



Forest machine operator students' experiences of simulation-based learning

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Abstract

Simulation-based learning (SBL) is widely used in different contexts where the purpose is to learn and train professional skills. The aim of this qualitative study was to examine forest machine operator students' meaningful learning experiences of skills training and performance, and guidance from the teacher and the simulator in a SBL session. Six operator students completed four tasks using the simulator under the teacher's guidance. After the SBL session, the students watched the screenshot videos of the tasks, annotated meaningful learning experiences, and were interviewed about them. A thematic analysis was used. The findings showed that learning experiences of skills training and performance were mainly described through errors, whereas successes were rarely mentioned. The teacher's guidance was perceived as advice and feedback which were considered useful and supportive for the learning and developing professional skills. The simulator's guidance was also characterised through advice and feedback, but these were perceived as overly strict. The findings suggest that the teacher's support is needed particularly in the initial phase of simulation training. It is important to foster the development of operator students' self-assessment skills and to encourage them to be active and responsible in their learning of new skills in SBL sessions.

Keywords: simulation-based learning, learning experience, students, skills training, forest machine operating, guidance



Introduction

In Finland, forest machine operator students in vocational education and training (VET) start to learn and practise professional harvester operation skills with simulators. Simulator training is widely used in operator students' education as fundamental skills can be trained safely and cost-effectively before working with real machines (Ovaskainen, 2005; Salakari, 2005). The demanding nature of operators' work and the challenging conditions in which they operate are well documented (e.g., Kymäläinen, 2021; Ovaskainen, 2009; Ovaskainen & Heikkilä, 2007). However, less is known about operator students' learning experiences of simulations when practising the skills needed in their future work. Exploring these experiences can provide valuable insights into how simulation-based learning (SBL) is perceived by operator students in VET and how it supports their learning. Therefore, this study examined first-year operator students' experiences of SBL.

The use of simulators is based on SBL which promotes the learning of complex skills (for a meta-analysis, see Chernikova et al., 2020) and enables practising approaches which are challenging to reach easily and safely (e.g., Lateef, 2010). Previous research has proven simulations' benefits for practising professional skills in versatile professional contexts such as aviation (Allerton, 2010), health-care (Aebersold, 2016; Cook et al., 2013), the minerals industry (Bergamo et al., 2022), and driver and vehicle crew training (Goode et al., 2013; Nyström & Ahn, 2025). Additionally, in studies of forest machine operating, several aspects of simulations have been examined. These include, for example, simulations' benefits such as increased training speed and cost-effectiveness (Burk et al. 2023; Lapointe & Robert, 2000), forest machine work in forest and simulator environment (Ovaskainen, 2005), operator students' frustration and mental workload in different learning settings (Lee et al., 2025), the conditions of students' self-evaluation and reflective practices in simulated learning environments (Messina Dahlberg & Gustavsson, 2024), and simulations' opportunities and hindrances to students' learning (Nyström & Ahn, 2025).

Simulations enable a connection between an educational setting and professional skills. However, little is yet known about VET students' own perspectives on SBL (Jossberger et al., 2018) even though the personalisation of one's learning experience is an important feature of simulations (e.g., Bergamo et al., 2022). Despite the wide use of simulators, empirical research on operator students' experiences of simulations has only recently begun to emerge (e.g., Nyström & Ahn, 2025). Examining in detail students' learning experiences and guidance they receive in a SBL session is crucial for identifying possible needs for more enhanced pedagogical practices. The aim of the present study was to provide new insights into operator students' meaningful learning experiences of

skills training and performance, and guidance from the teacher and the simulator in a SBL session.

Simulation-based learning

SBL involves a pedagogically structured process in which simulated experiences are used to support learning and development of professional skills. The foundation of it appears to lay in experiential learning (e.g., Poore et al., 2014; Silvennoinen et al., 2022; Zigmont et al., 2011) and on the experiential learning cycle (Kolb, 1984, 2014). In his experiential learning theory, Kolb (2014, p. 49) defines learning as ‘the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience’. In the experiential learning cycle, two modes of grasping experience are concrete experiences and abstract conceptualisation, and two modes of transforming experience are reflective observations and active experimentation which together can be portrayed as a cycle of the learning process in which the learner experiences, reflects, thinks, and acts (Kolb, 2014).

SBL involves scenario-based training of real-life problems which need to be solved by mastering specific skills (Lateef, 2010). Technology often has a central role in SBL, and different applications such as virtual reality (VR) and game-based platforms offer engaging and near-authentic learning experiences with immersive elements applied in SBL settings. SBL is particularly beneficial in terms of its flexibility as learning environments can be adapted to learners’ needs (Chernikova et al., 2020), and skills to be practised can be either technical or non-technical such as teamwork, communication, and decision-making (Østergaard et al., 2011).

A SBL session is a coherent whole built on purposeful tasks with clear goals. It includes three phases, namely: introduction, action, and debriefing (e.g., Dieckmann et al., 2009; Fanning & Gaba, 2007). In the introductory phase, learners familiarise themselves with an upcoming SBL session through, for example, written materials, the teacher’s instructions, or instructional videos, and set learning goals. In the action phase, learners carry out the task. The final phase is a debriefing, which is a discussion following the action phase. A traditional debriefing is guided and structured by learning goals, but the debriefed issues might also arise from the action phase, skills or knowledge acquired, or other issues that learners feel important to reflect afterwards (Fanning & Gaba, 2007). The debriefing is an important part of SBL, as it provides opportunities for learners to share and reflect on experiences (Dieckmann et al., 2009; Fanning & Gaba, 2007; Husebø et al., 2013; Lee et al., 2020). Thus, learning in SBL does not take place only in the action phase but also in the debriefing (e.g., Poore et al., 2014) and the teacher’s role is to facilitate this reflection and provide feedback

accordingly (Zigmont et al., 2011). When creating a purposeful SBL session, the teacher can have several roles such as information provider, role model, facilitator, assessor, planner, and resource (Dieckmann et al., 2009). Thus, adapting to versatile roles and recognising learners' needs are central characteristics of a teacher in SBL.

In contrast to healthcare simulation (often structured as episodic, scenario-based training sessions), VET simulation, such as forestry skills training, is more closely integrated with ongoing work practices. From a VET perspective, learning occurs in close connection with authentic work practices, where occupational competence develops through experiential and reflective processes as well as participation in workplace practices supported by guidance and engagement (Billett, 2002, 2011; Kolb, 1984). Although SBL has been extensively developed in healthcare and aviation education, several of its pedagogical principles, particularly reflective practices and structured feedback or debriefing, remain relevant for VET, even though in VET contexts their forms and purposes may differ across professional domains.

Forest machine operation simulations in VET in Finland

There are two main types of forest machines: harvesters and forwarders. Harvesters are used for felling trees, removing branches, and cutting the stems into logs. Forwarders then collect the logs from the forest and transport them to the roadside. Forest machine operators' work sets both physical and mental demands which have been widely addressed in previous research. The work is ergonomically challenging (Kymäläinen, 2021), independent (Gellerstedt, 2002), responsible, and stressful as multiple complex decisions need to be solved repeatedly and rapidly (Häggström, 2015). Instead of being superior in any specific cognitive ability, key characteristics of productive operators are their comprehensive perception, non-verbal deduction, spatial perception, coordination, concentration, motivation, and the wide use of memory functions (Ovaskainen & Heikkilä, 2007). In addition, operators should manage an increasing number of IT-skills (Häggström, 2015; Kymäläinen, 2021), withstand physical fatigue, have good sight for right immediate choices as well as sensorimotoric skills (Ovaskainen, 2009), good self-management, and an understanding of their own well-being at work (Kymäläinen, 2021). In terms of speed, it should be noted that it is merely a habit developed through training rather than a single ability (Ovaskainen & Heikkilä, 2007).

As operators' work practices aim for efficiency and productivity to meet the requirements of saving time and costs, it is natural that also the use of simulators is based broadly on the work's economical perspective. Forest harvesting, so called cut-to-length (CLT) operating, is highly mechanised (e.g., Kymäläinen et al., 2021) and simulators have the same functions as real machines, enabling

operator students to practise skills while reducing costs. Therefore, simulators are considered effective tools for practising skills that can be transferred from simulation environments to authentic contexts (Ovaskainen, 2005; Salakari, 2005).

In Finland, the pedagogical model for forest machine operator training developed by Salakari (2005, 2007, 2010) is often applied in VET. According to the model, teaching is guided by learning goals defined in the curriculum, and the teacher determines which goals are appropriate to pursue through simulator training. Learning is understood to occur through 'learning by doing' within a cognitive apprenticeship model, in which the teacher's role as an expert gradually decreases as novice students' skills develop. As students gain more responsibility and independence, the teacher's guidance correspondingly diminishes. Throughout this process, skills are expected to transfer to the authentic environment. The teacher should support the development of new skills by helping students set personal learning goals and guiding them in assessing their own performance in relation to these goals.

The increasing and changing demands of forest machine operation highlight the need for effective training environments. SBL has been proposed as one such environment; however, understanding how students experience these environments is crucial for evaluating their pedagogical potential. Additionally, previous research on forest machine operators in the Finnish context has, to our knowledge, primarily focused on the physical and mental demands of the work, the required competencies, and training outcomes, while less attention has been paid to operator students' subjective learning experiences of simulations in VET. This study addresses this gap by examining how operator students perceive and experience simulations and simulators as part of their learning process, thereby providing new insights into the pedagogical role of simulations.

The present study

The aim of the present study was to provide new insights into forest machine operator students' meaningful learning experiences of skills training and performance, and guidance from the teacher and the simulator in a SBL session. The research questions were as follows:

- (1) How do forest machine operator students describe their skills training and performance in a SBL session?
- (2) How do forest machine operator students describe the teacher's guidance in supporting their skills training?
- (3) How do forest machine operator students describe the simulator's guidance in supporting their skills training?

Methods

Study context: SBL in first-year forest machine operator education

The study was conducted in a forest machine operator education programme in Finland, where SBL is used as part of the students' vocational education. The vocational school of the present study offers education in agriculture, forestry, natural and environmental sciences, construction, and health and welfare. The study programme, Vocational Qualification in Forestry, is planned to take three years. It consists of 180 competence points including both degree-specific study units (145 competence points) and general study units of interaction and communication skills, mathematics and science, and society and working life (35 competence points). The degree-specific study units include for example, silviculture, mechanised harvesting, and the use and maintenance of forest machines. The study programme includes also workplace-based learning. During the first year of the studies, simulation training is essential part of education as students gain hands-on experience with forwarders and harvesters. As the control systems of the simulator and forest machines correspond, students first train their skills with the simulator before moving on to real machines. However, flexible transitions between working with real machines and the simulator are a common practice in the programme.

Participants

Data for this study were collected as part of an interdisciplinary consortium titled 'Development of educational service ecosystem using physiological data and intelligent systems'. The Ethics Committee of the University of Jyväskylä granted an ethical approval for the study before commencing the data collection. Participants were six males aged 16–18 years. They were first-year forest machine operator students from the same vocational school and they had studied for five months. They formed six student-teacher dyads with two teachers so that each student worked with one teacher. The students were recruited on a voluntary basis from the bigger group of first-year students to whom the project was introduced at school by the researchers. The students were given both oral and written information about the study before their decision to participate, including that all data would be treated confidentially, that no personal information would be disclosed, and that they would not be identifiable from the reported findings. A privacy notice with information on how the data would be used in the study was given before a written consent was obtained from the students and the teachers. Throughout the study, the ethical principles of research with human participants (Finnish National Board on Research Integrity, 2019) were followed. Participation in the study was not part of the students' studies and had no influence on their evaluation or any form of assessment.

The research setting for data collection was planned in collaboration with the participating VET teachers to align with their usual learning setting and to closely resemble their typical instructional practice. Therefore, close collaboration with these experienced teachers in the field supported the researchers' understanding of the research setting and the practical implementation of the data collection. This collaboration helped ensure the relevance and authenticity of the research setting within the vocational education context. The researchers did not have prior professional expertise in forest machine operation, and the teachers were not involved as co-authors of the study.

Data collection

Each student participated in an individual SBL session including three phases: an introduction, an action phase with four tasks, and a debriefing. The student and the teacher were sitting side by side at the simulator, which was a practice resembling a typical SBL session with three phases in this school. All students had operated with two different simulators, namely Ponsse SimTrainer and John Deere Timberskills. The simulation tasks were conducted using the John Deere TimberSkills 4.0 and the students were wearing VR headsets (HTC Vive) which enabled a 3D visualisation (see Figure 1). The simulator software recorded a screenshot video of each task. The teachers' expertise was utilised in planning the action phase as they selected four tasks which became progressively more challenging, so that the fourth task was estimated to partly exceed the students' current skills. All students performed the same four tasks.



Figure 1. Overview of a simulation task in John Deere TimberSkills 4.0 (on the left), and the SBL setting applied in the study (on the right).

In the introduction phase, the teacher and the student, that is, each student-teacher dyad, briefly discussed upcoming tasks and learning goals. Before each task, the teacher gave more specific instructions, and supportive instructional

material from the simulator (texts, pictures, videos) were watched together, which lasted approximately 5 minutes. The four tasks in the action phase were (i) loading logs, (ii) the work sequence in thinning, (iii) stopping at the work area to thin pre-marked trees, and (iv) selecting and felling trees for thinning. The first task was completed with a forwarder and the following tasks with a harvester. There was a time limit of 15 minutes to complete each task, and the student was allowed to restart the task within this timeframe if he did not get enough points to pass the task or if the task was terminated by the simulator due to a major error. After each task, the teacher provided brief feedback which lasted for a maximum of a couple of minutes. Additionally, the simulator generated a report comprising 11–13 factors, which produced an overall grade for each task. After all tasks were completed, the student and the teacher had a debriefing. The purpose of the debriefing was to have a more in-depth discussion with the student on his performance as well as experiences and feelings related to it. Screenshot recordings were utilised. The debriefings lasted approximately 10 minutes. Altogether, each SBL session lasted approximately 90 minutes. All three phases were kept as similar as possible with their usual SBL setting.

After the SBL session, the students were interviewed individually during the same or following day. The students were informed before providing consent that they would be interviewed and that their screenshot videos would be reviewed as part of the study. The use of videos was discussed again before each interview. The interviews were semi-structured and conducted by one researcher. They lasted 30–60 minutes and were recorded. By following the stimulated recall method, in which a person is provided with an opportunity to observe a video or audio recording of one's own performance to stimulate descriptions of their thoughts at the time (Calderhead, 1981; Kagan et al., 1963), the aim of the interview was to stimulate the student's memory and thoughts of the SBL session and to discuss it in detail.

Each interview started with a question on the student's overall thoughts and feelings of his former SBL session. Next, the researcher asked the student to describe each of the three phases of the SBL session, including what he remembered and how he felt during each phase. After this, the student and the researcher watched all screenshot videos of each task together. Along with the interview, the student annotated the videos to indicate episodes which he considered meaningful in terms of his skills training and performance in the tasks, that is, the student paused the video every time when a meaningful episode occurred, wrote down a timestamp as well as a brief description of the episode such as 'the grip hit the tree'. After each annotation, the student discussed the episode with the researcher before continuing to watch the video. The researcher asked clarifying questions about the episodes when needed. For example, one student said: 'I remembered the felling direction', and this was his description of

this episode. Here, the researcher asked the student to further describe what exactly happened in this particular episode. Along with clarifying questions, the researcher could ask for the students' thoughts and feelings about annotated episodes in detail. At the end of the interview, the researcher asked the student if he wished to add anything or elaborate on any of the topics discussed. The interviews were transcribed verbatim.

Data analysis

The analysis was theoretically informed by Kolb's (1984, 2014) experiential learning theory, which provided a sensitising lens for interpreting students' experiences. A thematic analysis (Braun & Clarke, 2006) was conducted, combining both inductive and deductive elements but primarily, the analysis was inductive. Initial coding was carried out in an open manner without applying predefined categories, allowing patterns and subcategories to emerge from the data through repeated engagement with the interview material. The research questions did not function as predefined analytical categories but were used later to structure the presentation of the findings in relation to the aim of the study. The analysis process was iterative and involved several phases of familiarisation, coding, categorisation, and refinement. In the first phase, the first author read and re-read the interviews to get familiar with the data. Initial codes were then generated, and data extracts were compared by identifying their similarities and differences. Through this iterative process, subcategories were developed inductively by grouping extracts with a similar meaning to one subcategory. Descriptions were then formulated for each subcategory to capture their content. These subcategories were further refined and organised into three broader themes. To enhance the credibility of the analysis, the themes, subcategories, and their descriptions were reviewed by the last author who independently coded one of the interviews. This process was done twice and between the rounds, any discrepancies in descriptions were discussed and clarified when necessary. After this, the first author analysed the remaining five interviews independently. Finally, the whole analysis and its findings were discussed with all authors to ensure credibility and consistency of the interpretations of the data extracts.

Results

Three broader themes were derived in relation to the research questions: (1) Students' skills training and performance, (2) Teacher guidance, and (3) Simulator guidance (see Table 1 for themes, subcategories, coding descriptions, and quotation examples). The themes and subcategories with illustrative extracts are described in more detail in the following sections. The extracts were selected to

be representative of the data and to both capture common patterns and add depth to students' experiences.

Table 1. Themes, subcategories, coding descriptions, and quotation examples.

Themes	Subcategories	Coding Descriptions	Quotations
Skills training and performance	Errors	Students described errors and possible reasons for them.	'The grip hit the tree.' 'I left a stump that was too high.'
	Successes	Students described successes.	'The felling directions were good.' 'At least those log piles were surprisingly good.' 'Stopping at the work area went well.'
	Self-assessment	Students described and assessed their skills training and performance.	'I worked in a way that there's no need for the driver to trim the logs.'
Teacher guidance	Advice and feedback	Students described how the teacher gave advice, pointed out errors, helped correct or avoid errors, provided feedback after simulation tasks, and discussed in the debriefing.	'Here the teacher had to tell me that the driving path was left too far.' 'I got advice on what I could do better and then [information on] what went well.' 'Here the teacher told me I should drop the stem [to the ground] and pick it up again.'

Themes	Subcategories	Coding Descriptions	Quotations
Simulator guidance	Advice and feedback	Students described the simulator's advice announcements during tasks, and the feedback report after each task.	'I got surprisingly good points, but I didn't pass though.' 'I passed also this task, at least meters were not above [the limits].'
	Comparisons between the simulator and real machines or between the simulators	Students described differences and similarities between the simulator and real machines or between the simulators by different manufacturers.	'When you drive the real machine in the forest, it's like, you can even feel the vibration and swaying. But when you're at the simulator, you just sit there and absolutely nothing happens.'

Students' skills training and performance

The first theme (i.e., the first research question) concerned students' meaningful learning experiences of skills training and performance in a SBL session and included three subcategories which described different aspects related to these experiences: (i) *Errors*, (ii) *Successes*, and (iii) *Self-assessment*.

Students described their skills training and performance mainly through concrete actions, such as selecting the correct commands, operating along the correct driving path, and using tools smoothly and accordingly. The emphasis in these experiences was on whether the student made (i) *Errors* or not during operating. Examples of typical errors were, for example, selecting the wrong tree to be felled, felling trees in the wrong order, and felling a tree in the wrong direction. Major errors terminated a task immediately. A major error occurred when Student 4 accidentally selected a wrong tool: 'There was nothing else than that I pressed the wrong button and the roller didn't go downward, I accidentally sawed.' Likewise, Student 2 caused severe damage to the forest machine which terminated the task: 'Here at the end I remember that the pile was too close so there wasn't enough space for [the grapple], there was a too tall stump and then the task stopped [because the grapple hit the tree].' All major errors were

annotated as meaningful learning experiences. Students perceived that it was easier to recognise errors compared to success. However, they considered it difficult to describe the reason other than that 'errors could be seen instantly'. Interestingly, Student 2 pointed out also that '...it is hard for a Finnish guy to praise oneself.'

In terms of making errors, students set themselves in a novice's position very naturally. Some emphasised that they were aware of being just in the early path of becoming professionals. Particularly in terms of performance in more difficult tasks, it was natural for beginners to make mistakes as Student 6 portrayed it: 'It's like a normal day when you're driving a harvester. [laughing] We are only just practising yet.' Even if a task terminated due to a major error, the overall performance could still be seen in a positive way and described as 'getting that far'.

Meaningful learning experiences of (ii) *Successes* were more seldom described than errors. An example of success was, for example, a situation where the student described that he worked in a steady and calm way and operated with the machine in compliance with the aims of the task. Student 2 described his success in the following way: 'And then those strip roads particularly, by the end [of the task] we got better all the time.' In addition, correct estimations of appropriate work areas and felling sectors, as well as having a grip in a correct position on a tree at the first attempt were annotated as meaningful.

(iii) *Self-assessment* extending beyond pointing out errors and successes was rarely described. Student 1 described how he assessed and further directed his current performance towards the upcoming work phases. He emphasised that he operated in a way which would help his colleague's upcoming work with the logs and concluded: 'No need for the driver to trim the logs [a short laugh].' This description indicated that Student 1 already assessed whether he was doing the right things. Instead, in other experiences of this theme, the focus was more on doing the things right and shortly describing technical aspects in the performance. Thus, there was hardly any speech of reasons behind the students' choices or performance which was illustrated in the following extracts by Student 1: 'I don't have anything else here really. It was like, basic performing.' and Student 4: 'I don't know, nothing [to say about my performance], none of those [tasks] stopped. ... Yeah and the stumps weren't left too tall.'

Teacher guidance in supporting the students' skills training

The second theme (i.e., the second research question) concerned the teacher's guidance in supporting students' skills training. Actions of guidance formed the subcategory (i) *Advice and feedback*. Each student described that the teacher gave them positive feedback in the debriefing. Additionally, some described getting positive and encouraging comments during tasks, for example, while

encountering a challenging moment. Students seemed to appreciate feedback that was not too detailed but rather concerned one's overall performance as Student 1 illustrated it: 'Well he [the teacher] told good and bad [things]. A bit like in a way, no, or some of those small [improvements] that there were, he rather watched those positive sides. He didn't get stuck on small things.' Feedback on the skill development and the student's overall improvement during tasks was perceived as relevant, useful, and encouraging. Based on the experiences involving feedback, the teacher was more active in speaking whereas the student was more in the role of a listener, such as Student 6: 'Well it [the debriefing] went quite well. The teacher told how things were and gave feedback, quite well. I got some advice on what to improve and then [I got feedback on] what went well.'

Students described how, during tasks, the teacher pointed out errors if the student did not notice them. This was also the case with Student 2: 'At this point the teacher mentioned to me about the grip's position. After this, [the teacher said] it [the tree] was left there [too] behind.' After pointing out an error, the teacher tended to give advice on how to either move on or how to fix the error if possible. Student 2 described also this type of an advice:

There was a good position for cutting a tree, I remember this, when that first one almost hit, but it didn't hit the other tree, the teacher said 'try to watch that you don't hit the other trees', and then I tried.

None of the students described that the teacher had asked them to explain or justify their action after an error. The teacher could also prevent the student from making an error, as with Student 4: 'Was it in that last work area or elsewhere when I was about to hit the tree. But I didn't even notice. He [the teacher] somehow noticed.' Students explained that the teacher's intention in these experiences was to avoid an upcoming undesired scenario and clarify it to the student. This allowed students to understand what was about to happen and adjust their subsequent actions accordingly. Moreover, the teacher's advice was described as guidance on corrective actions and as encouraging pushes which aimed for the student's improved operation as well as for more optimal performance, particularly in challenging and unfamiliar moments.

Simulator guidance in supporting the students' skills training

The third theme (i.e., the third research question) concerned the simulator's guidance in supporting the students' skills training. The theme consisted of two subcategories, namely (i) *Advice and feedback*, and (ii) *Comparisons between the simulator and real machines or between the simulators*. Generally, students deemed that the simulator either passed or failed them which Student 4 described in the following way: 'There were a bit too many errors, but I got surprisingly good

points though. Anyhow I didn't pass entirely.' Additionally, the simulator was seen to have gaming features. When a task was terminated due to a major error, Student 4 described: 'My game ended up with a mistake.' The overall impression arising from the students' experiences was that the simulator's advice and feedback were highly accurate. However, this was often interpreted as the simulator's strict character such as Student 1 perceived it: 'Well it was so that it was passed, it was good enough, I got five points. Yeah it, it would've been enough, for that computer [the simulator].'

Student 3, who already had some work experience, stated that according to his view, professional operators operated differently in the working life than students had been taught in their simulation training. He felt that the simulator was too judgemental for certain manoeuvres, as he had seen those to be routine-like for professionals in the field. This contradiction bothered the student and he portrayed his frustration in the following extract:

Well it was like, they [the felled trees] were positioned in the wrong place according to a textbook, but those things that I did were like things which like normal operators do. I tried to apply a bit but then; it's just that this simulator is so strict.

After each task, the simulator provided a feedback report containing values for the assessed factors. These included information on exceeding the limit values of certain manoeuvres, operation outcomes such as stump height, and the types and numbers of errors. The students appeared to place little value on these reports. Student 5 even criticised the report as useless: 'Well it [the report] was quite useless too. You can already see those [reported things] with those [instruction] videos and what you should do [in an upcoming task]. You know yourself what you should do.'

Based on the overview of the students' experiences, the simulator was found to provide opportunities for training skills before students were ready for operating with real machines. Along with this perception, experiences included (ii) *Comparisons between the simulator and real machines or between the simulators*. These comparisons were expressed, for example, by criticising the simulator as unrealistic and confusing when its features were compared with those of real machines. One comparison was illustrated by Student 3:

Well you don't need to ... basically you don't need to think like anything because ... when you're driving it [the real forest machine] you'll see what it's about to happen but it [the simulator] still alerts immediately, even though you see and know what's happening, it still alerts. But when you're at work and you make an error, you're the one who's responsible for it.

Further, also Student 4 criticised that the simulator's speed did not correspond to that of a real machine, nor the simulator put oneself to think hard enough: 'It's easier [to operate] with the simulator. You don't, you don't need to think if

something gets broken, but with that [a real machine] you need to think that you can break something if you operate too fast.' Furthermore, operating with the simulator was not always taken seriously as Student 6 described it: 'Yeah we operate with the simulator quite properly, but we've also played with it.'

Discussion

The aim of this qualitative study was to provide new insights into forest machine operator students' meaningful learning experiences of skills training and performance, and guidance from the teacher and the simulator in a SBL session. The findings indicated that first-year-students described their experiences of skills training and performance primarily in terms of errors made during tasks, whereas successes were more rarely mentioned. Self-assessment extending beyond describing successes or pointing out errors and their possible reasons was rarely described. The teacher's guidance in supporting skills training was perceived as advice and feedback which were considered useful and supportive in terms of learning and developing professional skills. The simulator's guidance was also characterised through advice and feedback which generally were perceived as overly strict. Even though students were to some extent aware of the simulator's benefits for a novice, the simulator was perceived as functioning merely to pass or fail them.

When considered through the lens of Kolb's (1984, 2014) experiential learning cycle, the findings appear to emphasise the dimensions of concrete experience, action, and situational thinking, while reflective observations remain less visible. This relative underrepresentation of reflection may influence how effectively learning experiences are connected to broader conceptual understanding and transferred to real-world work contexts. Reflective skills are unlikely to develop optimally through simulation experiences alone and therefore benefit from pedagogical structuring and support.

The fact that the students described their learning experiences mostly through errors is natural as one main aim of the study programme was to learn a large repertoire of professional skills. It is thus understandable that the students assessed whether they managed these skills or not. Errors were often associated with a feeling of insufficiency which was reasonable as the difficulty level in the tasks raised progressively and exceeded the students' current skills in the last task. Experiences of success mostly concerned operating in a steady and calm way towards a goal of a task. This was logical as operating in a safe and economic way is crucial in professional operators' work (e.g., Kymäläinen, 2021; Ovaskainen, 2005). Some students described that it was unnatural to praise themselves which suggests that successes were not perceived as natural to discuss as errors.

The teachers' guidance in supporting skills training was described as advice and feedback such as immediate corrections and suggestions for further operation. All tasks that were terminated due to a major error were annotated as meaningful. However, it was not always clear for students why the simulator terminated a task. This finding underlines the importance that while monitoring training, teachers should ensure that students maintain situational awareness throughout tasks (e.g., Dieckmann et al., 2009). At times, the teachers prevented students from making errors by stopping them and indicating what was likely to go wrong. On the one hand, it can be considered if allowing students to encounter all challenging situations would have been useful for their skills training. On the other hand, it might be that the teachers intended to prevent students from performing impractical actions, operating inefficiently, and subsequently adopting this type of working style. Despite the teachers' occasional, even intensive guidance as well as corrective feedback, the students did not directly indicate that their performance would have improved in the tasks. It is unlikely that the teachers' guidance did not play a role in the students' efforts, or that the students failed to recognise that role in their performance. Instead, it is probable that this type of relationship was still too abstract for the students to identify and describe in the interviews. This may be related to their young age, the early phase of their studies, and their limited experience with self-assessment, which may have made it more difficult to reflect on and articulate connections between their action and the teacher's guidance.

The teachers' feedback, described as brief comments, after each task and the debriefing discussion including more in-depth feedback were perceived as useful. This finding of the importance of the debriefing aligns well with previous research (Dieckmann et al., 2009; Fanning & Gaba, 2007; Husebø et al., 2013; Lee et al., 2020). In SBL, it would be beneficial to aim for a shared and reciprocal discussion involving learners to be active participants (e.g., Wickers, 2010). In this sense, the students did not indicate being actively engaged in speaking, commenting, or asking questions. Noteworthy, they described that the teacher was 'the one who knows how things should be done'. This description echoes a previous finding that a VET teacher can serve as a role model (Messina Dahlberg & Gustavsson, 2024). It should be noted that assessing one's performance in the debriefing requires a high level of psychological safety and, for example, awareness of that one does not need to know everything and that questions can be asked (Kolbe et al., 2020). Additionally, self-assessment can relate, for example, to one's motivation, metacognition, and self-efficacy (McMillan & Hearn, 2008). In light of this, students need support in developing their self-assessment skills, along with regular possibilities to practise them, so that self-assessment becomes a natural part of their skills training and learning. A study by Näykki et al. (2022) evidenced that implementing video as a tool for reflection was a particularly

useful pedagogical instrument enabling participants to reflect and verbalise their learning experiences as well as notice their personal strengths and weaknesses. This type of reflection could be used also in operator students' skills training, as simulators provide screenshot video recordings, which were utilised also in this study.

In terms of the simulator's guidance, it can be pondered if the students utilised the simulator's full potential. Interestingly, the students described that the simulator either passed or failed them. This type of speech gave the simulator a role as an authority with power rather than a tool for training skills. Moreover, none of the students annotated the simulator's feedback report (given at the end of each task) as meaningful. The reports were numerically detailed, containing the limit values of the factors included in each task. It is possible that to understand the report comprehensively was too demanding for the students. Eventually, one is likely to learn certain limit values that must be achieved. However, it is crucial that students acquire these values not only to pass a task, but also to understand what should be improved and how to implement these improvements. Thus, the teacher's role is fundamental in interpreting the simulator's feedback report together with students particularly in the initial phase of simulation training. This finding is in accordance with previous studies highlighting the importance of the teacher's presence, feedback, and guidance in simulations especially with young students, or novice learners (Jossberger et al., 2018; Kneebone, 2005; Rudolph et al., 2013). However, the availability of a sufficient number of teachers and guiding several students at the same time can constrain the extent to which detailed and individualised feedback can be provided.

The simulator was described with human-like features, such as 'nagging' and 'being too strict'. Further, the simulator was judged to be unrealistic when compared to real machines. These descriptions imply that students wanted the simulator to correspond to real machines as seamlessly as possible. These findings are consistent with a recent study (Nyström & Ahn, 2025) in which VET students reported that the simulator was more demanding than real machines. However, the effectiveness or meaningfulness of learning in SBL is not directly related to authenticity. It is also affected by factors such as the interaction between participants, the simulator, and the context, as well as by the process of orienting to relevant similarities and disregarding irrelevant differences (Rystedt & Sjöblom, 2012; see also Messina Dahlberg & Gustavsson, 2025; and Sellberg, 2018). Students' possibly too unrealistic expectations of the simulator's authenticity might influence both the use of the simulator as well as students' learning orientation. It is therefore highly essential for the teacher to justify the use of the simulator and its benefits carefully, and to involve students in the educational aims of SBL.

While this study provides valuable insights, certain limitations should be acknowledged. First, a small number of participants does not allow making any generalisations. Yet, the study provided a unique perspective on operator students' learning experiences of SBL. Second, to describe one's meaningful learning experiences in detail was a new and possibly a challenging situation for the young operator students, especially in the initial phase of their studies. In future research, students' learning experiences could be complemented with a detailed exploration of the interaction between the student and the teacher during a SBL session. Additionally, teacher interviews could shed light on their guidance practices in SBL.

All in all, SBL offers several possibilities to promote training of professional skills. Becoming a proficient operator involves applying prior experiences gained through SBL to authentic situations, and this process is important to be supported pedagogically. Supporting the development of students' self-assessment skills is important as is also the encouragement of students to be active and responsible in their learning of new skills in SBL sessions. SBL also offers approaches to structuring simulator training in ways that enhance reflective practices and facilitate more systematic feedback processes, which could further strengthen the pedagogical use of simulators. Teachers have therefore a crucial role in guiding students through SBL, supporting them in the understanding of simulators' potential, and fostering the self-assessment and reflective skills needed for professional development.

Acknowledgements

We would like to thank the operator students and the teachers for their participation and valuable contribution to this study. We also want to thank Dr. Anita Malinen for discussions and theoretical inspiration that have provided insights for the development of this study.

Declaration of conflicting interests

The authors have no competing interests to declare.

Funding

This study was supported by The European Regional Development Fund (Grant number A75070: 'Development of educational service ecosystem using physiological data and intelligent systems'), and Regional Council of Central Finland.

Data availability statement

The qualitative interview data analysed in this study are not publicly available due to ethical permission agreements with the research participants.

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