of simulator events.) The debriefing tool is a form that facilitates memory: initially as an artifact placed between the person and the thing (the simulator event), then between the person and his/her memory (Vygotskij, 2005). It is so first by actually replaying the event as seen by the examiner and by presenting again the positions and states of key instruments and tools. It is so in a second way as well in that its current state indexes the replayed event as a whole. As a memory device, the debriefing tool is incorruptible, as distinct from human memory, which decays or changes the events with hindsight.

Because an event is made present again in indisputable form, it can now be described, contrasted with descriptions of what ought to have happened, analyzed, and assessed. What can be seen also serves as the ground against which the talk appears. There is a mutual constitution between what appears on the monitor and the actions currently occurring. The relation between talk, iconic and deictic gestures (with finger or cursor), and other bodily movements, on the one hand, and what can or is to be seen, on the other hand, stand in a reflexive relation (Goodwin, 2000). Thus, for example, the critiqued performance—delay in Nina's actions to move the power lever to the ramp and pitching the aircraft until it reached the required 8°—is not as big issue when an aircraft has both

engines intact than it is with only one engine operating. The performance therefore both is and is not a major issue, which, perhaps, mitigates the severity of Matt's critique.

7. Conclusion

This study was designed to investigate teaching | learning (*obučenie*) in a formally organized (informal) workplace setting: the (type-rating) training of pilots and annual assessments of those already type-rated. The flight examiners and examiners are not formally trained in college or university programs. This study exhibits the *soci(et)al relation* as the sine qua non of teaching | learning (*obučenie*). In the relation, both immediate forms of learning through imitation and learning facilitated by external tools are enabled. Moreover, I show how a higher function exists *as soci(et)al relation* between two people that does not yet exist for the pilot herself.

The study shows that there are multiple tools in the training of pilots. The simulator affords training and assessment in non-normal situations that not only occur rarely in regular work but also are more dangerous. Also exhibited are the multiple functions of the debriefing tool. It serves as a sign that facilitates memory in a situation where, as apparent both in the interviews and in the debriefing sessions, pilot remember little from the stream of experience. They are afforded both third-person (e.g., video, representations such as power levers) and first-person aspects (e.g., instruments) on their previous flight experience. This allows them to see, describe, and analyze what they had not seen, said, or done. Again, these tools come to be employed in the context of a *soci(et)al relation* that will have been the first appearance of the pilots' reflective stance towards their own experiences during the training and assessment sessions.

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