How Do They Learn: Types and Characteristics of Medical Student Engagement in the Simulation-Based Learning Environment

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Research article

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Abstract

Background Student engagement can predict successful learning outcomes and academic development. Expansion of simulation-based medical education will bring about challenges to educators and require them to help medical students to engage themselves in a simulation-based learning environment.

Methods We conducted semi-structured interviews with ten medical students to explore their learning types and characteristics in the simulation-based learning environment. The thematic analysis was used to analyze the data.

Results The interviews were thematically analyzed to form three types of student engagement in the simulation-based learning environment: reflective engagement, performance engagement, and interactive engagement. The analysis also identified eight sub-themes: active, persistent, and focused thinking engagement; self-directed-learning thinking engagement with the purpose of problem solving; active “voice” in class; strong emotional experience and disclosure; demonstration of professional leadership; interaction with realistic learning situations; support from teammates; and friendship-like facilitator-student interaction.

Conclusions The findings explain the mechanisms behind student engagement in the simulation-based learning environment from two perspectives: the two-way construction of individuality and space in learning along with the interdependence of the learner and the learning community. That is, expanding the learning space centering around “inquiry” helps strengthen reflective communication and dialogue. It also facilitates imagination, stimulates empathy, and builds an inter-professional learning community. In this way, medical students are expected to learn from the two-way transmission of information, cultivate and reshape the interpersonal relationship, so as to improve engagement in the simulation-based learning environment.

Background

Student engagement is a key topic and becomes very popular that is widely researched in academia. Studies have shown that student engagement can directly predict learning outcomes [1], critical thinking skills [2], academic achievement and learning satisfaction [3]. Therefore, student engagement has become an important indicator of the quality of higher education. Countries such as the United States, China, the United Kingdom, and Australia conducted national surveys of college student engagement [4]. College student engagement usually refers to the time and effort that college students invest in participating in educational activities with educational purposes [5]. The classic “three-dimensional theory” of student engagement identifies behavior engagement, cognitive engagement and affective engagement. The emphasis point of behavioral engagement is participation, which refers to students' participation in academic, social and extracurricular activities; the emphasis point of cognitive engagement is investment, which refers to students’ willingness to make efforts in terms of understanding complex issues and mastering complex skills; emotional engagement refers to the positive

or negative reactions of students to teachers, peers, schools, etc., and emotional reactions in the classroom [6]. The “four-dimensional theory” mainly include academic engagement, including behaviors related to direct participation in the learning process; Social engagement, includes students’ behavior in observing classroom discipline, lecturer-student interaction and peer interaction; Cognitive engagement refers to the deep thinking required to understand complex concepts; Affective engagement refers to the sense of identity and belonging to the school. [7]. The main difference between the two is that the latter divides behavioral engagement into academic engagement and social engagement.

The diverse learning fields give rise to heterogeneity within the space and manners of medical student engagement. Some scholars studied medical student engagement in the clinical environment by using the Moodle system, which is based on the visual learning environment. They found that students adopted a strategic learning approach in the clinical environment by using more Internet resources to answer medical questions under time constraints, in comparison to traditional learning techniques that students obtain information from books [8]. Medical student engagement is also reflected in the tasks that simulate clinical situations and online settings. Some scholars have studied the degree of medical student engagement in interprofessional cooperative communication and researched into emotional obstacles to e-learning engagement of medical students including a sense of injustice, passivity and feeling overwhelmed [9,10]. Increasingly, many studies have conducted in-depth analyses on student engagement in different curricula and teaching styles. Researchers found that greater use of cognitive engagement such as elaboration and critical thinking was associated with higher levels of students’performance in a medical gross anatomy course [11]. In addition, reflective writing exercises were more likely to be an effective strategy than grades to foster student engagement in medical humanities courses [12]. The research will also been conducted on the relationship between different learning styles and student engagement [13].

Medical education is media-dependent and resource-dependent in nature. It has become increasingly prevalent to integrate Technology Enhanced Learning (TEL) resources and promote the reform of information technology (IT)-based teaching models in higher medical education [14]. The most representative example in the field is simulation-based medical education, especially the high-fidelity simulation which can bridge the gap between theory and practice by immersing the learner in the realistic setting [15]. In recent years, simulation-based training has gain popularity in global medical education and many discussions have been made on the inevitable reform and development trend in the future. The purpose is to improve the competence of medical workers, ensure the quality of medical care, and promote patient safety. Simulation-based medical education is carried out in a simulation-based learning environment. In contrast with traditional classrooms, the newly developed strategies and instructional methods(e.g. simulated clinical environment laboratory learning, virtual simulated medical equipment, team-based learning, problem-oriented learning, scenario, role-playing, virtual or standardized patients) changed students’ learning environment and learning methods profoundly.

Driven by this movement, educators begin to focus on medical student engagement in the IT-based learning environment. Most research focuses on the effect of using IT in the objective physical

environment and the impact of teaching methods on student engagement which include classroom mobile technology [16], online learning aids [17], online test [18], visualized virtual patient [19], audience response system [20], role-play-based simulation [21], etc. Many of the existing studies including those listed above focus on the impact of IT on student engagement, but little is known what and how student engagement itself has changed. Medical simulation-based training has changed the traditional medical teaching and learning methods, which imposes profound impact on the types and characteristics of medical student engagement. The simulation-based learning environment also poses challenges to the original classification and measurement of student engagement type within traditional classrooms as to whether the original framework may be still applicable to the simulated environment. By studying medical college student engagement in the new learning environment and classifying the types and characteristics of student engagement, adjustments can be made to help medical students engage in meaningful learning in a more targeted manner.

At present, quantitative research is the mainstream research paradigm for studying college student engagement. However, many scholars have questioned the reliability and validity of questionnaires used by quantitative research and the validity of student responses. For that reason, researchers point out that student engagement is a complex, dynamic and contextualized concept. It cannot be measured solely by quantitative surveys. Furthermore, students are unable to express their thoughts beyond the questions within the questionnaire [22]. Therefore, current and future research methods should not be limited to large-scale questionnaires, but extend to multiple methods including qualitative research because of its strength and suitability[23].

Medical education has always been highly contextualized in a specific historical, ethnic, and regional development setting. The simulation-based learning environment involves various contextualized learning activities and practices that resemble real life practice and experiences. Thus, the study of medical student engagement in this environment needs to convert from the traditional quantitative research paradigm to a qualitative one as the latter can offer more insights into the interactive mechanisms between college students’ learning behavior and the environment.

Methods

Interprofessional education course

The 10 participants all took the same interprofessional education course before the interview. The course has 10 teaching periods, each for 2 hours. Seven periods were conducted in the discussion room, equipped with 1 tutor and 1 teaching assistant. Students needed to discuss cases in groups and reflect on the professional value of their roles in the case. Students performed high fidelity simulations in the laboratory twice accompanied by 3 tutors, one for "Neonatal respiratory distress syndrome rescue" and the other for "A rescue of the cardiac and respiratory arrest patient with coronary heart disease". Students needed to play different roles to run the case in groups. Students made desktop deduction in the discussion room for one time under the guidance of 3 tutors, the theme of which is "A rescue of a large

number of the injured suffering from a sudden explosion in the emergency room". Students needed to use the hospital department plan, teaching aids, etc., to conduct interactive discussion and deduct emergency decision-making and on-site disposal instead of running the case. Every simulation study carried out in the laboratory includes three steps: 1. Orientation, including an introduction to the learning objectives and the operating environment of the case. 2. Simulation, students running cases. 3.Debriefing, teachers giving feedback to and summarizing the students' performance in the laboratory.

Semi-structured interviews

Qualitative research commonly uses semi-structured interview which enable the participants to constantly reflect on past experiences. Meanwhile, it also allows the participants to generate new ideas on student engagement based on their instant retrospection and thus promote student engagement. This shed light on useful and effective learning strategies. The main questions of the interview include: How does your student engagement and participation unfold in a simulation-based learning environment? What characteristics do they entail? What are the differences between student engagement in the simulation-based learning environment and learning in traditional classrooms? To what extent do you think you have invested more in student engagement in a simulation-based learning environment? After obtaining consent, we conducted the interviews. When collecting data, we would "epoche" our previous theoretical views, allowing participants to express their personal feelings without restriction, and tried to help them to say as many real and comprehensive feelings and different experiences as possible, in order to obtain richer themes, a more comprehensive display of different types and characteristics of student engagement.

During the interview, researchers conducted in-depth interviews mainly around these open research questions, and always allowed the interviewee to fully express their thoughts without interference. Follow-up questions and detective questions were asked if needed. Follow-up questions were used when researchers were very interested in the views the interviewee talked about and wanted to have a deeper understanding. Researchers would ask the interviewee to give more detailed information. Detective questions helped us manage the conversation with the interviewee, so that the conversation always revolved around the main research questions. We used some simple phrases, for example, "You did a good job, please continue", to suggest the discourse depth we need to the interviewees, or encourage them to further expand the conversation. Researchers used almost the same main questions and interview techniques for the 10 interviewee. Interviewee could fully express their views about these broad questions. But at the same time, researchers would reflect on the interview recording after each interview with 2 students to better guide the next interview.

Participants

This study used purposeful sampling, i.e. non-probability sampling to select the interviewees so as to draw the maximum amount of information for the research questions in light of the research purpose [24]. We followed the following principles: (1) Participants are those who could provide essential and sufficient information regarding the research questions so as to enhance the intensity sampling principle.

That is, in the current study, priority is given to participants who were interested in the research topic, good at expression, open-minded and willing to share their experiences with others. (2) Adhering to the “Maximum Difference Sampling” principle [24], the results should reflect the heterogeneity within various learning experiences to the greatest extent, accounting for the factors such as majors and gender which have proven to be influential in student engagement. We adopted snowball and convenient sampling and conducted in-depth interviews with 10 medical students. They were all sophomores from a Chinese medical university. Participants have the following characteristics: sophomores aged between 18 and 21, including 4 males and 6 females , 2 majoring in Clinical Medicine, 2 in Health Care Management, and 1 in Preventive Medicine, 1 in Rehabilitation Medicine, 1 in Imaging Science, and 3 in Nursing Science. The descriptive information is shown in Table 1. Our choice was based on China’s medical education condition. In China, there are many independently established medical universities that recruit students majoring in Clinical Medicine, Nursing, Preventive Medicine, and Rehabilitation Medicine, all of whom referred are classified as medical students. As a result, "medical students" we use here is a broad-sense concept related to the context of Chinese medical education. In addition, in the management of medical education at the national level, including medical-education-related documents issued by the state, clinical medicine, public health, rehabilitation, nursing and other majors are included in the scope of medical education for unified management. The numbers were capitalized according to the initials of the professional names and sorted by numbers.

Data analysis procedure

Data collection and analysis basically carried out simultaneously, that is, we would carry out data analysis immediately after interviewing 2 participants. The determination of the specific number of interviewee generally followed the "theoretical saturation principle". That was, when the newly extracted information about the types and characteristics of the learning input of the interviewee didn’t contribute to new coding, the new interview would no longer be carried out. All the interviews were audio recorded. In the process of thematic analysis, our own theoretical views on student engagement in a simulated learning environment provided the basis for in-depth dialogue with the materials. This study conducted interviews in China, taking into account that the use of native language can accurately reflect the ideas of participants, and the trend of using native languages in qualitative research more and more frequently[25]. Two authors of this article, the first author majoring in English at the undergraduate level, translated the article. Also, three scholars were invited to conduct a strict review of the translation. Two of them studied and have obtained doctoral degrees in English-speaking countries and the other one a master degree. This process will ensure the professionalism of translation, and will not affect the research results due to translation.The participants verified the transcribed text and opted out of any information that they no longer hoped to be used in the current study after we emailed them the completed transcription. We coded and analyzed each text to find any content related to the research questions and identified the concepts and topics associated with the research interest. Before the analysis, the two authors discussed the theoretical framework and reached an agreement, and then analyzed the transcripts independently. After the independent analysis, they discussed to resolve code discrepancies, and chose more appropriate coding and themes. The texts were organized and analyzed

by MAXQDA qualitative data analysis software version 10, with meaningful words, phrases, sentences, and paragraphs marked with a specific code. After the text data was coded, the codes were classified according to the theme. Then we established a category and finalized the corresponding model framework. The final generic list is shown in **Table 2**.

Results

The characteristics of student engagement in the simulation-based learning environment were summarized into three types: reflective engagement, performance engagement and interactive engagement. Furthermore, sub-themes were also identified as described below.

Reflective engagement with the purpose of problem solving and active thinking engagement

Active, persistent, and focused thinking engagement

One of the most significant features of cognitive performance in a simulation-based learning environment is “active reflective engagement”. Many participants in our study emphasized in the interviews that this is a kind of active thinking and active engagement.

“*Everyone knows what they want to do, what tasks they have to accomplish, and how they can cooperate with others. In this way, our way of thinking dedicates towards what we take the initiative to think about, what we want to do. We also take the initiative to complete our own tasks, start proactive communication and cooperation with others. In this sense, everyone’s way of thinking has become more active.*” [W1]

Different from the short-term thinking in traditional class, the simulation-based learning environment requires constant and persistent thinking. Another frequently used word is “focus”. For students who were highly focused in a simulation-based learning environment, they were deemed to have a “strong and attractive energy field” [L1]

“[In traditional classrooms] Sometimes students are asked some questions but given limited time for a response. Many times, the class continues without giving enough time for student’s reflection on the questions.” [L1]

“[In a simulation-based learning environment] If you don’t take time to think about it, the patient in front of you may die, and you will feel a strong sense of guilt ... if you don’t solve the problem, things won’t work out. I will try my best to do it, not to give up halfway ... unlike in a traditional classroom, when the teacher asks a question, you just need to give a standard answer and it all ends.” [H1]

The simulation-based learning environment also allows students to be more focused on listening to the facilitator. You should take the lesson seriously, because the follow-up session contains real-life practices.

“In traditional classrooms, sometimes the teacher talks too fast, and you will feel a bit unwilling to listen ... In the simulation-based learning environment, *the possibility of being distracted is very little, you can focus more on the teacher, and you can take more notes.”* [W2]

“In order not to make mistakes in front of everyone, you have to listen to the teacher more seriously. Therefore, students are more motivated to learn.” [H2]

Self-directed-learning thinking engagement with the purpose of problem solving

Students must familiarise themselves with the knowledge before entering the simulation-based learning environment. This is different from the passive learning practices in traditional classrooms where students just follow the teacher’s thinking. Instead, it is a re-understanding of the original learning process and outcomes. Students are able to experience the self-directed learning process of self-knowledge construction through observation, reflection, practices as well as problems-discovery and resolutions. Problem solving is the driving force of thinking activities, and the thinking process is reflected in the process of problem solving.

“I feel more self-driven to solve the problems if they come up. I do not rely on teachers to guide me to solve the problem. After all, I cannot just leave the problem there without doing anything… what is more important is the way of thinking. That is, how to find problems and how to find better ways to solve problems.” [H1]

Problem-solving reflective engagement is accompanied by close connections between knowledge. Because it solves real-life problems, the knowledge being connected is situated in a multidisciplinary context and the voices of the patients are also being heard.

“In a normal session of your major, you just passively accept theoretical knowledge. You would not evaluate doctor-patient relationship from multiple perspectives, such as the potential influence over society and a humanistic perspective. I think my way of thinking has become more active.” [Y1]

The process of problem solving is usually accompanied by communication and mutual affirmation among peers. After questions and thinking are valued, students are more motivated to think actively.

“If you have your own thinking and vocalize it, everyone will listen more carefully to your suggestions, and then put forward their own views ... your own thinking is built up or challenged by others, which pushes you to do more active thinking.” [L1]

Active “voice” in class

“Speaking” in the classroom is another important manifestation of reflective engagement. On one hand, an individual has more opportunities to ask constructive questions than in the simulation environment.

“When the student listens to the facilitator very carefully and asks questions; or when analyzing the case, the student can politely interrupt others in a timely manner, and give their own opinion ... especially when

the questions they ask are constructive, or if they really facilitate others to think more about the questions. " [L1]

On the other hand, unlike the commonly seen shyness and silence among East Asians [26], in a simulation-based learning environment, students are more willing to actively engage in conservations and answer questions raised by peers.

"I am more involved than usual in [simulation] class. In traditional classrooms, students just sit in class and dare not answer teachers' questions. And now [in simulation class], if your peer asks you questions, you can quickly give a response. Since if no one knows the answer, the game will not continue. The teacher usually asks questions in class. The class gets embarrassing if no one speaks ... [in simulation class] I feel the need to talk about it myself, whereas there is no such feeling in [traditional] class." [H2]

When it comes to the reason why students want to speak up more in a simulation class, many participants think that "because of the group-discussion format, the group activities ease the classroom tension, which makes you more relaxed and can stimulate your thinking." [Y1]

Many participants also admit that this spontaneous and self-driven engagement stems from the novel teaching mode.

"First of all, we would not be sleepy, because we usually have a lot of academic stress, especially during the exam month. Under such circumstances, this new teaching mode allows us to be more engaged and focused in the classroom. Secondly, this novel learning mode allows us to understand some relevant knowledge better as it spurs us to combine theory with practice when evaluating problems." [Y1]

Performance engagement characterized by strong emotional expression and leadership

Strong emotional experience and disclosure

Learning in a simulation-based learning environment usually requires medical students to play different roles, such as doctors, nurses, patients, and family members. Through these exercises, the students are expected to be familiar with different roles and therefore achieve the learning goals. Therefore, they often claim to be students from "a certain performing university" or "a performance major". "Acting Elf" often refers to those who are particularly good at acting.

Performance means that it is necessary to channel emotions into the character and act out the character's behaviors. The current study found that strong emotional experience and disclosure is an important manifestation of performance engagement.

"As far as I observe, the extent of student participation is diverse. Some people are more active to participate, while some individuals are indifferent to emotional performance if they don't pay much attention to this course." [W1]

The emotions in the simulation-based learning environment change in accordance with the progress of problem resolution and are most associated with the outcome of the patient. There could be “unconsciousness, excitement, tension, eagerness, expectation” when the situation of the “patient” is unknown; there could be “happy feeling, confidence, excitement and sense of fulfillment” if the operation is successful; there could also be “regret, discomfort, guilt, inferiority, depression, depression and feeling lost, unconvinced or even condemned” when the operation fails.

It is the strong emotional engagement that enables students to be physically and psychologically involved in the learning activities, contributing towards a state of “presence”.

“That kind of atmosphere is different [in a simulation environment]. The physical environment and learning atmosphere affect my psychological state and make me more focused on being involved in the task. I do not feel like just physically being in a classroom while mentally distracted by something else.” [H1]

Many students even enter a state of “flow” when they fully immerse themselves in the tasks.

“In the laboratory, I don’t care too much about how long the course takes. I think even if this class overruns, I won’t be too bothered.” [H2]

Emotions and feelings are attitudinal experiences stimulated by the sense of “need”, revealed through behavioral outcomes. Although emotions and feelings are inspired by objective experiences, their nature is determined by people’s perception of the situation[27]. During the interview, some participants compared the emotions that were more “calm” in traditional classrooms with those that were “fuller” in the simulation-based learning environment. Compared with the traditional classroom atmosphere, which suppresses the expression of emotions, a more relaxing simulation-based learning environment helps release various emotions.

“Generally, in the classroom, because everyone is listening to the teacher to gain knowledge, the atmosphere is more serious. Even if we have some emotions, we will not express them. Everyone remains calm and does not respond much. But when we perform a live simulation in the laboratory, first of all, there is a sense of tension. You have to complete the tasks given by the teacher. You don’t know if you can do it well. Second, when we engage in this work, we can easily reveal our emotions regarding whether the work progresses well, whether the result is good, and what has happened in the process. For example, if something goes wrong or when we make a mistake, we will be very anxious, there may be a sense of shyness and even shame. In short, our moods are fully revealed.” [W1]

Demonstration of professional leadership

The simulation-based learning environment usually creates a realistic hospital scene. In this atmosphere, there are many actions that reflect professional leadership. These include whether one can take the initiative to take the responsibility of the leader, whether one can lead the team to facilitate the learning process, or actively follow the leader, quickly adjust to their role, analyze the problems, and offer

responses. A deeper level of participation is reflected when those “leaders” use their knowledge and demonstrate their capabilities. As some participants said,

“Some people will take the responsibility of leadership voluntarily and spontaneously assign people to do certain things. I will consider that person very devoted and motivated. For those who follow the lead, I also think that they are thinking deeply and engaged entirely”. [L1]

“When the leader is directing the group, the leader will do their job meticulously. This includes how many people should be allocated to every activity and what every member should do... when the leader organizes everything very thoroughly, I could tell that the leader was very engaged at that time.” [W1]

Interactive engagement as a result of multidimensional interactions between learners, learning communities and the environment

Interaction with realistic learning situations

The most prominent feature of the interactive learning environment is the realistic working session, including mimicking the busy atmosphere as well as the vivid “doctor-patient” interactions in a physical hospital setup, which enable students to be fully drawn to the learning context.

“The more realistic the environment is, the stronger feeling I could have that similar situations would happen in real life practices.” [K1]

“At the time, the assessment involved a little baby [model] ... we played with him, and we felt a kind of attachment. We would say, ‘look at those babies’. There would be a kind of motherly love – a kind of feeling expressed spontaneously.” [L1]

“Children can survive by double-compression. I feel that I have to do a good job ... and then I would carefully read the materials given by the teacher, and then delve deeper into the textbooks. I want to successfully rescue the baby ... because the baby would cry disparagingly, that would make the atmosphere very intense ... and then the sense of urgency in that situation is much stronger than the pressure imposed by teachers or exams in reality.” [H2]

The professional responsibility of medical students is also stimulated by the simulated medical environment that fully brings the medical students into their professions.

“For example, if you rescue the senior simulator successfully, it will give out some responses. For example, during the rescue, the student can monitor the “patient’s” pulses, blood pressure etc. ... in that simulated context, because of the role you play, you will develop a strong sense of responsibility and want to do it well.” [H2]

“I will subconsciously think that I am a professional and I can do this well. Then, I will not be distracted by others since I just need to do the operation based on what I have learnt. Building on that, I will also think about how I can better use the knowledge.” [H2]

This sense of professional responsibility also motivates students to achieve a higher level of engagement.

"I'm probably more engaged at that time [in the simulated learning environment] than I would be if I were alone. That is, when someone wants to interact with you, it makes me feel that this is not my own business. It is not like normal practice which is solely operated by a single student, which easily makes one lonely and bored. Because there are interactions in a strongly collaborative atmosphere, which promotes my sense of responsibility. That is, if I do it wrong, my teammates will have to bear the consequences too, so it is not my own business." [H3]

Support from teammates

Peer interaction is mainly manifested in the sharing of information, mutual discussion, and skill guidance required in the process of problem solving.

"You exchange views with your peer ... and jointly solve this problem, which leads to increasing peer support." [K1]

Unlike ordinary peer communication, in the simulation-based learning environment, peers are more conscious and conduct more in-depth communication within the profession, and develop the ability to think about problems holistically.

"What are their [my peers'] concerns? What are my concerns? What are the similarities and differences between my peers' and my own concerns?" [H1]

The "companion" in the simulation-based learning environment is not simply a learning partner, but a buddy who needs to complete a task that is very challenging. The mutually facilitative interaction between peers promotes active engagement. However, if the interaction is not harmonious, it will hinder further engagement. Attention and responsiveness from peers will drive the next round of positive emotional experience and student engagement.

"If everyone is very cooperative and actively participates, the interactions would be smoother, it will have a more positive effect on participation. If everyone is cold and everyone does not want to talk, then this task cannot carry on." [H3]

"In order to complete a group task, we need mutual encouragement and support. I feel that someone is listening and someone is willing to respond to you. This sense of mutuality is very fulfilling and very encouraging." [W2]

The impressive performance of other students in the process of peer interaction will also motivate the students themselves to be more engaged.

"During interaction, I can feel the kind of enthusiasm of the classmates. They are motivated to do the task, because they really value the patient and imagine what if the same experience should happen to

themselves." [H3]

"The students who participated in that course are very active and full of positivity. I enjoy interacting with them, and I am willing to speak up if I feel like to... when my classmates are thinking about the problem very seriously and trying to solve the problem, I feel that I can't stand by but need to help out." [K1]

"Especially if your peers are very good at acting, they convince you that the entire process is very authentic and make you more engaged in solving the problems." [H2]

The friendship-like facilitator-student interaction

The role of the facilitator in the simulation-based learning environment is more like a guide, directing the students forward instead of just giving out answers. Furthermore, they give students ample space for thinking. The facilitator also takes on the role as a "director", setting up scripts and scenes, observing the actors' performance, and giving guidance. "The facilitator, as an observer and a questioner, is not an answerer, um, is a helper, a prompter." [H1] The facilitator-student interaction in the simulation-based learning environment is more "easy-going" and "informal" than that in the traditional classroom.

"The facilitator also participates. The facilitator and we students feel like friends. Unlike in the classroom where one needs to be more respectful when asking the facilitator questions, there is no distinct boundary between the facilitator and students in a simulated learning environment." [L1]

"The facilitator is more easy-going. The sense of distance and barriers are eliminated." [Y2]

The facilitator-student relationship in the simulation-based learning environment is based on a more equal footing. There is no hierarchical relationship during knowledge transfer. Instead, the facilitator acts as a consultant. If students are given positive feedback and affirmation in time, they will be more willing to participate.

"That is to say, the facilitator has high expectations for us. Thus, we must definitely treat the course seriously and put in more efforts so as not to disappoint the facilitator." [W1]

Discussion

For the first time, this research studies the feelings and experience of medical students in a simulated learning environment from the perspective of student engagement, and reclassifies the types of student engagement, forming a new student engagement type that fits the simulation-based learning environment and differs from the classic student engagement type. The results of the research are helpful for teachers to improve the instruction method in accordance with the type of student engagement to adapt to the student engagement and help them improve their learning outcomes.

Types and characteristics of medical student engagement

This study provides insights into medical student engagement in the

simulation-based learning environment, which involves reflective engagement, performance engagement, and interactive engagement. Reflective engagement is problem-oriented with a focus on inducing active, persistent and focused thinking practices. It involves a deep, reflective and concrete processing activity. As D. H. Jonathan states, “learners learn from thinking, but not from technology” [28]. Even in a simulation-based learning environment with advanced technology, it remains the fundamental principle to stimulate students’ persistent, active and focused reflective engagement. Reflective engagement is a primary student engagement among medical students as students use it to reflect and practice existing knowledge. A literature review also suggested that the emphasis on reflection and reflective practice is increasing in medical curricula [29]. Through reflective engagement, students are able to fully utilize critical thinking to perform in-depth understanding and conduct advanced knowledge construction, which bridges knowledge and experience, facilitates supportive peer interactions and reduces the amount of “silence” in classrooms.

The study also found a special form of student engagement in the simulation-based learning environment, namely, performance engagement, which is a role-based emotional and behavioral engagement. It promotes empathetic experiences, facilitates interprofessional practice and encourages a stronger desire for leadership. Similar to the research conducted by Ulrich et al., the role play simulation allows participants to actually feel the emotions they might experience in the future and develops their professional values [30]. Emotional engagement is an important aspect of medical student engagement. Cognitive scientists tell us that learning is a multi-level communication process at cognitive, emotional and physiological levels. However, this study also found that, unlike the positive emotions in general student engagement, which positively affect learning outcomes [31], there are mixed emotions promoted by medical students in simulation-based learning environments. Many participants considered that, as long as the affective level is high, whatever emotions and feelings all indicate engagement. The special nature of medical practices to deal with doctor-patient relations and intense emotional responses makes the emotional development of medical students particularly important in medical education. Medical students need to develop the emotions of compassion, care and empathy, as well as developing moral sensitivity and emotional regulation. This is in accordance with the findings about the value of emotional intelligence in medical education, with increasing research evidence showing that doctors’ emotional intelligence can improve their ability to deliver safe and compassionate health care [32]. In this way, they can always adjust the balance within an emotionally rich environment to avoid emotional burnouts. Medical educators need to understand how emotions develop and how technology facilitates emotional development. In addition, the simulation-based learning environment creates a more vivid professional identity for students beyond a pure learner status. Students show group or individual leadership when they “act in the professional role”; this process also confirms that the integration of technology into teaching helps promote students’ individual psychological functions from purely cognitive development to meaning acquisition and the dual development of identity.

Interactions within student engagement are reflected in the responses to the high-fidelity simulator, mutually supportive peer interactions and friendship-like facilitator-student interactions in a realistic simulated environment. The origin of learning is the real-world social construction of environmental

interaction and social interaction. The application of emerging technologies such as virtual reality and augmented reality has gradually made the simulation-based learning environment an important learning space for medical students[33]. In this space, peers, teachers and students constantly construct knowledge through interactions and cooperation. Teamwork is crucial for success: varied backgrounds and interests enable them to solve the problems from different perspectives [34]. Eismann et al. showed simulation courses have an influence on teamwork [35]. This study found that the more closely learning context is related to real-life practices, the more mutual encouragement takes place among peers along with more positive feedback from the facilitator, which in turn promotes student engagement. Similarly, as studied by Behrens et al., well-designed clinical scenarios, teamwork and feedback support students' learning [36].

Logical relationships between different types of student engagement

Medical student engagement in a simulation-based learning environment promotes students' whole-hearted focus. Specifically, reflective engagement facilitates deeper levels of critical thinking and knowledge construction; interactive engagement emerges from interactive activities in the learning space; performance engagement gives rise to role-based group activities, promoting participation and reflections. These three forms of engagement are subject to the influence of many environmental and pre-existing factors. For instance, when students engage with the roles they play, they need to constantly reflect on the role's behaviors, feelings and thinking while modifying their acting based on their knowledge and previous experiences. The step-by-step practices and the immediate stimulus in the learning environment prompt more reflections, encouraging students to continuously conceptualize and act on the experience; at the same time, they facilitate the interaction between the character and the external environment, thereby forming a relationship framework as shown in **Figure 1**.

The use of IT highlights the multidimensional interaction between individuals, groups and the technology environment. In this framework, medical students' reflective engagement, performance engagement and interactive engagement mutually influence each other. Particularly, the horizontal axis represents the two-way construction of individuality and space in learning in a simulation-based learning environment. The learning space provides a field of personalized practices accounting for individual differences. Teachers, students, and peers interact with each other through performance interaction, idea exchange and sharing, and constant reflections to develop and enhance practical wisdom. Moreover, the vertical axis represents the interdependence of individual-oriented and community-oriented learning experiences in a simulation-based learning environment. The individual-oriented learning focuses on students' internal reflective knowledge construction, while the community-oriented learning emphasizes that learning outcomes are based on the interactions within the groups and also between the groups and the environment. Such interactions range from individual reflective engagement, to performance engagement between individuals and peers, and also to interactive engagement between groups and environments. Learners, learning communities as well as learning spaces form a coupling and ecological system that promotes the completion of learning tasks.

The findings indicate two perspectives that explain the mechanisms behind student engagement: the two-way construction of individuality and space in learning, and the interdependence of the learner and the learning community. That is, expanding the learning space centering around “inquiry” helps strengthen reflective communication and dialogue and further facilitates the process of knowledge construction. Students should be encouraged to take on role-based responsibility, express their opinions, actively ask and solve problems, thereby breaking the “silence” of traditional classrooms. Facilitators should focus on knowledge accumulation beyond in-class learning space, reflection on practices within simulation learning space during the lesson, as well as the knowledge consolidation of online learning space after class to establish a continuum of learning space that promotes the students’ learning experiences and outcomes.

Performance engagement in the simulation-based learning environment also facilitates imagination, stimulates empathy, and builds an interprofessional learning community. Interprofessional education research evidence provides a clear indication that it can improve collaborative attitudes/perceptions and knowledge/skills necessary for collaborative practice [37]. It also reinforces the union of medical students from different majors when studying together, such as clinicians, nurses, pharmacists, radiologists and health managers[38]. By solving complex clinical problems together, it encourages exchanges and interactions between students of different majors, thereby promoting the establishment and development of professional responsibility and professional leadership.

Faculty members need to set the stage with a relevant and realistic scenario [39]. The case in role-play simulation should come from real clinical practices but needs to undergo an adaptation of the plot to make it more challenging. Besides, each role normally has distinct characters. In this way, the context could stimulate students’ use of professional knowledge as well as promote students’ compassion and respect for lives. This can also enhance emotional engagement among students. Gradually, they can turn this feeling into a long-lasting emotional experience. In this way, medical students are expected to learn from the two-way transmission of information, cultivate and reshape the interpersonal relationship, as well as improving student engagement in the simulation-based learning environment.

Furthermore, there are two dimensions that contribute to the improvement of interactive engagement in the simulation-based learning environment. First of all, it is important to strengthen faculties’ capabilities of integrating IT into teaching contents, teaching methods and evaluation methods. Also, professional development courses should strengthen the role of teachers in guiding students, train teachers to be the guides of learning, and observers of practical activities so as to help students build intersubjectivity and in turn promote learning. Secondly, in terms of peer relationships, it is important to create a learning atmosphere that is conducive to communication, sharing and discussion. The process of thinking, knowledge construction and the rich emotional experience can be fully achieved by learning from their peers. Students can enjoy a strong and cooperative relationship centering around boosting professional knowledge and helping everyone to be integrated into the team.

Limitations

The purpose of this research is to reflect on student engagement in the simulation-based learning environment from students' perspective, making this one of the basis for teachers to improve their ways of instruction. However, this is also the limitation of this research, which fails to make judgments about students' learning achievement in combination with their objective learning performance. Our follow-up research direction is to break through the limitation.This research focuses on the learning experience and subjective feelings of students in the simulation laboratory. However, we cannot know their possible reactions in the real world, nor can we make sure whether the learning experience in the laboratory will affect their performance in the real world. This is also the possible direction of our future research.

Conclusions

Student engagement in the simulation-based learning environment is different from that in the traditional classroom learning environment. The current study provides evidence for the unique nature of simulation teaching, which promotes reflective learning and clinical environment immersion by facilitating reflective engagement, performance engagement and interactive engagement. These three types of student engagement help to achieve the expected learning result via two-way construction of individuality and space in learning as well as the interdependence between the learner and the learning community.

Abbreviations

TEL: Technology enhanced learning; IT: Information technology.

Declarations

Ethics approval and consent to participate

The study was approved by Nanjing Medical University Ethics Committee. All participants were asked whether they would like to accept the interview. Those that agreed to do provided verbal consent to participate and for the data to be used in publication.

Consent for publish

Not applicable.

Availability of data and materials

As these data are semi-interviews, raw data will not be made available to protect participant confidentiality.

Competing interests

The authors declare that they have no competing interests.

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Author's contributions

JY contributed to the design of the study, ethics application and acquisiton and analysis of data. WYS interpreted data and drafted the manuscript and revised it. Both authors read and approved the final manuscript.

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Tables

Table 1 Basic information and numbers of the students interviewed

Serial Number	Profession	Grade	Gender	Age range	Numbering
1	Nursing	Two	Male	18~21	H1
2	Clinical medicine	Two	Female	18~21	L1
3	Preventive medicine	Two	Female	18~21	Y1
4	Nursing	Two	Female	18~21	H2
5	Health Care Management	Two	Male	18~21	W1
6	Nursing	Two	Female	18~21	H3
7	Clinical medicine	Two	Male	18~21	L2
8	Imaging Science	Two	Female	18~21	Y2
9	Health Care Management	Two	Female	18~21	W2
10	Rehabilitation medicine	Two	Male	18~21	K1

Table 2 List of medical students' learning categories

Secondary Coding Classification	Create A Generic	Learn Engagement Type
Focused, very focused Wholeheartedly involved Active thinking Comprehend Find problems, analyze problems, solve problems Observe and listen Respond Record, write and reflect;	Concentrate On Concentration Mind And Body Involvement Active Thinking Problem Found Analyze Problem Solve The Problem Watch And Listen Submit Questions Express opinions Record Reflection	Reflective engagement
Upset, excitement, tension, excitement, eagerness to try, expectation; enthusiasm, joy, happiness, joy, excitement, sense of accomplishment; Discomfort, inferiority, depression, disappointment, loss, condemnation, guilt, Relax, tense; unconvinced, regret; Emotional expression, full of emotions; Strong emotional expression and indifferent emotions; Play a role Leadership, assignment of tasks, core members; Actual operation; Show oneself Not absent during important times	Positive Emotion Negative Emotion Emotional Expression Emotional Filling Strong Mood Indifferent Cosplay Leadership Core Member Actual Operation Strict Attendance	Performance engagement
Immersive performance Rescue senior simulators and interact with them Identify peer issues; Drive peers; Discuss, communicate and communicate within the profession; Peer awareness Peer collaboration Ask questions; Observer, questioner, helper, prompter; Teacher guidance Positive teacher feedback	As It Is Contextual Interaction Peer Correction Drive Companions Professional Communication Peer Awareness Peer Collaboration Ask Questions Identity Change Teacher Guidance Teacher Feedback	Interactive engagement

Figures

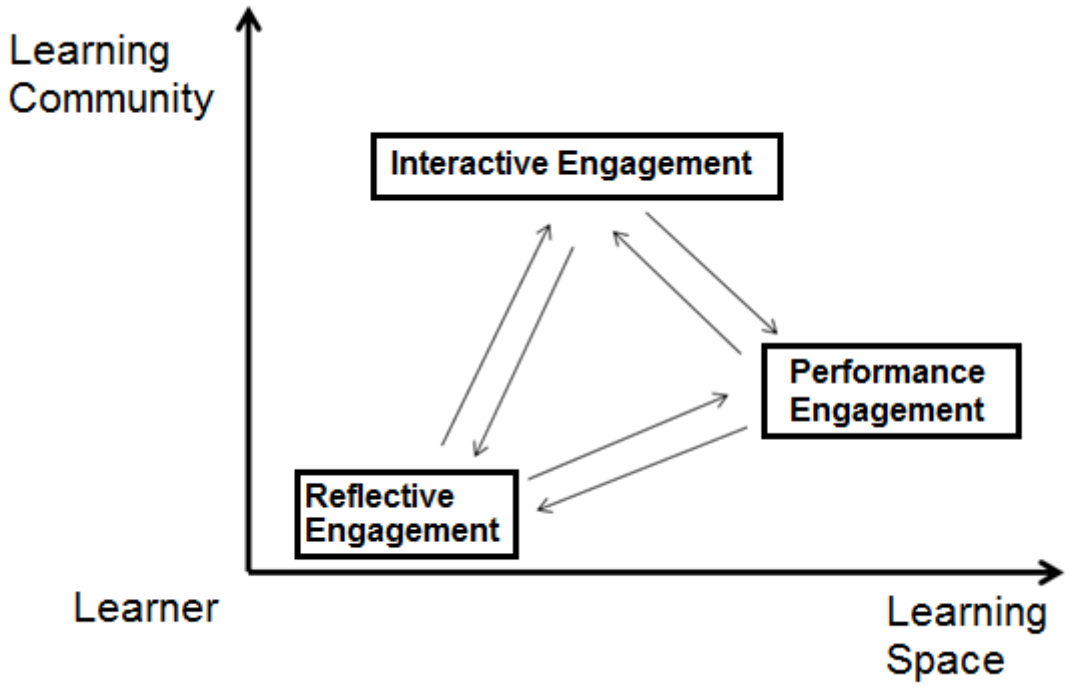

Figure 1

A framework for the reflection, performance and interactive student engagement of medical students The framework represents logical relationships between different types of student engagement. Medical students' reflective engagement, performance engagement and interactive engagement mutually influence each other. The horizontal axis represents the two-way construction of individuality and learning space. The vertical axis represents the interdependence of individual-oriented and community-oriented learning experiences. Such interactions range from individual reflective engagement, to performance engagement between individuals and peers, and also to interactive engagement between groups and environments. Learners, learning communities as well as learning spaces form a coupling and ecological system that promotes the completion of learning tasks.