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Learning attitudes and problem solving attitudes for blended problem-based learning

1. Introduction

Current thinking in education emphasizes a transition from traditional course design to enhance flexibility in instructional materials and methods to better meet learner needs and enhance learning outcomes. New “blended learning” approaches combine face-to-face learning in traditional classrooms with internet-based learning. Young (2002) notes that blended learning is an established trend in higher education, and predicts this format will eventually become the mainstream.

Accelerating economic change and industrial disruption emphasizes the need to provide students with flexible problem solving skills which can be adapted and applied to future conditions which are difficult to anticipate. Problem-Based Learning (PBL) and other educational strategies have been found to significantly improve learning outcomes and to promote the development of effective problem solving attitudes and abilities (Schoenfeld and Herman, 1982; Brown and Kane, 1988; Lin, 1992; Huang, 2005; Hsieh, 2007; Huang, 2011). This research seeks to develop a concept of blended problem-based learning (blended PBL), which is then applied in university biotechnology courses to assess the impact on learning attitudes and attitudes and abilities for problem solving.

Keywords: Blended learning, problem-based learning, learning attitudes, problem solving attitudes

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2. Literature review

2.1. Blended learning

Blended learning is a method of distance education which combines elements of traditional instruction methods with information technology functions (Smith, 2001; Chen and Huang, 2012; Chen and Lin, 2016; Huang et al., 2016) including multimedia, animation, video, computer-based simulations, VOIP and email. These features allow for learning to be extended beyond the physical and temporal confines of the classroom, thus enhancing learning outcomes. The role of instructors also shifts away from conventional teaching and increasingly emphasizes coaching and mentoring (Rosenberg, 2001).

Blended learning partially depends on teacher-led classroom instruction to ensure that learners have the required foundational understanding and skills to access knowledge through the course's online components. The format also encourages lateral communication between peers through digital learning platforms and chat rooms, allowing the instructor to assume a facilitator role (Ward & LaBranche, 2003).

While a single definition of blended learning has yet to emerge, the consensus holds that it extends conventional instruction through the use of information technology. Singh and Reed (2001) suggest that blended learning offers advantages such as improved learning effectiveness and reduced dropout rate. Terashima et al. (2004) also suggest that blended learning has different impact on participants with higher-education and promote their autonomous learning.

Singh (2003) noted that blended learning incorporates learning activities such as face-to-face classroom, live e-learning, and asynchronous self-paced learning. Thus, the effectiveness of blended learning depends heavily on the learning environment design and the quality of teacher-student interaction. The learning environment includes the physical environment (e.g., classroom, physical instructional materials,

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etc.) and the virtual environment (hardware and software resources, digital platforms, etc.). Learning activities can be synchronous (i.e., "live") or asynchronous. This study uses Moodle as the e-learning platform for an undergraduate level bioinformatics course designed to emphasize problem-based learning.

Liu (2009) suggests that traditional face-to-face learning and various forms of online synchronous and asynchronous learning have their own distinctive benefits. When integrated, these forms of interaction complement each other, thus producing improved learning outcomes. Liu (2010) suggested that there exists a range of blended learning models, and that teachers should choose the mix of face-to-face learning and e-learning most appropriate to their needs. The advantages of blended learning include improved learning outcomes, increased social interaction, complementary benefits for different instruction modalities, reduce cost and time for deployment, and increased flexibility.

Blended learning offers the possibility of flexible integration of traditional learning and e-learning to best fit the teacher's instructional needs and the student's learning requirements. Blended learning thus not only improves learning outcomes, but also directly and effectively helps students to exercise learner autonomy. Moreover, through online interaction and discussion, students can effectively learn through team activities, thus significantly reducing learning time and costs.

2.2. Problem-based learning

Problem-based learning (PBL) was initially proposed by Barrows and Tamblyn in 1965 as part of an effort to reform medical education. PBL was designed seeks to train medical students how to assess and resolve clinical problems through systematic situated learning activities to develop their clinical reasoning and response.

PBL is also called problem oriented learning, and a range of definitions have

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been proposed. Barrows & Tamblyn (1980) stress that PBL is a means by which students are taught to understand and solve problems via real-life situations. Barrows (2002) and Savery (2006) defined PBL as a student-centered pedagogy in which students should take the initiative to do the specific research, integrate theory and practice, and use their knowledge and skills to develop feasible solutions to problems. Tam (2001) on the other hand considered PBL as a teaching morphology which uses real-life problems in small group classroom activities and discussion to promote self-directed learning. During this learning process, the teacher serves a catalytic and guidance role.

In summary, PBL is student-centered and emphasizes the use of real-life problems as the source of learning. Throughout the PBL learning process, students actively explore, recognize, and analyze real-world problems, develop remediation plans and finally propose a feasible solution. Students take an active role throughout the process, with the teacher largely assuming a consultative and resource organizing role.

The development and ubiquity of mobile internet technologies raise significant possibilities for revolutionary developments in education. Abdualla et al. (1983) first proposed combining PBL with information networks, with computer-based simulations allowing students to actively engage in problem-solving processes.

E-learning environments provide easy access to learning materials, both designed and authentic, and also facilitate peer-to-peer communication through email, chat rooms, etc. Internet-based resources and tools are widely seen as having potential to enhance learning outcomes through integration with PBL (Pelletier, Ness & Murphy, 2001). Cho and Jonassen (2002) pointed out online discussions during problem-solving activities are automatically recorded and logged, providing a useful future reference. In the context of professional training for teachers of visually

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impaired children, McLinden and Hinton (2006) found that learners effectively used online learning resources to develop solutions in PBL exercises. Moreover, enrollment, attendance and general morale in such activities was found to be high, and that the tools and platforms were seen by participants as promoting social interaction and cooperative learning. This suggests that online PBL environments are also appropriate for professional training in special education.

Empirical studies on online PBL have found a positive effect on learning outcomes. Such tools not only cultivate positive attitudes towards problem-solving, but also help students improve their ability to effectively and rationally apply information and experience to real-life challenges.

2.3. Problem-solving Attitude

So-called "problem-solving attitudes" incorporate thoughts and emotions generated during the problem-solving process, in other words, the cognitive concept one uses when approaching and dealing with a problem. However, problems can arise when the scenario changes, or when an individual wishes to achieve a certain goal, making it necessary to change the current state (Kuo 2001). Liu (2004) suggested that an individual's attitude towards a problem will trigger various reactions as the individual seeks to assess and resolve the problem.

Previous studies have found that the problem-solving attitudes and ability of students can be enhanced through the use of appropriate teaching strategies or training such as cooperative learning, constructivism-oriented physical education, game-based cooperative learning, STS learning, and PBL-related learning. The abovementioned studies suggest a positive impact on problem-solving ability and attitude. This study applies PBL strategies in an undergraduate bioinformatics course to stimulate student

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engagement and learning motivation during problem-solving activities to cultivate positive problem-solving attitudes and effectively enhance student problem-solving ability.

2.4. Learning Attitudes

Koballa (1988) defined learning attitude is a lasting and stable performance, and changes in attitude are provoked by extrinsic causes. The formation of attitude, behavior, and change are impacted by factors including personality, experience, learning style, and external environments. Fishbein and Ajzen (1972) defined learning attitude as an affective, cognitive, and understanding behavior tendency, specifically student behavior in favor of or against learning. Liu (2007) suggests that learning attitude is a lasting and consistent view and tendency towards learning, and also a psychological state of readiness for learning. Therefore learning attitude leads different students in different learning directions, can be acquired or developed through experience, and should be consistent and persistent (Chen and Chen, 2017). Summarizing these definitions, this study defines learning attitude as consistent positive or negative beliefs, cognition, and ideas towards all learning-related activities. Learning attitude is eventually revealed through learning achievement or lack thereof. Learning attitude is variable and can be shaped and acquired post-natural through counseling, or adjusted by change in educational policy (Huang, 2005).

Choice of learning method has been found by Zang (2003), Lee (2004) and Tsai (2011) to be the most significant factor in determining improvements to learning attitudes, but Li (2002) was unable to replicate this effect. Thus, the impact of different learning strategies on learning attitude still needs to be confirmed.

3. Research Methodology

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3.1. Research Subject and Research Tools

In this research, experimental subjects included two classes of undergraduate MIS students at Taiwan's National Chung Hsing University (NCHU). Two sections of a bioinformatics elective course were recruited, one serving as the experimental group while the other served as a control. Both classes were conducted over eight weeks with identical numbers of instructional hours. The experimental group (14 male students and 12 female students) was taught through blended learning while the control group (7 male students and 8 female students) used conventional teaching methods. A quasi-experimental research method was used to identify the impacts of different teaching environments and learning modes on learning effectiveness.

The open source online learning platform Moodle was used to establish a PBL environment based on the Bioinformatics curriculum (Fig. 1).

3.2. Learning Attitude Scale

To measure improvements to learning attitudes, this study adapted a learning attitude scale designed by Tseng (2003) and Tung (2011).

The content of the scale focuses on the three dimensions – "Confidence in learning Bioinformatics", "interest in learning Bioinformatics" and "values and beliefs toward Bioinformatics". Each of the 29 questionnaire items is scored on a 5-point Likert scale from "Strongly disagree" to "Strongly agree". The survey instrument was found to have a Cronbach's α coefficient of 0.715 for "confidence in learning Bioinformatics", 0.837 for "interest in learning Bioinformatics" and 0.730 for "values and beliefs towards Bioinformatics". Thus the scale is shown to have a high level of reliability. The validity and appropriateness of the instrument was assessed by the advising professor and teachers in relevant fields.

3.3. Problem-solving Attitude Scale

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The scale used to assess problem-solving attitudes was established by Lin and Hwang (2011), focuses on university students and is based on the problem-solving attitude theory developed by Heppner and Petersen (1982) and the "Problem-Solving attitude scale of high school students" developed by Xu (2007). The scale was adapted to suit experimental context and requirements, and includes 30 items focused on assessing ideas, feelings and practices of university students in the process of solving problems.

The scale is divided into three sections: problem cognitive oriented, problem aversion oriented and problem confidence oriented, with each item scored on a 5-point Likert scale. Reliability testing finds Chronbach's α values of 0.732, 0.822, 0.767, respectively for the three sections, indicating a high degree of reliability. Validity testing and factor analysis shows that the cumulative explained variance of the three factors is 51.6%, thus the meaning of each factor and questionnaire item matches the structural concept of the original scale, and thus shows good structural validity.

3.4. Teaching Strategy and Experimental Design

The developed Bioinformatics course is based on department teaching objectives in reference to the relevant literature, and is integrated into the university curriculum in accordance with student ability (as shown in Table 3.2). The control group uses traditional teaching methods, in which the curriculum content is delivered through classroom lecture, the course material is provided by the instructor, and the students are only required to take notes from the lecture without having to collect data by themselves.

The experimental group adopts a blended learning method, which involves alternating weekly traditional lectures with use of the online PBL environment.

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Implementation requires the use of networked computers and multi-media equipment including PowerPoint, and online presentation applications. Students are required to conduct online group discussions search online for relevant information, and use of word processing software to organize data results and produce a report.

The experimental process is described as follows:

(1) This research uses a quasi-experimental research method and applies a non-equivalent group pretest-posttest design for “learning attitude” and “problem-solving attitude” to an experimental and a control group.

(2) The experimental group undergoes blended learning while the control group is instructed using traditional lecture methods.

(3) Following the experiment, participants took post-tests for “learning attitude” and “problem solving attitude”, and selected participants were interviewed to assess participant reaction and attitudes toward the different learning methods.

Table 1: Experiment Design

Group	Pre-test	Process	Posttest
Experimental group	O_1	X	O_2
Control group	O_3	C	O_4

O_1: Prior to the course, the experimental group took a pre-test for the “learning attitude scale” and “problem-solving attitude scale”.

O_3: Prior to the course, the control group takes took a pre-test for the “learning attitude scale” and “problem-solving attitude scale”.

O_2: Following the course, the experimental group took a posttest for the “learning attitude scale” and “problem-solving attitude scale”.

O_4: Following the course, the control group took a posttest for the “learning attitude scale” and “problem-solving attitude scale”.

X: The experimental group begins the blended learning course.

C: The control group begins the traditional instruction course.

4. Experimental Results

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Quantitative data analysis was conducted using the one-way ANCOVA. Prior to the teaching experiment, the researchers surveyed both groups using the ”learning attitude scale” and “problem-solving scale” pre-tests. Post-tests for both scales were then conducted one week following the conclusion of the course. SPSS was used for statistical analysis. Analysis results were supplemented through interviews and coursework products (e.g., group learning sheets) to assess the impact of blended PBL on learning attitudes.

4.1. The effect of blended PBL on the learning attitudes of college students

The “learning attitude scale” pre- and post-tests were used to assess confidence, interest, and value beliefs of participants in both groups, and results were analyzed through the following three procedures. First, descriptive statistical analysis was applied followed by testing of the homogeneity assumption for within-group regression coefficients. The results of pretest scores showed no significant relationships between different groups. Having met the basic assumptions, ANCOVA was used to assess significant differences in the posttest scores of both groups.

(1).Descriptive statistics

A total of 41 completed surveys were collected, including 26 from the experimental group and 15 from the control group. Table 2 summarizes descriptive statistics for the confidence, interest, and value subscales, along with those for the total scale of both groups:

Table 2: Score means and standard deviations for the learning attitude subscale and total scale in both groups

Confidence	Experimental group （n＝26）		Control group（n＝15）	
	Mean	Standard deviation	Mean	Standard deviation

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pretest	35.92	4.97	36.46	3.55
posttest	42.88	4.33	39.31	3.01
Interest	Mean	Standard deviation	Mean	Standard deviation
pretest	26.81	3.15	26.23	2.04
posttest	28.96	2.72	28.62	1.85
Value	Mean	Standard deviation	Mean	Standard deviation
pretest	30.88	3.42	29.92	2.06
posttest	33.50	3.47	33.50	2.84
Total scale	Mean	Standard deviation	Mean	Standard deviation
pretest	93.62	10.47	92.62	5.6
posttest	105.35	8.93	101.46	5.68

(2).Test for homogeneity

To assess the significance of differences in the posttest performance of both groups, the posttest scores were treated as the dependable variables and the pretest scores were treated as the covariates, using ANCOVA with SPSS. ANCOVA requires a high degree of homogeneity between both groups, thus a test for homogeneity for intra-group regression coefficients for each subscale and total scale was administered. Differences were considered statistically significant at p=.05, and the results are summarized in Table 3:

Table 3: Test for homogeneity of regression in learning attitude subscales and total scale for both groups

Source of variation (confidence)	*SS*	*df*	*MS*	*F*	*p*
Homogeneity of within-class regression coefficient	.039	1	.039	.003	.957
Error	464.170	37	13.262		

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Source of variation (interest)					
Homogeneity of within-class regression coefficient	2.553	1	2.553	.400	.531
Error	223.454	357	6.384		
Source of variation (value belief)					
Homogeneity of within-class regression coefficient	.814	1	.814	.073	.789
Error	391.651	37	11.190		
Source of variation (total scale)					
Homogeneity of within-class regression coefficient	10.777	1	10.777	.181	.673
Error	2080.440	37	59.441		

The results in Table 3 show that the p value in the subscales and total scale did not reach a level of significance, indicating no significant interaction between the pretest and posttest scores for both groups, and thus both the experimental and control groups met the homogeneity assumptions of within-group regression coefficients and ANCOVA can proceed.

(3). Analysis of Covariance (ANCOVA)

In applying ANCOVA, the pretest scores of both groups were treated as covariates and the groups themselves were treated as independent variables, with the posttest scores treated as dependent variables. Results are summarized in Table 4:

Table 4: Analysis of covariance in learning attitude subscales and total scale of both groups

Source of variation (confidence)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	98.125	1	98.125	7.610	.009**

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Error	464.209	38	12.895		
Source of variation (interest)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	1.064	1	1.064	.169	.683
Error	226.008	38	6.278		
Source of variation (value belief)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	.087	1	.087	.008	.929
Error	392.466	38	10.902		
Source of variation (total scale)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	151.686	1	151.686	2.611	.115
Error	2091.217	38	58.089		

$^{*}p < .05$ $\quad ^{**}p < .01$

The above results show that both the experimental and control groups demonstrated improvement in terms of learning attitude following the course. Table 5 showed that the experimental group showed significant improvement in terms of confidence, but not for interest and value belief, thus there was no significant difference between the experimental and control groups in terms of interest and value.

Table 5: Experimental Results for Learning Attitudes

Item	Result
Confidence scale	Significant improvement
Interest scale	No significant improvement
Value belief scale	No significant improvement
Total scale	No significant improvement

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4.2 The effect of blended PBL on college student attitudes toward solving problems

The researcher asked participants in both groups to complete a "problem solving attitude scale" one week before and after the teaching experiment to assess differences between both groups in terms of problem aversion, problem cognition, problem confidence and total scale before and after the course. The results were analyzed in the following three ways.

(1).Descriptive statistics

A total of 41 completed surveys were collected, including 26 from the experimental group and 15 from the control group. Table 6 summarizes the descriptive statistics for "problem solving attitude" for both groups:

Table 6: Means and standard deviations for problem solving attitude subscales and total scale of both groups

	Experimental group（n＝26）		control group（n＝15）	
Aversion	Mean	Standard deviation	Mean	Standard deviation
pretest posttest	39.38	2.54	42.85	3.33
	48.88	4.14	45.77	2.86
Cognition	Mean	Standard deviation	Mean	Standard deviation
pretest posttest	36.69	1.76	36.69	2.09
	41.33	4.43	39.85	2.07
Confidence	Mean	Standard deviation	Mean	Standard deviation
pretest posttest	18.96	2.01	20	1.82
	23.65	2.31	21.77	1.23
	Experimental group（n＝26）		Control group（n＝15）	

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Total scale	Mean	Standard deviation	Mean	Standard deviation
pretest	95.04	4.53	99.54	5.06
posttest	114.62	9.06	107.38	4.71

(2).Test for Homogeneity

To further assess the significance of problem solving attitude posttest performance differences among the two groups, SPSS was used to test the homogeneity of intra-group regression coefficients. Significant difference was found to occur if p=.05. The results are summarized in Table 7:

Table 7: Test for regression homogeneity in problem solving attitude subscales and total scale of both groups

Source of variation (problem aversion)	*SS*	*df*	*MS*	*F*	*p*
Homogeneity of within-class regression coefficient	4.339	1	4.339	.292	.593
Error	520.725	37	14.878		
Source of variation (problem cognition)					
Homogeneity of within-class regression coefficient	1.484	1	1.484	.074	.787
Error	699.316	37	19.980		
Source of variation (problem confidence)					
Homogeneity of within-class regression coefficient	3.698	1	3.698	.886	.353
Error	146.026	37	4.172		
Source of variation (total scale)	*SS*	*df*	*MS*	*F*	*p*
Homogeneity of within-class regression	2.193	1	2.193	.034	.855

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coefficient			
Error	2261.498	37	64.614

From Table 7, the p value for the problem solving attitude subscales and total scale did not reach the level of significance, indicating there was no significant interaction between pretest scores and posttest scores of both groups. As a result, the homogeneity assumption of intra-group regression coefficients was met, allowing for the application of ANCOVA.

(3).Analysis of Covariance

In conducting ANCOVA, the pretest scores of both groups were treated as covariates and the groups themselves were treated as independent variables. The posttest scores of both groups were dependent variables. The results are summarized in Table 8:

Table 8: Analysis of covariance in problem solving attitude subscales and total scale of both groups

Source of variation (problem aversion)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	73.834	1	73.834	5.062	.031*
Error	525.064	38	14.585		
Source of variation (problem cognition)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	43.128	1	43.128	2.215	.145
Error	700.8	38	19.467		
Source of variation (problem confidence)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	33.232	1	33.232	7.990	.008**
Error	149.724	38	4.159		

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Source of variation (total scale)	*SS*	*df*	*MS*	*F*	*p*
Groups (Experimental group & control group)	33.232	1	33.232	7.990	.008**
Error	149.724	38	4.159		

$*p < .05$ $**p < .01$

The above results show that, following the course, both groups improved in terms of problem solving attitudes. As shown in Table 9, after excluding the pretest scores, the scores in the problem cognition subscale did not improve significantly, but those for problem aversion and problem confidence did improve significantly, indicating that blended PBL generally improves student problem solving attitudes.

Table 9: Experimental Results for Problem Solving Attitude

Item	Result
Problem aversion scale	Significant improvement
Problem cognition scale	No significant improvement
Problem confidence scale	Significant improvement
Total scale	Significant improvement

4.3 Discussion

This section further discusses the quantitative data obtained from the survey results and qualitative data obtained from interviews, along with participant comments on the different learning formats.

4.3.1. Analysis of Learning Attitude Scale

The results of the learning attitude scale showed that, after excluding the influence of the pretest, the experimental group significantly outperformed the control group in the “confidence” subscale. Participant interviews suggested that learners in the experimental group felt improved confidence in terms of their ability to understand bioinformatics through enhanced learner autonomy. The blended learning process enhanced learner perception of learning challenge along with their perception of their skills communication, expression and discussion skills. Through requiring

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students to solve problems by actively searching for relevant bioinformatics information, the experimental instructional process enhanced learner teamwork skills and ability to effectively engage in collaborative learning, thus enhancing learner confidence.

However, the scores in the "interest" and "value belief" subscales did not show statistically significant improvement, nor did the total scale. Previous studies (Zang, 2003; Lee, 2004; Tsai, 2011) have suggested that blended learning could increase students' perception of the value of learning, but our results do not confirm these findings. Other quantitative and qualitative studies have found that changing learning attitudes takes time. Chang (1989) noted that individuals exhibit persistent and consistent learning attitudes towards specific people, things, and surroundings. The eight week course duration was arguably too brief to produce significant results, and longer exposure to the experimental teaching method could produce a stronger impact.

On the other hand, in interviews students suggested they felt the experimental teaching style was more lively and interesting than conventional teaching styles. Students also indicated they felt improvement in their ability to collect and applying information, and gained confidence in their learning skills since they had to "do everything themselves", from collecting relevant data to conducting group discussions. However, several students indicated they felt the blended BPL approach required more time and energy. In the Moodle-based group discussion records, more passive learners expressed frustration with the data collection tasks, and were less likely to actively participate in online discussions regarding the developed lesson plans. Passive learners also expressed less interest in the subject material and exhibited poorer learning outcomes.

In terms of value belief, both groups improved to a similar extent from the

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pretest to the posttest. In interviews with students, some students in the experimental group said that, in addition to improving their problem solving ability, blended problem-based learning also helped them further grasp practical knowledge in topics including genomics, sequence alignment analysis, and biological evolution. However, the bioinformatics knowledge they acquired in the course would only have any practical significance in their lives if they pursued careers in the biotechnology industry, thus the experimental group showed no significant improvement in the value belief subscale.

While both groups showed improvement in overall learning attitude, the scores of the experimental group improved from 93.62 to 105.35, indicating significant improvement, supporting the findings of Li (2002), Huang (2012), and Lee (2011).

4.3.2. Analysis of Problem Solving Attitude Scale

Following the experimental teaching, assessment of students' problem solving attitude showed that only the "problem cognition" subscale did not achieve a significant difference. Both the "problem aversion" and "problem confidence" subscales and total scale were statistically significant. Generally speaking, blended PBL can thus be seen as conducive to improving problem solving attitudes.

For problem cognition, the experimental group average scores improved from 36.69 to 41.33, and are thus not statistically significant. Problem cognition refers to students' cognition and understanding of problem solving. The students had no prior familiarity with bioinformatics subject matter. Review of the Moodle discussion contents and student interviews indicated that learners sometimes had difficulty understanding bioinformatics concepts, and required guidance from teachers or

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teaching assistants to find the correct approach to solving problems.

Overall problem solving attitude scores in the experimental group increased from 95.04 to 114.62, a considerably greater improvement than that of the control group, suggesting that blended PBL can effectively improve problem solving attitudes, which supports previous research results (Ji, 2003; Lee, 2003; Chen, 2006; Kuo, 2009; and Wu, 2009)

5. Conclusions

Based on the research results, the following conclusions are drawn:

(1) The use of blended PBL used in a bioinformatics course does not significantly improve student learning attitudes

The following factors were found to influence the impact on learning attitudes: (I) The experimental course only lasted eight weeks, making it difficult to obtain the expected experimental result. (II) Students in the experimental group improved their learning attitudes, but the degree of change was not statistically significant. On the other hand, it is possible that students in the control group also changed their learning attitudes to become more active. For example, they will actively search for related data to increase their knowledge in the field of bioinformatics. Such behavior might reduce the gap in improvement between the two groups. (III) Different individuals have different beliefs in regard to the value of bioinformatics.

(2) Blended PBL used in a bioinformatics course significantly improves student problem solving attitudes

Following the course implemented using blended BPL, the experimental group, using blended BPL, showed positive attitudes towards problem solving in bioinformatics, and the degree of improvement was significantly greater than that shown by students taught through traditional methods. In other words, learners'

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problem solving attitude and problem solving ability can be enhanced through the application of appropriate instructional strategies. Such improvements to problem solving attitudes will enable learners to better respond to a range of problems encountered later in life.

(3).Lesson plan content must be designed based on the PBL theory and actual scenarios

Analysis of online group discussions found that incorporating real-world scenarios and events into PBL lesson plans enhances learner engagement and interest in the course material., prompting them to be assume a more active posture in addressing problems and in peer discussion.

(4) Students indicated approval of the blended PBL approach with online group discussion

Interviews found that the students generally appreciated the different learning experience provided by the blended PBL method. In addition, in the process of applying the experimental instruction method, the researcher discovered that students were highly motivated to engage in real-time online discussion with the instructor and other students. This mode of communication allowed them to obtain immediate feedback if they encountered difficulties, and the online platform also allowed them to read and comment on assignments posted by their peers, helping them clarify issues encountered in each instructional unit. Through blended PBL, students also enhanced their learning autonomy, critical thinking and creative thinking, which can significantly contribute to improved lifelong learning ability.

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