

Medical students' learning experiences using a virtual patient simulator

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Abstract

Patient-centred learning has always been a fundamental element of medical education. Consequently, the use of virtual patient simulators has become increasingly common in medical education. The aim of this study was to generate new knowledge on the pedagogical value and impact of a virtual patient simulator, specifically in relation to students' learning processes. The study was conducted in Finland at one university as part of an elective course offered to fourth- and fifth-year medical students (n = 25) between 2023–2025. The course focused on practising clinical reasoning by solving 10 virtual patient cases designed to simulate primary healthcare scenarios. The students received personalised feedback from the simulator. The students were then required to reflect on their reasoning processes. The patient cases were subsequently reviewed in joint face-to-face sessions. The data for this study consisted of students' written reflections and written course feedback. The research methodology applied a qualitative, theory-guided, abductive thematic analysis. Targeted learning outcomes for licentiates of medicine, activity theory and expansive learning theory were used as the conceptual framework for examining virtual patient cases. The results indicate that virtual patient cases can effectively support medical students' deep learning and clinical reasoning skills, as reflected in students' written reflections. The findings suggest that the added value of virtual patient cases lies in their ability to integrate several key competence areas. From the perspective of expansive learning, virtual patient cases may challenge the traditional teacher-centered activity system by shifting the initiative for learning towards students' own learning needs.

Keywords: simulation training, high fidelity simulation training, medical education, teaching method

Introduction

Patient cases have always been central to medical education, and simulation-based learning later built on this tradition [1]. In recent decades, the use of virtual patient cases has become increasingly prevalent [2]. In this study, virtual patient simulators are conceptualised following Berman et al. [2] as multimedia, screen-based interactive patient scenarios. Virtual patient resources have also been described as shared educational infrastructures that enable reuse and collaboration across institutions, reflected in the concept of a “virtual patient commons” [3]. Previous studies suggest that well-designed and interactive activities can promote deep learning [2,4]. Virtual patient simulations can support the development of clinical reasoning, decision making, student engagement, self-efficacy and information retention [2,3,5–8]. Virtual patient cases can therefore complement existing teaching methods [6,8]. However, technology alone cannot guarantee effective learning. Evidence-based instructional design and well-structured interactive learning activities facilitate the effective use of learning technologies. Pedagogical elements often contribute more to effective learning outcomes than the underlying technology itself [2,5,9–12]. Previous studies highlight the importance of shared pedagogical objectives and collaborative efforts among educators implementing digital learning

tools [2,4,13]. Particularly important is examining how virtual patient cases complement existing learning opportunities and how teachers integrate them with other teaching methods [3].

This study provides evidence-based insights into how virtual patient cases support learning and which pedagogical strategies enhance these processes. This study uses a virtual patient simulator originally developed by two medical students at the University of Helsinki in 2018. The development took place in close collaboration with all Finnish medical faculties. The software has been used in all Finnish medical faculties since 2020, including a piloting phase during 2020–2021. We utilized The Targeted Learning Outcomes for Licentiate of Medicine [14] as a theoretical framework to classify students’ reflections (later abbreviated as the TLOLM framework), as these nationally agreed learning outcomes have been widely adopted in Finland since 2020 (see Supplementary material S1).

Furthermore, we used the concept of an activity system as an analytical tool derived from cultural-historical activity theory (CHAT). The activity system model [15] provides a structural representation of human activity by depicting the relationships between the subject, object, mediating artefacts, rules, community and division of labour (see Figure 1).

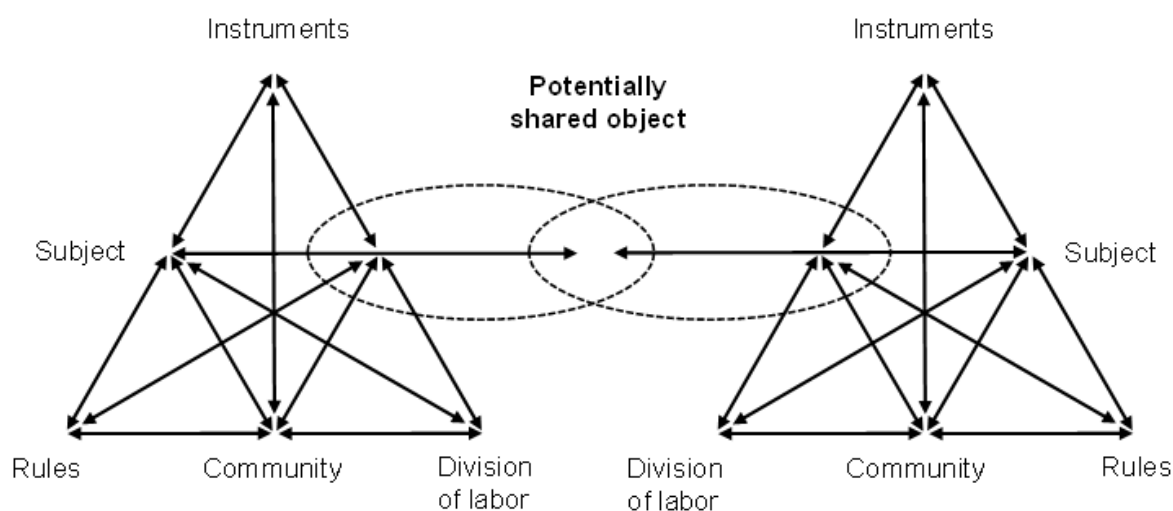


Figure 1. Human activity as a dynamic model of interlinked activity systems. Modified from Engeström [16].

These interconnected elements form historically evolving systems of activity that coexist and interact with neighbouring activity systems within an organisation. While the activity system framework helps illuminate the configuration of teacher and student activities and their relationships, the theory of expansive learning offers a dynamic perspective of how these systems transform. According to Engeström [17], expansive learning is triggered when a community encounters contradictions that generate a need for change, initiating a collective and cyclical process through which new models of activity are created, tested and stabilised. Often, the organisational boundaries and differentiated and compartmentalised division of labour prevent members of the community working together [18,19]. By applying CHAT, this study conceptualises the national implementation of the virtual patient simulator as both a configuration of interacting teacher and student activity systems and as a collective learning process. This dual perspective enables a holistic examination of how students' learning experiences and teachers' pedagogical actions jointly shape the emerging practices of using virtual patient cases in teaching.

Against this background, the study aimed to address the following research questions (RQs):

- RQ1. What have medical students learned from solving virtual patient cases, and how are these learning experiences connected to the Targeted Learning Outcomes for Licentiate of Medicine?
- RQ2. Which pedagogical solutions supported students' learning processes?
- RQ3. What activity-theoretical and expansive learning features are evident in medical students' reflection process?

Materials and methods

This study was conducted within an elective course offered to fourth- and fifth-year medical students (n = 25) and implemented twice during the 2023–2025 academic years at one Finnish university. They were entering a phase in which they could work independently in primary care under the supervision of a practising physician.

The course focused on practising clinical reasoning by solving 10 virtual patient cases designed to simulate primary healthcare scenarios (see Supplementary material S2). After completing the case, students received immediate, personalised feedback from the simulator together with the correct diagnosis. Students also received quantitative information about their performance from the simulator, such as the number of relevant questions, ordered diagnostic investigations, time and money spent. The students were also given information about the performance of peers. At the end, each student received a model answer prepared by the teacher, a medical treatment recommendation and follow-up care guidance. Subsequently, students were required to reflect on their reasoning processes and document their insights (25 students x 10 cases = 250 reflective reports). One to two post-simulation face-to-face group meetings were organised one to two months after the patient case-solving process. In these group meetings, patient cases were reviewed, and the clinical teacher facilitated deeper learning by guiding students through treatment decisions. The group meetings were organised in a student-centred fashion, so students presented patient cases. Finally, comprehensive student feedback on the course was collected.

The focus of this study was students' reflection texts and their feedback on the course. The research methodology utilised a qualitative, theory-guided, abductive thematic analysis. The expressions emerged from the data; however, their grouping was guided by theory. The TLOLM framework was used to classify students' reflections [14] (RQ1), and Engeström's activity theory informed the analysis related to activity systems [16] (RQ3).

In phase one, the data were collected. In phase two, data were analysed by tentatively classifying and grouping the reflection texts and feedback thematically, which enabled the detection of similarities and differences. In the third phase, the data were analysed using thematic analysis in greater detail, identifying and collecting themes that recurred regularly.

RQ1's aim was to answer questions about which content medical students felt they had mastered best, and in RQ2, students indicated which pedagogical solutions in the course most supported learning. In RQ3, we examined what kind of activity theory and expansive learning features are evident in medical students' reflection process. The unit of analysis was a sentence or phrase written by the student. A researcher (Author 2) with a medical background also participated in the data analysis to ensure the study's reliability. Author 2 helped to review unclear reflections and feedback text from a medical perspective with Author 1. Authors 1 and 2 did not perform analysis independently because both authors had complementary expertise.

Results

Table 1 summarises the main themes emerging from students' reflections and feedback. The themes are organised according to the TLOLM framework [14]. Some competence areas overlap across themes. Student quotations illustrate the identified themes. The original reflections were written in Finnish and translated into English. The final subsection presents findings related to activity theory and expansive learning (RQ3).

Table 1. Themes and sub-themes identified in the qualitative analysis of students' reflections and feedback, organised according to the framework of the Targeted Learning Outcomes for Licentiates of Medicine [14] (RQs 1–2).

| RQ1 Learning experiences related to solving virtual patient cases | |
|--|--|
| Competence area (Targeted Learning Outcomes framework) | Key themes from students' reflections and feedback |
| 1. Learning Experiences Related to the Practical Skills of a Physician | 1a) Working a clinical encounter 1b) Patient examination 1c) Clinical reasoning and differential diagnostics 1d) Safe medication practices |
| 2. Learning Experiences Related to the Physician's Knowledge Base | 2a) Treatment pathways |
| 3. Learning Experiences Related to the Physician's Values and Actions | 3a) Professional and ethical responsibilities 3b) Tolerating uncertainty in a physician's work while maintaining agency 3c) Flexible problem-solving methods |
| RQ2 Pedagogical solutions supporting learning | |
| | 1) Making one's own competence visible and gaps in competence 2) Reviewing what has been learned 3) Feedback on virtual patient cases 4) Reflection |

Learning experiences related to the practical skills of a physician

Working in a clinical encounter

Students practised managing clinical encounters using virtual patient cases. They simulated authentic clinical encounters, and must solve patient cases through interviews, examinations and laboratory studies. Students reported that this can facilitate clinical work and support the formation of strategies for managing real patient encounters. Simulating and practising clinical encounters can help

students form a mindset that structures clinical decision-making during patient encounters.

'For once, the work of a general practitioner is taught in more detail.' (Feedback Fragment 38)

'This way of learning how to examine and treat patients is really pleasant and interesting, it feels like you are actually there in a health center treating a patient.' (Student 3 Group 1, Patient case 1)

The students found the monitoring of time use meaningful. Regarding each patient case, the

students received information about how much the patient's treatment would cost and how other students spent money, as well as optimal costs. The ideal price used by the system is based on real-world cost data and is therefore comparable to actual expenses. Based on students' reflections, experiences with monitoring the use of money were generally positive.

Patient examination

Students found it highly valuable to practice cases commonly encountered in primary care and to solve them independently. In their reflections, the students emphasised the importance of gaining personal experience regarding the core duties and workflows of clinical practice. According to the students, it is important to know how to order appropriate laboratory and imaging studies for a patient, to set a working diagnosis thoughtfully and to simultaneously consider diagnostic options before the final diagnosis. Students found it eye-opening that many diagnostic investigations can be ordered in primary care, yet choosing those that add real diagnostic value requires expertise and careful judgment.

'The less I know what is possibly wrong with the patient, the more I order unnecessary tests and hope that they will find something to explain.'
(Student 12, Group 1, Patient Case 3)

Clinical reasoning and differential diagnostics

According to the students, it is essential for medical professionals to understand clinical reasoning and diagnostic processes, including their key phases, and to develop their own reasoning skills. Student reflections indicated that practising clinical reasoning through virtual patient cases was highly valuable because it required activating, recalling and integrating previously learned knowledge with new

patient-specific information in authentic problem-solving situations. The critical examination of the reasoning process seemed to deepen the students' understanding and make clinical reasoning process more explicit, as well as bring out the students' tacit knowledge.

'I forgot to consider the differential diagnosis options. It's probably because arthritis is a bit of a difficult topic for me and I didn't suddenly think of all the differential diagnosis options.'
(Student 13, Group 2, Patient Case 6)

Safe medication practices

Based on the reflection texts, students found medication-related issues educational. These included e.g. starting a new medication for a patient and managing associated uncertainties, changing a patient's medication, adjusting dosages, considering the patient's overall medication regimen and potential drug interactions, and deciding how and where a medication should be initiated.

'I should have asked detailed questions about the history of the patient's medication use, and I should have taken into account the metabolic pathways of the medications he was using.'
(Student 9, Group 1, Patient Case 2)

Learning experiences related to the physician's knowledge base

Treatment pathways

The students described defining treatment plans as challenging. In each case, they had to choose whether to send a patient home, admit them to the emergency room, refer them to hospital, or make a non-urgent referral to specialised healthcare.

'It is still difficult for me to think of a plan, and sometimes, it is difficult to find information

about it. Now, I used the physician's handbook, lecture slides and national treatment recommendations, but it is surprisingly difficult to find clear instructions on how to act even in simpler situations like this.' (Student 8, Group 2, Patient Case 3)

Learning experiences regarding the values and activities of a physician

Professional and ethical responsibilities

According to students' reflections, the virtual patient cases also provided opportunities to develop professional and ethical competence areas. Virtual patient cases guided students to reflect on their values, beliefs and preconceptions in clinical encounters.

'I forgot to ask the patient about drug use. Drug use could very well cause urinary retention. However, the patient seemed unlikely to be a drug user. However, such preconceptions are dangerous in a doctor's work, and I should get rid of them.' (Student 5, Group 2, Patient Case 9)

Tolerating uncertainty in a physician's work while maintaining agency

Students highlighted feelings of uncertainty during clinical reasoning and challenges encountered in decision making. Challenges often related to incomplete information (not all the desired information is available), the need for immediate decision making and working under pressure (a seriously ill patient who needs treatment).

'However, I noticed myself getting a little nervous when solving the case, when I thought that now I had to get the sick patient examined and treatment started quickly. However, I had to

keep a cool head and focus on solving the case in peace.' (Student 5, Group 1, Patient Case 7)

Flexible problem-solving methods

According to students' reflections, virtual patient cases can serve as problem-solving exercises, allowing students to comprehensively apply and integrate previously learned knowledge. Independent reflection and reasoning can support the construction of persistent knowledge and competence.

'Rare courses go through the problem solving that actual patient work entails in such a comprehensive way, but in other courses, the problems are narrow, in the category of "here are the symptoms, what is the diagnosis?" or "which medicine do you use to treat symptom X?'. (Feedback Fragment 2)

Pedagogical solutions supporting learning (RQ2)

The students highlighted that solving virtual patient cases revealed their competence level. Solving virtual patient cases helped them review and apply previously learned theoretical knowledge. This supports deep learning, where new conceptual structures are formed and integrated with prior knowledge. Automatically generated, highly individualised feedback from the patient simulator, along with a comprehensive model solution provided after each case, significantly supported students' learning (e.g. whether all essential examinations were conducted and relevant laboratory tests were ordered). Reflection made visible the thinking process, which may otherwise be difficult to access.

Activity theory and expansive learning features (RQ3)

According to this study, the needs expressed by the students seem to create a contradiction with the teachers' activity system, as the students hope for

the widespread adoption of the patient simulator in basic education. In the reflections and feedback, this was manifested in students' wish to use virtual patient cases more widely and systematically in the learning process. Simultaneously, teachers seem slower in implementing these practices. From a teacher's perspective, the introduction of virtual

patient cases means changing previous pedagogical practices, which may be very well established. The findings of this study indicate students' learning experiences and teachers' pedagogical actions jointly shape these emerging practices. Remarkably, students' initiatives have the potential to challenge the existing teacher activity system.

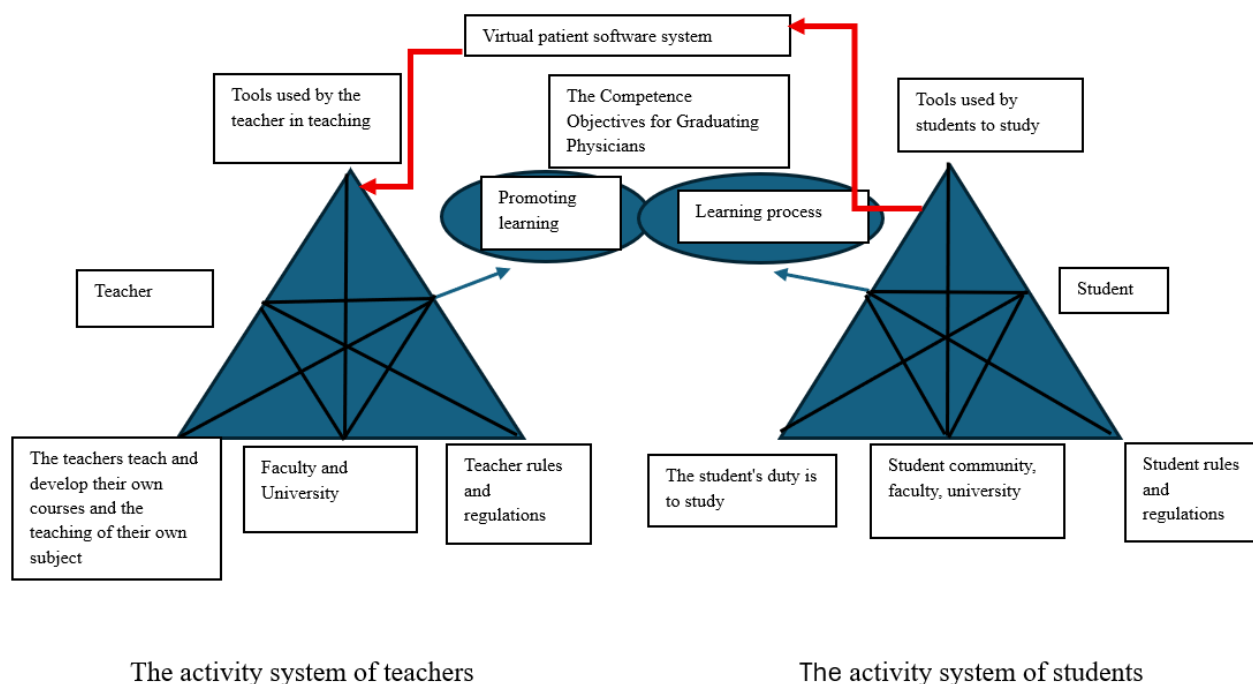


Figure 2. Medical teachers and medical students have their own activity systems based on Engeström's activity theory [20]. The virtual patient simulator, which originates from the students' activity system, causes a change, a disruption, to the teachers' activity system, and to move forward, the boundaries between these activity systems must be crossed. The figure is based on Engeström's activity theory [20].

Discussion

This study generated new insights into the educational use of virtual patient cases from the perspective of students' learning experiences. At the micro level, the findings describe how students perceived the benefits of using a virtual patient simulator for learning. At the macro level, we examined how virtual patient cases entered the teacher activity

system when the initiative originated from students' learning needs.

This study confirms previous findings [2,3,6] that well-designed virtual patient cases can promote learning. In RQ1, we posed the question of what medical students have learned about solving virtual patient cases. Based on this study, the added value of virtual patient cases lies particularly in their ability to integrate multiple key competence areas

essential in medical education. The virtual patient platform provides a safe environment for practising patient encounters and core elements of physician work.

According to previous studies [21,22], medical students benefit when cost awareness is incorporated into educational practices during their training. In this study, monitoring the costs of patient care led some students to monitor their spending too closely, creating a risk that too few diagnostic investigations would be ordered. The students recognised this tension in their reflections and indicated that they would aim to order investigations more appropriately in future clinical practice. These findings suggest that introducing more information on the costs of patient care and diagnostic investigations during training may support cost-conscious clinical decision-making.

In RQ2, we examined pedagogic solutions supporting students' learning processes. Virtual patient cases can be integrated in courses in multiple pedagogical ways. Effective integration requires understanding the pedagogical traditions of medicine, each medical specialty, and the broader learning objectives of the course [3]. This study confirms earlier findings that the effective use of virtual patient cases requires careful pedagogical planning. In our course, several pedagogical approaches appeared to deepen students' learning including guided written reflections, automatically generated and highly individualised feedback from the simulator, and comprehensive model solutions after completing each case. The ability to examine one's own actions is crucial in the development of professional competence; reflective practices can help identify areas for improvement.

RQ3 focused on activity theory and features expansive learning. A key observation was that virtual patient cases may challenge teachers' activity system.

In this sense, virtual patient cases can be seen part of a broader pedagogical development process rather than merely an individual course innovation. Traditionally, pedagogical development has been located within teachers' activity system. The introduction of virtual patient cases can therefore be interpreted as a disruption of established pedagogical practices. In this case, the students' activity—through the development of virtual patient software—introduced an initiative that challenges existing practices (see Figure 2). Moving forward from such disruption, boundaries between activity systems must be crossed. This necessitates increased cooperation, dialogue, and collaborative development - key elements of the expansive learning processes. We suggest that students could be more systematically involved in educational development and that their perspectives should be more actively considered. As a result, students' learning experiences and teachers' pedagogical actions may jointly shape, emerging practices in the use of virtual patient cases. Future research could examine how virtual patient cases might be integrated more systematically into early stages of medical education, including pre-clinical training.

Students' reflections and feedback indicated a clear desire for more systematic use of virtual patient in medical education. When assessing the role of virtual patient cases, it is important to consider their educational value broadly rather than focusing on a single instructional purpose. Wider implementation may be most effective when organised collaboratively within teacher teams in order to maximise local and national impact [13]. Accordingly, the responsibility for implementing virtual patient cases should not rest solely on individual teachers but should be integrated more systematically within medical curricula. National efforts are also needed to promote shared objectives among educators to strengthen digital pedagogy and to support

sustainable and proactive curriculum development in response to changes in medicine and society.

This study has several strengths, including detailed descriptions of students' learning processes based on their reflection and feedback texts. It highlights students' perspectives and experiences in regarding the educational use of virtual patient simulations. A limitation of the study is that it was conducted at a single university, and the course was implemented only twice. Since the course was optional, the participating students may not fully represent the broader medical student population.

Conclusion

Virtual patient cases can support medical students' deep learning processes. Based on this study, the added value of using virtual patient cases stems from their ability to integrate several key competence areas. Pedagogical design appears to play a more important role than the technology itself. Well-structured cases and interactive elements, combined with reflection and personalised feedback, enhance learning outcomes. Students perceived reflection as a meaningful part of the learning process. Virtual patient cases can complement face-to-face teaching and provide a safe

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environment for practising clinical decision-making. From the perspective of expansive learning, introduction of virtual patient cases may challenge traditional teacher activity systems, as educational innovation can also originate from students' learning needs.

Conflict of interest

The employer of Paula Veikkolainen, Petri Kulmala, and Jarmo Reponen received support for salaries from the MEDigi project funded by the Finnish Ministry of Education and Culture in year 2018 - 2021 [MEDigi OKM/270/523/2017] where the use of virtual patient cases has begun. Tiina Salmijärvi has worked since 2022 as a national MEDigi-coordinator. In this role, national cooperation in medical education is promoted. This cooperation includes also virtual patient softwares.

The first author (Tiina Salmijärvi) has participated in the pedagogical design and implementation of the course "As a substitute physician at Virtual Village health centre" study course and in promoting the use of the virtual patient simulator at the national level.

Otherwise, we have no conflicts of interest to disclose.

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