Examining students' perceived reasoning skills in wiki-based PBL internship courses

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This study aimed to investigate whether web-based problem-based learning (PBL) implemented using wiki applications (wikis) would result in differences in undergraduate students' relationship commitment, interpersonal trust, knowledge-sharing behaviour (KSB) and reasoning skills in healthcare courses. Wikis have some features (e.g., extensive editing, version preservation and multi-user content editors) that are useful for enhancing collaborative learning, knowledge co-creation and authentic problem-solving in the PBL context. A quasi-experimental design was adopted to execute this survey. A total of 185 students were separated into either an experimental group (EG) with wikis or a control group (CG) without wikis, according to their PBL activities. Independent *t* tests showed a significant difference in four variables between the EG and the CG. The EG students exhibited a statistically significantly higher degree of relationship commitment, interpersonal trust, KSB and reasoning skills than the CG students. The conclusion of the results can provide beneficial information on students' PBL experiences for instructors who aim to redesign their course materials and improve their higher education teaching methods. The research findings thus enrich the literature on healthcare education by addressing the influence of wikis on students' PBL effectiveness, which is an under-researched area.

Implications for practice or policy:
Wikis' collaborative authoring function can encourage collaboration.

- Using a wiki-based PBL approach can enhance students' trust and commitment.
- Using a wiki-based PBL approach can facilitate students' KSB.
- Using a wiki-based PBL approach can enhance students' reasoning skills.
- Using a collaborative learning method can complement wiki-based PBL approach.

Keywords: collaborative learning, wiki-based problem-based learning (PBL), relationship quality, knowledge-sharing behaviour (KSB), quantitative method

Introduction

Web 2.0 tools and applications (i.e., Twitter, Facebook and LinkedIn) are vital for students' learning processes and have drawn instructors' attention to explore how these tools may add value to educational processes (Goldstein & Peled, 2016; Hosen et al., 2021). Research has stated that Web 2.0 applications provide a virtual space for students to interact with each other and obtain new knowledge through information exchange, knowledge sharing and collaboration (S. C. Lai, 2022; X. Li & al., 2022; Van Den Beemt et al., 2020; Yusop & Basar, 2017). Scholars have found that the students within a scaffolding mind tool group had more meaningful learning experiences and diverse cognitive thinking than those in a control group in a collaborative problem-solving environment using Web 2.0 technologies (Wu, 2020). In a similar vein, the pages of the wiki applications (wikis), as one of the Web 2.0 applications, serve as a platform for user-generated content that allows users to co-author or co-write information, thereby producing the desired content and offering users the opportunity to browse, exchange and share content (Shu & Chuang, 2012). In addition, students often overlook online education resources (i.e., Web 2.0) in the learning experience for implementing positive professional values, particularly in medical or healthcare education (Hettige et al., 2022). Tambouris et al. (2012) also stated that the functions of Web 2.0 have the potential to facilitate students' active learning and implement problem-based learning (PBL) practices through knowledge exchange and sharing.

In particular, PBL is an instructional and/or learning method for improving students' problem-solving skills by asking them to solve complex and ill-structured real-world problems as a small group. PBL promotes students' in-depth learning and problem-solving skills via collaborative learning experiences. Studies have indicated that PBL subject courses should fully use Web 2.0 technologies (i.e., wikis, Google Docs and Internet applications) as a repository of lesson plans, materials and course management to aid the progress of PBL courses (Fan et al., 2018; Goldstein & Peled, 2016; S. C. Li & Lai, 2022). The wikis in higher education often emphasise pedagogical use (Chen et al., 2015), collaborations or interactions (e.g., Jung & Suzuki, 2015; Rehm et al., 2018; Yusop & Basar, 2017) and learning or academic achievement (López-Belmonte et al., 2020; Trocky & Buckley, 2016). The results of wiki-related studies have indicated that learners' PBL learning experiences can improve their argumentation and reasoning or critical thinking skills in collaborative PBL activities (Ioannou et al., 2015; Psycharis & Kallia, 2017; Wu, 2020) or asynchronous mathematics discussion forums. Because the research scope of these studies does not relate to healthcare internship courses, there are insufficient studies that explore the healthcare teaching or learning method of combining PBL courses with wikis. Therefore, the results of education-related studies of wikis may not be generalisable in the context of healthcare internship programmes. Consequently, this study aimed to examine the influences of the joint use of wikis and PBL in the context of healthcare internship programmes on interns' reasoning skills.

Nevertheless, researchers have reported certain difficulties, such as PBL groups failing to meet deadlines for finishing tasks, lack of PBL participants' commitment to their responsibilities and uncertainty in trusting in-group members (Goldstein & Peled, 2016). Rousseau et al. (1998, p. 395) defined interpersonal trust as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another". Research indicates that individuals are generally involved in knowledge-seeking, exchange and collection when interpersonal trust is stable, thus increasing their contributions (Liou et al., 2016). Additionally, several studies have confirmed that relationship commitment influences collaboration via trust and that the intensity of interpersonal collaboration might decrease when both parties are less willing to maintain a long-term relationship and commit to devote time to collaborative activities (Morgan & Hunt, 1994). Consequently, Schroeder et al. (2021) argued that the way in which trust affects learning performance in the virtual context is an under-addressed issue. In this study, we adopted Shen et al.'s (2014) definition of relationship commitment, which refers to an individual willing to sustain a relationship with a virtual environment member. A reciprocal, beneficial and valuable relationship will encourage students to create identification and expend effort in their PBL group. The sociocultural learning view proposed by Vygotsky (1986) argued that thinking moves from the social to the individual. The social and communicative process is an essential factor affecting an individual's learning development. Additionally, commitment to devoting time to collaboration is a driver of knowledge-sharing behaviour (KSB). KSB refers to the extent to which students share their knowledge with others. Rehan et al. (2016) demonstrated that students' willingness to spend time on active learning activities and to share their knowledge enhances their reasoning skills for comprehending difficult concepts using interactive educational approaches. Reasoning skills can be regarded as an individual's ability to argue and think in a given condition (i.e., assumptions, relevant facts). In other words, students can acquire essential reasoning skills for solving critical real-world problems by enrolling in PBL courses that support self-directed, active and deeper learning (Fan et al., 2018). From this view, a wiki-based PBL group needs to construct a structure consisting of close relationship quality (e.g., interpersonal trust and relationship commitment) and active KSB and integrate these elements to solve the problems based on students' prior and new knowledge.

Wikis provide a ready-made environment for students to share knowledge, acquire new insights to update professional information and enhance writing experience and other reasoning or problem-solving skills, thus facilitating knowledge acquisition (Hu et al., 2018). Given this context, evaluating students' reasoning skills is vital to ensure sufficient skill competency and the effective design of meaningful PBL courses. Moreover, relationship quality, interactions and knowledge sharing with others in wiki-based PBL activities are under-addressed in the current literature. In response, we aimed to address these research gaps via the following research question: How do the interpersonal trust, relationship commitment, KSB and reasoning skills of students in EG and CG differ in wiki-based PBL courses?

Literature review and hypothesis development

The features of wiki-based PBL

Generally, wiki-based PBL activities allow students to co-author shared content or co-create knowledge on their own or as a group based on a constructivist approach for generating and sharing content, constructing knowledge and facilitating engagement, thus promoting personal reflective thinking (X. Li et al., 2022; Scheibenzuber et al., 2021; Zheng et al., 2015). From a technological perspective, wikis are open and free collaborative online platforms. Wikis have the characteristics of a simple visual style and easy editing, intuitive tracing and retaining, and ease of linking to enriching knowledge based on persuasive interfaces, all of which can benefit students during the process of collaborative learning (H. C. Hsu, 2019; Shu & Chuang, 2012). Wiki interfaces allow PBL members to provide feedback on their comments, interact flexibly and edit or add content (W. T. Wang & Lin, 2022). Generally, studies have indicated that wikis with these critical characteristics allow users to create a robust collaborative ecosystem (Leuf & Cunningham, 2001; Wang & Wei, 2011). Some studies have indicated that a teaching or learning activity needs to help learners reduce the unnecessary complexity of PBL-based learning content and support the sense-making process (Marshall, 2018). Therefore, several primary characteristics of wikis can be identified as follows (Rossi & Di Iorio, 2018; W. T. Wang & Wei, 2011; Yueh et al., 2015; Zhang et al., 2019):

- Wikis support online open editing or collaborative authoring. Wikis, as online platforms, operate based on universal internet protocols. This feature makes it easy for individuals to co-write or co-edit the content with others using their web browsers without worrying about the potential threats of incompatibility among different software packages, devices or platforms.
- Wikis offer the functions of knowledge structuring or linking and creating pages. This means that shared content is presented based on a semantic structure, and users can build links between internal wiki pages and external web pages, making it easy and effortless for users to acquire knowledge in an organised and comprehensive manner.
- Wiki administrators can set different privacy preferences to determine which specific users can view or edit the content to ensure its reliability and relevance.
- Wikis enable learners to intensively interact with one another for knowledge-sharing and construction purposes, thus facilitating the formation of communities of practice that can motivate learners to learn continuously (Ismail, 2020; Rehm et al., 2018), which can hardly be achieved by using other co-authoring applications (e.g., Microsoft Office 365 or Google Docs).
- To support learning activities, everyone can use the wiki technologies to develop their own wikis for free, while using some advanced functions of other emerging applications that offer functions similar to wikis (e.g., Microsoft Office 365 and Google Docs) may incur costs.

As mentioned above, wikis offer various conveniences for students in PBL groups, thus providing new perspectives at their own learning pace. Students have enough time to reflect on the core issues, engage in deep learning and reduce their self-concept conflicts with external information (L. Wang, 2019). Thus, confidence in their problem-solving abilities is built through a negotiation process, and their reasoning skills are promoted (Chen et al., 2015; H. C. Hsu, 2019; Tee & Lee, 2011). Snodgrass (2011) argued that the application of wikis results in users' active and collaborative behaviours, ensuring their reasoning skills in learning activities. The page content of wikis is user-generated and an effective open system, allowing learners to share knowledge or update information in a virtual collaboration environment. More specifically, anyone can edit the content and has an equal right to add, delete or modify content through the Internet, which is not organised by any approved rules (Abdekhodaee et al., 2017; Hu et al., 2018; Yusop & Basar, 2017). Currently, some learning platforms do not have the function of collaboration, and just one author (e.g., blogger) can edit, add or modify the content of a web page (Rehm et al., 2018; Su & Chuang, 2012). In contrast, wikis can track changes and retain all modifications' history records, allowing learners to be flexible and have more time to reflect and identify the content in formal and collaborative learning environments. In such cases, wikis empower learners to experience collaborative learning with others who have diverse prior knowledge as well as to communicate, connect and exchange ideas to gain

different perspectives through the process of knowledge sharing and co-editing (Ioannou et al., 2015; Jung & Suzuki, 2015; Scheibenzuber et al., 2021; Ung et al., 2022; L. Wang, 2019).

Wiki-based PBL benefits for developing students' reasoning skills

Wiki-based PBL is an active learning method that can be used to train individuals to integrate, recognise, and interpret contextual signals. Thus, wikis are promising resources (Scheibenzuber et al., 2021; Zheng et al., 2015) because they are easy to access and use to interact with partners, facilitating collaboration in the PBL context (Zorko, 2009). PBL is characterised by a feeling of trust and enables students to explore or be aware of their peers' research ideas and learning task progress (e.g., Gonzalez et al., 2021; Orban et al., 2017). Research has indicated that in groups a strong sense of trust (i.e., interpersonal, professional) could go beyond superficial exchanges while also motivating people to be more willing to mutually provide support, communicate or develop ideas and KSB (Hosen et al., 2021; M. H. Hsu & Chang, 2014; Schroeder et al., 2021). In this case, individuals have the opportunity to enhance their interactions with peers and their reasoning skills through collective authorship on wiki pages.

Because interpersonal trust is developed through frequent interactions that can contribute to students' behavioural changes (i.e., relationship commitment), in a wiki-based PBL context, it can help the individual gain a sense of belonging by developing a high level of relationship quality (Robertson, 2008; Trocky & Buckley, 2016). Based on commitment-trust theory, a study has indicated that interpersonal trust is a determinant of relationship commitment, especially in relationship marketing areas (Morgan & Hunt, 1994). Interpersonal trust and relationship commitment, which are likely to motivate students to exchange resources or knowledge and/or information and to maintain and exchange valued relationships with their peers, are two primary variables of relationship quality (Abruzzo et al., 2019; Shen et al., 2014).

In general, wikis have the advantage of knowledge reuse and allow users to perform co-authorship or co-writership behaviours based on collective prior knowledge about sharing knowledge, particularly in the context of internship education, thus benefiting their reasoning skills (Khin-Htun & Kushairi, 2019). Therefore, in this study, we focused on examining whether using wikis could produce a difference between EG and CG regarding students' interpersonal trust, relationship commitment, KSB and reasoning ability.

Research framework and the antecedent factors of reasoning skills

Studies have demonstrated that the learning model of PBL with Web 2.0, compared to conventional classroom instruction, can improve students' learning outcomes (e.g., confidence, communication ability and reasoning skills) (L. F. Lin, 2018). Research has pointed out that risk is low and less formal in a wiki environment because it often encourages students to engage in intensive discussions on important learning issues in a causal manner, which helps develop interpersonal trust and favourable relationships among students in knowledge-construction processes (Robertson, 2008; Tee & Lee, 2011). Additionally, students' engagement in those knowledge-construction processes tends to facilitate the formation of the students' commitment to achieving shared learning goals, performing reciprocal knowledge-sharing behaviours, continuously readjusting their perception about the world to enhance their logical reasoning skills and engaging in intensive interactions with their peers (Balderas et al., 2019; X. Li et al., 2022). Goldstein and Peled (2016) argued that learning from cases related to real-world issues can lead to students' deep understanding of the learning materials through sharing insights and handling challenges or difficulties with their peers and thus promote their higher-order thinking in a wiki-based PBL context. In this study, we employed the commitment-trust theory (Morgan & Hunt, 1994) as a research framework in wiki-based PBL activities. This theory is vital for social relationship guidance and examines an individual's behaviour in the online environment.

In professional practice, learners must have reasoning skills and develop an appropriate solution based on the evidence in an uncertain situation. Research has provided evidence that students' diagnostic reasoning skills are important for obtaining accurate clinical diagnoses for their patient outcomes (Orban et al., 2017). Thus, practical problems and issues can challenge students' thinking to improve critical

thinking skills. Therefore, these skills could be achieved by teaching general reasoning skills. It can be inferred that the proper use of knowledge sharing, cooperative problem resolution and co-creative knowledge construction can facilitate students' reasoning skills or reduce their anxiety or isolation.

Hypothesis development

It is possible that students' learning experience can be positively affected in a wiki-based PBL activity using a social virtual space, which is beneficial for their interactions (e.g., active learning, feedback, trust, identification and participation) and affects their learning performance (Balderas et al., 2018; X. Li et al., 2022; L. F. Lin, 2018; Tee & Lee, 2011). Researchers have indicated that relationship commitment and interpersonal trust could be regarded as a social influence or environmental factor that predicts KSB in virtual environments (Naeem et al., 2019; Schroeder et al., 2021). In the interpersonal relationship literature, several researchers have indicated that learners are more likely to contribute their knowledge or information when they believe the knowledge will not be misused (Chai et al., 2011; C. Y. Lin et al., 2020). Some researchers have posited that relationship commitment can affect KSB (e.g., Hashim & Tan, 2015; Ma & Chan, 2014; W. T. Wang & Lin, 2021). In this case, PBL members must create an interactive and comfortable atmosphere that will motivate them to share opinions and engage in deep thinking to solve various problems, thereby enhancing students' perceived effectiveness of PBL (Chung, 2019; Hosen et al., 2021; L. F. Lin, 2018). In general, forming reasoning skills is an essential part of problem-solving. Knowledge co-construction or knowledge sharing of PBL activities makes learners connect and assess the situation better, enhancing their capabilities (Hettige et al., 2022). We believe that wikis that support PBL activities will provide useful educational value in formal learning environments. Based on this study's research question, we examined whether using wikis in PBL contexts results in differences in learners' behaviour. Therefore, we derived four hypotheses from the findings of the literature that intertwine with one another as follows:

- H1. There is significantly greater interpersonal trust in the experimental group than in the control group.
- H2. There is a significantly greater relationship commitment in the experimental group compared to the control group.
- H3. There is a significantly greater student KSB in the experimental group than in the control group.
- H4. There are significantly greater students' reasoning skills in the experimental group than in the control group.

Research material and methods

Experiment

As shown in Figures 1 and 2, our research context took place in wiki-based PBL courses in an internship context. This study examined students' learning experiences when engaging in the ongoing use of web-based educational tools. All PBL courses had a length of 4 weeks, and all learning strategies, including problem definition, analysis, discussion, solution and reflection, were conducted by collaborative learning in each PBL activity in the case study. Additionally, the duration of the internship programmes for the experimental and control groups was 1 semester. A quasi-experimental design of the wikis in this study was approved by the university governance framework for our institute (HREC-109-088-2), and all participants provided informed consent.

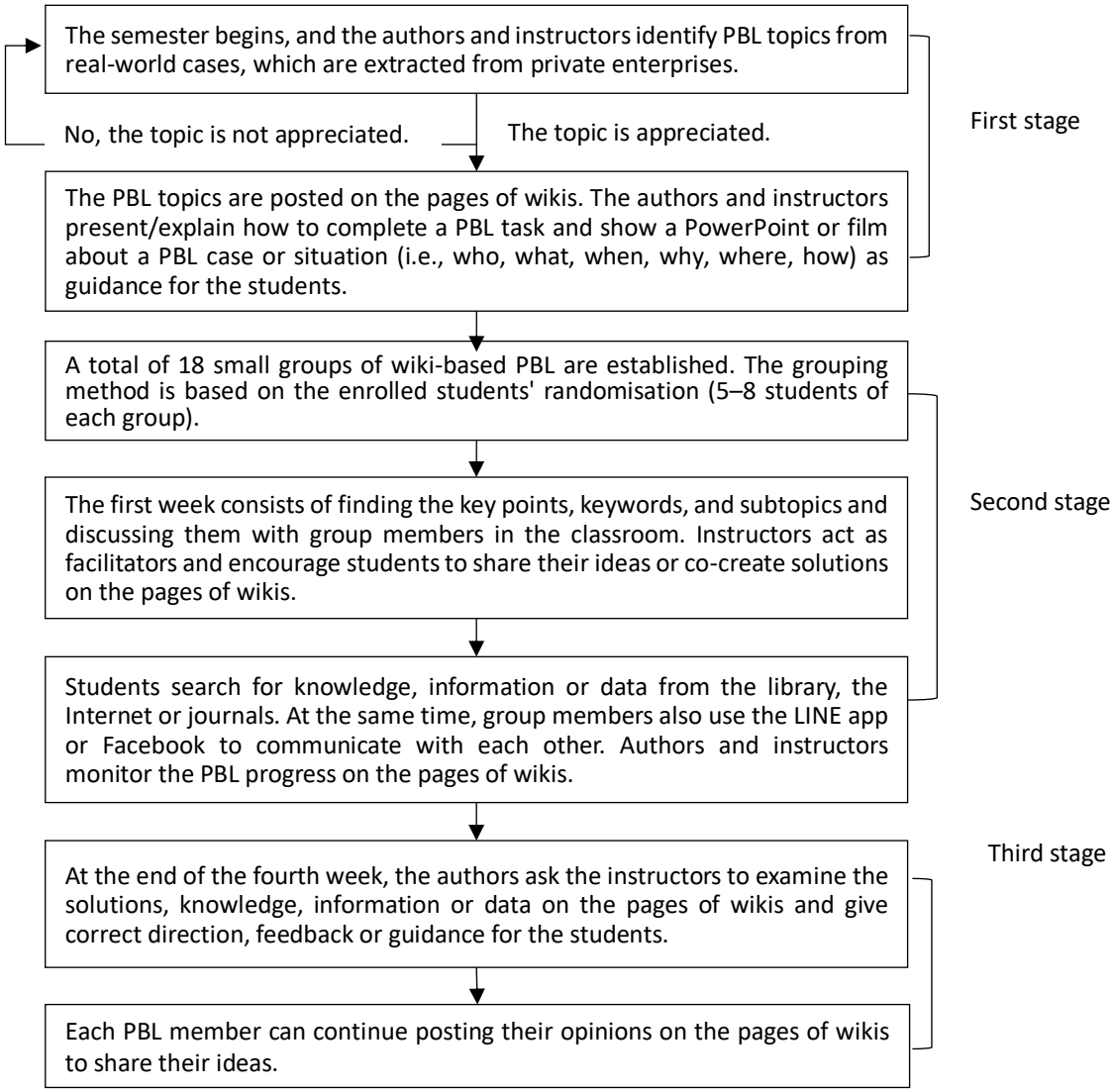

Figure 1. The PBL procedures of the experimental group (EG)

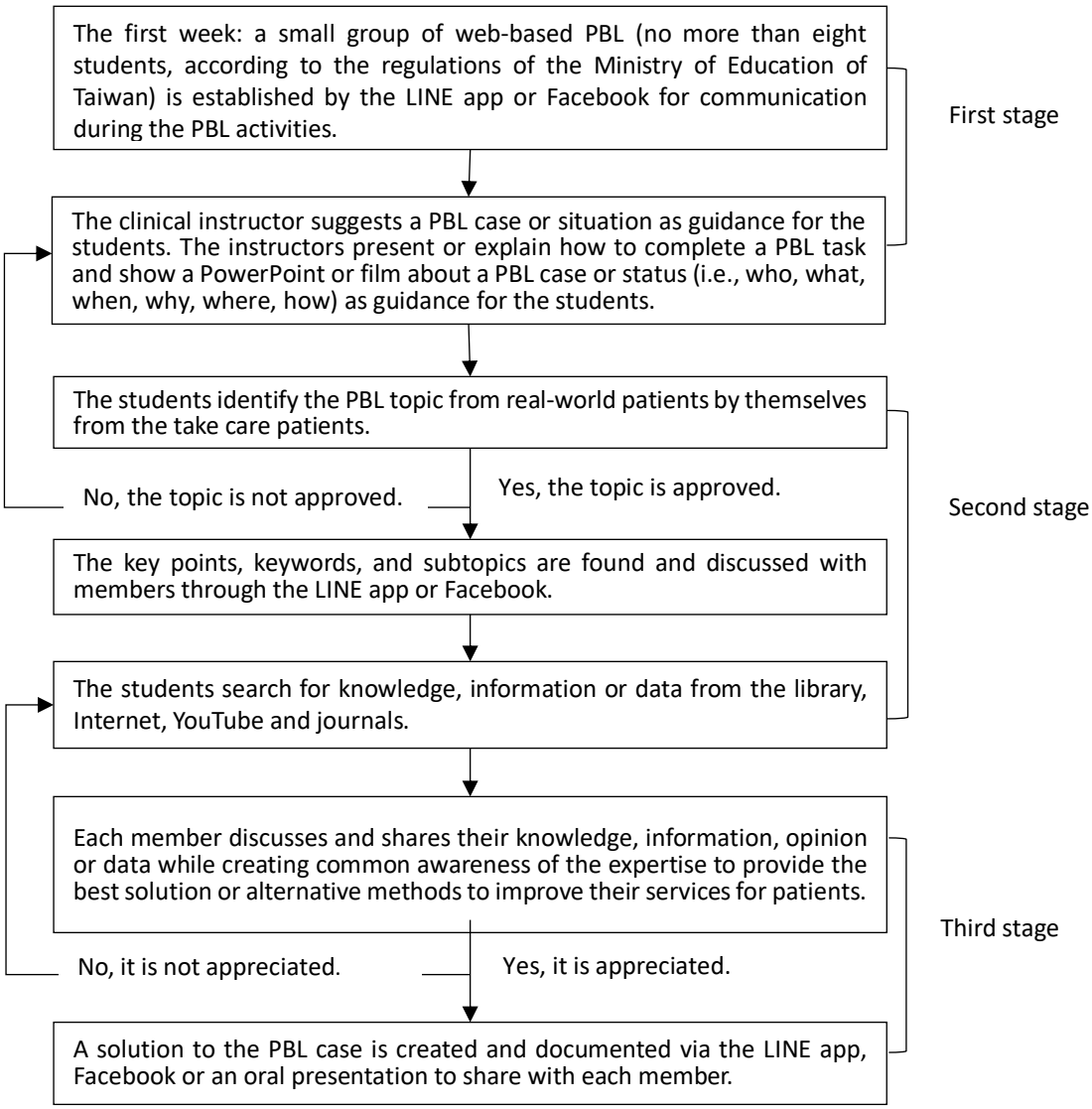

Figure 2. The PBL procedures of the control group (CG)

Courses

The current study aimed to explore the differences between the approaches of wiki-based PBL and those of PBL without wikis regarding students' interpersonal trust, relationship commitment, KSB and reasoning skills in healthcare courses at three Taiwanese universities. The learning content of the EG PBL was conducted among the enrolled students of the courses on tracing heavy metals in pharmaceuticals, cosmetics, foods, and other goods. In the universities attended by our participants, the internship-oriented courses that use the word "internship" in their course title only enroll the students from healthcare- or medical-related departments (e.g., biomedical, pharmacy, clinical pathology and cosmetic students). Additionally, each instructor of the internship programme is qualified with a license from the Taiwan Ministry of Education. Moreover, none of us (the authors) of this study were instructors of the internship programme. The participants in the EG group did not have experience using the wiki-based PBL pages to interact and communicate with their classmates. During the weekly intervention of wiki-based PBL activities, instructors provided each EG group with explicit instruction on how to solve the real-world problems of private enterprises to enable students to practise reflecting on learning. Each PBL group was asked to plan, design, examine, analyse, discuss, co-create or co-write and document on the pages of the

wikis while collaboratively learning how to solve real-world cases. This approach indicates that those PBL courses in which our EG participants were enrolled, although they have different course titles, have similar properties to internship-oriented courses. We can thus consider them to be members of a more general category of internship-oriented courses. The EG students used wikis and other e-tools (i.e., LINE app, Facebook and YouTube). In contrast, the PBL of the CG was performed in nursing internship courses by using all the e-tools used by the EG except for wikis. Additionally, each EG had a group leader responsible for coordinating the PBL activities assigned by the instructor, contacting the instructor and delivering course-related materials, including the experimental modules, videos and files, to their peers. On the other hand, the instructor of the CG actively initiated a group chat using the LINE app to communicate with all the enrolled students. The PBL processes, strategies and tools used for each group are shown in Figures 1 and 2.

All PBL case studies were reviewed and approved by the instructors of these courses before the activities began. All undergraduates used Web 2.0 tools to download or upload multimedia files and/or documents anytime anywhere, and to view text, graphics and presentations. These tools helped students understand content material, and their features allowed them to engage in PBL activities and supported instructors in managing their courses. All participants spent 4 weeks browsing, searching and discussing the diverse learning resources on the web-based PBL and evaluated the optimal solutions, and responded to our survey via Google Forms or hard copies. Initially, in the first week, the students of the EG logged into the wikis that were designed for the current study to review the PBL cases. Subsequently, students were encouraged to co-create or co-write content on a wiki page to solve the authentic real-world problem during the experimental progress. In the collaborative PBL process, they could freely add, delete or modify content to express their thoughts or opinions.

Participants

This study used the survey approach to collect the empirical data required to validate the proposed hypotheses. We acquired the consent of the course instructors and then distributed the questionnaire to the students. The participants completed our questions based on their perceptions of PBL with and without wikis. Most of the participants completed the Google Forms document, while some participants preferred to fill in the hard copies. A total of 217 undergraduate students participated in our experiment in 2020. Among the participants, 108 served as the EG, while the remaining 109 were the CG. The final sample comprised 185 valid questionnaires (94 samples for the EG and 91 samples for the CG) after removing 32 systematic or incomplete responses (e.g., more than one missing value for a relevant construct) for statistical analysis.

Table 1 shows the demographics, such as sex, age and grade, use of the Web tools for their PBL homework exemplars of discussions, KS and dialogue content. Additionally, the participants often used learning resources or e-learning tools, such as the LINE app, YouTube, Facebook or Twitter and Google Scholar, for their tasks, which are listed in Table 2.

Table 1
Demographic details of the participants

Categories	Frequency	Percentage
Sex		
Male	54	29.19%
Female	131	70.81%
Age		
20–23	136	73.51%
Above 23	49	26.49%
Grade		
Senior	100	54.05%
Others	85	55.95%
Web tools hours (each day)		
Less than 1 hour	23	12.42%
2–3 hours	47	25.41%
4–5 hours	50	27.03%
Over 5 hours	65	35.14%
382 items posted by 18 groups		
Fewer than 10 exemplars (groups)	26 (4)	6.81% (22.22%)
10–20 exemplars (groups)	103 (9)	26.96% (50%)
Over 20 exemplars (groups	253 (5)	66.23% (27.78%)

Table 2
The frequency of participants using other Web 2.0 tools for their learning

Categories of Web 2.0	Experimental group with wikis (*N* = 94)	Control group without wikis (*N* = 91)	Total
Google Scholar	65	65	130 (70.27%)
LINE app[a]	67	56	123 (66.49%)
Facebook or Twitter	67	38	105 (56.76%)
YouTube	33	55	88 (47.57%)
E-library	15	18	33 (17.84%)
Blog	5	5	10 (5.41%)

Note. [a]All instructors of the courses used the LINE application to communicate with the group leaders during the progress of PBL activities.

Measures

We measured the constructs using variables adopted from the literature and revised to correspond to our research context. We conducted a confirmatory factor analysis (CFA) using Smart PLS software to evaluate the reliability and validity of the constructs of students' relationship quality, KSB and reasoning skills during a Web-based PBL process. First, five items, which we adopted from Shen et al. (2014) and Mpinganjira (2018), measured interpersonal trust. An example is "In the PBL group, I do not doubt members' honesty". Additionally, we employed six items to capture relationship commitment (Vatanasombut et al., 2008). An example is "I am oriented toward the long-term future of the PBL group". Moreover, according to the scales for the measurement of KSB, our research adopted eight items from Chai et al. (2011). Because the factor loading of the two items of the construct of KSB (e.g., "When discussing a complicated issue, I am usually involved in the subsequent interactions" and "I usually involve myself in discussions of various topics rather than specific topics") was lower than the criteria, we removed them. An example is "I frequently participate in knowledge-sharing activities in the PBL group". Finally, we used six items to assess the degree of reasoning skills (Y. L. Lin & Wang, 2023; Valle et al., 1999)

but we discarded one item because the factor loading was lower than the criteria. An example is “I would ask questions related to the PBL case". In total, we retained 22 items from the CFA measure. Table 3 lists all the remaining items according to the CFA results and presents the statistics of Cronbach’s alpha, factor loadings, composite reliability (CR) and average variance extracted (AVE). The questionnaire used a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*) to indicate the degree to which each of the 25 statements described the relationship with their peers while collaborating on the learning tasks.

Results

Table 3 shows that the items had high factor loadings (over 0.7), that is, interpersonal trust ranged from 0.76 to 0.86, relationship commitment ranged from 0.77 to 0.85, KSB ranged from 0.76 to 0.86 and reasoning skills ranged from 0.75 to 0.85. Additionally, all items had high Cronbach’s alpha and CR values (over 0.7), that is, the interpersonal trust had values of 0.89 and 0.91, relationship commitment had values of 0.87 and 0.91, KSB had values of 0.90 and 0.92 and reasoning skills had values of 0.87 and 0.91 respectively. Moreover, the AVE values (over 0.5) of each construct were larger than the criteria, that is, 0.64 for interpersonal trust, 0.67 for relationship commitment, 0.66 for KSB and 0.66 for reasoning skills. These results indicate that good convergence validity was present. Additionally, all the variance inflation factor values were lower than 3, that is, interpersonal trust ranged from 1.73 to 2.61, relationship commitment ranged from 1.93 to 2.52, KSB ranged from 2.08 to 2.88 and reasoning skills ranged from 1.56 to 2.60. These results suggest that multicollinearity was absent in this study (Hair et al., 2010).

Table 3 shows that all correlations (ranging from 0.53 to 0.65) were smaller than the square root of the AVE values, indicating that the proposal constructs had good discriminant validity. Relationship commitment, interpersonal trust and KSB were significantly associated with students’ perceived reasoning skills. The findings are consistent with previous studies (e.g., Chung, 2019; L. F. Lin, 2018; Naeem et al., 2019).

Table 3
Discriminant validity

Construct	Mean	SD	1	2	3	4
1. Interpersonal trust	4.98	1.00	**0.82**			
2. Relationship commitment	4.51	1.12	0.64	**0.80**		
3. KSB	4.53	1.01	0.57	0.65	**0.81**	
4. Reasoning skills	5.14	0.84	0.58	0.53	0.64	**0.81**
Cronbach’s alpha			0.89	0.87	0.9	0.87
composite reliability			0.91	0.91	0.92	0.91
AVE			0.64	0.67	0.66	0.66
Factor loadings			0.76–0.86	0.77–0.84	0.77–0.86	0.78–0.85

Note. All correlation is significant at $p < 0.01$ (two-tailed). The square root of AVE is on the diagonal, and the other matrix entries represent the constructs’ correlations.

Table 4 reveals that the mean of the EG were larger than those of the CG, including interpersonal trust (5.29 > 4.66), relationship commitment (4.82 > 4.19), KSB (4.68 > 4.38) and reasoning skills (5.26 > 5.02). These results suggest that using wikis and other e-tools was helpful for the EG students’ knowledge co-creation or co-writing and sharing compared to those of the CG students, who used other e-tools only in their PBL process. Additionally, the *p* value of the homogeneity variance test for the four constructs ranged from 0.13 to 0.46, which is larger than 0.05 (95% confidence interval). Finally, the *p* values of the independent *t* test for H1, H2, H3 and H4 were less than 0.001, 0.001, 0.05, and 0.05 respectively; thus, all the hypotheses are significant and supported.

Table 4
The differences between the experiment group and the control group

Construct		Mean	SD	Normality test		Homogeneity of variance test		Independent sample test	
				Skewness	Kurtosis	Levene's test	*p* value	*T* value	*p* value
Interpersonal trust	CG	4.66	0.98	-0.44	0.16	0.80	0.37	-4.51***	< 0.001
	EG	5.29	0.91						
Relationship commitment	CG	4.19	1.17	-0.56	0.34	2.32	0.13	-3.98***	< 0.001
	EG	4.82	0.97						
KSB	CG	4.38	0.92	-0.22	0.31	0.98	0.32	-2.01*	< 0.05
	EG	4.68	1.08						
Reasoning skills	CG	5.02	0.77	-0.5	0.18	0.54	0.46	-1.98*	< 0.05
	EG	5.26	0.89						

*$p < 0.05$; ***$p < 0.001$.
Note. CG scored as 1; EG scored as 2.

Discussion and limitations

The findings of this study have filled the research gaps through the use of commitment-trust theory and a quasi-experimental approach to obtain insights into the difference between the EG and the CG; therefore, this research has expanded the wiki-based PBL literature in relation to healthcare courses. First, Table 3 demonstrates that relationship commitment, interpersonal trust, KSB and students' perceived reasoning skills are significantly associated with each other in relation to PBL progress.

Additionally, the confirmation of Hypothesis 1 shows that the students in the EG have high levels of trust in their peers' professionalism or in their friendship and reciprocal behaviour. Because the content of wikis is co-written or co-edited by the enrolled students and verified by the internship courses' instructors, it is credible. Interpersonal trust plays a critical role in the repeated interactions related to creating confidence and a sense of belonging that motivates students to decide whether to collaborate with peers and participate in creating new knowledge or solving problems. Similarly, students can use wikis to share individual expertise or monitor and control the progress of PBL activities, which is convenient for them. These processes encourage students to freely express their opinions to facilitate critical thinking, reflect professional knowledge and obtain an optimal solution in practice (C. Y. Lin et al., 2020; Wu, 2020).

Moreover, the confirmation of Hypothesis 2 indicates that the high level of relationship commitment among EG students fosters a sense of belonging among peers through co-writing and knowledge sharing on the wiki pages (López-Belmonte et al., 2020). This result raises their participation levels and drives them to consider such a relationship to be valuable, with meaningful effort required to maintain it. These students are likely to commit to maintaining favourable relationships with fellow students, and they should thus provide knowledge and do their best to contribute relevant information, ideas and expertise to solve PBL problems during the progress of the course.

Furthermore, the confirmation of Hypothesis 3 is consistent with the results of previous studies (Shu & Chuang, 2012), which means that EG students are more likely to exhibit KSB than CG students. EG students have a highly collaborative relationship with their peers in regard to creating or gaining new knowledge in a wiki-based PBL context. Since wiki-based PBL emphasises the learning process, wikis can be used to keep detailed records and track the problem-solving processes, which helps students assess various aspects of their problem-solving abilities. However, this study did not collect data on the perceived ease of use of wikis. We argue that exploring those data is beyond the scope of this study and may be addressed by future studies. Therefore, this study focused on students' behaviours regarding how to co-edit or co-author content and share information or new knowledge with one another by using the wiki pages.

Finally, the confirmation of Hypothesis 4 shows that EG students' reasoning skills are higher than those of CG students in the problem-solving process, which is consistent with the findings of previous studies (Psycharis & Kallia, 2017). This finding indicates that students can promptly obtain a better understanding of healthcare issues and highlights the usefulness of wikis compared to the PBL teaching of CG. The functions of wikis may provide students with the ability to support their peers in regard to learning, as well as to reduce their individual dissatisfaction and frustration levels during PBL-related processes.

The results of this study have a couple of implications: the wikis assisted instructors in course management, namely, observing the students' experience of PBL, assessing students' reasoning skills, and guiding solution direction; the mean of all proposal constructs of the EG was higher than that of the CG, which implies that the PBL experience of the EG was better than that of the CG.

Additionally, this suggests that wiki-based PBL activities successfully motivate different class members to contribute their ideas or information to the wiki pages. Research has indicated that the volume of contributions does not necessarily equate to the level of interaction (Dascalu et al., 2014). We cannot rule out that some students may not be very willing to participate in or be exposed to the PBL teaching approach. This result suggests that future research may need to consider more intensive instructor guidelines during the PBL process, facilitate collaborative behaviours and encourage students' self-directed learning to cultivate high levels of professional competence through the PBL approach.

Moreover, in wiki-based PBL activities, high relationship quality motivates students to be active participants in KSB by reinforcing the sense of belonging that encourages helping others learn based on commitment-trust theory. Thus, they gain reasoning skills from searching, reading, discussing and reflecting with their peers. In particular, we believe that struggling students can more freely assimilate knowledge and information on the wikis and be encouraged to be engaged and access this platform more frequently. Accordingly, wikis support individuals' reasoning skills development that gradually form formal learning in Web 2.0.

Finally, Table 2 shows that the EG frequently used Web 2.0 tools; in contrast, the CG commonly used video-sharing websites (i.e., YouTube) for their learning. This phenomenon seems to suggest that Web 2.0 tools extend formal education to out-of-class for all students. We infer that the professional characteristics of the CG are extremely dynamic, and students, therefore, might resort to YouTube videos or resources for updating their knowledge or information or content development. The information or knowledge generated on the wikis may provide free, cumulative and updated teaching materials or learning resources for multiple future PBLs.

This study also has some limitations. First, the standard deviation of dialogue content was high, which suggests that some members of the EG might not have been effective collaborators in wiki-based PBL activities. Thus, future studies may consider issues related to the instructional design of PBL to encourage participants' engagement, facilitate teachers' or students' immediate feedback or offer guidance when students encounter learning problems or face frustrations, eventually reducing participants' emotional isolation (Abdekhodaee et al., 2017; Balderas et al., 2018). Second, relationship commitment and interpersonal trust are long-term and dynamic phenomena, and many factors (i.e., socialisation, culture, communicative competence) impact their development. This study was a cross-sectional investigation, and therefore we suggest that future studies could use a longitudinal perspective to verify the effects of commitment-trust development on individuals' behaviour. Third, we considered only the differences between teaching or learning methods and thus did not examine the causal relationship between the four constructs. Future studies could further investigate this relationship by regression or other analytical methods. In addition, we suggest that future researchers who extend the research aims of the current study should be aware of the potential influences of the grouping method of the EG and CG on their results. Finally, the reasoning skills were based on the data of students' self-reported and perceived mastery behaviour rather than the students' actual course scores. In the future, researchers should consider these issues when extending our method to examine related research topics.

Conclusion

By adopting a quasi-experimental research design, this study provides educators with insight into how wikis can benefit students' PBL activities. First, the wiki's functions (i.e., interlinking between the discussion page, preview article page and search collaborative edition) offer well-balanced collaboration among students (i.e., co-author or co-write, perceived interactions, trust and knowledge or data storage). Concerning the wiki-based PBL context, EG students are more willing to trust and identify peers (i.e., honesty, abilities) and to develop a close relationship with peers than are CG students. In other words, using wikis as PBL tools embedded in an authentic context of internship courses can result in more KSB and improved reasoning skills for students via high levels of interaction (i.e., interpersonal trust, relationship commitment) in real-world cases.

Second, we observed that EG students tend to spend significant time on the PBL task and do their best to develop effective answers to the learning questions. Concerning KSB in regard to the wiki pages, students may have perceived feedback adequately and share ideas or opinions with peers which can be shown by the number of postings on the pages of wikis (average = 21.22). The collaborative authoring or co-writing functions of wikis can effectively integrate students' prior knowledge during the processes of planning, analysing and communicating that are undertaken by students to solve complex or challenging topics in PBL activities while improving individual conception from microscopic to macroscopic levels.

Third, we found that the use of wikis in formal healthcare educational settings can be effective in terms of facilitating knowledge sharing and accumulation. The features of knowledge or data storage can help students obtain supplemental knowledge. For example, the hyperlink and monitor functions are useful to students in efficiently acquiring critical expertise or bridging the differences between theoretical and practical knowledge gaps.

Finally, we found that EG students have a positive attitude toward comprehending the context of the learning process during the internship courses. We can thus recommend that wikis be added to PBL activities to increase their effectiveness. Given that the instructors of most internship courses have multiple teaching goals that they have to address in a limited number of class hours, the assistance of wikis in the curriculum is essential. Therefore, more research efforts are needed to investigate whether and how the use of wikis in other educational contexts may be beneficial to both instructors and students.

Author contributions

Y. L. Lin: Conceptualisation, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review and editing; **W. T. Wang**: Conceptualisation, Writing – review and editing.

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