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Investigating the role of self-assessment in enhancing self-regulated learning amongst medical students in problem-based learning

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Abstract

Background Lifelong learning is integral to providing safe and effective healthcare. This requires effective strategies for self-regulated learning (SRL). Problem-based learning (PBL) is one recognized method for fostering SRL skills. While self-assessment is known to promote SRL, its effectiveness within PBL tutorials, especially for new medical students, remains underexplored. Given the established evidence of self-assessment's impact on SRL, this study examines its role specifically within PBL to explore whether it enhances self-regulatory processes in novice learners.

Methods Using a post-positivist approach, a multi-method study was conducted, with Zimmerman's SRL framework as a theoretical lens. A correlation analysis assessed the relationship between self-assessment and SRL. A pre-test post-test interventional study without a control group measured changes in SRL following implementation of self-assessment. Hierarchical multiple regression analysis was conducted to assess whether self-assessment predict students' self-regulated learning improvement. The intervention used a previously validated tool the "Self-assessment Scale for Active learning and Critical Thinking (SSACT)." Additionally, qualitative methods explored the impact of self-assessment on SRL skills in the PBL tutorial context.

Results Our findings indicate a positive correlation between self-assessment and SRL, suggesting a potential dynamic relationship between the two constructs. The students' motivation after implementation of self-assessment is significantly increased. Self-assessment played a crucial role on the development of students' self-regulated learning. Qualitative analysis reveals that self-assessment contributes to heightened self-awareness, goal orientation, and effective task planning among medical students in PBL tutorials. Furthermore, the provision of external feedback and revision opportunities enhanced students' self-regulation in the learning process.

Conclusion This study sheds light on the promising role of self-assessment in augmenting SRL skills among novice medical students within PBL settings. The findings underscore the potential of self-assessment as a valuable tool to cultivate self-regulation. By bridging the gap in understanding the impact of self-assessment on SRL within PBL, this research not only contributes valuable insights but also informs the design of effective educational interventions. The use of a validated self-assessment tool can empower medical learners to develop the crucial skill of self-regulation, thereby enhancing their overall educational experience.

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Keywords Self-assessment, Self-regulated learning, PBL

Introduction

Effective medical practice demands continuous lifelong learning and adaptation to ever-evolving advancements in healthcare. The key to navigating this complex landscape lies in self-regulated learning (SRL) which relates to learners' capability to manage the cognitive, motivational, and behavioural aspects in achieving optimal outcomes. Evidence suggests that SRL skills should be taught to medical students and stimulated during the education process [1, 2].

Problem-based learning (PBL) is one of the learning methods that enables students to sharpen their SRL skills. Students can demonstrate their self-regulated learning abilities as they sustain motivation and engage their cognitive faculties throughout problem-based learning (PBL) activities [2]. These activities include analysing problems, generating hypotheses, determining hypotheses, self-studying, and reporting. Previous studies also show that self-assessment is one of the assessment methods promoting SRL skills [1]. De Bruin and van Gog (2012) highlight the importance of self-monitoring and metacognitive regulation in improving students' ability to accurately assess their own learning and adjust their study strategies [3]. Biwer et al. (2020) emphasize that many students struggle with self-regulation due to reliance on passive learning strategies and inaccurate self-assessment [4]. Their study found that explicit training in self-regulated learning (SRL) strategies, such as practice testing and metacognitive reflection, improved students' ability to monitor and adjust their learning.

Self-assessment plays a crucial role in SRL, traditionally viewed as a reflection-phase tool that allows learners to evaluate their own performance. However, it also serves as a regulatory mechanism, influencing goal setting in the forethought phase, monitoring progress during the performance phase, and guiding adjustments in the reflection phase [5, 6]. Self-assessment assists students in learning in the PBL context, especially novice learners still forming their metacognitive strategies. For example, completing a structured self-assessment before a tutorial encourages learners to anticipate expectations and plan strategically, while during the tutorial, it supports monitoring of participation and task engagement. Novice medical students often lack prior experience with self-directed learning approaches like PBL. Their early encounters with PBL demand the rapid acquisition of content knowledge and learning strategies [7]. Without explicit scaffolding, novice learners may struggle to regulate their learning effectively. Structured self-assessment offers a metacognitive scaffold, helping them navigate the unfamiliar dynamics of tutorial-based learning.

Self-assessment has inherent limitations as an unguided, personal judgment of ability [8]. Cognitive biases and a lack of external benchmarks often result in inaccurate self-evaluations, making self-assessment alone insufficient for meaningful learning. However, structured approaches, such as self-directed assessment seeking, external feedback, and guided reflection, can enhance the accuracy and effectiveness of self-assessment. In PBL, where students must independently assess their knowledge and learning needs, integrating structured self-assessment practices could foster better self-regulation and improve learning outcomes.

However, to our knowledge, there is little research showing the effectiveness of self-assessment in the context of PBL tutorials, particularly in assisting medical students to develop self-regulated learning. Most previous self-assessment studies in PBL tutorials emphasized the students' accuracy in assessing themselves and did not use tools with sufficient validity evidence for this context [9–12]. Given that PBL relies on students' ability to regulate their own learning, a deeper understanding of how structured self-assessment influences SRL is necessary to contribute to the overall preparedness of medical students for lifelong learning and effective medical practice.

We address this important gap in the research, by investigating the relationship between self-assessment and self-regulated learning in PBL tutorials. To achieve this goal, our study was guided by an integrated theoretical framework, which combines self-regulated learning and self-assessment, in the context of problem-based learning. We anticipate our findings will describe new ways optimize the acquisition of self-regulated learning skills in the PBL process.

Self-regulated learning

The foundational framework of this study is based in the concepts of self-regulated learning (SRL) as outlined by Zimmerman [13]. SRL is a cyclic process encompassing three interconnected phases: forethought, performance, and self-reflection. Each phase has distinct processes, reflecting the motivational, cognitive, and behavioural aspects of learning regulation. The forethought phase occurs before active learning engagement and entails task analysis and orientation towards being self-motivational. Task analysis involves students creating individualized objectives and formulating plans that are relevant to the learning task at hand [5, 13]. Self-motivational beliefs are composed of multiple subcomponents including objective orientation, intrinsic interest, and self-efficacy. Amongst these, self-efficacy is one of the most crucial elements of motivational beliefs as it influences the kind

of task chosen, the effort and sustained perseverance while completing learning tasks [14, 15]. An additional subcomponent of self-regulated learning is goal orientation, which contributes significantly to the formation of motivational ideas [16].

During the performance phase, students actively engage in educational tasks. The ideas and strategies created during the forethought stage are put into practice by the students. Self-control and self-observation are two activities that are involved at this stage. Self-control is described as the use of techniques decided upon during the planning stage of a particular learning task. This is accomplished via techniques including creative thinking, self-education, attentional focus, and task-planning which integrate both mental and physical effort. Self-monitoring involves the efforts made by students to keep track of their performance by self-reporting and self-experimentation [5, 13].

A self-reflection phase follows the culmination of the learning exercises. During this phase, students evaluate the success of their learning outcomes and tactics employed in the previous phase. They evaluate their own performance in comparison to predetermined standards or by contrasting it with that of their peers, which is called self-assessment [13].

Self-assessment

Self-assessment is a formative assessment process in which students reflect and judge their own performance based on specific learning goals or criteria to identify their own strengths and areas for improvement [17, 18]. Self-assessment has many benefits in assisting students' learning and enhancing academic performance [19, 20]. The effectiveness of self-assessment in assisting students' learning can be optimised through three strategies. The first approach entails increasing the relevance of self-assessment to students' learning activities. The second approach involves improving students' engagement in the self-assessment process, one strategy for which is assessing students' accuracy in assessing themselves. The third approach is by enhancing the impact of self-assessment by providing constructive feedback and by allowing students to refine their performance based on the outcomes of self-assessment [21]. Accurate self-assessment is crucial for effective self-regulated learning (SRL), guiding goal setting, strategy selection, and progress monitoring [5]. However, lower-performing students often overestimate their abilities [22], while higher-performing students may underestimate theirs. Such biases disrupt the SRL cycle, highlighting the need for external feedback and metacognitive training to improve accuracy [6]. Strategies such as guided reflection, modification of the task design, scaffolded rubrics, and triangulation with tutor feedback have been shown to improve the accuracy and usefulness of self-assessment practices [8, 23]-.

The evidence shows that self-assessment and peer assessment were effective in stimulating students' self-regulated learning skills when applied formatively in the PBL context [24]. However, other research showed that implementing peer assessment in collectivist cultures, such as Eastern cultures, faced many challenges [25]. Students perceived assessments from teachers to be more trustworthy than peer assessments. They also tended to give higher scores to their peers and displayed face-saving behaviours to avoid embarrassing their peers whilst giving feedback.

Implementation of self-assessment in the PBL context

Novice students might have little or no experience in performing in PBL tutorials, since they may not have applied this learning method during their previous education. This inexperience could potentially hinder their ability to effectively regulate their own learning, a skill indispensable for successful PBL engagement. Continuous self-monitoring is needed to guide them to be self-regulated learners and to adapt to the PBL environment. Self-assessment that is specifically designed for a PBL tutorial context might be one of the approaches to achieve these goals. While some literature exists on the integration of self-assessment in the PBL tutorial process, previous studies have often used self-assessment tools that were not explicitly designed for PBL contexts [9, 26–28]. To bridge this gap, our prior work developed the Self-assessment Scale for Active learning and Critical Thinking (SSACT) designed specifically to explore the degree of self-assessment undertaken in the context of PBL [29].

An opportunity to further explore the relationship between self-regulation, and self-assessment in the context of problem-based learning arose at the Faculty of Medicine, Universitas International Indonesia (FM UII). Here we have undertaken proactive steps to integrate self-assessment into PBL tutorials for new students. These include: providing knowledge of the importance of self-assessment, applying this tool continuously, providing external feedback from tutors, and providing students with opportunities to refine their performance. We were interested to understand self-assessment as a key mechanism within self-regulated learning (SRL), facilitating both reflection on performance and regulation of future learning. By analysing its role within PBL, this study aims to explore how structured self-assessment can enhance SRL processes among novice learners.

In this context, our research questions for this study are:

1. What is the association between self-assessment and self-regulated learning in a PBL tutorial context?

2. In what ways does the process of completing a structured self-assessment tool impact students' SRL skills in a PBL tutorial context?
3. What are the ways in which self-assessment could assist students' learning and achieving their learning outcomes in a PBL tutorial context?

Through our research, we aim to uncover new insights into these relationships and better understand the implications to further optimise the use of self-assessment to promote self-regulation in the PBL process.

Methods

Research orientation

This study follows a post-positivist approach, integrating quantitative and qualitative data to analyse self-assessment's role in self-regulated learning (SRL) [30]. A post-positivist perspective on socio-cognitive SRL theory balances objectivity with an understanding of human complexity by incorporating triangulated data sources, such as surveys, interviews, and observations. This approach refines theoretical assumptions about how learners regulate their behaviour and cognition, recognizing knowledge as provisional yet rigorously constructed.

Context of the study

The study was conducted at the FM UII, which uses PBL as the main learning method during the first years of a 6-year medical program. Tutorial or small group discussion is the main learning activity and is conducted three times a week. The curriculum of FM UII consists of five phases, starting from an introduction and the basics of biomedical science in phase 1, through to patient management in phase 5. The preclinical year includes phases 1–4, and the clinical year is phase 5, conducted over two years. The curriculum in preclinical years consists of 24 courses or blocks, each of which consists of 5–6 units and runs approximately for 5–6 weeks. This study was conducted during the second course in the first year (neuromusculoskeletal course), which consisted of five units. During the first course (Introduction), students were trained in PBL and how to learn using this method. They practiced participating in PBL tutorials and applying appropriate learning strategies based on their individual characteristics. In the course, students also learned how to manage their own learning.

The tutorial at FM UII applies the seven jumps method from Maastricht, which was conducted over two meeting sessions. At the first meeting, students analyse the problem using their prior knowledge. Students apply Steps one to five of the 7 jumps method, which are: (1) clarifying unfamiliar terms, (2) identifying the problem, (3) analysing the problem using prior knowledge, (4) organizing and creating inferences based on the explanation in step three, and (5) defining the learning objectives. After finishing the first meeting, students conduct self-study over two or three days to search for the information that answers the defined learning objectives. This self-study is part of Step six of the seven jump method. In the second meeting, students perform Step seven of the seven jumps method. Students report their self-study and synthesis results and apply the acquired knowledge [31].

During the tutorial meetings, the tutor facilitated the tutorial and observed each student's tutorial performance using a tutorial assessment tool developed by FM UII. The tool has sufficient evidence of content validity and good inter-rater reliability for this context. The content of this assessment tool is in line with the content of the Self-assessment Scale for Active Learning and Critical Thinking (SSACT) [29]. It includes students' performance in applying critical thinking and communication skills. The evaluation also includes students' responsibility and skills in using the information. All tutors at FM UII received training on PBL tutorial facilitation and assessment at least twice a year. Additionally, they participated in a forum to refresh their knowledge of the content of each block prior to facilitation. Tutors facilitated small group discussions by giving directions and feedback to the students.

Participants

The population in this study was all students taking the neuromusculoskeletal course. The subjects were selected using a total sampling method. All participants who met the criteria were invited to join the study. The criteria were: (1) students taking the neuromusculoskeletal course for the first time and (2) the tutorial would be facilitated by a tutor who had undergone training in feedback to ensure that feedback was delivered in constructive way. One hundred and forty-two students agreed (100%) to join this study.

Design of research study

This study employed a multi-method design, where the quantitative phase was followed by a qualitative phase to enhance the understanding of the research questions [32]. This study has three components. First, a correlation analysis assessed the relationship between self-assessment and SRL. Second, a pre-test post-test interventional study with no control group measured the change in SRL following the implementation of self-assessment as an intervention. Third, a qualitative thematic analysis explored the impact of self-assessment on SRL skills in the PBL tutorial context.

Before starting the neuromusculoskeletal course, students took pre-tests by completing a Modified Strategies for Learning Questionnaire (MSLQ) consisting of 81 Likert scale questions. The MSLQ is a questionnaire

based on SRL theory and has sufficient validity evidence [33]. Internal consistency is universally high for all MSLQ items together (Cronbach's $\alpha = 0.93$) and for each domain ($\alpha \geq 0.67$) [34].

During the neuromusculoskeletal course, students ($n = 90$) completed a self-assessment form representing the learning process in PBL tutorials, i.e., active learning and critical thinking (Fig. 1). This used a validated tool, the Self-assessment Scale for Active Learning and Critical Thinking (SSACT), consisting of two domains and 14 items. The internal consistency of the tool was high overall and for each domain (Cronbach's $\alpha > 0.8$) [29]. The items in SSCAT also correspond to the activities in all steps of the seven jump tutorial method.

Students completed the SSACT three times during the course (at the end of units 1, 3, and 5), and the tutors provided written feedback in each unit based on the students' self-assessment (Fig. 1) and their own observation during the tutorial. The tutors' feedback focused on the way students assessed themselves and improved their tutorial performance. To reduce bias, tutors were not given access to students' self-assessment responses before providing written feedback. This condition ensured that their observations and feedback remained independently derived.

There were 90 students who completed all three self-assessments. At the end of the course, students then completed the MSLQ again as a post-test. The required sample size would be approximately 63 participants for each group (pre- and post-test) to achieve a power of 0.80 with a significance level of 0.05, assuming a Cohen's effect size of 0.5 [35].

For the qualitative component, an open questionnaire explored the students' perspectives and experience of applying self-assessment during the particular course. Questions asked included 1) How did the self-assessment assist your learning during the PBL tutorial session? 2) How did the self-assessment affect your learning during the course? 3) "Please share your opinion on whether you agree with the implementation of self-assessment in another course 4) What is your feedback regarding the implementation of the self-assessment?

Data analysis

To identify whether a self-assessment variable is associated with SRL skills, we analysed the correlation of self-assessment and the score of the MSLQ after the implementation of self-assessment (RQ1) We then analysed the impact of self-assessment using a paired t-test of students' pre- and post-tests using the MSLQ (RQ2). The paired t-test was conducted for both total MSLQ score and each subscale: motivation, cognitive strategies, and management of learning resources. (RQ2).

After analysing the differences in the score of MSLQ before and after applying self-assessment, hierarchical multiple regression analysis was applied. This regression aimed to assess the relationship between multiple predictor variables (MSLQ pretest, self-assessment, gender, motivation, cognitive strategies, and learning resources) and a single outcome variable, while also exploring the added benefit of incorporating additional predictors. The motivation, cognitive strategies, and learning resources variables were selected based on SRL theory, where motivation represents forethought, cognitive strategies reflect performance and resource management aligns with learning environment navigation. These constructs provide a multidimensional view of SRL development and are commonly used in SRL-related research.

Four models were examined to determine if self-assessment significantly predicted students' self-regulated learning skills (MSLQ post-test). In Step 1 (Model 1), the scores of the MSLQ pretest (score before intervention) were analysed. In Step 2 (Model 2), the self-assessment score was also analysed in addition to the pretest score of

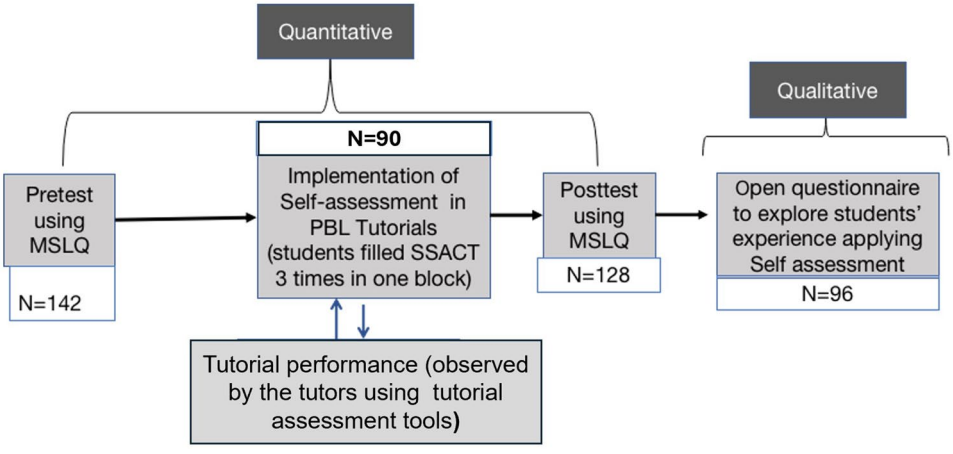

Fig. 1 Research Design

MSLQ. In the next step (Model 3), each score of MSLQ subscales (motivation, cognitive strategies, and learning resources) was added. In the final Step (Model 4), gender was entered along with the other variables added in the previous model.

For the qualitative analysis, this study was situated within a post-positivist paradigm and guided by socio-cognitive theory, specifically Zimmerman's theory which emphasises the interplay between social and the cognitive aspects of learning. The authors adopted a socio-cognitive lens to explore how students perceived and experienced self-assessment. The qualitative data was analysed thematically to establish the ways in which self-assessment could assist students' learning (RQ3). A combination of deductive and inductive approaches was applied in this analysis [36]. The deductive approach used predefined concepts from self-regulated learning theory to guide the analysis, while the inductive approach allowed for open exploration of emerging themes. First, the authors familiarized ourselves with a sample of the data by repeatedly reading students' responses in the open questionnaire. After comparison and resolving disagreements in creating themes and sub-themes, the first author then coded all the data. Themes were cross-checked with the theoretical framework and data to ensure accuracy and relevance. Rigor was maintained through critical reflection on the authors positions in relation to the research, triangulation of methods, and detailed documentation of decisions [37].

Reflexivity

As researchers with significant educational experience, especially in facilitating PBL tutorials, this prior experience influenced the way we analysed the qualitative data. Our role as a teacher or tutor in the PBL context provided a deep understanding of the student's learning process and the challenges of conducting self-assessment. This familiarity assisted in interpreting the data. However, our commitment to supporting the implementation of the "assessment for learning" concept may have inclined us to interpret the data more favourably toward self-assessment in PBL. To minimize this bias, we applied continuous self-reflection to remind us that our position in this study was as a researcher. We attempted to put aside our experience as PBL tutors when collecting, analysing, and interpreting the data. We also conducted a peer review process to minimize the bias. The first author (UK), who was primarily responsible for analysing the data and was familiar with the research context, constantly reviewed the data with the second author (CR) to ensure that the interpretation was truly grounded in the data.

Table 1 Correlation between SRL and SA ($n=65$)

MSLQ	Self-assessment		
	Active learning	Critical thinking	Total score
Motivation subscale	0.578** (0.000)	0.519** (0.000)	0.537** (0.000)
Cognitive strategies	0.545** (0.000)	0.500** (0.000)	0.513** (0.000)
Resources management	0.498** (0.000)	0.517** (0.000)	0.519** (0.000)
Total score of MSLQ	0.607** (0.000)	0.562** (0.000)	0.576** (0.000)

Confidence Interval = 95% significant p value < 0.05

Results

Different numbers of students participated in each stage of the study (Fig. 1). There were 65 of 142 students (72.3% female and 26.7% male) who completed all the questionnaire and self-assessment forms. We now present the results to each of the research questions.

RQ 1: *What is the association between self-assessment and self-regulated learning in a PBL tutorial context*?

Table 1 shows that each subscale of the MSLQ and each corresponding subscale of self-assessment has significant correlations ($p<0.05$). These correlations are of medium strength, with correlation coefficients (r values) exceeding 0.5. The associations remain consistent when considering the total scores of both the MSLQ and self-assessment. This pattern also holds across all subscales and the overall scores after analysing each individual subscale.

RQ 2: *In what ways does the process of completing a structured self-assessment tool impact students' SRL skills in a PBL tutorial context?*

Table 2 presents the changes in students' Self-Regulated Learning (SRL) skills, as measured by the Modified Strategies for Learning Questionnaire (MSLQ), before and after the implementation of self-assessment in tutorials. The data were categorised into three subscales of the

Table 2 MSLQ score before and after the implementation of self-assessment (SA) in tutorials ($n=65$)

Aspect	Min		Max		SD		Mean		Paired t-test
	pre	post	pre	post	pre	post	pre	post	*P* values (CI = 95%)
Motivation	70	96	188	201	17.3	20.1	124.6	169.4	0.000*
Cognitive strategies	92	100	208	205	24.8	26.9	163.1	158.7	0.081
Resources management	57	45	115	127	11.1	13.6	93.1	93.0	0.956
Total score	256	259	522	519	50.9	53.5	426.5	421.2	0.296

*Significant p value < 0.05

Table 3 Hierarchical regression analysis for variables predicting self-regulated learning (MSLQ post test) ($n = 65$)

Predictor variable	Model 1	Model 2	Model 3	Model 4
MSLQ (Pre test)	0.69***	0.49***	0.99	1.02
Self-assessment		0.37***	0.37***	0.38***
Motivation			-0.26	-0.28
Cognitive strategies			−0.01	-0.02
Learning resources			-0.32	-0.31
Gender				-0.84
R^2	0.48	0.58	0.64	0.65
Adjusted R^2	0.47	0.57	0.61	0.61
R^2 Change	0.48	0.10	0.05	0.07
F	59.03***	14.89***	3.04*	1.10

*$P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

MSLQ, which are motivation, cognitive strategies, and resource management. Table 2 indicates that the mean of students' motivation after the implementation (169.4) was higher than before it. Students' cognitive strategies before applying self-assessment also trended higher after the implementation. On the other hand, students' capability to manage resources was almost the same before and after the implementation of self-assessment, with a mean of around 93. The mean of the total MSLQ score indicates that students had a higher MSLQ score before the implementation of self-assessment.

Students' motivation before and after the implementation was significantly different ($p < 0.05$) as shown in Table 2. The students' motivation after implementation of self-assessment was significantly increased. However, students' cognitive strategies, resource management and total score of the MSLQ before and after the test were not significantly different ($p > 0.05$). This analysis offers insights into the specific areas where self-assessment's impact was most pronounced in enhancing students' self-regulated learning skills. The lack of significant improvement in cognitive strategies and resource management may reflect the short duration of the intervention or the absence of explicit instruction targeting these skills. Further, these domains may require more intensive scaffolding and practice over time to show measurable change.

Table 3 shows that Model 1 (pretest score only) explained 48% of the variance in SRL ($R^2 = 0.48$, $p < 0.001$). Model 2 (adding self-assessment) significantly improved the prediction ($\Delta R^2 = 0.10$, $p < 0.001$), showing that self-assessment independently predicts SRL beyond initial SRL levels. In Model 3, adding motivation, cognitive strategies, and learning resources increased the explained variance ($R^2 = 0.64$). The results showed a statistically significant correlation with the post-test score of MSLQ with variability ($F = 3.04$, $p < 0.05$). However, only self-assessment had a significant predictive value ($t = 0.37$, $p < 0.001$). In Model 4, the results were also similar to Model 3, in which only self-assessment played a significant role in predicting MSLQ post-test scores ($t = 0.38$, $p < 0.001$).

RQ3: What are the ways in which self-assessment could assist students' learning and achieving their learning outcomes in a PBL tutorial context?

In this research stage, 96 of 142 students provided qualitative comments. The comments represented students' reflections and experiences in applying self-assessment in the PBL tutorials. We developed five themes from the data in terms of students' perspectives and experiences in applying self-assessment using the lens of self-regulated learning within the PBL process: (a) stimulating self-judgement and self-evaluation, (b) providing direction in monitoring learning, (c) increasing learning motivation, (d) improving tutorial performance and (e) raising awareness of the importance of external feedback.

Stimulating self-judgement and self-evaluation

The introduction of self-assessment in the neuromusculoskeletal course facilitated a culture where students could judge their own learning, especially regarding their preparation before the tutorial session, their performance during tutorials, and their independent study. Participants described how structured self-assessment allowed them to judge the quality of their performance by comparing their progress across multiple tutorial meetings.

> *"By using self-assessment, I could identify whether my tutorial performance is increased or decreased." (T1R49).*

Many participants also highlighted that self-assessment helped them identify strengths and weaknesses, making it a key tool for self-evaluation.

> *"I give myself time to evaluate my performance by filling out the assessment. This makes me more aware of my strengths and weaknesses." (T1R27).*

This aligns with Zimmerman's self-reflection phase in SRL, where learners evaluate their progress and adjust their strategies accordingly. The ability to recognize patterns in performance across sessions suggests that self-assessment serves as a self-monitoring mechanism that extends beyond passive reflection to active self-regulation.

Providing direction in monitoring the learning

The self-assessment questionnaire was described as more than just a tool; it acted as a guide for students to monitor their learning progress. The structured nature of the questionnaire (SSACT) provided a framework for self-assessment, giving students clear benchmarks for their performance in the distinct phases of the tutorial process:

problem analysis, independent study, and the reporting phase.

> *"It helps us, since the form consists of evaluation of myself in terms of the tutorial process. I could understand the things that should be done during preparation, process, and conclusion of the tutorial." (T2R12).*
> *"By using self-assessment, I could understand the things that should be improved to have better performance in tutorial…" (T2R9).*

Beyond assessing performance, students also used self-assessment to understand their ability to adapt to the PBL environment, particularly as PBL was a new learning approach for many of them.

> *"My friends and I could assess ourselves on how well we can adapt to the PBL tutorial method." (T2R40).*

These findings suggest that self-assessment not only serves as a tool for self-reflection but also provides a structured approach to monitoring learning progression within an unfamiliar educational context.

Increasing learning motivation

Students described structured self-assessment as a motivational catalyst that drove them to improve their learning behaviours and tutorial performance.

> *"It seems that I am more motivated to be a better student, especially in terms of explaining things, managing my time, and searching the literature or references." (T3R48).*

For many, identifying weaknesses in the self-assessment process was a turning point that encouraged them to actively work on minimizing these weaknesses.

> *"By applying self-assessment, I can be more motivated to improve myself." (T3R43).*

The quantitative findings support this qualitative insight, demonstrating a significant increase in motivation post-intervention ($p < 0.01$). This highlights how self-assessment serves as an intrinsic motivational tool, reinforcing goal-setting behaviours and sustained engagement in self-directed learning.

Improving tutorial performance

After identifying weaknesses through self-assessment and recognizing the need for improvement, many students reported taking active steps to enhance their tutorial performance. Several students described improvements in their communication and explanation skills, which helped them engage more effectively in discussions.

> *"…help us to talk smoothly and could explain something comprehensively." (T4R23).*
> *"After understanding my own conditions, I then could share appropriate learning material during discussion, and I never say something that is out of topic (OOT)." (T4R527).*

Some students also became more active in sharing ideas, which enhanced group dynamics and collaborative learning. These findings suggest that self-assessment does not merely serve as an individual reflection tool, but also acts as a social regulatory tool, enhancing students' ability to engage with peers more effectively in tutorial discussions.

The awareness of the importance of external feedback

Although self-assessment played a crucial role in self-regulation, students acknowledged that its benefits were greatly enhanced when paired with tutor feedback. Several participants noted that while self-assessment helped them recognize gaps in their learning, they sometimes struggled to determine the best way to improve without external input.

> *"…because assessment from another person is very helpful for us to increase our learning quality. For example, feedback from the tutor…will be a concrete action to do it." (T5R14).*

Students further described how tutor feedback enhanced their ability to participate in collaborative learning, reinforcing good discussion practices and encouraging them to rely on valid references.

> *"Because feedback from the tutor helps us improve our discussion skills. The feedback also informs us whether the discussions conducted are good or need further improvement. Feedback from the tutor also includes encouragement for us to be active in discussions and to provide information based on reliable sources." (T5R48).*

These findings reinforce the SRL literature that highlights the complementary role of self-generated feedback and external guidance [38]. While self-assessment fosters self-awareness and independent regulation, tutor feedback ensures that self-reflection leads to meaningful improvement in learning behaviours.

In summary, the qualitative analysis provides insights into the already-established quantitative correlation between self-assessment and self-regulated learning (MSLQ). The qualitative analysis sheds light on the ways

in which there is an interplay between self-assessment and self-regulated learning, which influences the PBL performance. By stimulating self-judgement and self-evaluation as part of self-reflection, guiding learning monitoring, boosting motivation, enhancing tutorial performance, and raising awareness of the role of external feedback,, self-assessment emerges as an important catalyst for developing self-regulated learners in the PBL context.

Discussions

Summary of key findings

This study provides evidence that self-assessment plays a crucial role in self-regulated learning (SRL) within the context of PBL tutorials. For our first research question, our findings show that that self-assessment, as measured by the SSCAT score, correlated significantly with the strategies for self-regulated learning as measured by the MSLQ score. These findings suggest that the application of self-assessment in the PBL tutorial context is associated with how students regulate their learning, including their motivation, learning strategies, and management of learning resources (Tabel 1). This finding also indicates that the SSACT could be used as a tool to stimulate SRL skills and to assist students' learning, particularly in the context of PBL tutorials. The SSACT helps students better understand the core activities of the PBL tutorials. In other words, following the tool's content improves their procedural knowledge of PBL tutorials. By applying this self-assessment, students became aware of their learning weaknesses in the PBL tutorial.

For our second research question measuring the effectiveness of self-assessment in stimulating SRL skills, the MSLQ score before and after the course was compared through a paired t-test. The findings show that there was no significant difference in the mean of total MSLQ score before and after the implementation of self-assessment ($p > 0.05$). On the other hand, the hierarchical multiple regression analysis confirmed that self-assessment was a significant predictor of post-test SRL, explaining an additional 10% of the variance in SRL after controlling for pre-test SRL scores. In contrast, motivation, cognitive strategies, and learning resources did not significantly predict SRL when self-assessment was included in the model. These findings underscore the distinct role of structured self-assessment in supporting the development of SRL within PBL tutorials, beyond students' initial levels of self-regulation. The results indicate that that self-assessment contributes to SRL development over time.

Even though the results of the hierarchical multiple regression indicate that motivation did not predict self-regulated learning, the paired t-test shows that the motivation subscale differs significantly before and after the course ($p < 0.05$). This suggests that self-assessment could induce learning motivation significantly. The qualitative data also showed that self-assessment motivated students to make improvements based on the learning weaknesses they had identified in the self-assessment. This occurs because knowing their own strengths and weaknesses will make it easier to take action towards achieving the learning goals [18].

For the third research question, the qualitative data contextualizes the quantitative findings by exploring students' perceptions of how self-assessment influenced their learning within PBL tutorials. Five key themes emerged, illustrating how students engaged with self-assessment in the tutorial process. First, stimulating self-judgment and self-evaluation was central, as students described how self-assessment helped them reflect on their tutorial performance, preparation, and independent study. Second, students reported that self-assessment provided direction in monitoring their learning, offering a structured approach to evaluating progress across different tutorial phases, including problem analysis, independent study, and reporting discussions. Third, students highlighted how self-assessment increased their motivation to learn, particularly by helping them recognize weaknesses and set learning goals in a way that aligned with the self-directed nature of PBL. Fourth, many students noted that self-assessment improved their tutorial performance, as it helped them refine their communication, participation, and discussion engagement, key aspects of collaborative learning in PBL. Finally, students emphasized the importance of external feedback from tutors, stating that while self-assessment was valuable, its impact was maximized when paired with constructive feedback from facilitators, reinforcing the role of tutors as guides in student-directed learning within PBL.

Comparison with existing theory and literature

This study adds to the literature by showing that structured self-assessment in the PBL tutorial context engages all three phases of the self-regulated learning (SRL) cycle, forethought, performance, and self-reflection. While previous studies have focused mainly on self-assessment as a reflective tool, our findings demonstrate its broader role in motivating students, guiding their actions, and prompting meaningful change in learning behaviour.

The findings in term of the impacts of self-assessment in the PBL tutorial context (RQ2) are part of the SRL cycle, i.e., forethought, performance, and self-reflection phases [3]. In our study, learning motivation was significantly improved. Motivational beliefs are part of the forethought phase in the SRL cycle. These beliefs influence other self-regulation phases, i.e., performance and self-reflection. Students' willingness to improve their learning

will lead to real action to improve tutorial performance. This action is part of the self-reflection phase, specifically self-reaction, referring to a reaction after receiving the results of the performance phase. These findings are in line with previous research which showed that self-assessment could increase students' learning and their ability to increase the quality of their work [39].

The qualitative findings in terms of RQ 3 contribute new insights by reporting that students were stimulated to perform self-judgement and self-evaluation. In the SRL cycle, this activity is part of the self-reflection phase. Students identified their strengths and weaknesses compared to the standards related to learning activities that should be performed in the PBL tutorial context. Students also noticed that self-assessment became a guide for monitoring their tutorial performance. This means that self-assessment stimulates students to monitor themselves as one of the activities in the performance phase of the SRL cycle. The last impact of self-assessment indicated in this study is that students became aware of the importance of external feedback. External feedback is one of the crucial parts of the SRL cycle. It becomes a catalyst that enhances the SRL process [38]. External feedback from the tutors could enhance learning motivation, guide selection of the appropriate strategies and direct the way students behave towards achieving the learning goal.

The qualitative data also offer insight into the range of self-assessment processes in the PBL tutorial context, encompassing self-observation, self-evaluation, and self-reaction. In our conceptualization of the role of self-assessment, we emphasize that behaviour change, manifested through tangible action, is a crucial and integral component. Our findings showed that self-assessment enabled students to observe their performance during the tutorial process. Students then evaluated their strengths and weaknesses during the tutorial. Lastly, students conducted self-reactions by showing a willingness and then taking action to improve their tutorial performance, followed by real action, such as improving their ideas in the PBL tutorial. These results contrast with literature that claimed that students' behaviours in reflecting and evaluating their performance were the only purpose of self-assessment. The process of self-assessment did not continue to students' actions to improve their weaknesses [40, 41].

The finding of this study also aligns with previous studies that applied a specific learning strategy training program to increase study behaviour and academic performance [42]. That study showed that the training program impacted students' strategic knowledge, metacognitive awareness, and the application of self-regulated learning strategies. Taken together the findings of both studies indicate that students' self-regulated learning skills could be enhanced through a range of structured learning or assessment methods.

This study further adds to the literature regarding the impact of self-assessment in the PBL context. The self-assessment may benefit the students more when its content is explicitly aligned with the learning activities required in PBL tutorials. The research findings also suggest that self-assessment supports all phases of the self-regulated learning cycle, not just the self-reflection phase. Self-assessment assists students in enhancing their motivation, which is part of the forethought phase. Self-assessment is also associated with the performance phase as it helps guide students in monitoring their own learning processes. Lastly, self-assessment stimulates self-reaction in the self-reflection phase.

Finally, this study adds to the literature by showing that combining self-assessment with tutor feedback enhances self-regulated learning through the provision of both internal and external motivation. Previous study indicated that offering feedback from a tutor without incorporating self-assessment can prompt students to engage their prior knowledge through various effective learning strategies, assist them in developing a learning plan, and encourage reflection That study implied that tutor feedback alone can influence each self-regulated learning (SRL) cycle stage [43]. Conversely, our study shows that self-assessment engages each stage of the self-regulated learning cycle and boosts internal factors such as student motivation and metacognitive awareness. Thus, integrating self-assessment with tutor feedback can expedite the development of self-regulated learning skills, which are essential in PBL and represent the ultimate objective of PBL.

Implications for educators

This study has shown that the Self-assessment Scale for Active Learning and Critical Thinking (SSACT) can be used as a structured tool to stimulate SRL skills and to assist students' learning, particularly in the context of tutorial PBL. In better understanding the interplay between self-assessment and self-regulated learning, educators have an easily applicable tool that can cultivate self-regulated learners in PBL by stimulating self-reflection, providing structure for self-monitoring of learning, enhancing tutorial performance, and highlighting the importance of external feedback. Integrating self-assessment tools like the SSACT can empower educators to foster active engagement, enhance metacognitive awareness, and ultimately enhance learning outcomes within the framework of PBL. Moreover, educators can mitigate common self-assessment biases by using structured tools like SSACT, combining them with tutor feedback, and integrating guided peer discussion. These strategies help students develop a more accurate understanding of their

own learning by aligning their self-perceptions with their actual performance.

Beyond PBL, the SSACT may also be applicable across courses or institutions. Its structured focus on active learning and critical thinking makes it suitable for integration into a range of educational contexts as a formative assessment or self-reflection tool. With sufficient validity evidence, particularly for its educational impact, the SSACT can support the longitudinal development of self-regulated learning by fostering goal setting, metacognitive awareness, and habitual reflection, key capabilities for lifelong learning and professional growth.

Implications for further research

This study offers a useful approach for further exploration in the field of self-assessment and SRL. To enhance the robustness of results and implications, future research could involve broader cohorts, multiple courses, and various educational contexts. Additionally, extending the duration of self-assessment implementation and combining it with external feedback mechanisms, such as tutors' guidance, could provide a more comprehensive understanding of its effectiveness in nurturing SRL skills.

Methodological strengths and challenges

The strength of the study is that it is a multi method study that captured the research outcomes from various perspectives, allowing for both breadth and depth of understanding. The combination of quantitative and qualitative data enhanced the trustworthiness of the findings and offered a more comprehensive view of the impact of structured self-assessment on SRL in a PBL context. A limitation of this study is that the implementation of the self-assessment took place in only one course in one institution, with one cohort of students. We acknowledge it may have been underpowered to detect statistically significant changes across all MSLQ subscales. For the qualitative analysis, we believe we had a sample with sufficient information power given our focused aim and the richness of the student comments [44]. The written feedback from the tutors in this study was provided for each student personally. This might be a confounding factor affecting the research results since the contents of feedback might be different for each student.

Conclusions

This study demonstrates that self-assessment correlates significantly with students' self-regulated learning in the PBL tutorial context. This finding indicates that both skills are interconnected. Self-assessment is part of the self-regulated learning cycle. Additionally, self-assessment stimulates students' SRL skills. Self-assessment in the PBL tutorial influences each phase of the SRL cycle, namely forethought, performance, and -reflection. By harnessing the power of self-assessment to nurture self-judgement and self-evaluation, monitoring, motivation, and performance enhancement, educators can amplify the effectiveness of the PBL process. Educators have a unique opportunity to apply self-assessment to mould self-regulated learners who excel in the student-centred environments such as problem-based learning.

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Author contributions

The research was conceptualized by UK, who also oversaw its design, data collection, analysis, and interpretation. CR provided support for this work. The first draft of the manuscript was written by UK, and CR provided critical review, revision, and English grammar correction. The final manuscript was read and approved by all authors.

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethical approval

was obtained from the Faculty of Medicine Universitas Islam Indonesia. All of the students gave written informed consent before participating in this study

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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