Efficacy Verification of Team Learning Satisfaction, Problem Solving Ability, and Communication Ability of Problem Solving Process Classes Applying Action Learning, Problem-Based Learning, and Mentoring

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The purpose of this study was i) to design a teaching and learning model for problem solving ability class to which action learning (AL), problem-based learning (PBL), and Mentoring are applied, ii) implement the model to verify the effects of AL's on team learning, iii) analyze the enhancement of problem solving ability through PBL and iv) review development of communication skills through mentoring. The effect of team learning, improvement of problem solving ability within PBL, and improvement in communication through mentoring was verified through comparison of results from quantitative pre- and post-tests. Data was collected two times in the form of a questionnaire for 62 students at the beginning and at the end of the first semester of 2020. A paired samples t-test was among the methods of average comparison on the SPSS 18.0, used to determine differences in team learning satisfaction, problem solving ability, and communication skills based on experiences in AL, PBL, and Mentoring. The results of the test verified the efficacy of PSP class to which AL, PBL, and Mentoring were applied.

Keywords: Action Learning; Problem-Based Learning; Mentoring; Problem Solving Process

INTRODUCTION

The World Economic Forum (WEF) in 2017 publicized ten skills required to thrive in the Fourth Industrial Revolution: (1) Complex Problem Solving, (2) Critical Thinking, (3) Creativity, (4) People Management, (5) Coordinating with Others, (6) Emotional Intelligence, (7) Judgment and Decision Making, (8) Service Orientation, (9) Negotiation, and (10) Cognitive Flexibility. A competent, talented person for the 21st century can be one who not only possesses a wide range of knowledge but also accepts new knowledge, applies it to problem solving, and carries out roles and functions as a member of society. Given the WEF's list of skills, vocational colleges in the provinces in Korea, in particular, should develop a variety of teaching methods; consideration needs to be given to the significance of nurturing talent, as well as seeking improvement in adaptability, problem-solving ability, communication skills, and interpersonal ability. In these abilities there is a perceived deterioration in student levels of ability.

This researcher has been conducting problem solving process (PSP) classes since 2016 in line with the trend of the times and the goal of cultivating talent in college students. The PSP class consists of AL, PBL, and Mentoring. Here, AL is a method where learning occurs

through a process to derive a solution to a task. PBL is a method in which learners jointly discuss problem-solving methods and then prepare a common solution through both individual and cooperative learning processes. Mentoring is a way to improve a mentee's skills and potential with the guidance and advice of a mentor.

The purpose of this study was i) to design a teaching and learning model for PSP class to which action learning (AL), problem-based learning (PBL), and Mentoring are applied, ii) implement the model to verify the effects of AL's on team learning, iii) analyze the enhancement of problem solving ability through PBL and iv) review development of communication skills through Mentoring. Quantitative tests were applied with the aim of presenting directions for teaching and learning that can effectively respond to the college's quest to contribute to a knowledge-based society.

The research hypotheses used in this study were as follows:

1) Verification of the significance of responses to the question: "Does AL change learners' satisfaction with team learning?" AL is a method of education and training in which teams are formed to solve problems. Therefore, this paper mainly studies the effect on learning among team members through collaboration.

Hypothesis: AL education is effective in increasing learners' satisfaction with team learning.

2) Verification of the significance of responses to the question: "Does PBL change learners' problem solving ability?" Hypothesis: PBL education is effective in increasing learner's problem solving ability.

3) Verification of the significance of responses to the question: "Does Mentoring change learners' communication skills?" Mentoring involves mentors who give advice and mentees who receive advice. Therefore, in this paper, the effect of communication between mentor and mentee is central to perceived outcomes.

Hypothesis: Mentoring education is effective in improving learners' communication skills.

4) Verification of the significance of responses to the question: "Does Mentoring improve mentors' satisfaction with their college life?"

LITERATURE REVIEW

Theoretical Review: This section examines a selection of concepts within previous studies on the effects of team learning satisfaction, problem solving ability improvement, and communication skills, the variables within the PSP classroom approach.

1) Team learning

Team-based learning (TBL), first introduced by Larry Michaelsen, a professor at Oklahoma University in the 1970s, is a special teaching strategy in which simple small groups are converted into teams for optimal performance (Michaelsen, 2009). The TBL instructors are designers and managers of overall curriculum, serving as a manager of knowledge (Shin, 2019). TBL can have positive effects on learner's motivation, learning attitude, participation, communication skills, academic achievement, self-directed learning, academic self-efficacy, emotional intelligence, and satisfaction (Kim Yun Kyung, Kim Nuri, 2015; Lee Kyung Hee, Son Eun Kyung, 2012; Ha Chae Yeon, Lee Soo Young, 2014). According to these studies, TBL affects attitudes to learning and satisfaction of learners on a relatively consistent basis. This study aims to examine team participation, reliability between team members, team learning satisfaction, and team learning effectiveness through TBL.

2) Problem solving ability

Problem solving ability is an intellectual and creative process of quickly and effectively resolving differences between the current state and the target to be achieved by a problem solver (Kahney, 1986). Solving a problem requires a goal achievement, a process of change in thinking and behavior to achieve the goal (Lee et al., 2003; Park, 2017). In the mid to late 1900s researchers of cognitive theory regarded problem solving ability and creativity as the same cognitive phenomenon (Guilford, 1967) or viewed creativity as a form of problem solving (Mumford, et al., 1991). Originality, flexibility, and fluency of creativity are generally regarded to be inseparable from problem solving ability; the two concepts of problem solving ability and creativity were combined into one complex concept, called Creative Problem Solving (CPS) (Feldhusen & Treffinger, 1985). To analyze problem solving ability, this study examined orientation of problems, analysis of problem causes, deduction and verification of solutions, practicability of solutions, and verification and evaluation of practice.

3) Communication skills

A mentor and mentee are involved in mentoring; communication skills between the two is very important. Carkhuff (1972) cited empathy, respect, warm expressions, specificity of expression, genuineness, self-disclosure, confrontation, and immediacy as factors communication skills (as cited in Ryu, 2014). According to Lee et al., (2003), the components of communication skills include (1) interpreting dialogue from collecting information about and listening to them, (2) playing a role by overcoming stereotypical thinking and communicating creatively and with

open-mindedness, (3) expressing their own thoughts without pretension, (4) setting goals to lead communication in which one presents one's own opinions clearly, and (5) converting messages to understand the words and stance of the other person (Shin, 2014). This study examined listening, sincerity, the positive nature of expression, consideration and understanding, and satisfaction with college life, in order to analyze the appropriateness of communication skills.

Communication of Teaching Methods: Previous studies on AL, PBL, and Mentoring, highlighted the relationships among components of teaching and learning models of PSL class.

1) AL - consists of six components: a task to be solved, a constituent learning team, a reflection on learning effects and a set of questions mutually agreed upon by learners, a willingness to practice, an approach to learning through task solving, and involvement of a learning coach (Marquardt, 1999). To experience successful learning in AL, all criteria should be satisfied (Kim & Um, 2014, 2011).

Table 1, shows how participation in the six components of action-oriented learning has the potential to lead to solutions to problems posed by a team (or organization), in this case, through the action learning process proposed by Lee (2018).

2) PBL has been the focus of scholars for decades. PBL is, according to Barrows & Tamblyn (1980), i) learning from processes and activities for understanding or solving prob-

lems, or ii) a method of learning or teaching in which problematic situations are used for students to actively participate in learning processes. Albanese & Mitchell (1993) defined PBL as a teaching method in which problems are used to teach students problem solving ability and basic knowledge. Gallagher & Stepien (1996) reported that PBL is a cyclical process of defining a problem, selecting hypotheses for learning, and detecting concrete learning problems. Cho Yeon Sun (2006) defined PBL as an educational approach in which learners are led to learn the necessary knowledge by themselves through processes of problem solving from real-world, non-structured problems (Kim, 2010).

3) Mentoring - Park Sung Mi (2006), using psycho-social, career-development, role-modeling, friendship protection as a criterion-related mentoring function scale, reported development and validation of tools to measure Mentoring functions for college students. Kim Ji Eung (2008) dealt with the effects of college students' Mentoring functions on adaptation to and satisfaction with college life (Kim, 2010).

METHODS

This paper has received IRB approval from Suncheon Jeil College Industry-Academy Cooperation Foundation (IACF) (Approval number: IACF-2020-1).

Table 2 shows the group of study subjects divided into mentors and mentees.

Figure 1 shows the conceptual model used in the study; N = 62 subjects - mentors and mentees

Figure 2 shows the approach to this study and the flow of the teaching and learning method. This study began at the end of 2019 and consists of the steps of development of an APM teaching and learning model, modification and supplementation of the model, model application, results analysis.

In this study, 65 freshmen majoring in electrical engineering at Suncheon Jeil College who took the PSP class were divided into three groups A, B and C according to their Student Number. Three were excluded due to military enlistment; 62 students

Table 1. AL processes presented in previous studies

Division	O'Neil & Marsick (2007/2014)
Clarification and cause analysis of tasks	1. Checking tasks
	2. Drawing and verifying hypotheses
	3. Drawing necessary items
	4. Collecting data and benchmarking
Drawing solutions for tasks	5. Developing ideas for solution
	6. Decision making
Practicing task solutions	7. Authorization and participation
	8. Practicing
Reflection and evaluation	9. Evaluating performance
	10. Feedback

Table 2. Subject groups and mentors and mentees (Unit: Persons, %)

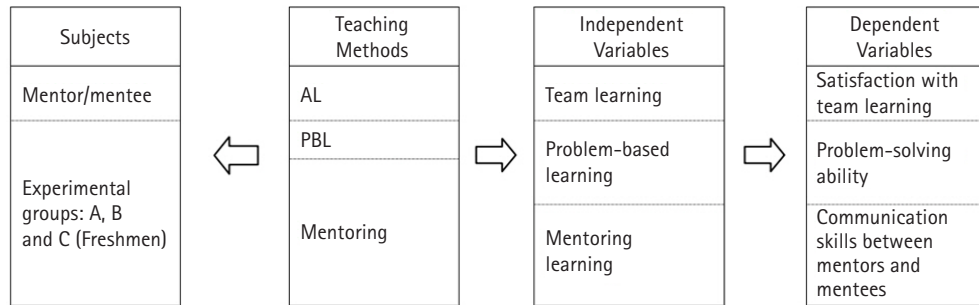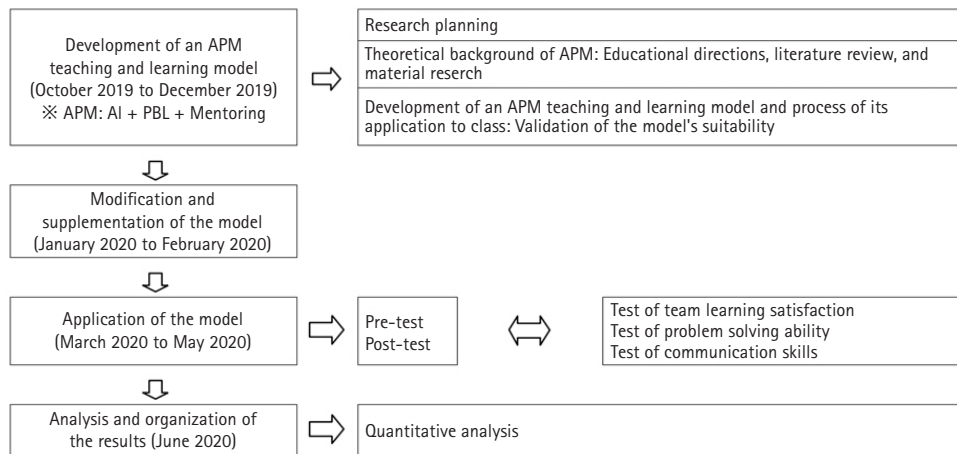| Groups	Freshmen						Total	
	A		B		C			
Experimental groups	21		21		20		62 (persons)	
	33.9		33.9		32.2		100 (%)	
Subject groups	Mentors	Mentees	Mentors	Mentees	Mentors	Mentees	Mentors	Mentees
	4	17	4	17	4	16	12 (persons)	50 (persons)
	19.1	80.9	19.1	80.9	20	80	19.4 (%)	80.6 (%)

Figure 1. Conceptual model of study.

Figure 2. Research model and flow of teaching and learning.

were surveyed. Of the 62 students taking PSP classes, 1 female and 61 males - 12 were Mentors (19.4%) and 50 Mentees (80.6%).

The following test tools were used to determine team learning satisfaction, problem solving ability, and the nature of communication skills.

1) Team learning satisfaction

This study modified and supplemented the tool for learning satisfaction revised by Kim Yeon Soon (2013) to measure learner's satisfaction with team learning. The sub-elements included the following items - two for team participation, two for reliability among team members, three for team learning satisfaction, and five for team learning effectiveness. For responses to 12 questions, a five-point Likert scale was used - 1 indicating negative to 5 positive.

2) Problem solving ability

To measure the problem solving ability of learners, the tool used, focused on college students and adults, one of the life-competencies measurement tools developed by the Korean Educational Development Institute (KEDI) (Lee et al., 2003). The

sub-elements included three items for orientation of problems, two for analysis of problem causes, three for deduction and verification of solutions, two for practicability of solutions, and two for verification and evaluation of practice. A five-point Likert scale was applied to 12 questions, from 1 point as negative to 5 points - positive.

3) Communication skills

This researcher reorganized the tool for measuring communication skills of college students and adults, one of the life-competencies measurement tools developed by the KEDI (Lee et al., 2003). The sub-elements included four items for listening, two for sincerity, three for positivity of expression, and three for consideration and understanding. Responses to 12 questions were based on a five-point Likert scale (1 indicating negative and 5 positive).

DESIGN AND PROCEDURES

1) Experimental design

A quantitative explanatory design involved comparison between pre- and post surveys of perceptions of 62 freshmen who

took the PSP class; 12 mentors and 50 mentees participated. A control group was not used. The first survey immediately after forming teams with mentors at Week 1 and the second in Week 14 at the end of the course. The questionnaire consisted of 12 questions for team learning satisfaction, 12 for problem solving ability, and 12 for communication skills.

2) Experimental procedures

Figure 3 illustrates the experimental process from mentor selection to school termination. Completion of service was the criterion for mentor selection of 12 students. Mentors with military service were deemed credible among their classmates, had a strong spirit of service, could establish smooth relationships and were interested in mentoring their peers. The mentor's main role was to listen to mentee's concerns and provide psychological support and academic support.

3) PSP class content

Table 3 shows PSP lectures conducted weekly, attended by both mentors and mentees. Hourly classes were held for 15 weeks.

ANALYSIS

The first of 2 surveys included all the original 65 subjects; Week 14 involved 62 as 3 took leave due to military service enlistment. Their surveys were excluded from the data. Comparisons across the identical surveys showed perceptions of the effects of AL, PBL, and Mentoring on the learning experience. SPSS 18.0 was used to input and analyze the data. A paired sample t-test among was used to determine differences in perceptions about team learning satisfaction, problem solving ability, and communication skills, based on experiences in AL, PBL, and Mentoring.

RESULTS

Pre-and post-surveys provided insight into student perceptions of their experiences with a PSP class to which AL, PBL, and Mentoring were applied. Comparison between the baseline and summative data verified the effects of team learning within AL and improvements in problem solving ability and communication skills.
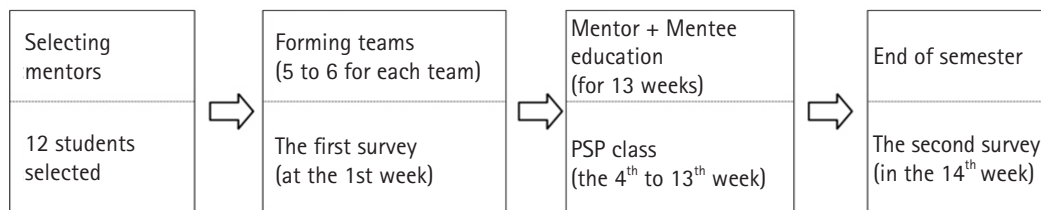
Figure 3. Flow of problem solving process class.

Table 3. Problem solving process class content per week

	Schedule	Topic	Main Content
APM	The 1st to 3rd week	Understanding of AL, PBL, and Mentoring	• Personal communication skills
			• Team communication skills (how to improve team dynamics)
			• How to run a team meeting
	The 4th to 6th week	PBL-type task execution	• How to select tasks
			• Understanding models of task performance
			• Learning task definition steps
	The 7th to 11th week		• Learning task research steps
			• Learning steps of deduction and validation of solutions
			• Learning steps of preparing action plans
	The 12th to 13rd week	PBL comprehensive practice	• Practicing step-by-step team roles (actual activities by teams)
			• Mutual feedback
	The 14th to 15th week	PBL follow-up	• Sharing experiences of practice
			• Identifying difficulties and mutual feedback
			• Skill-up for improving team learning competency

1) Effects of AL on team learning satisfaction

To analyze statistical differences in team learning satisfaction based on AL experiences, paired sample t-tests were applied, with two items for team participation, two for reliability between team members, three for team learning satisfaction, and five for team learning effectiveness on the Likert 5-point scale. In this study, "AL education" was selected as an independent variable, and team participation, reliability between team members, team learning satisfaction, and team learning effectiveness at the beginning and the end of the semester were selected as verification variables for analysis. To interpret and determine the results, a null hypothesis "AL education is not effective on increasing learners' satisfaction with team learning" and a research hypothesis "AL education is effective on increasing learners' satisfaction with team learning" were used.

The analysis methods used in Table 4 and 5, Table 6 and 7, Table 8 and 9 show paired t-tests. This analytical method measuring one sample twice (pre-post measurement), determines any difference between the two measurements. Table 4, Table 6, and Table 8 are 'paired sample statistics and analyze the difference in satisfaction between results at the beginning and the end of the semester. Table 5, Table 7, and Table 9 are 'paired sample tests' to determine whether the study hypothesis is rejected given the significance level.

Table 4 shows the results of analyses at the beginning and the end of the semester for evaluating team learning satisfaction based on AL experiences. The number of samples (N) is 62, and average means the average satisfaction based on AL experiences. In all the verification variables, the averages remarkably increased at the end of the semester in comparison to the beginning; for 'Team participation', the average increased from 1.66 (low satisfaction) at the beginning to 4.21 (high) at the end.

Table 5 shows the results of analyzing test differences in the paired samples used at the beginning and end of the semester to evaluate team learning satisfaction based on AL experiences. When the significance levels were analyzed, the absolute value of the t-value was from 22.774 (min.) up to 36.421 (max.), which exceeded 1.96, for all the verification variables. The significance

Table 4. Differences in statistics of team learning satisfaction based on action learning experiences

		Statistics of paired samples				Correlation coefficients of paired samples		
		Average	N	Standard deviation	Standard error of average		Correlation coefficients	Significance probability
Team participation	Beginning of semester	1.66	62	0.651	0.083	Beginning & end of semester	0.215	0.093
	End of semester	4.21	62	0.750	0.095			
Reliability between team members	Beginning of semester	1.35	62	0.630	0.080	Beginning & end of semester	0.094	0.466
	End of semester	4.66	62	0.676	0.086			
Team learning satisfaction	Beginning of semester	1.71	62	0.555	0.070	Beginning & end of semester	-0.038	0.772
	End of semester	4.35	62	0.482	0.061			
Team learning effectiveness	Beginning of semester	1.39	62	0.523	0.066	Beginning & end of semester	-0.037	0.776
	End of semester	4.77	62	0.493	0.063			

Table 5. Test differences in paired samples of team learning satisfaction based on action learning experiences

		Test of paired samples							
		Paired differences							
		Average	Standard deviation	Standard error of average	95% confidence interval of difference		t	Degree of freedom	Significance probability (both)
					Lowest	Highest			
Team participation	Beginning to end of semester	-2.548	0.881	0.112	-2.772	-2.325	-22.774	61	.000
Reliability between team members	Beginning to end of semester	-3.306	0.879	0.112	-3.53	-3.083	-29.604	61	.000
Team learning satisfaction	Beginning to end of semester	-2.645	0.749	0.095	-2.835	-2.455	-27.819	61	.000
Team learning effectiveness	Beginning to end of semester	-3.387	0.732	0.093	-3.573	-3.201	-36.421	61	.000

probability (for both) was 0.000. Thus, it is reasonable to consider that the research hypothesis is supported. The significance probability is between 0 and 1, and if the significance level is less than 0.05, the research hypothesis is adopted with a probability of 95%.

2) Effects of PBL on problem solving ability

To analyze statistical differences in problem solving ability

Table 6. Differences in statistics of problem solving ability based on problem-based learning experiences

		Statistics of paired samples				Correlation coefficients of paired samples		
		Average	N	Standard deviation	Standard error of average		Correlation coefficients	Significance probability
Orientation of problems	Beginning of semester	1.66	62	0.626	0.079	Beginning & end of semester	0.023	0.859
	End of semester	4.69	62	0.642	0.082			
Analysis of problems' causes	Beginning of semester	1.48	62	0.62	0.079	Beginning & end of semester	−0.090	0.486
	End of semester	4.35	62	0.482	0.061			
Deduction and verification of solutions	Beginning of semester	1.82	62	0.529	0.067	Beginning & end of semester	−0.093	0.471
	End of semester	4.77	62	0.493	0.063			
Practicability of solutions	Beginning of semester	1.6	62	0.664	0.084	Beginning & end of semester	−0.001	0.991
	End of semester	4.92	62	0.275	0.035			
Verification and evaluation of practice	Beginning of semester	1.53	62	0.646	0.082	Beginning & end of semester	0.059	0.648
	End of semester	4.73	62	0.45	0.057			

Table 7. Differences in paired-samples test of problem solving ability based on problem-based learning experiences

		Test of paired samples							
		Paired differences							
		Average	Standard deviation	Standard error of average	95% confidence interval of difference		t	Degree of freedom	Significance probability (both)
					Lowest	Highest			
Orientation of problems	Beginning to end of semester	−3.032	0.886	0.113	−3.257	−2.807	−26.934	61	.000
Analysis of problems' causes	Beginning to end of semester	−2.871	0.82	0.104	−3.079	−2.663	−27.585	61	.000
Deduction and verification of solutions	Beginning to end of semester	−2.952	0.756	0.096	−3.144	−2.760	−30.746	61	.000
Practicability of solutions	Beginning to end of semester	−3.323	0.719	0.091	−3.505	−3.140	−36.379	61	.000
Verification and evaluation of practice	Beginning to end of semester	−3.194	0.765	0.097	−3.388	−2.999	−32.880	61	.000

Table 8. Differences in statistics of communication skills based on Mentoring experiences

		Statistics of paired samples					Correlation coefficients	Significance probability
		Average	N	Standard deviation	Standard error of average			
Listening	Beginning of semester	1.68	62	0.647	0.082	Beginning & end of semester	0.077	0.550
	End of semester	4.16	62	0.729	0.093			
Sincerity	Beginning of semester	1.5	62	0.647	0.082	Beginning & end of semester	−0.037	0.774
	End of semester	4.65	62	0.680	0.086			
Positiveness of expression	Beginning of semester	2.23	62	2.614	0.332	Beginning & end of semester	−0.078	0.549
	End of semester	4.35	62	0.482	0.061			
Consideration and understanding	Beginning of semester	1.6	62	0.664	0.084	Beginning & end of semester	−0.182	0.156
	End of semester	4.77	62	0.493	0.063			

Table 9. Differences in paired samples test of communication skills based on Mentoring experiences

		Test of paired samples							
		Paired differences					t	Degree of freedom	Significance probability (both)
		Average	Standard deviation	Standard error of average	95% confidence interval of difference				
					Lowest	Lowest			
Listening	Beginning to end of semester	-2.484	0.936	0.119	-2.722	-2.246	-20.887	61	.000
Sincerity	Beginning to end of semester	-3.145	0.956	0.121	-3.388	-2.903	-25.918	61	.000
Positiveness of expression	Beginning to end of semester	-2.129	2.695	0.342	-2.813	-1.445	-6.221	61	.000
Consideration and understanding	Beginning to end of semester	-3.177	0.897	0.114	-3.405	-2.950	-27.901	61	.000

based on PBL experiences, this study conducted a paired sample t-test before and after the educational event, with three items for orientation of problems, two for analysis of problems' causes, three for deduction and verification of solutions, two for practicability of solutions, and two items for verification and evaluation of practice.

In this study, "PBL education" was selected as an independent variable, and orientation of problems, analysis of problems' causes, deduction and verification of solutions, practicability of solutions, and verification and evaluation of practice at the beginning and the end of the semester were selected as verification variables for analysis. To interpret and determine the results, a null hypothesis "PBL education is not effective on increasing learner's problem-solving ability" and a research hypothesis "PBL education is effective on increasing learner's problem-solving ability" were used. According to the definition of Gallagher & Stepien (1996), PBL is a cyclical process of defining a problem in a problem situation, setting hypotheses necessary for learning, and finding specific learning problems. Therefore, we needed to verify student problem solving ability after learning with PBL methods.

Table 6 shows the results of analysis at the beginning and end of semester to evaluate satisfaction with problem solving ability based on PBL experiences. Average means the average satisfaction based on PBL experiences. In all the verification variables, the averages remarkably increased at the end of the semester in comparison to the beginning; for orientation of problems, the average increased from 1.66 at the beginning to 4.69 at the end.

Table 7 shows the results of analyzing test differences in paired samples used at the beginning and the end of the semester to evaluate problem solving ability based on PBL experiences. When the significance levels were analyzed, the absolute value of the t-value was from 26.934 (min.) up to 36.379 (max.), which exceeded 1.96, for all the verification variables. The significance probability (for both) was 0.000. Thus, it is reasonable to consider that the research hypothesis is supported.

3) Effects of Mentoring on communication skills

To analyze statistical differences in communication skills based on Mentoring experiences, a paired sample t-test before and after the educational initiative was undertaken, with four items for listening, two for sincerity, three for positivity in expression, and three for consideration and understanding.

"Mentoring" was selected as an independent variable, and listening, sincerity, positivity of expression, and consideration and understanding at the beginning and end of semester were selected as verification variables for analysis. To interpret and determine the results, a null hypothesis "Mentoring education is not effective on improving learners' communication skills" and a research hypothesis "Mentoring education is effective on improving learners' communication skills" were used.

Table 8 shows the results of correspondence analysis at the beginning and end of semester for evaluating satisfaction with communication skills based on Mentoring experiences. Average means the average satisfaction based on Mentoring experiences. In all the verification variables, the averages remarkably increased at the end of the semester in comparison to the beginning; for listening, the average increased from 1.66 at the beginning to 4.16 at the end.

Table 9 shows the results of analyzing test differences in paired samples used at the beginning and the end of semester to evaluate communication skills based on Mentoring experiences. When the significance levels were analyzed, the absolute value of the t-value was from 6.221 (min.) up to 27.901 (max.), which exceeded 1.96, for all the verification variables. The significance probability (both) was 0.000. Thus, it is reasonable to consider that the research hypothesis is supported.

4) Effects of Mentoring on improvement in Mentors' satisfaction with college life

The mentors generally showed high satisfaction with Mentoring (4.58 to 4.92), probably because they were systematically educated and a variety of programs were provided to create rapport

Table 10. Effects of Mentoring on satisfaction with college life (at the end of the semester)

		General satisfaction	Satisfaction with methods used	Satisfaction with mentor roles	Active participation	Satisfaction during Mentoring	Willing to invite others	Improvement in adaptation of mentees
					Statistics			
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Average		4.83	4.92	4.92	4.92	4.58	4.92	4.83
Standard deviation		0.389	0.289	0.289	0.289	0.515	0.289	0.389
Variation		0.152	0.083	0.083	0.083	0.265	0.083	0.152
Sum		58	59	59	59	55	59	58

between mentors and mentees. The various programs referred to here refer to the peer mentoring training courses conducted by the Suncheon Jeil College Student Counseling Center, including weekly PSP classes in Table 3. The peer mentoring training course consists of the basic attitude of conversation, helpful conversation, knowing the type of learning personality, and knowing the learning type of mentee.

The average shown in Table 10 is obtained by the satisfaction of mentoring activities to 12 mentors.

DISCUSSION

This study aimed to i) design a teaching and learning model of PSP class to which AL, PBL, and Mentoring were applied, and ii) implement the model to verify the effects of AL on team learning and identify improvements in problem solving ability through PBL and communication skills through Mentoring by conducting quantitative tests.

The statistical significance of the research results are as follows.

First, based on the significance of the research hypothesis, AL was proven to have effects of positively changing students' team learning satisfaction. When the significance level was analyzed, the absolute value of the t-value exceeded 1.96 in all the verification variables. The average satisfaction considerably increased from 2.548 (min.) at the beginning to 3.387 (max.) at the end of the semester.

Second, based on the significance of the research hypothesis, PBL was verified to have effects of positively changing learners' problem solving ability. When the significance level was analyzed, the absolute value of the t-value was from 26.934 (min.) to 36.379 (max.), which exceeded 1.96, and the significance probability (both) was 0.000. As for orientation of problems, the average considerably increased from 1.66 at the beginning to 4.69 at the end of the semester.

Third, based on the significance of the research hypothesis, Mentoring was verified to have effects of positively changing learners' communication skills. When the significance level was analyzed, the absolute value of the t-value was from 6.221 (min.) to 27.901 (max.), which exceeded 1.96, and the significance probability (both) was 0.000. As for listening, the average increased from 1.66 at the beginning to 4.16 at the end of the semester.

Fourth, Mentoring had effects of increasing Mentors' satisfactions with college life. The general satisfaction of the Mentors' with Mentoring activities was high, from 4.58 (min.) to 4.92 (max.).

Academic and practical implications

First, this study designed a teaching and learning model to which AL, PBL, and Mentoring were applied. Having implemented the model, analysis was undertaken of the effects of AL on team learning, of PBL on improving problem solving ability, of Mentoring on improving communication skills, and satisfaction of Mentors' with Mentoring activities.

Second, this study conducted a paired sample t-test to analyze the effects of AL, PBL, and Mentoring to prove their significance.

Acknowledgements

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