



The effectiveness of Moodle's "Lesson" feature in pre-learning about arterial puncture and blood transfusion procedures

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Background: This study evaluated the effectiveness of Moodle's "Lesson" feature as a pre-learning tool for clinical skills among medical students.

Methods: The performance of 69 fourth-year medical students during practical sessions on arterial puncture and blood transfusion was assessed. These students engaged in pre-learning activities via Moodle's "Lesson" feature. We analyzed the survey results to gauge students' satisfaction and perceived usefulness of the pre-learning approach. Additionally, we compared the performance of the 2023 cohort, which took part in the pre-learning process, with students from 2020 to 2022 who did not have this preparatory component.

Results: Among the students surveyed, data from 59 respondents were analyzed. Satisfaction with the pre-learning segment was high, with a mean satisfaction score of 4.69 (standard deviation [SD]=0.62) and Cronbach's alpha of 0.918. The tool's perceived usefulness was also rated highly, with a mean score of 4.77 (SD=0.53) and Cronbach's alpha of 0.956. Students who used the pre-learning tool had a mean score of 84.20 (SD=14.74), whereas those who did not use the tool scored slightly lower, with a mean of 80.40 (SD=13.07); however, this difference was not statistically significant ($p=0.196$). Nonetheless, the 2023 cohort scores were generally higher across the various percentile measures than those of the 2020–2022 groups.

Conclusions: The pre-learning tool using the "Lesson" feature on Moodle proved useful and satisfactory for students learning clinical procedures. Further research with larger cohorts is required to validate these findings.

Keywords: Clinical skills; Lesson; Moodle; Pre-learning; Prior knowledge

Introduction

When teaching procedural skills, educators can use the nine instructional events outlined by Gagne to facilitate learning [1]. This framework is grounded in the information processing perspective, which examines the cognitive pro-

cesses triggered in adults when exposed to different stimuli. The third stage involves prompting the recollection of prior learning, allowing students to link new data with existing knowledge [2].

From the perspective of cognitive load theory, which classifies cognitive load into three primary categories (in-

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trinsic, extraneous, and germane), a learner's preexisting knowledge plays a significant role in influencing the intrinsic load, which is determined by both the complexity of the content and the learner's background knowledge [3]. For effective learning, it is crucial to have well-structured educational content to ensure a reduction in extraneous load through clear and streamlined presentations, while also maximizing the germane load, leading to better knowledge retention and application [4].

While self-directed learning may offer numerous benefits over traditional teaching for aspiring healthcare professionals, it is essential that educators act as guides, ensuring that learners meet their deadlines [5]. From this perspective, a well-designed course on procedural skills should offer tailored guidance to students [6]. In essence, it is beneficial to provide students with a tool that provides guidance based on their academic level or previous knowledge before they begin to practice.

At the authors' institution, students voluntarily practice arterial puncture and blood transfusion techniques using diverse resources in an objective structured clinical examination (OSCE) practice room, either alone or in groups. They gather pertinent resources and refine their proficiency through self-directed learning. The authors crafted a structured pre-practice activity using the "Lesson" feature using Moodle version 3.0 software (Martin Dougiamas, Perth, Australia; <http://www.moodle.org/>) to guide their initial learning. This study sought to evaluate the effectiveness of this preparatory activity by examining survey responses and comparing the proficiency of students in arterial puncture and blood transfusion procedures with that of prior students using this structured approach. The goal of this evaluation is to ascertain the value of the pre-learning method incorporated with the "Lesson" tool on Moodle.

Methods

1. Research subjects

This study used data from 69 fourth-year medical students who had undergone practical arterial puncture and blood transfusion sessions between 2020 and 2023. We analyzed students' procedural performance assessments from 2020 to 2023 and delved into the learning activities of the 2023 cohort. To assess the effectiveness of pre-learning activities using the "Lesson" feature on Moodle, we looked at per-

formance results spanning 3 years, from 2020 to 2022. This approach aims to minimize yearly variations in evaluations based on traditional methods and enhance the reliability of the study. We then compared these results with the performance evaluations of the new 2023 system. From 2020 to 2022, the pre-learning process was not incorporated into conventional procedural practice. In 2023, it was introduced to help students acquire prior knowledge of arterial puncture and blood transfusion procedures.

2. Applying the Lesson module for interactive learning in clinical procedures

In 2023, 69 fourth-year medical students participated in this study to assess newly introduced pre-learning sessions for prior knowledge acquisition. Students were tasked with completing activities on a web-based instruction (WBI) website for the first 3 days of their practice class, which was developed using the Moodle platform at the authors' institution. Students were informed that the pre-learning session would not be included in the final assessment results, and that they were required to complete the pre-learning course to proceed to the next procedural practice activity. The Moodle system automatically controlled the completion of the pre-learning sessions. We anticipated that by undergoing the pre-learning process, students would gain prior knowledge of arterial puncture and blood transfusion procedures.

For the pre-learning activity, we adopted the "Lesson" feature on Moodle platform [7]. This feature presents students with a series of HTML pages, each prompting them to make decisions based on the provided content. Depending on their choices, the students were guided to specific pages within the lesson, as shown in Fig. 1. This interactive tool not only generates personalized feedback and responses from instructors based on each student's decisions but also directs them through various sections of the lesson. By employing this approach, we enabled students to embark on customized learning journeys along predefined paths. Moreover, the module's ability to guide students is a key strategy for fostering self-directed learning.

For the lesson on arterial puncture and blood transfusion procedures, we incorporated 14 questions and 11 content pages as well as an essay component. The content covered in the lesson was derived from the standard teaching points established previously in regular lessons. We divided the

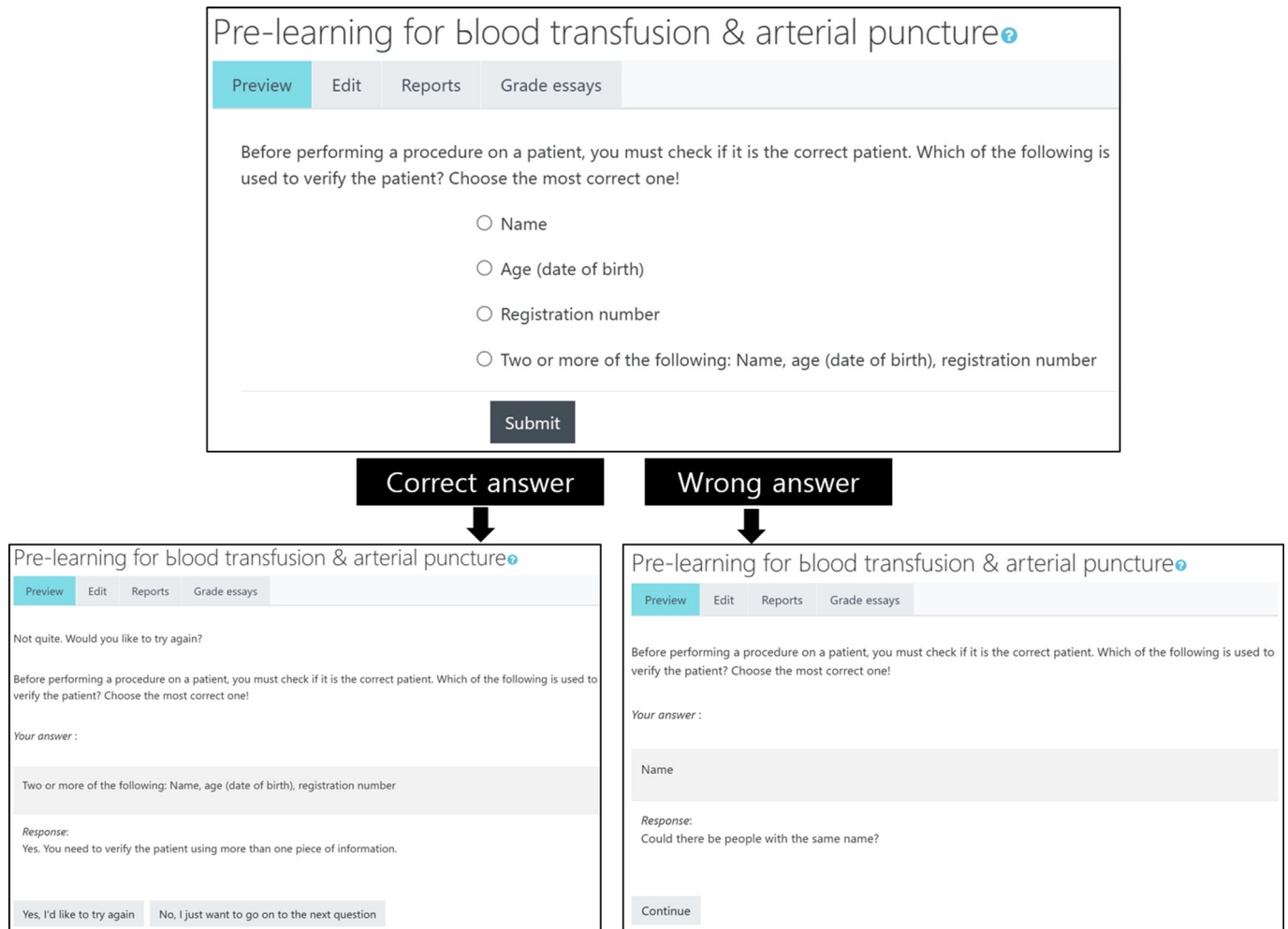


Fig. 1. Flowchart illustrating the pre-learning process for arterial puncture and blood transfusion procedures. Students followed the procedure outlined in the web-based instructional system. They engaged in a pre-learning activity using the "Lesson" feature on the Moodle platform. Here, students responded to questions, and subsequent instructions were tailored based on their answers.

learning process into two clusters to specifically address pleural procedures. The content pages set up a virtual clinical scenario before asking questions related to the procedure. After completing the procedural portion of the lesson, students were provided with explanations of the concepts and knowledge. The essay question was designed to allow students to reflect on and hypothesize the rationale behind certain steps in the procedural process. During the pre-learning phase, as students gained insight into the clinical skills they would be practicing, we provided feedback on their questions related to arterial puncture and blood transfusion procedures. For this purpose, we employed the "Forum" function on the Moodle platform. The "Forum"

feature in Moodle is an effective and flexible tool for communication, and is specifically crafted to support interactive learning and discussion [7]. It allows users to post messages and structure conversations on a range of topics, fostering meaningful engagement between students and teachers through targeted discussions.

To bridge the gap between prior knowledge and practical skills, the students were instructed to voluntarily practice arterial puncture and blood transfusion procedures in an OSCE room during this period. This approach was aimed at offering students a hands-on learning experience that would improve their mastery and memory of these essential clinical procedures.

3. Assessments

After completing their pre-learning process on the WBI, the students were assessed by an instructor to evaluate their performance and provide feedback. On the fourth day of practice, instructors evaluated their procedural skills. The instructor provided feedback to each student in each class to ensure consistency and avoid any potential bias from varying teaching styles. Before starting, students logged into the Moodle app on their smartphones and accessed the assessment quiz. They then handed their devices to the instructor, who completed the evaluation. The instructor observed the students performing the arterial puncture and blood transfusion procedures. The quiz was concealed by a passcode. The instructor unlocked the quiz using the code and rated the students based on their observed skills. Feedback was shared through a smartphone application [8], and brief comments were provided immediately after the students practiced their procedures [9].

The assessment consisted of 36 items that addressed the essential criteria for effective arterial puncture and blood transfusion procedures. The items had graded responses that reflected students' proficiency levels. The instructor chose a response that represented the student's aptitude, which serves as the official assessment tool. Supplemental feedback could be provided if needed. After the evaluation, students reviewed the criteria and any immediate feedback provided by the instructor.

4. Survey

After completing the OSCE assessment, students were instructed to complete a "survey" presented on WBI about the pre-learning system provided for arterial puncture and blood transfusion procedures. We analyzed the survey results from the last session of the practical course to assess students' perspectives on the satisfaction and usefulness of the pre-learning process they engaged in for the first 3 days. The questionnaire consisted of 15 items. The initial seven items measured satisfaction levels, whereas the remaining eight evaluated the perceived usefulness of the educational system. Students indicated their agreement with each statement using a 5-point Likert scale, where 1 represented strongly disagree, 2 was disagree, 3 stood for neither agree nor disagree, 4 meant agree, and 5 denoted strongly agree [10].

5. Comparative analysis of arterial puncture and blood transfusion procedure assessment outcomes with prior results

We evaluated the performance of students in 2023 who underwent the recently implemented pre-learning process against that of students from 2020 to 2022 who practiced and were assessed without such a process. For comparison, we calculated the mean score and standard deviation (SD) from the 2023 assessment results, and determined the mean score (SD) using the combined data from 2020 to 2022.

6. Statistical analysis

After gathering feedback on the courses related to arterial puncture and blood transfusion procedures, Cronbach's alpha was used to assess the reliability of the survey items. We determined the mean and SD of the student answers for each question. To compare the performance outcomes of the procedures between 2020–2022 and 2023, we employed the independent *t*-test and the Mann-Whitney *U* test to compare the mean scores of both groups. All statistical analyses were performed using SPSS version 26 (IBM Corp.). Statistical significance was set at $p < 0.05$.

Results

1. Assessment of the students' pre-learning activity

A total of 69 students were evaluated, with a mean score of 74.84 and an SD of 10.57. The scores ranged from a minimum of 38.90 to a maximum of 90.30 (Fig. 2). When the 69 students were split into two groups, the 18 students who took the arterial puncture and blood transfusion examinations and the 51 who did not, the mean scores (SD) of the procedural assessments were 75.38 (10.10) and 74.65 (10.82), respectively. No significant difference existed in the mean values between the two groups ($p = 0.802$).

2. Satisfaction and usefulness of the pre-learning process for arterial puncture and blood transfusion procedures

Of the 69 students surveyed regarding the pre-learning segment utilizing the "Lesson" feature within the WBI system, 92.8% ($n = 64$) responded. Valid data were extracted from 59 respondents, accounting for 85.5% of the total sample. The mean satisfaction score was reported at 4.69 with an SD of 0.62 (Table 1). For perceived usefulness, the mean score

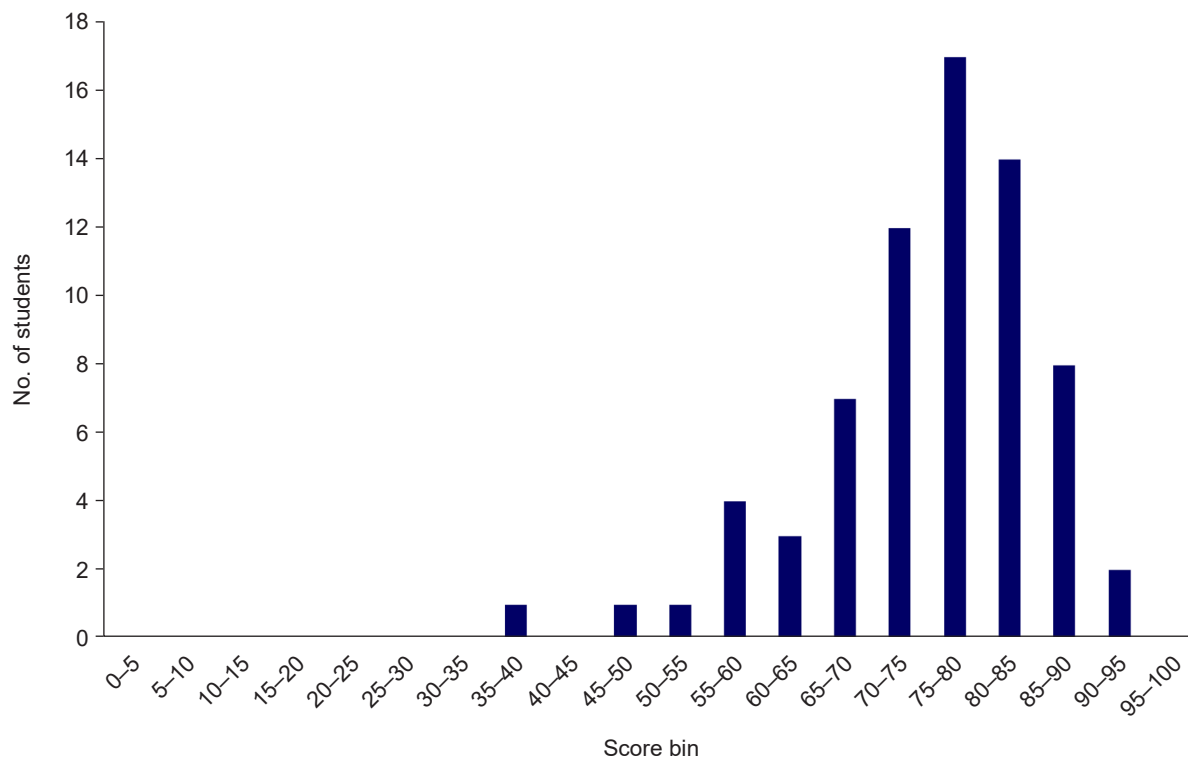


Fig. 2. Frequency distribution of student scores on the procedural assessment. In total, 69 students' scores were plotted with a bin width of 5.

Table 1. Degree of satisfaction with the pre-learning segment using the "Lesson" feature in the WBI system

Question	Min	Max	Mean	SD	Cronbach's α if item deleted	Cronbach's α (p -value)
1. I enjoyed the arterial blood puncture and blood transfusion procedure.	2	5	4.64	0.69	0.902	0.918 ($p < 0.001$)
2. The teacher was adequately prepared to teach the procedure.	3	5	4.85	0.45	0.908	
3. I received adequate information for the procedure practice through the "pre-learning" process for arterial blood puncture and blood transfusion.	3	5	4.69	0.57	0.904	
4. The "pre-learning" process for arterial blood puncture and blood transfusion in the WBI system helped me acquire the skills.	3	5	4.73	0.55	0.899	
5. The "pre-learning" process for arterial blood puncture and blood transfusion in the WBI system was technically convenient and easy to learn.	2	5	4.54	0.82	0.923	
6. The "pre-learning" process for arterial blood puncture and blood transfusion was helpful for self-directed learning.	3	5	4.69	0.59	0.901	
7. Overall, I am satisfied with the "pre-learning" process during the arterial blood puncture and blood transfusion practice.	2	5	4.68	0.65	0.900	

WBI, web-based instruction; SD, standard deviation.

forum during the course indicates the course's thoughtful design and clarity.

Despite anticipation that the lesson course may be highly effective in this study, the mean assessment score during

the practice period was not as elevated as expected, sitting at 74.84 with an SD of 10.57, which is considered the mean based on data from recent years. However, the 2023 cohort exhibited a trend toward higher scores in the collaborative

Table 2. Degree of usefulness of the pre-learning segment using the "Lesson" feature in the WBI system

Question	Min	Max	Mean	SD	Cronbach's α if item deleted	Cronbach's α (p -value)
1. The WBI "pre-learning" process for learning arterial blood puncture and blood transfusion was a useful tool for receiving the necessary information for actual practice.	3	5	4.75	0.54	0.944	0.956 ($p < 0.001$)
2. The "pre-learning" process for arterial blood puncture and blood transfusion remains stored online even after the practice session has ended, so I can revisit and learn whenever necessary. This helps maintain procedural skills.	3	5	4.71	0.62	0.951	
3. The knowledge gained from the arterial puncture and blood transfusion "pre-learning" will be helpful when performing the procedure on actual patients.	3	5	4.76	0.54	0.947	
4. The "pre-learning" process for arterial blood puncture and blood transfusion using the WBI system is useful because there are no time and space constraints.	3	5	4.80	0.52	0.953	
5. I can repeat the arterial puncture and blood transfusion "pre-learning" process indefinitely, which helps with repetitive learning.	3	5	4.76	0.54	0.949	
6. The "pre-learning" process for arterial blood puncture and blood transfusion provided online can be accessed through smartphones, making it convenient to use during practice.	3	5	4.86	0.43	0.953	
7. There is an online space (forum) for feedback on the "pre-learning" process for arterial puncture and blood transfusion, making it useful as I can receive additional feedback when needed.	3	5	4.81	0.43	0.949	
8. If a "pre-learning" process is provided for other procedural practices, it will be helpful for learning the procedure.	3	5	4.69	0.62	0.951	

WBI, web-based instruction; SD, standard deviation.

was 4.77 with an SD of 0.53 (Table 2). The internal consistencies, as measured by Cronbach's alpha, for the satisfaction and usefulness scales were 0.918 and 0.956, respectively, indicating high reliability. Overall, the students were satisfied with the pre-learning tool and found it beneficial to their learning.

3. Comparative analysis of arterial puncture and blood transfusion procedure examination outcomes with prior results

While 69 students completed the pre-learning process for arterial puncture and blood transfusion procedures, only 18 had the opportunity to undergo examination for these two procedures. This was because the items on the collaborative regional procedural examination were randomly assigned to the students who applied for the exam. In 2023, the performance of 18 students in conducting arterial puncture and blood transfusion was tested. The performance of 65 students for the same procedures between 2020 and 2022 were examined.

The mean score of students who completed the pre-learning segment before the assessment was 84.20 (SD=14.74).

Table 3. Descriptive statistics of examination scores: 2023 versus 2020–2022

	Group	
	2023	2020–2022
No. of participants	18	65
Examination score		
Minimum	60.34	37.60
25th percentile	69.83	73.68
Median	92.24	81.82
75th percentile	96.55	90.19
Maximum	100	100
Range	100–60.34	100–37.60
Mean \pm SD	84.20 \pm 14.74	80.40 \pm 13.07

p -value was calculated using the independent t -test ($p=0.292$) and using the Mann-Whitney U test ($p=0.196$).

In contrast, students who did not undergo the pre-learning process had a mean score of 80.40 (SD=13.07) (Table 3). The difference in scores was not statistically significant ($F=2.081$, $p=0.292$ for the independent t -test; $p=0.196$ for the Mann-Whitney U test), as shown in Fig. 3. However, the mean, 75% percentile, median, and minimum scores for the

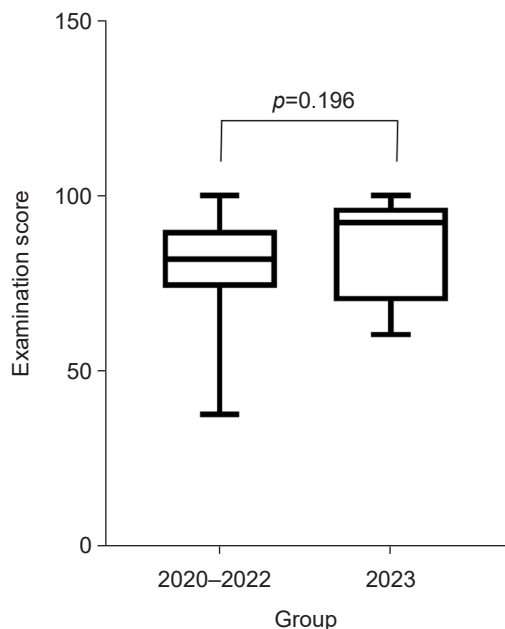


Fig. 3. Examination score distribution: 2023 versus 2020–2022. We employed parametric and non-parametric methods to compare the mean difference between the two groups due to the smaller sample size in the 2023 group. Consequently, we utilized the independent *t*-test as a parametric method and the Mann-Whitney *U* test as its non-parametric counterpart.

2023 group were higher than those for the 2020–2022 group.

Discussion

Various theories emphasize the critical role of prior knowledge in learning clinical skills. According to skill acquisition theory, students with existing relevant knowledge progress faster through the learning stages (cognitive, associative, and autonomous) [11,12]. They may skip the initial stages, that focus on basic concepts, and quickly move on to refining their skills. Constructivist learning theory suggests that learners build on existing knowledge to assimilate new information, enabling students with a strong knowledge base to integrate new skills more deeply and cohesively [13]. Schema theory posits that preexisting knowledge helps form schemas, which are conceptual frameworks that simplify the understanding of new information. In clinical skills, having a schema for a similar procedure facilitates the learning of new tasks by adapting existing schemas [14,15].

Students with prior knowledge typically show greater

confidence and motivation to acquire new skills, which leads to more active engagement with educational materials [16,17]. Their solid foundation in relevant areas results in fewer mistakes during skill acquisition because they can anticipate and navigate challenges more effectively [18]. This extensive background is vital for clinical reasoning, which is a key component of clinical skill execution, and enhances their problem-solving abilities and decision-making during clinical procedures [19].

Given the vast amount of knowledge available in medical education, teaching strategies have shifted from simply imparting information to facilitating self-directed learning [20,21]. During the COVID-19 pandemic in particular, this paradigm shift in medical education became even more pronounced owing to the challenges of in-person instruction, emphasizing the need for self-directed learning [22].

With the advancements in online educational technology, educators now have a variety of tools to choose from to enhance student learning [23,24]. The “Lesson” feature in Moodle, which we utilized in this study, offers versatile functions and significantly enhances the effectiveness of self-directed learning. One of the most powerful features of a lesson is that educators can design a learning path tailored to students’ capabilities, such as their prior knowledge [7]. Despite being one of the world’s most popular learning platforms, Moodle often has a limited range of capabilities put to use, with features such as assignments, quizzes, and forums being most frequently employed by users [25]. This might stem from the fact that many educators, given their busy schedules, find it challenging to fully explore and utilize all of Moodle’s features or adopt new teaching methods. Additionally, some of Moodle’s features lack an intuitive design, complicating the content-creation process [26]. However, certain features such as “Lesson” have great potential for enhancing medical education.

We addressed a weakness in the lesson course by introducing a “Forum” section. The course module was designed to impart knowledge on arterial puncture and blood transfusion techniques. However, we acknowledge that students, due to their varying academic backgrounds, may encounter unresolved questions. To accommodate this, students could post outstanding issues or inquiries that were not addressed during the lessons. Instructors would provide responses to these queries in the forum section. The fact that we received only nine questions from the students via the

regional examination focused on arterial puncture and blood transfusion procedures (Table 3). Although this slight increase in scores for the 2023 cohort was not statistically significant compared to the other groups as shown in Fig. 3, it is still noteworthy for the purpose of improving academic performance.

When using Moodle's editing mode, educators can easily import questions, create new content pages, or add question pages to the lesson module [27]. By setting specific learning objectives for different sections of the lesson, instructors can organize the material into clusters. This organization facilitates the creation of a branched learning path, guiding students to the next relevant step in their study. The lesson includes a variety of multi-choice questions, content pages, and essay pages, all of which are interconnected to tailor the learning experience based on student responses. This approach enables the algorithm to provide personalized instruction that accommodates the diverse academic backgrounds of students. Nevertheless, extant literature on the use of Moodle's lesson modules is scant, with only a few studies exploring their application outside the field of medical education [28].

According to a survey evaluating student satisfaction and the usefulness of the prior learning component within the lesson module, students were reportedly fully satisfied with the course and their academic achievements were correspondingly high. As shown in Table 1, students assigned relatively lower scores to the question concerning the user-friendliness of the pre-learning process, with a mean (SD) of 4.54 (0.82). This may be attributed to the fact that while Moodle's lesson activity is relatively straightforward to use, it may lack advanced features that enhance user friendliness, probably because of technical limitations. Visually, it also falls short of other commercial programs, which could have influenced the survey's somewhat lower scores.

Despite these issues, students regarded the previous learning course that incorporated Moodle's "Lesson" features as more valuable. This positive perception appears to be linked to the recognition of the course's significant benefits, despite any technical shortcomings of Moodle with mean item means (SDs) of 4.77 (0.53) and 4.69 (0.62) for usefulness and student satisfaction, respectively.

We developed this prior-learning course using the lesson module in Moodle exclusively for the two clinical procedures, which limited its generalizability to other

OSCE items. Additionally, we analyzed the postprocedural practice assessment results of 18 students who underwent arterial puncture and blood transfusion as part of the 2023 collaborative regional examination and compared them to those of 51 students assessed with different procedures. Despite finding no statistically significant differences between the two groups, the limited number of students tested with arterial puncture and blood transfusion procedures constrained the generalizability of our findings. Consequently, any conclusions drawn from these data should be considered with caution because of potential interpretative limitations. Although we used the mean values from the 2020 to 2022 cohorts for our analyses to mitigate the differences between groups, potential biases could still affect the results and their interpretation.

In conclusion, prior knowledge is an important factor for procedural clinical skill competency. From this standpoint, it is beneficial for students to gain knowledge before performing these skills. The lesson course, utilizing Moodle's "Lesson" features, provided satisfaction and was useful for students to acquire prior knowledge of arterial puncture and blood transfusion procedures. To extend the generalizability of Moodle's "Lesson" features to pre-learning clinical procedural skills, further research with a larger sample of student data is warranted.

Article information

Conflicts of interest

Hyunyong Hwang is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

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Author contributions

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