

Limited effects from professional identity formation-oriented education on self-regulated learning in a hybrid problem-based learning curriculum: a mixed-method study in Japan

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Abstract

Background: Developing self-regulated learning (SRL) in a teacher-centered curriculum is challenging. Previous studies indicate professional identity formation (PIF), or the formation of self-identity with internalized values and norms of professionalism, might improve SRL. We designed a PIF-oriented education format for hybrid problem-based learning (PBL) and tested its effectiveness on SRL in a mixed research method.

Methods: A randomized controlled crossover trial was conducted using 112 pre-clinical year students at Jichi Medical University. In the six one-day PBL sessions, Groups A ($n = 56$, female 18, mean age $21.5y \pm 0.7$) and B ($n = 56$, female 11, mean age $21.7y \pm 1.0$) experienced PIF-oriented pre-PBL learning: Group A had three sessions in the first half, B in the second half. Between-group PIF and SRL levels were compared using Professional Identity Essay (PIE) and Motivated Strategies for Learning Questionnaire (MSLQ). A qualitative thematic analysis of potential reasons for PIF improvement was performed using the PIE description.

Results: Two-level regression analyses showed moderate improvement of PIF stages over time ($R^2 = 0.069$), regardless of intervention. PIF-oriented pre-PBL learning alone did not significantly improve PIE stages or MSLQ scores. Thematic analysis indicated that PIF-oriented pre-PBL learning helped students recognize realistic difficulties in clinical practice, and articulate professional image and values. However, encounters in extracurricular clinical settings had diverse and meaningful impacts on PIF.

Conclusions: Limited effect of PIF-oriented pre-PBL learning on PIF and SRL indicate challenges in SRL-oriented education for pre-clinical year students within a teacher-centered hybrid PBL curriculum.

Background

Medical professionals need to update knowledge autonomously in line with rapid advances in medicine. Therefore, life-long learning self-regulation has become an essential competency for medical professionals [1-4]. Self-regulated learning (SRL) is defined as learners' active participation in learning process from metacognitive, motivational, and behavioral perspectives [5]. Zimmerman described SRL as a cyclical process in three phases [6, 7].

1. Forethought phase: Learners set goals and choose strategies to attain them
2. Performance phase: Learners monitor and control behavior to attain goals
3. Self-reflection phase: Learners formulate new goals and strategies for future situations

Because pre-clinical education cannot prepare learners for all challenges faced in less-structured learning situations in clinical clerkships, the robust development of SRL-oriented education in pre-clinical settings is justified [8-10]. Actually, lack of readiness to engage in SRL may result from the pre-clinical curriculum.

SRL in problem-based learning

Problem-based learning (PBL) is defined as learning from processes of working towards understanding or resolution of a problem [11]. Essential goals of PBL include supporting knowledge structuring in clinical contexts, developing clinical reasoning skills and self-directed learning skills, and increasing students' learning motivation [12].

Theoretically, students acquire SRL skills through repeated PBL sessions. For instance, students extract problems in a self-reflective manner (corresponding to the self-reflection phase) and formulate learning goals in PBL discussion sessions (corresponding to the forethought phase). Additionally, participants undertake self-study between PBL discussion sessions to accumulate relevant information, so discussion sessions are more meaningful (corresponding to the performance phase) [2, 6, 12-13].

While PBL has been recognized in medical education around the world, in some regions, its operation has detracted from the original model due to educational culture and resource issues [14]. In Japan, PBL sessions are held only several times a year in a lecture-based curriculum, and limited SRL is promoted. In such a 'hybrid' PBL curriculum [14], attempts have been made to promote SRL somehow [15-17]. This study describes a new approach with similar goals in a Japanese setting.

Professional identity formation as a promoting factor of SRL

Previous studies indicate individual future image as a unique professional could promote clinical student readiness to accept diverse learning strategies in a self-regulated manner [18, 19]. Therefore, professional identity formation (PIF) could be a critical factor in promoting SRL in undergraduate clinical settings.

PIF is defined as formation of "a representation of self, achieved in stages over time during which the characteristics, values, and norms of the medical profession are internalized [20, p1447]." Cruess et al. advocate that PIF results in individuals considering their clinical environment behavior [20]. However, while many studies have explored outcomes of PIF-oriented medical education regarding professional and unprofessional behaviors [21-26], only Matsuyama et al. [18, 19] have directly assessed effects of PIF-oriented educational approaches on learning behaviors. One study [19] illuminated a PIF-oriented education format with a functional communication platform between students and their physician mentors. The format provided in-depth communication opportunities regarding students' future self-images, plus norms and values of professionalism. Eventually, PIF-oriented education promoted *intrinsic motivation* and strategic improvement with *elaboration* and *critical thinking* [19].

PIF-oriented learning format for PBL

In this study, a PIF-oriented education format based on Matsuyama et al.'s design was arranged for PBL to improve SRL in a university adopting a hybrid PBL model due to teacher-centered culture [14,17-18].

Our format is characterized by pre-PBL in-depth communication

1. regarding current values or norms of professionalism and the formation of students' future medical professional images;

2. linking students' self-image as a medical professional to PBL scenario settings; and
3. receiving tips for learning strategies in PBL based on 1) and 2) from their future role models.

In this study, we tested the effects of PBL with PIF-oriented pre-PBL learning (PIF-oriented PBL) on SRL in pre-clinical year students by a mixed-method explanatory approach.

The primary purpose of this study is to verify our hypothesis that the formation of individual professional identity via the PBL model could improve SRL even in hybrid PBL. If PIF or SRL improved in this context, the secondary purpose is to understand how. To clarify the purposes of the study, we formulated four research questions (RQ1-4).

RQ1. Does PIF-oriented PBL improve PIF levels in a hybrid PBL curriculum?

RQ2. Does PIF-oriented PBL improve SRL levels in a hybrid PBL curriculum?

RQ3. Do SRL and PIF levels correlate with each other?

RQ4. If PIF or SRL improves in this study, why?

This study was approved by the university's ethics committee (reference number: 18-168). Informed consent was obtained from all participants. This study was conducted from May 2019 to April 2020.

Methods

Settings

Jichi Medical University (JMU) is a private medical university founded in 1972 in Japan. The curriculum of JMU complies with the standardized model core curriculum outlining fundamental learning contents for undergraduate medical education in Japan [27]. While the pre-clinical curriculum is partly integrated, it remains mostly stepwise: Before Year 4 to 6 (Y4-6) clinical clerkship, students mainly learn clinical medicine in traditional didactic lectures, and their progress is assessed through end-of-unit tests. JMU students study liberal arts in the first and second trimesters of Y1. Lectures and experiments in basic medicine also begin in Y1 second trimester. Clinical medicine lectures start from Y2 second trimester. Each basic and clinical medicine class is capped by end-of-unit tests where lecturers create test items based on lecture content. Before Y3 end, students finish almost all subject lectures in basic and clinical medicine.

Y3 has seven sessions of one-day hybrid PBL, each divided into four segments: morning case discussion for the formulation of self-study objectives, self-study period for research on objectives and preparation for afternoon discussion, afternoon discussion including within-group information sharing, and a 60-minute wrap-up lecture from a specialist. In every PBL, faculty facilitators assess each student's opinion statements, cooperative attitudes, and appropriateness of self-study using a 3-point scale. However, the assessment does not affect grade point average, and students never receive individual feedback.

Currently, students read the introductory part of a clinical scenario before PBL and preview morning discussion content. For example:

'A 56-year-old man came to your hospital because he had 20-min anterior chest oppression after breakfast this morning. Please find clinical problems or possible differential diagnoses as best you can.'

The full story containing clinical history and findings is provided on the date of the PBL session.

Because of prevailing teacher-centered education culture at this university, implementing large-scale curriculum reform towards full PBL-based implementation is difficult. Students attend only seven one-day hybrid PBL sessions a year with the rest of the Y3 curriculum lecture-based. This partial use of the PBL concept does not guarantee its full efficacy [14].

PIF-oriented PBL

The core component of the PIF-oriented PBL is the pre-PBL communication platform composed of an online instruction video and the essay format. The instruction video aimed at encouraging students to articulate their future image as an independent medical professional tackling patient problems via life-long learning. The essay format meant to provide pre-PBL in-depth communication between students and their future role models (Figure 1).

After watching the instruction video and reading the PBL scenario introductory, students were asked to answer three essay questions:

Q1: Please recall as much knowledge as possible you have about this case.

Q2: Please formulate your future professional images, and articulate how useful this PBL case-study would be to you as a doctor responsible for this case.

Q3. Based on your answer for Q2, please articulate how you will optimize your self-study for this case to make this opportunity most meaningful.

Aside from these questions, students were asked to submit the professional identity essay (PIE) proposed by Kalet et al. [28] three times. PIE is useful for helping learners articulate their values and norms about medical professionalism, and teachers provide feedback by referring to rubrics based on Kegan's constructive developmental theory [28, 29]. This study used a Japanese version of PIE (PIE-J) as a reference for mentors' feedback on Q1-3 and as an assessment tool for students' PIF levels (see also *Instruments*).

Those materials were provided on a Moodle online learning management system. Through the Moodle platform, eligible JMU-graduate mentors provided feedback on Q1 to Q3 by simultaneously referring to each student's PIE. As a rule, the mentor feedback did not contain hints for the PBL scenario in order to

avoid teacher-centered instruction. In this study, six JMU graduates with clinical experience of 18-37 years were chosen as feedback providers. All of them have agreed to received intensive training for appropriate PIE use and feedback on Q1-3 before the study.

We hypothesized Moodle-based pre-PBL learning would raise student awareness of their future professional image and the relevance of PBL scenarios for their future professional selves. We also proposed that a clearer image of their future professional selves and relevance of PBL contents would encourage them to apply learning strategies encouraged by thoughtful mentor comments. Overall, we expected that the pre-PBL PIF-oriented education format would promote PIF and accordingly improve SRL.

Participants and design

We used a quantitative analysis for RQ1 to RQ3 and a mixed explanatory method to address RQ4 regarding causes of PIF or SRL improvement. We used this method because we expected qualitative analysis would illuminate the mechanisms for PIF or SRL changes in this research context; i.e., qualitative data could help explain quantitative results [30]

1) Quantitative Approach: RQ1-RQ3

A randomized controlled crossover trial was designed for the quantitative arm. All JMU 2019 Y3 students ($n = 124$) were invited to participate in this research. Eventually, 112 agreed were randomly divided into two groups: Group A ($n = 56$, female=18, male=38, mean age $21.5y \pm 0.7$) and Group B ($n = 56$, female=11, male=45, mean age $21.7y \pm 1.0$). Group A used Moodle-based PIF-oriented format before the second to fourth PBL, while group B did before the fifth to seventh PBLs in 2019. Both groups conducted the six one-day PBLs in the same manner on PBL dates, and SRL and PIF levels were compared between the two groups (Figure 2). Group A and B did not mix in the PBL group session. We hypothesized that PIF and SRL levels should improve in parallel, i.e., Group A in the first half of the research period, with Group B becoming equivalent to Group A in the second half.

2) Qualitative Approach: RQ 4

Following quantitative analysis results, we explored potential reasons for PIF improvement using responses from the PIE-J from 112 students (see also *Instruments*). The analysis was conducted in March and April of 2020.

Instruments

1) PIF data collection

For quantitative analysis, the PIF levels for norms and values of professionalism were measured using PIE, an essay-based measurement tool with 9 question items. Referring to Dr. Kalet and colleagues' rubric [28] based on Kegan's identity stage [28, 29], assessors chose learners' professional identity levels from

Stage II to II/III, III, III/IV, IV, IV/V, and V. The PIF measurement by PIE has been validated in undergraduate settings [28, 31]. In this study, we used a Japanese version of the PIE form and rubric (PIE-J) originally in English. Back translation between English and Japanese was conducted by the main author (YM, Japanese) and an American professor living in Japan literate in both English and Japanese (AJL). PIE stages from all students were assessed by two authors (YM & MN) by in-depth discussions following the rubric until full agreement was reached.

Responses to all PIE-J questions were investigated for the qualitative analysis. However, we especially focused on PIE-Q9 'Reflect on your experiences in medical school or in the community that have been critical in fostering change in your understanding of what it means to be a professional/to be a physician' to illuminate change processes in PIE stages.

2) SRL data collection

Learners' SRL levels were measured by a Japanese-language version of the Motivated Strategies for Learning Questionnaire (MSLQ-J) [32] in the quantitative analysis reported to be useful in measuring SRL in undergraduate medical education [19, 33, 34]. MSLQ is composed of 81 items with seven-point Likert scales which quantify levels of nine types of learning strategies (rehearsal: R, elaboration: ELA, organization: O, critical thinking: CT, metacognitive self-regulation: MSR, time and study environment: TaSE, effort regulation: ER, peer learning: PL, and help-seeking: HS), and six variables of motivation states (intrinsic goal orientation: IGO, extrinsic goal orientation: EGO, task value: TV, control of learning beliefs: CBaL, self-efficacy for learning and performance: SEfLaP, and test anxiety: TA). All 81 items were translated into Japanese and back-translated by the main author (YM) and an American professor (AJL).

Analysis

1) Quantitative Approach

Effects of treatment and time (fixed effects) on MSLQ-J scores and PIE-J stages were tested and estimated (RQs 1-2) using two-level regression analysis (upper level: participants; lower level: occasion) in the Open Source statistical package *jamovi* (version 1.2.9) [35]. Treatment and time were treated as fixed effects (estimated with full informed maximum likelihood), and participant-level random intercept served as a random effect (estimated with restricted maximum likelihood). For the first measurement of all scales, the two groups were treated as one because the first measurement took place before any treatment (see Chapter 15 in [36] for a detailed explanation of this model and the rationale behind it). Marginal R^2 , a multilevel equivalent of the R^2 -statistic commonly used for traditional linear regression models, was used to estimate the effects of time and treatment (values of around 0.01, 0.06 and 0.14 represented small, medium and large effects). The Bayesian Information Criterion (BIC) was used to determine which of the time-effect-only and the time-and-treatment-effect model is to be preferred (i.e., the model with the smallest BIC) [36]. Correlations between MSLQ-J scores and PIF-J stages (RQ3) were analyzed and visualized using network analysis in the Open Source statistical package JASP (version 0.12.1.0) [37].

2) Qualitative Approach

From a constructivist paradigm in which 'reality' is subjective and context-specific, and multiple truths are constructed by and between people [38], qualitative data from PIE-J were analyzed using constructivist thematic analysis. We coded anonymized transcripts of the Japanese essays following the six phases proposed by Braun and Clarke [39]. Coding was conducted by the two Japanese researchers (YM and MN). YM was the lead author, who engaged in the development of PIF-oriented PBL and had experienced qualitative studies relevant to SRL. MN was chosen to conduct coding because he is not involved in the JMU curriculum but had experienced qualitative studies relevant to SRL. The PIE statements were thoroughly read and analyzed using an inductive coding approach until agreement on coding was achieved between the pair. In the inductive coding approach, we referred to the PIF stages measured in the quantitative approach. We intensively analyzed statements from those with increased PIE-J stages or intentionally compared statements between those with and without PIF improvement to illuminate meaningful codes and themes.

Results

Quantitative data

Table 1 shows the mean \pm SD of 15 MSLQ-J categories in Group A and Group B and the distribution of PIE-J stages.

In Table 2, a two-level regression analysis showed the R^2 -value of 0.069 in the time-effect-only model in PIE indicated moderate improvement of PIF-J stages over time. However, the time-effect-only model and the time-and-treatment-effect model yield almost the same marginal R^2 -value and BIC. Therefore, there is no reason to assume treatment effects beyond time-effects only. For the 15 MSLQ scales, we see relatively small differences in score between times (i.e., marginal R^2 -values in the [0.002, 0.034] range) and reach the same conclusion about treatment: almost no change in marginal R^2 -value and BIC due to treatment over the time-effect-only model.

Figure 3 shows the network plot of PIE-J stages and MSLQ-J category scores in the three phases, with thicker lines reflecting stronger correlations than thinner lines, and blue for positive/red for negative correlations. Overall, correlations between PIE and MSLQ-J scales were rather weak.

Qualitative data

Table 3 shows three themes and representative codes for RQ4 'Why did PIF improve?'. Although the PIF-oriented pre-PBL format did not receive much mention in overall responses, it seemed to contribute to student identity formation as follows. First, the PIF-oriented pre-PBL format helped PBL tasks appear realistic, allowing them to recognize the vast amount of knowledge necessary to make decisions in

stressful situations. Second, it helped students articulate their professional images and values, leading to the awareness of unrecognized perspectives regarding medical professionals.

On the other hand, the majority of students described their experiences outside the curriculum, especially during the summer holidays (between PIE 1 and 2 in Figure 2). These medical students appeared to use their summer vacation time to visit doctors who are graduates or to take tours of hospitals where they might work in the future. They formed images of themselves as physicians through their experiences in the clinical site visits. In other words, professional identity was formed by the real-life experience of being in a clinical setting, recognizing diverse roles and perspectives of the physician, and being impressed by abilities of the clinician beyond medical knowledge and skills.

Discussion

Contrary to the hypothesis, PIF-oriented education for a hybrid PBL in this study did not significantly improve PIF or SRL. Moreover, contrary to the previous study results in clinical contexts [18, 19], PIF levels in this pre-clinical year context did not significantly correlate with SRL. During the seven months in the pre-clinical year, the PIE-J stages of the students improved moderately, but the PIF improvement has contributed little to the improvement in SRL.

According to thematic analysis, students were able to imagine their realistic future scenes where clinicians encounter difficulties through PIF-oriented PBL. They recognized the vast amount of knowledge for medical professionals necessary to make decisions under stressful circumstances. However, outside of the curriculum, what the students encountered in a real medical setting made them recognize not only real difficulties but also the unrecognized aspects of the physician's professionalism and the abilities beyond knowledge and skills needed in clinical practice. As a result, they fostered a multifaceted professional identity beyond the context of PBL.

Many pre-clinical students described extracurricular clinical scenes in PIE. This finding is reasonable. The research period was mostly composed of didactic lectures (approximately 130 hours per month) and written test assessment (18 clinical subjects, three social sciences, and one pathology). Few opportunities to engage in real clinical settings in the formal curriculum might cause students to draw attention to the real settings in their extracurricular experiences.

The thematic analysis of PIE helped us recognize the importance of authentic medical settings to conduct PIF-oriented education. Even one real clinical encounter with a JMU-graduate mentor or a comment from a patient seemed to foster PIF more than actively encouraging students to think about professionalism in a fictional clinical setting of repeated PBL. This is consistent with the results of previous research that shows that future professionalism responsibilities are less likely to be recognized in a non-clinical university setting [24-26]. This study demonstrates the need to give pre-clinical students as much exposure to real clinical situations and communication with real patients as possible. At the same time, the importance of the hidden-curriculum in PIF was also reiterated [21, 23, 24-26]. Medical educators should consider that the student's daily living environment is part of PIF-oriented education.

Even though we introduced repeated PIF-oriented PBLs in the curriculum, we did only once a month for two hours of pre-learning and eight hours of one-day PBL while approximately 130 hours of didactic lectures per month took place. The PIF-oriented PBL was an attempt to foster SRL within the hybrid PBL in a teacher-centered institutional culture. However, we realize that a relative lack of time for PBL sessions may have led to the lack of expected results. Therefore, fostering pre-clinical student SRL in institutions where teacher-centered culture is prevalent may require extensive curricular reform.

Strengths

1. By minimizing threats to internal validity, the experimental setup constitutes an important strength of the study at hand.
2. Subjects were Japanese students placed in a teacher-centered curriculum with teacher-centered institutional culture [15-19]. We believe our study can provide educators with evidence that sporadic SRL-oriented educational schemes in such a context cannot improve SRL significantly.

Limitations

1. This study was conducted in one country and one medical school and for only one year. We would like to expand the content of PIF-oriented PBL further and further verify it at multiple centers.
2. There are no reports that have validated the Japanese version of both MSLQ and PIE. In this study, we used a rigorous back translation by faculty members literate in Japanese and English, but more time examining outcome evaluation methods may be necessary.
3. JMU is a medical school with a mandatory in-dormitory residence for six years, and with a culture in which students frequently share information about their studies in the dormitory. In this study, we permitted only the intervention group students to access the Moodle pre-learning by their IDs and explained in advance that they should not share information with those in the control group. However, some information might have been shared between Groups A and B. A variety of preventive measures can be considered, including investigating at a medical school where students do not board together on campus

Conclusion

This mixed-method study conducted in a hybrid PBL curriculum showed considerably limited effects of PIF-oriented education on SRL. Within the study period, PIF improved moderately, but not sufficiently to improve SRL. Thematic analysis showed that encounters in extracurricular clinical settings might mainly contribute to PIE improvement. The PIF-oriented PBL was an attempt to foster SRL within hybrid PBL in a teacher-centered institutional culture. However, results suggest a more focused and extensive approach may be necessary.

Abbreviations

JMU: Jichi Medical University; PBL: Problem-based learning; SRL: Self-regulated learning; PIF: Professional identity formation; PIE: Professional identity essay; PIE-J: Japanese version of PIE; MSLQ: Motivated Strategies for Learning Questionnaire; MSLQ-J: Japanese version of MSLQ; IGO: Intrinsic Goal Orientation; EGO: Extrinsic Goal Orientation; TV: Task Value; CBaL: Control Beliefs about Learning; SEfLaP: Self-Efficacy for Learning and Performance; TA: Test Anxiety; R: Rehearsal; ELA: Elaboration; O: Organization; CT: Critical Thinking; MSR: Metacognitive Self-Regulation; TaSE: Time and Study Environment; ER: Effort Regulation; PL: Peer Learning; HS: Help-Seeking.

Declarations

Ethics approval and consent to participate

The study was approved by Jichi Medical University Clinical Research Ethics Committee (reference number: 18-168). Informed consent was obtained from all participants. The same statement is written at the end of the Introduction section.

Consent for publication

Informed consent was obtained from all participants for publication. All the authors have approved this publication.

Availability of data and materials

All datasets analyzed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors report no conflicts of interest.

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Authors' contributions

YM, JL, and CV substantially contributed to the conception and research design. YM and YA substantially contributed to the creation and management of Moodle learning content. YM, TS, YY, MM, AG, SI, and HO substantially contributed to data collection. YM and JL substantially contributed to statistical analysis. YM and MN contributed to thematic analysis. YM and AJL contributed to the Japanese-English translation of data collection tools (MSLQ and PIE). YM wrote the manuscript together with JL, and CV.

YM, AJL, JL, and CV contributed to manuscript proofreading. All authors have read and approved the manuscript.

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Tables

Table 1. (a) The mean \pm SD values of 15 MSLQ-J categories. (b) Distribution of PIE-J stages in Group A and Group B.

(a)

MSLQ	Group	Baseline	PBL1	PBL2	PBL3	PBL4	PBL5	PBL6
IGO	A	3.76 ± 1.05	3.84 ± 1.27	3.90 ± 1.29	4.15 ± 1.35	4.04 ± 1.49	4.17 ± 1.46	4.12 ± 0.99
	B	4.10 ± 1.25	4.23 ± 1.00	4.12 ± 1.33	4.15 ± 1.17	4.22 ± 1.27	4.34 ± 1.64	4.34 ± 1.25
EGO	A	3.34 ± 1.29	3.48 ± 1.33	3.63 ± 1.43	3.75 ± 1.43	3.66 ± 1.56	3.54 ± 1.53	3.84 ± 1.38
	B	3.68 ± 1.32	3.69 ± 1.15	3.82 ± 1.34	3.94 ± 1.30	3.91 ± 1.41	3.94 ± 1.62	3.81 ± 1.43
TV	A	4.99 ± 0.91	4.64 ± 1.41	4.48 ± 1.38	4.74 ± 1.54	4.59 ± 1.58	4.56 ± 1.65	4.74 ± 1.10
	B	4.95 ± 0.97	4.91 ± 0.93	4.49 ± 1.29	4.74 ± 1.33	4.64 ± 1.44	4.59 ± 1.77	4.90 ± 1.31
CBaL	A	4.57 ± 0.93	4.41 ± 1.21	4.21 ± 1.18	4.33 ± 1.32	4.21 ± 1.44	4.22 ± 1.53	4.47 ± 1.00
	B	4.63 ± 0.99	4.64 ± 0.83	4.27 ± 1.27	4.43 ± 1.21	4.41 ± 1.30	4.37 ± 1.59	4.60 ± 1.20
SEflaP	A	3.00 ± 1.19	3.42 ± 1.37	3.51 ± 1.26	3.64 ± 1.34	3.66 ± 1.46	3.92 ± 1.56	3.75 ± 1.17
	B	3.24 ± 1.16	3.68 ± 0.96	3.90 ± 1.33	4.07 ± 1.16	4.03 ± 1.26	4.03 ± 1.50	3.94 ± 1.19
TA	A	4.09 ± 1.24	4.06 ± 1.28	4.10 ± 1.43	4.15 ± 1.41	4.10 ± 1.60	3.94 ± 1.59	4.13 ± 1.30
	B	3.79 ± 1.26	3.90 ± 1.05	3.83 ± 1.28	4.03 ± 1.15	3.75 ± 1.30	3.83 ± 1.51	3.99 ± 1.27
R	A	3.93 ± 0.90	4.19 ± 1.20	4.20 ± 1.22	4.19 ± 1.32	4.10 ± 1.43	4.17 ± 1.45	4.21 ± 1.03
	B	3.79 ± 1.12	4.13 ± 0.86	4.15 ± 1.25	4.05 ± 1.16	4.12 ± 1.21	4.42 ± 1.64	4.37 ± 1.14
ELA	A	4.72 ± 0.90	4.47 ± 1.19	4.39 ± 1.20	4.55 ± 1.40	4.48 ± 1.54	4.41 ± 1.56	4.57 ± 1.06
	B	4.59 ± 1.14	4.54 ± 0.90	4.44 ± 1.33	4.40 ± 1.22	4.35 ± 1.38	4.38 ± 1.66	4.60 ± 1.22
O	A	4.18 ± 1.26	4.31 ± 1.34	4.34 ± 1.37	4.46 ± 1.51	4.42 ± 1.57	4.41 ± 1.60	4.40 ± 1.14
	B	4.09 ± 1.14	4.21 ± 1.02	4.38 ± 1.32	4.33 ± 1.34	4.20 ± 1.35	4.22 ± 1.61	4.44 ± 1.28
CT	A	4.15 ± 0.85	4.28 ± 1.14	4.29 ± 1.27	4.18 ± 1.32	4.20 ± 1.51	4.22 ± 1.47	4.26 ± 0.88
	B	4.14 ± 1.08	4.20 ± 0.76	4.22 ± 1.27	4.09 ± 1.23	4.12 ± 1.22	4.14 ± 1.57	4.36 ± 1.15
MSR	A	4.06 ± 0.62	4.22 ± 0.99	4.26 ± 1.06	4.24 ± 1.17	4.25 ± 1.31	4.27 ± 1.34	4.28 ± 0.65
	B	4.03 ± 0.77	4.19 ± 0.55	4.16 ± 1.12	4.16 ± 0.95	4.15 ± 1.12	4.20 ± 1.43	4.33 ± 0.98
TaSE	A	4.25 ± 0.74	4.23 ± 0.99	4.21 ± 1.00	4.46 ± 1.18	4.28 ± 1.28	4.29 ± 1.36	4.37 ± 0.63
	B	4.15 ± 0.77	4.28 ± 0.66	4.32 ± 1.13	4.22 ± 0.98	4.06 ± 1.12	4.33 ± 1.46	4.38 ± 1.01
ER	A	4.50 ± 0.89	4.46 ± 1.17	4.21 ± 1.07	4.38 ± 1.20	4.31 ± 1.35	4.32 ± 1.41	4.31 ± 0.63
	B	4.28 ± 0.91	4.49 ± 0.81	4.26 ± 1.22	4.21 ± 1.11	4.14 ± 1.20	4.31 ± 1.51	4.29 ± 1.10
PL	A	4.51 ± 1.05	4.33 ± 1.38	4.27 ± 1.32	4.44 ± 1.53	4.33 ± 1.60	4.36 ± 1.65	4.40 ± 1.09
	B	4.56 ± 1.27	4.64 ± 0.94	4.38 ± 1.42	4.37 ± 1.32	4.30 ± 1.43	4.25 ± 1.73	4.50 ± 1.32
HS	A	4.46 ± 0.93	4.36 ± 1.23	4.23 ± 1.16	4.32 ± 1.25	4.25 ± 1.40	4.34 ± 1.54	4.29 ± 0.82
	B	4.58 ± 0.77	4.42 ± 0.71	4.25 ± 1.21	4.21 ± 1.16	4.18 ± 1.21	4.39 ± 1.53	4.31 ± 1.10

(b)

PIE-J stages	Group A			Group B		
	PIE1	PIE2	PIE3	PIE1	PIE2	PIE3
II	7	2	2	6	5	1
II / III	21	14	15	28	18	15
III	22	20	10	16	26	18
III / IV	4	13	19	4	3	13
IV	0	0	8	0	1	3
IV / V	0	0	0	0	0	0
V	0	0	0	0	0	0

Table 2. Two-level regression with participant-level random intercept and fixed effects of time and treatment for PIE and the 15 MSLQ scales

Intraclass coefficient (ICC), marginal R^2 -value, and Bayesian information criterion (BIC).

	Random	Fixed part			
Scale	Intercept	Time and treatment effect		Time effect only	
	ICC	R^2	BIC	R^2	BIC
PIE	0.66	0.07	410.143	0.069	399.323
MSLQ					
IGO	0.269	0.007	10070.636	0.005	10027.532
EGO	0.346	0.007	10420.826	0.005	10377.412
TV	0.312	0.014	14179.596	0.012	14136.058
CBaL	0.221	0.011	9878.656	0.009	9832.988
SEfLaP	0.334	0.036	19428.128	0.034	19388.875
TA	0.253	0.002	13404.573	0.002	13357.443
R	0.165	0.01	10571.942	0.008	10529.513
ELA	0.292	0.006	14222	0.005	14178.355
O	0.319	0.005	9866.504	0.004	9822.927
CT	0.263	0.003	11751.478	0.002	11703.7
MSR	0.122	0.003	29923.339	0.003	29872.557
TaSE	0.085	0.004	22008.123	0.002	21966.763
ER	0.157	0.005	10085.647	0.004	10041.528
PL	0.296	0.006	7569.559	0.004	7529.637
HS	0.112	0.004	10977.313	0.004	10930.299

Table 3. Themes and representative codes in thematic analysis for ‘why did PIF improve?’

Themes	Subthemes	Relevant representative codes
# Realistic difficulties that generate tense emotions	# The vast amount of knowledge for clinical practice # Encounters with realistic scenes	# Realistic experiences in PIF-oriented PBL # Encounters with death and agony from illnesses
# Awareness of unrecognized perspectives regarding medical professionals	# Recognition of diverse roles of physicians # Encounters with different perspectives that shake-up pre-existing thoughts	# Encounters with medical professionals in clinical practice in the extracurricular time Narratives from various medical professionals met in the extracurricular time # Articulation of professional images and values in PIF-oriented PBL
# Recognition of expected ability beyond knowledge and skills	# Recognition of important abilities beyond medical knowledge and skills # Patients' expectations of doctors	# Encounters with physicians in clinical practice in the extracurricular time # Patients' narratives

Figures

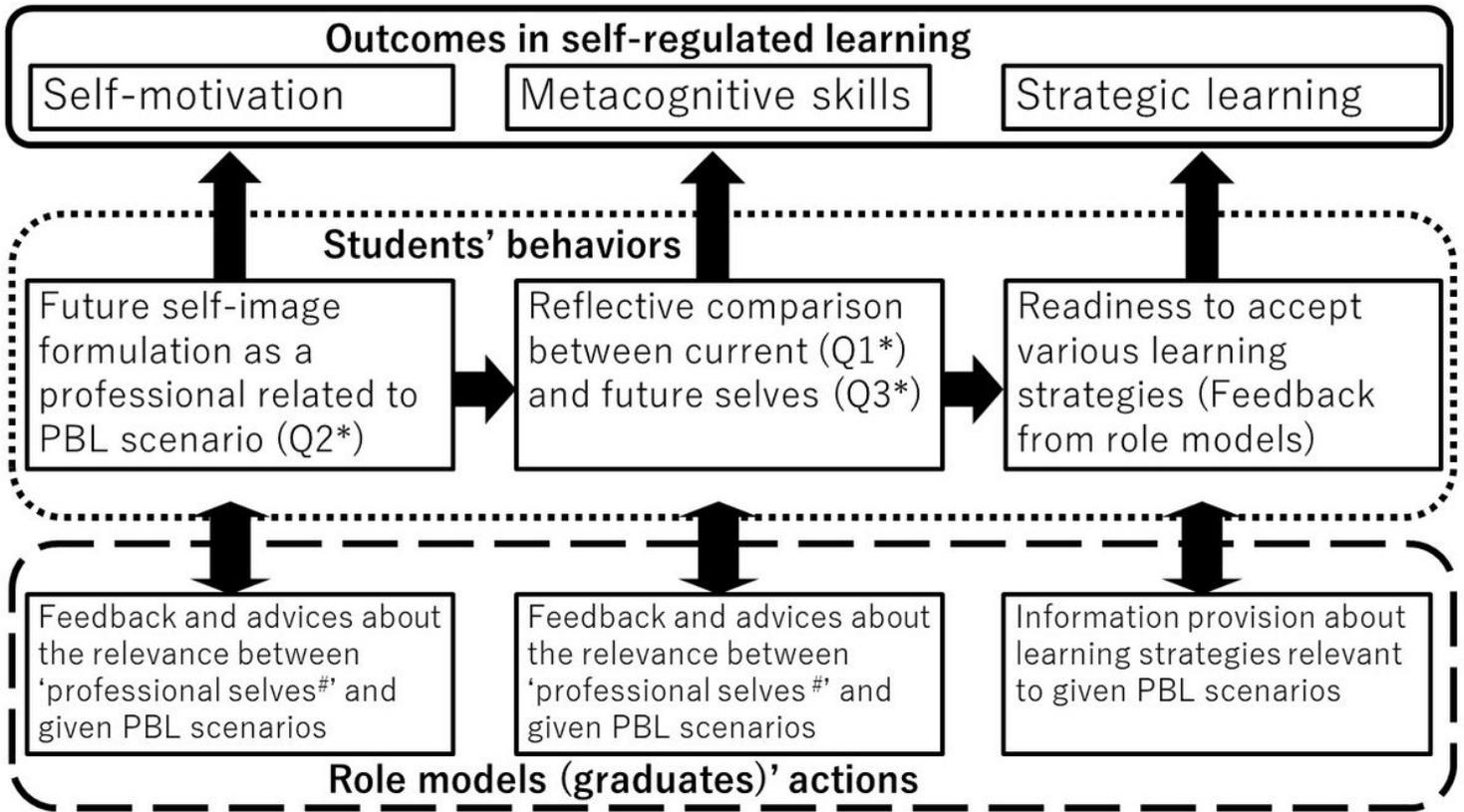


Figure 1

Conceptual framework of PIF-oriented PBL with pre-PBL learning using Moodle *Q1-3 mean the question item number in Moodle pre-PBL learning form. # 'professional selves' means not only students' self-images illustrated in Q2 and Q3 but also students' values and norms illustrated in Professional Identity Essay.

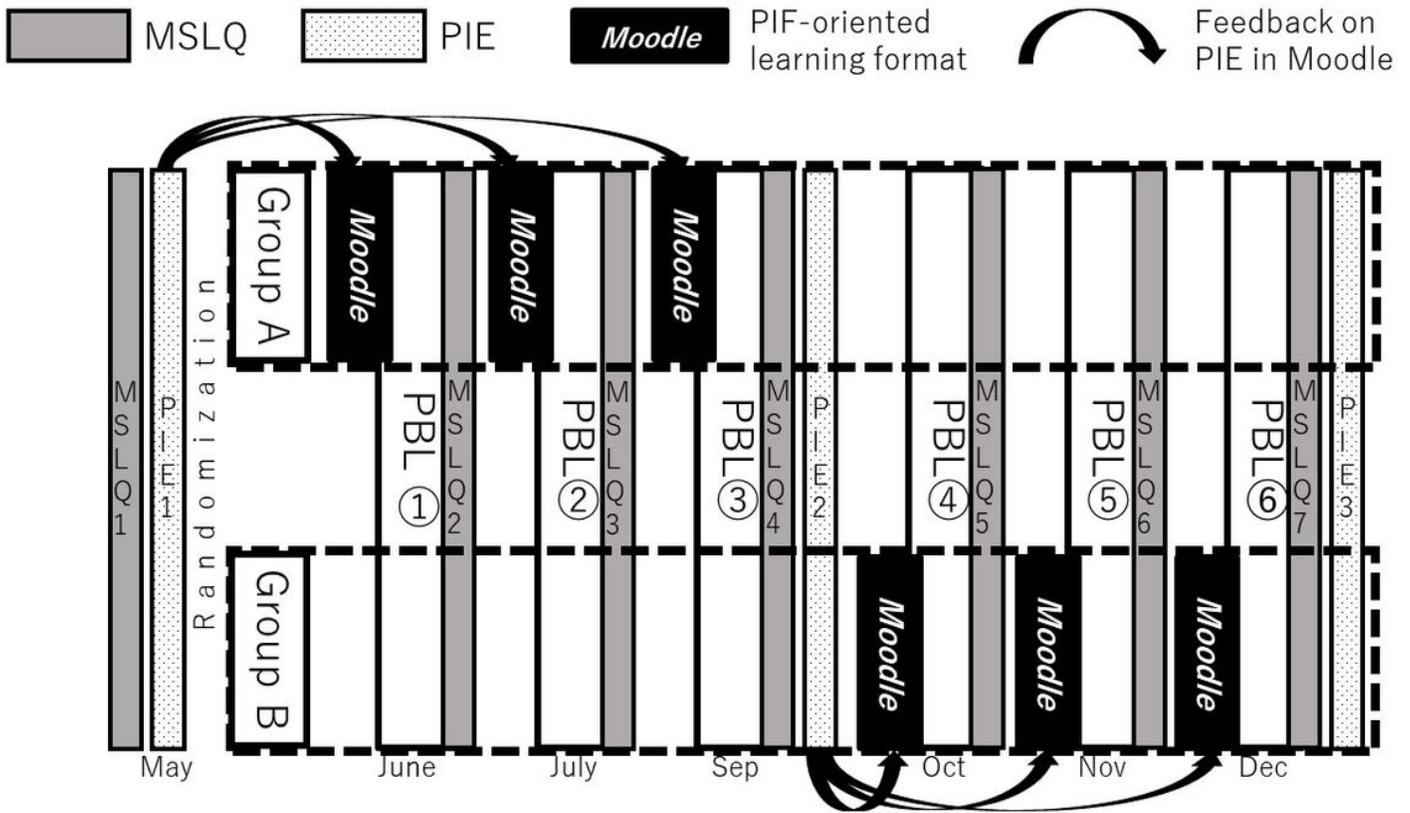


Figure 2

Study design in the quantitative part (No legends)

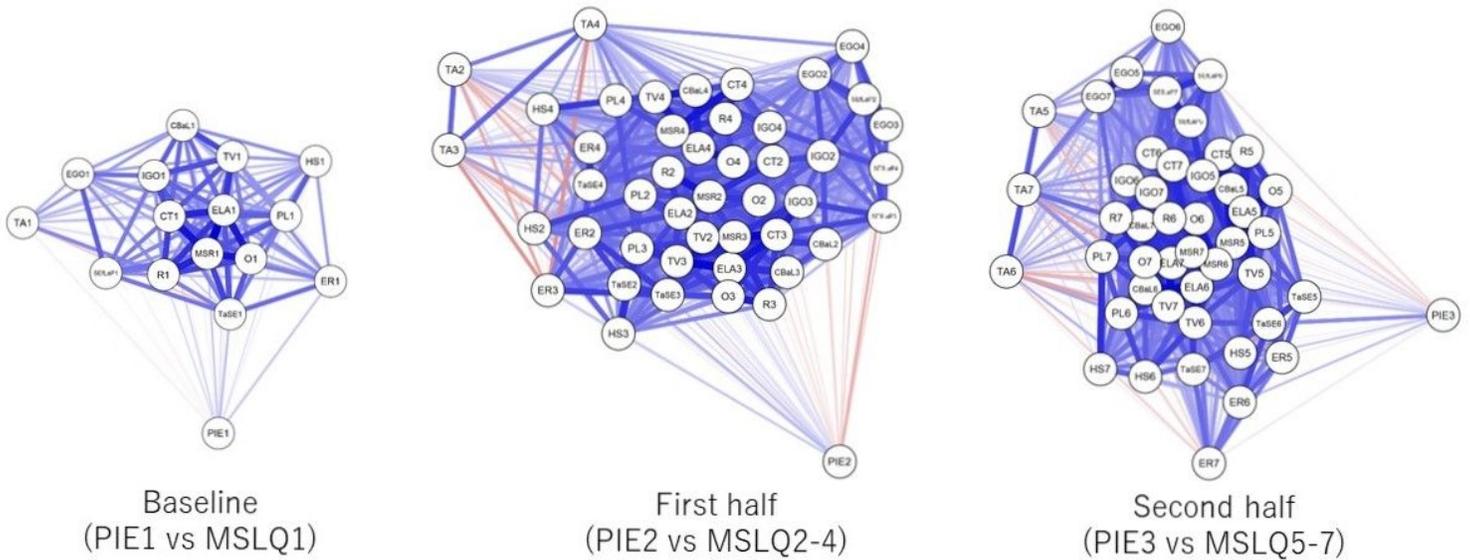


Figure 3

Network plot of PIE and MSLQ categories. Blue and red lines represent positive and negative correlations, respectively. Thicker lines represent stronger correlations. Weaker lines usually result in longer lines to indicate which variables are more closely related.