AI-Supported Simulation-Based Learning: Learners' Emotional Experiences and Self-Regulation in Challenging Situations

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1 Introduction

Emotions—both positive and negative—play an important role in learning (McConnell and Eva 2012), and previous research has shown that using simulations can meaningfully enhance learning (Brewer 2011; Keskitalo et al. 2014; Konia and Yao 2013). Learners' emotional reactions to simulation-based learning have been shown to improve both learning and recall of experiences and information (DeMaria

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et al. 2010). In this study, a simulation is an imitation of reality as “a means to do something in the ‘as if’, to resemble ‘reality’, [and to] learn something without the risks or costs of doing it in reality” (Rall and Dieckmann 2005, p. 2). As such, simulation-based learning is regarded as an experiential and a fun and safe way to learn (Brewer 2011; Hope et al. 2011; Keskitalo and Ruokamo 2017; Konia and Yao 2013; Weller 2004).

In this multidisciplinary study, we will explore trainees’ emotional experiences and how they overcome stressful situations in a simulation-based learning environment (SBLE). The participants are operator trainees in oil production at Neste Engineering Solutions Ltd. The study integrates chemical engineering and educational sciences, and it concerns the learning of behavioral, emotional, motivational, and cognitive processes. In essence, we are interested in the key factors that either facilitate or inhibit the learning during the simulation.

2 Theoretical Framework

2.1 Self-Regulated Learning

Self-regulated learning (SRL) plays an important role in the learning process in helping learners to optimize their practice (Zimmerman 2006). The term *self-regulated learning* emphasizes learners’ responsibility and autonomy during their learning (Paris and Winograd 1998). According to Zimmerman (2000a), the term describes “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goal” (p. 14). In the process of regulation, learners can plan, set goals, organize, self-monitor, and self-assess, which makes them self-aware and knowledgeable of the learning procedures. They employ effort and persistence rather than giving up when tasks are challenging. By taking strategic action, learners seek out appropriate and helpful advice, information, and strategies to support their learning, and they self-instruct and self-reinforce during performance enactments (Zimmerman 2000b; Perry and Rahim 2011; Pintrich 2003). The objects of the regulatory processes are the different behavioral, motivational, and emotional aspects of the learning process (Zimmerman 2006). In this study, we approach the topic of SRL from an emotional perspective and focus on emotional determinants through which the simulator trainees regulate their learning process.

Technological development, especially the adaptation of the intelligent tutoring system (ITS), can be a transformative factor for understanding learning patterns, and it can support SRL through discovering and responding to students’ emotional states during learning with AI systems (Channa et al. 2021; Kelly and Heffernan 2015). ITS provides a friendly platform to explore and encourage self-regulated behaviors, and it has an effect on students’ emotional states so as to facilitate reasoning deeply, such as critical thinking, problem-solving, and connecting previous knowledge with current problems (Channa et al. 2021; Kelly and Heffernan 2015; Sabourin et al.

2013). ITS, driven by AI technology, helps students perceive emotions as a way to encourage optimal learning, and it supports students to regulate their learning (Channa et al. 2021; Kelly and Heffernan 2015; Sabourin et al. 2013).

Previous research has identified the potential of AI tutors to facilitate students' learning progress and their skills mastery in ITS (Long and Aleven 2013; Koedinger and Aleven 2007). Unlike other computer-supported education systems, AI tutors can "respond dynamically to the individual learning needs of each student" (Johnson et al. 2009, p. 31). That is, an AI tutor can understand students' problems and assess their analyses; thus, they can structure a response immediately (Johnson et al. 2009; Lane et al. 2015; Koedinger and Aleven 2007). For example, an AI tutor can provide students with feedback and hints gradually based on specific analyses and difficulties in each student's response (Johnson et al. 2009; Lane et al. 2015). Johnson et al. (2009) indicate that an AI tutor acts as a human tutor. In this study, we focus on the situations when an AI tutor could promote simulator trainees' SRL.

2.2 Positive and Negative Emotions in Simulation-Based Learning

Emotions are always intertwined with learning (Engeström 1982; Immordino-Yang and Faeth 2010; Schutz and DeCuir 2002; Schutz et al. 2011), and they can strongly modulate learning outcomes and experiences (Tyng et al. 2017) and affect learners' motivation, their behavior in learning environments, and their recall ability (Damasio 2001; DeMaria et al. 2010; McConnell and Eva 2012; Schwabe and Wolf 2009; Trigwell 2012). Emotional experiences can have a crucial impact on other cognitive processes, such as attention, memory, reasoning, and problem-solving (Jung et al. 2014; Tyng et al. 2017; Um et al. 2012; Vuilleumier 2005). Understanding emotions and their relationship to learning may be key for the development of educational settings that are more conducive to the success of both learners and instructors (Trigwell 2012). Emotions—also referred to as moods, feelings, affects, or attitudes—are the affective contents, states, and lived experiences (McConnell and Eva 2012; Schnall 2011). They can both facilitate and hinder learning, and their effects on learning are mediated by several factors (Keskitalo and Ruokamo 2017; Vesisenaho et al. 2019).

Emotional experiences are situated—and socially and personally constructed—within sociohistorical contexts that emerge from conscious or unconscious appraisals of a particular event (Schutz et al. 2011); they are usually categorized as positive, negative (Fraser et al. 2012), or neutral (Nummenmaa et al. 2013). According to the literature, negative emotions hinder learning, while positive emotions facilitate learning. When feeling positive emotions, individuals are more likely to concentrate on the bigger picture, and when feeling negative emotions, they tend to focus on details (McConnell and Eva 2012). As McConnell and Eva

(2012, p. 1317; see also Fredrickson 2001) indicate, “Positive emotions encourage people to see the forest, whereas negative emotions lead them to focus on leaves.”

However, the relationship between emotions and learning is complex (Fraser et al. 2012; McConnell and Eva 2012; Peterson et al. 2015; Schutz et al. 2011). When learners perceive a learning situation as threatening or frightening, they may have a better memory of the emotional event because of their cognitive activity, but it may be more challenging for them to make broader connections and thus transfer the knowledge to other contexts (McConnell and Eva 2012).

According to many researchers, positive emotions were more likely to be as conducive to learning than negative emotions (Duffy et al. 2016; McConnell and Eva 2012; Postareff et al. 2017), and they were considered to “facilitate approach behavior” (Fredrickson 2001, p. 219). Learners who experienced positive emotions were found to be more likely to engage with their learning environment, and positive emotions were also connected with deep learning approaches (Trigwell 2012). They were found to increase cognitive flexibility and verbal fluency and facilitate decision-making and creative thinking. However, they could also reduce perseverance and exacerbate distractibility, while negative emotions tended to narrow thinking to a focus on details while facilitating more accurate decision-making (Dreisbach and Goschke 2004; Duffy et al. 2016; Fredrickson 2001; McConnell and Eva 2012; Staal 2004). Stress and anxiety both have negative connotations but may benefit learning in certain cases (DeMaria et al. 2010; Pekrun et al. 2006; Postareff et al. 2017). Overall, both positive and negative emotions can be harmful to learning when they focus the learner’s attention on something that is an irrelevant content. It also seems that both positive and negative emotions may benefit learning to some degree, but further research is needed to clarify this (Duffy et al. 2016; Keskitalo and Ruokamo 2021; Postareff et al. 2017).

Simulation-based learning is considered a fun, an experiential, and a safe way to learn (Brewer 2011; Hope et al. 2011; Konia and Yao 2013; Weller 2004). Research has shown that simulation-based learning is more than just fun (Rosen 2008); it is also an effective way to learn (Cook et al. 2011; McGaghie et al. 2010). Simulations can be more powerful experiences than traditional learning methods due to authentic connections to the emotions and the reflections that they stimulate, if these are debriefed (Silvennoinen et al. 2020).Essentially, simulation is an imitation of reality, and a simulation setting can be expected to arouse strong feelings and a motivation to learn (Dieckmann et al. 2007). In an SBLE, scenarios and materials are usually constructed to elicit particular emotions (DeMaria et al. 2010) because comparable real-life situations might be challenging and stressful or cause cognitive overload (Andreatta et al. 2010). Simulation-based learning is generally expected to provide learners with active and experiential learning opportunities to help them better integrate theory into practice (Cleave-Hogg and Morgan 2002; Gaba 2004; Keskitalo 2012; Keskitalo and Ruokamo 2016; Rall and Dieckmann 2005). However, simulation-based learning must be planned appropriately to be effective (Kneebone 2003; McGaghie et al. 2010), considering educational principles and human nature (Keskitalo 2015).

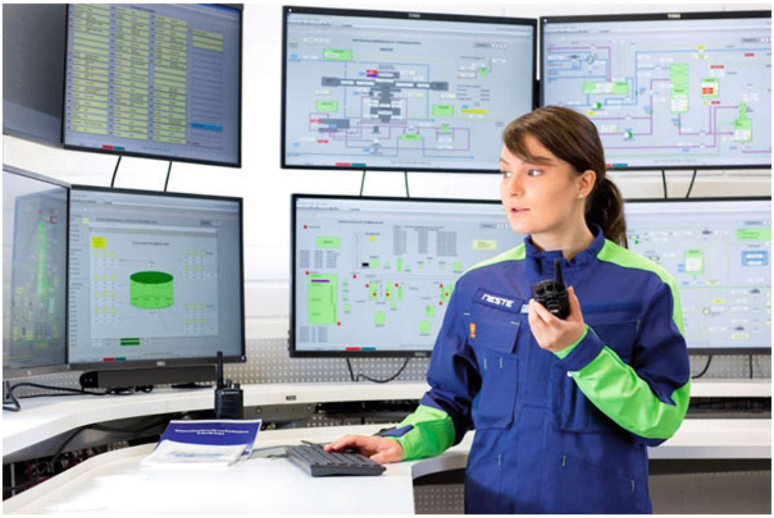

Fig. 1 Simulator training environment replicating the actual workstation of the operator

2.3 Simulation-Based Learning Situations

Simulation-based learning builds on learners' interaction with the facilitator, with other learners, with the simulator environment, and with and through other technical devices.

The trainees involved in the research experiment were participants in a basic training phase at Neste, and learning topics involved in operating a large-scale process industrial plant. These topics cover usage of different automation systems, basic controls, using automatic process controllers, and operating different process units. Additionally the trainees had been previously working as summer interns operating the real process plant, and during the simulation training sessions, they had to employ their accumulated knowledge in individual training scenarios. The operator training simulator (OTS) environment very closely replicates the actual workstation of the plant operator, allowing seamless transfer of knowledge from the simulator training to the day-to-day operations of the plant (Fig. 1).

3 Research Questions

On the basis of the theoretical framework and previous research, the research questions for this study are as follows:

1. What kinds of emotions do learners experience in simulation-based learning situations?

2. Through what kinds of SRL operations do learners aim to overcome challenging situations during simulation-based learning?
3. In what kinds of situations could an AI tutor be used to facilitate simulation-based learning?

4 Method

4.1 Data Collection

The data were collected in two phases. The first phase took place during a 1-week experiment conducted in August 2021. Four simulation-based learning sessions were organized in a simulation environment provided by Neste Engineering Solutions Ltd. in Finland. The four sessions were identical in terms of content and pedagogy. Each session was facilitated by two simulation instructors and lasted for 1 working day. The simulation environment was a classroom equipped with four workstations and an instructor observation room in the middle (see Fig. 2). In the workstations, learners used simulator software provided by NAPCON Neste. The simulator represents the operational software used in steering the chemical processes in the field. During the training, the simulator and the operations were first introduced to the trainees. Next, the trainees operated the system (i.e., the simulator) independently and learned how to operate in typical error situations that may occur in the processes of the chemical industry. In these challenging situations, instructors provided help when needed.

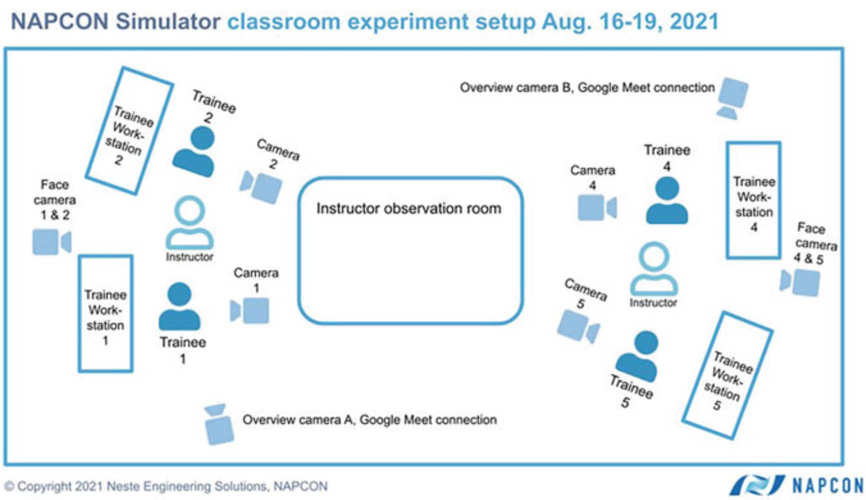

Fig. 2 Data collection setup in the simulation environment

The participants of this study ($N = 12$; nine males and three females) were summer employees at Neste Engineering Solutions Ltd. at the time of data collection. Each of them participated in one of the four training sessions. Participants were asked to provide informed consent to take part in the study. The data were collected in two phases. The first data collection phase was carried out through online observations and video recordings in the simulation environment (Fig. 2).

The setup included two overview cameras (A and B) with a Google Meet connection. These overview cameras were used by authors 1, 2, and 3 of this article to collect online observation data. On-site observations were not allowed, due to COVID-19 pandemic restrictions. Researchers observed each of the training sessions from beginning to end and wrote field notes during observations either by hand or using a word processor. Additionally, there was one over-the-shoulder camera recording the activities on each workstation (cameras 1–4) and two face cameras that recorded two workstations each. The first data collection phase yielded 161 h and 42 min of video data and 77 pages of observation notes written either by hand or a word processor.

The data collected in the first phase were used in preparing and conducting the second phase of data collection (i.e., the dSTR interviews). During the 2–3 weeks following the simulation training sessions, the researchers viewed the videos and read their field notes to identify situations that seemed to be challenging to participants. *Challenging learning situations* here mainly refer to cognitive learning challenges (Zimmerman 2011) that involve difficulties in understanding the concepts and solving the problems at hand. Motivational challenges (Zimmerman 2011) were not seen as relevant to the study, because all the participants practiced in the simulation environment to better succeed in their future work, so it could be assumed that they were motivated to enhance their knowledge and skills. Focusing on the challenging situations was considered important in determining how students aimed to overcome challenging situations and in determining in what kinds of situations an AI tutor could be used to facilitate learning. After getting familiarized with the video data and field notes, dSTR interviews were organized. Of the 12 participants in the first phase of data collection, 6 volunteered to take part in the second phase.

The basic idea of the STR interviews is that learners can relive the original situation with vividness and accuracy when presented with several cues or stimuli that occurred in the original situation (Bloom 1953). STR is an advanced interview method (Alexandersson 1994) that can be approached from different methodological perspectives and can produce an interpretation of the situation as the learners themselves conceive and understand it (Calderhead 1981). STR may also be elicited introspectively, with learners observing their internal processes in the same way they observe external real-world situations (Gass and Mackey 2000). STR involves the verbal reporting of learners' thinking processes in decision-making and problem-solving situations, and it is related to a variety of process tracing methods, including *think aloud* methods, and retrospective interviews (Shavelson and Stern 1981; Shavelson et al. 1986; Vesterinen et al. 2010).

In the dSTR interviews, the participants were first asked about their learning aims and general experiences in the simulation training. Next, the interviewees watched video clips from the situations identified as challenging. The researchers then asked questions to elicit participants' thoughts on those situations, as well as their actions and emotions when experiencing them (Keskitalo and Ruokamo 2017). At the end of the interviews, participants were presented with a short online questionnaire that included a list of 36 emotions, and they were asked to estimate how strongly they felt them during the simulation training on a scale from 1 (*not at all*) to 5 (*very strongly*). The questionnaire was designed using the Webropol online survey tool. The dSTR interviews lasted 22–45 min each. The interviews were recorded, and the data were transcribed verbatim, yielding 16,973 words of interview data.

4.2 Analysis

The researchers involved in data collection were also responsible for data analysis. The interview data was analyzed through a deductive thematic analysis process (Terry et al. 2017). The first step of the analysis was creating an analysis framework. The framework included three categories according to the research questions (Maguire and Delahunt 2017): emotions, operations, and experienced challenges. Second, each of the three researchers read through their interview data to get an overall picture of learners' experiences and to become familiarized with the data. The third phase of the analysis consisted of coding the data and marking everything related to the analysis framework. This included learners' expressions of thoughts and emotions during simulation-based learning, their descriptions of the operations through which they aimed to overcome challenging situations, and descriptions of situations experienced as challenging. Any expressions of experienced deficiencies in their own skills or the simulator software were also coded.

The fourth phase of the analysis began by combining the coded data extracts from the three researchers. All data extracts with the same code were aggregated, and the codes were collated into potential themes. Next, the collated data were reread, some of the coded data extracts were reorganized, and potential differences in interpretations were negotiated within the team. After that, sub-themes were created on the basis of the coding. The final step of the analysis included combining the sub-themes into primary themes and ensuring that each theme was justified and addressed to the research questions. Despite the linear presentation here, the analysis process involved moving back and forth between steps, which is common in qualitative research (Maguire and Delahunt 2017).

5 Results

5.1 Learners' Positive and Negative Emotional Experiences During Simulation-Based Learning

Research question 1 is "What kinds of emotions do learners experience in simulation-based learning?" Results from the emotions survey that participants completed during dSTR interviews show that positive emotions seem to be emphasized in learners' experiences. The five most reported and the five least reported emotions are presented in Fig. 3.

It seems that the simulation-based training was generally a positive experience for the learners. All five most reported emotions presented in Fig. 3 can be interpreted as positive, and the five least reported can be interpreted as negative. To get a deeper understanding of participants' experiences, their expressions regarding their emotions were coded from the data. Tables 1 and 2 below present examples of these codings and the emotions interpreted from them.

Learners experiencing positive emotions are more likely to engage with their simulation-based learning environment (SBLE) (Trigwell 2012). Positive emotions may increase learners' cognitive flexibility and verbal fluency and may facilitate decision-making and creative thinking.

Both positive and negative emotions can facilitate and hinder learning (Keskitalo and Ruokamo 2017; Tyng et al. 2017). The difference in the effects of positive and negative emotions is dependent on the learner's state of mind (McConnell and Eva 2012).

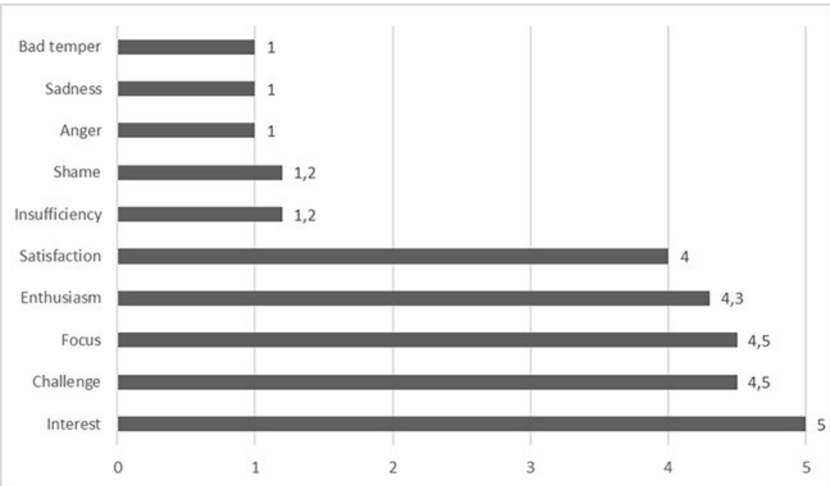

Fig. 3 Five most reported and five least reported emotions

Table 1 Data examples of positive emotional experiences during simulation-based learning

Data example	Positive emotion
That is a good place to practice then, and I was quite enthusiastic ... [Trainee 6]	Enthusiasm
But if there comes only one, so it is a bit different, you can take it more relaxed, and you can act as though. [Trainee 6]	Relaxed
That for sure in that situation was relieved per se, that you were quite in the same situation with others considering your own way of thinking. [Trainee 5]	Relieved
I was feeling super good because I didn't care that I made a mistake and because I was making at first an even bigger mistake ... so I was not so disturbed ... because I was really happy that I did the right thing. [Trainee 2]	Happy
Yeah, I have maybe never thought about how I feel when I am at work. It was not at all stressful ... [Trainee 2]	Non-stressful
I did not recognize that I would have been especially excited, neither before nor in that situation. [Trainee 2]	Non-excited
I'm not panicking because I'm used to it, that it sounds an alarm ... so those alarms in that kind of situation when we are in the simulator, those for sure have not frightened me. [Trainee 2]	Confidence
Kind of start to focus, and for sure a bit excited about what is going to show up. [Trainee 6]	Focused
In other words, the stress level decreased. I was really able to concentrate on what I was doing, and I was able to get a lot out of that. ... That was the first time in that situation I was able to apply what I had learned already. [Trainee 3]	Concentrated

Table 2 Data examples of negative emotional experiences during simulation-based learning

Data example	Negative emotion
I remember my heartbeat was very high, and I was very excited because I didn't know at all how I would react to that ... thought that was only a simulation ... I haven't had so much experience with it, so it was very exciting. [Trainee 3]	Excitement
So my ideas were escaping, and I was in that phase still a bit excited, so kind of impatient... [Trainee 3]	Impatience
Here comes just the uncertainty. I realized that I was not exactly sure how I should act. I had done too little with those pumps. [Trainee 3]	Uncertain
anxiety that, but ... [Trainee 6]	Anxiety
I might have been a bit frustrated when I wasn't able to put the pump on ... [Trainee 2]	Frustration
that it is always very bad that you have to be able to concentrate ... [Trainee 6]	Challenged
It took quite a long time to understand what you should have done when you were only reading those guidelines ... [Trainee 1]	Confusion
So it was quite an empty feeling when you couldn't or felt you couldn't do anything, yet you should then do something anyway. [Trainee 4]	Emptiness

5.2 Self-Regulated Learning Operations in Challenging Situations

In this section we answer research question 2., "Through what kinds of SRL operations do learners aim to overcome challenging situations during simulation-based learning?" During simulation-based learning, the trainees met several challenging situations related to chemical engineering and process operating. These tasks were often experienced as stressful, and emotional regulation was needed to cope with the situation. The findings show that to overcome challenging situations, the trainees resorted to the following SRL operations: (1) metacognitive monitoring, (2) social scaffolding, (3) cognitive operations, and (4) emotional regulation.

First, *metacognitive monitoring* (Zimmerman 2008) occurred in the situations when trainees did not know what to do or expect. During the simulation, unexpected situations were faced, and the trainees needed to solve emergency problems using their own screens. The metacognitive monitoring strategies they used included intensively studying at the charts on the screen, going through working phases in their mind, prioritizing tasks, and predicting and envisaging forthcoming problems and challenges.

> I prepared and anticipated which screens [of eight screens] those [changes in chemical processes] would come. As you can notice [from the video], I moved the small screen boxes here to make room for ... well, there, I assumed the alarm would come; I made room for the screen so that I could see what would be happening there, because I had earlier been in an operating room, so I roughly knew or guessed and presumed what the instructor was aiming to do, and I prepared for that so I would be instantly there when something would happen. [Trainee 3]

> Well, I looked at the chart that was there. Then I tried to go through those operational phases ... you know, in my head—where to start, and what to do first. [Trainee 4]

Signs of metacognitive monitoring in the trainees' responses were verbs such as *predicting*, *assuming*, *knowing*, *guessing*, *figuring out*, and *thinking about*. Metacognitive monitoring enables learners to plan and monitor their own knowledge and skill levels, thus helping them to proceed in the task (Tzohar-Rosen and Kramarski 2014; Zimmerman 2008). Metacognitive monitoring can be seen as a systematic form of self-observation in an endeavor to understand the problem, devise a plan to proceed, implement a strategy, and check the accuracy of one's own thinking (Tzohar-Rosen and Kramarski 2014).

Second, although the trainees had to take active charge of their learning, the instructors provided them with help if needed. In addition, other trainees provided help in challenging situations. These strategies are called *social scaffolding* (Naukkarinen and Sainio 2018; Pea 2004) and include social support received to overcome the situation. The trainees asked questions to the instructors, or the instructors provided them with help and feedback if they noticed the trainees were stuck. The following excerpts illustrate the learning situations where social scaffolding was received.

> Yes, it was [the trainer's help]; it was really good. Without it I wouldn't have noticed that point there. [Trainee 4]

> I remember that the instructor came and said straightforwardly that I should do this, and then I moved forward from there. I was a bit in trouble there. The instructor said that I was on the right track, that I just needed to finish what I was doing. I had made a mistake, and he told me to fix that ... so the instructor gave me the final solution. ... As you can see [from the video] I have quit touching my hair and mask. [Trainee 3]

The last excerpt shows that the trainee noticed that her nonverbal communication no longer appeared restless after receiving social scaffolding and getting back on track. In the SBLE, the trainees felt it important to receive social support and feedback, even though they also had some ideas for developing SBLEs digitally so that scaffolding could be provided by an AI tutor. Wood et al. (1976) coined the term *scaffolding* for the first time and stated that scaffolding enables a novice to solve a problem and achieve a goal that would otherwise be beyond their unaided ability.

Third, to overcome stressful situations, the trainees also leaned on *cognitive operations*. Here, *cognitive operations* refer to cognitive processes and operating actions in the SBLE. The trainees reflected that by focusing and concentrating on those operations, they could go on and overcome difficult situations. Those activities included both mind-on activities, such as reasoning and problem-solving, and screen-on activities, such as reading through the alarm list, looking through the regulators, and checking the status of the regulators. The following excerpts illustrate the trainees' experiences:

> At first, I was really confused trying to figure out what would be the first task. Then I realized I had to increase the gas intake to fuel the fire and increase the air level simultaneously to maintain balance. I got the hang of it there; honestly, I was quite confused. Of course, I checked the alarm from the list to find out which regulator the alarm was about and then I checked the regulator, what's the situation there. If the alarm is red or blinking the situation is quite bad, and one should really react and figure out what to do with it. [Trainee 6]

> Well, I can remember I couldn't get the point directly, when there were many notifications at the same time. And they [the instructors] did not say exactly what the problem was, so I needed to sort out a bit before you realized that, okay, the incinerator is out of gas. ... It took a while to understand that this is ... this is the matter. [Trainee 5]

> After those alarms I saw what started to happen, and it took a couple of minutes to figure out what I can and cannot do. Then the tension stopped and I was able to use my brain normally and think normally. [Trainee 3]

Fourth, to overcome stressful situations, emotional regulation was needed. This manifested as accepting a possible failure, understanding realities, or taking a time-out.

> At that point I had a blackout. I knew in principle what to do but wasn't sure at all if I was on the right track. You know what's right and what's left but suddenly get all mixed up and can't show where right is. That's why I was quiet for a while. I gathered my thoughts and waited ... counted how to justify myself that my decision was right. That is why I'm quiet here for quite a long time as I was calculating that, yes, this is what I have to do, and I have to close those vents. I don't remember what I said to the radio earlier, but I guess I asked to close that vent or something. [Trainee 3]

This excerpt shows that the trainee was aware of her stress reactions and that she needed to gather her thoughts to calm down and think clearly. This example shows that, in this case, negative feelings and feelings of stress hindered the learning process. As earlier research demonstrated, when feeling positive emotions, individuals are more likely to be cognitively flexible, open to information, and able to concentrate on the bigger picture; when feeling negative emotions, they tend to focus on details associated with a learning scenario, which may be beneficial in tasks that require a strong attention to detail (McConnell and Eva 2012).

5.3 Toward Developing AI Tutors in Simulation-Based Learning

Next, we will answer the research question 3.: "In what kinds of situations could an AI tutor be used to facilitate simulation-based learning?" The findings of this study reveal that AI could support the learning and operating processes in the following ways: (1) by providing decision-making aid, (2) by visualizing critical spots in the system, and (3) by asking questions to help check the system and make decisions.

First, it was evident that an AI tutor could provide support for making decisions (i.e., it could act as a decision-making aid for the learner). One option would be to provide a list of possibilities concerning how to continue when a difficult situation is faced. The trainees considered it important, however, that they could make the final decision by themselves, based on clues provided by the system.

> At that point I faced another problem: how to open that vent, as it was automatically closed. I had to do something before I could open it, but I didn't know what that something would be. So there was a bit of a blackout. [Trainee 4]

> what to do. Could there be for example a list of choices or just everything you need to ... yes, there could be a list of all the possible choices, and then you could figure out what to do and in what order. Then you would know all the things you should do but would need to figure out the order by yourself. [Trainee 2]

The second way to facilitate the learner's process through an AI tutor would be to provide visual clues of the critical spots in the system. This would help the learners to focus their attention on the relevant things in the situation.

> I couldn't check the route on the computer; that all would be green, and the pump could be started. That's why I couldn't make the final decision. [Trainee 4]

> That [leaking pump] should have been shut down, but there was some obstacle for that, and I just couldn't see what it was. [Trainee 4]

The third possible way to use an AI tutor in the process would be through presenting the learner with questions during the process. Through well-formulated questions, the learner could check the system and make decisions.

> Yeah, well, he didn't exactly say I should do this or that, but he just asked those right questions, and I started to think that of course that would be it. [Trainee 5]

Previous research shows that the dynamic features of an AI tutor can provide many benefits for students to regulate their own learning behaviors and emotions (Koedinger and Aleven 2007; Long and Aleven 2013). The instruction and feedback provided by the AI tutor are immediate and designed to further the process and outcomes of problem-solving simultaneously; they are thus adapted to individual students' needs (Johnson et al. 2009; Koedinger and Aleven 2007; Lane et al. 2015). These interventions can also teach learners to assess their learning performance and to select appropriate strategies in response to those assessments (Long and Aleven 2013). Zheng et al. (2021) state that learners have different emotions when experiencing these interventions, which thus play a part in self-regulating their learning.

6 Conclusion

The results of this study support the earlier findings of McConnell and Eva (2012): emotions are deeply connected with how learners use available information and with how they act on that information in learning and practice scenarios. During simulation-based learning, learners experience various positive and negative emotions that can both enhance and hinder learning. Further research is needed to describe these connections in more detail.

The ability to use metacognitive monitoring strategies (Zimmerman 2008) is evident from the progress made in simulation-based learning, and when receiving social support from others (i.e., social scaffolding; Naukkarinen and Sainio 2018; Pea 2004), these strategies enable learners to overcome challenging situations. Cognitive operations and emotional regulation are also important in all simulation-based learning to enable learners to proceed. The results of this study suggest three ways to involve an AI tutor in the simulation-based learning process. An AI tutor can provide help for decision-making, visualize critical points in the system, and ask questions that help the learner to check vital points in the system.

This study has some limitations. First, the number of participants is rather small. However, the group was self-selective, as the participants were summer employees at Neste at the time of data collection, and additional participants were not available. The data were gathered by three researchers, and they all analyzed their own interview data, which may have caused variation in the interpretation. This variation effect was minimized through negotiations and discussions during the analysis process. Collecting data through online observation and analyzing participants through videos may have caused misinterpretations, but watching the video clips together with the interviewees helped us to clarify those interpretations. Having video cameras on-site may have caused disturbances during observation, but having researchers present may have had the same effect.

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