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Impact of Peer Learning on Students Academic Achievement and Personal Attributes*

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Mechanics of materials courses are important and very challenging basic professional courses in civil engineering. The peer learning method is student-centered and has been widely applied in engineering education. This paper proposes many original insights into concrete ways to apply peer learning in a mechanics of materials course, which can provide guidance or inspiration for similar courses. A quasi experimental research method, final examination scores, psychological scales, and structured interviews were used to conduct quantitative and qualitative analyses on the benefits of peer learning to the undergraduate civil engineering students (N = 61). The results indicated significant differences between the experimental and control classes in terms of improved academic performance, psychological scores, and character. Specifically, the experimental class improved significantly in terms of final examination scores, deep approach, critical thinking, soft bullying, social avoidance, teamwork, etc. Thus, peer learning in a mechanics of materials course can effectively improve students' academic, character, mental health and satisfaction benefits.

Keywords: engineering education; curriculum benefits; team-based learning; collaborative learning; cooperative learning

1. Introduction

A mechanics of materials course (MMC) aims to teach students about the stress and strain undergone by materials under the influence of external forces with a focus on maintaining their strength, stiffness and stability. A MMC is an important and foundational professional course in various fields of engineering education, such as civil engineering, mechanical engineering, material engineering, and aerospace engineering. MMCs are quite challenging because the task of achieving good academic results requires not only good knowledge of theoretical mechanics as a foundation but also the devotion of considerable time to tedious formula derivation and calculation. Various approaches for improving the teaching effectiveness (academic achievements and student satisfaction) of MMCs have been proposed by international scholars; these include flipped classrooms [1, 2], cooperative learning [3], mixed classrooms [4, 5], etc. However, these attempts may not necessarily yield effective results, as, for example, Ahn and Nelson [3] found that cooperative learning improved students' satisfaction but did not improve their scores in a hybrid MMC. Therefore, continuous improvement and research are necessary.

The training objectives associated with civil engineering (CE) include not only professional knowledge, but also character and generic skills, including communication, leadership, teamwork, and problem-solving skills [6], concepts related to environmental protection and professional ethics [7], and concepts pertaining to sustainable development [8] The development of these abilities is expected to be achieved through universal professional courses rather than limited to specific educational processes. Diverse teaching methods and activities are applied in CE education to enhance the aforementioned characters and general skills, such as problem-based learning [9], project-based learning [10], peer learning [11], or simply additional inclusive concepts [12]. Student-centered learning is a good method for engineering education, and this approach includes using peer learning (PL) [13, 14], team-based learning [15], and problem-based learning [16], among other methods, to address challenges pertaining to sustainability, the fourth industrial revolution, and employability [17]. PL has been applied in various disciplinary contexts and has achieved good results, such as in a marketing course [18], a research methods course [19], an engineering ethics course [20], and an epidemiology course [21]. Furthermore, the effectiveness of PL in eliminating campus bullying and reducing stress has also been recognized [22].

Few studies have investigated the application of PL in MMCs, and the attempts made in previous research [3] have failed to improve students' performance. The research team has previously applied problem-based learning and PL in a structural mechanics course, where this approach successfully improved students' scores, but it nevertheless seemed to reduce students' positive

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feelings regarding the course and their evaluations of teachers [13]. This paper improves the specific measures involved in the PL method in the context of MMC and hopes to answer the following questions:

Question I. Can PL significantly improve students' academic performance?
Question II. Can PL significantly improve students' moral character?
Question III. Can PL significantly improve students' level of mental health?
Question IV. Can PL significantly improve students' evaluations of the course?

2. Participants and Course Design

2.1 Participants

The participants in this study were fourth-semester students (enrolled in 2021) majoring in Civil Engineering at Jiaxing Nanhu University; a total of 61 students across two classes participated. The prerequisite course for MMC is theoretical mechanics. All the students were taught and assessed by the third author independently in the same class of the theoretical mechanics course. MMC is taught by the first author and the third author. The final examination of the two classes was the same.

Table 1 shows the scores in theoretical mechanics and MMC obtained by students in the previous year (i.e., those who enrolled in 2020). No significant differences between the two teachers are evident.

The teaching method used in the control class was the same as the method used the previous year, that is, problem-based learning; in contrast, for the experimental class, the PL method was used. The first author randomly selected a class as the experimental class (n = 30), and so the third author taught another class as a control class (n = 31). Although students in the two classes were admitted with nearly the same scores in the college entrance examination, they exhibited significant differences in terms of their scores in theoretical mechanics during their third semester. Specifically, the mean scores of the experimental and control classes were 50.5 and 63.1, respectively, with a difference of –12.62 points and a single tailed p value of 0.009.

2.2 Course Design

The differences in the teaching process between the experimental and the control class are shown in Table 2, and the overall evaluation scores of both classes are calculated according to Formulae (1)–(3):

$$\textit{Overall evaluation score} = 0.6 \times \textit{Final examination score} + 0.4 \times \textit{Process score} \tag{1}$$

$$\textit{Process score} = \textit{Benchmark process score} + \textit{Bonus point} - \textit{Penalty point} \tag{2}$$

$$\textit{Benchmark process score} = \frac{1}{16}\sum_{i=1}^{16} (\textit{Homework score}) \tag{3}$$

The experimental class was divided into fixed groups to meet the requirements for peer learning, and benchmark process scores were assigned on a group basis; in contrast, the control class was focused on independent work on the part of individuals.

Table 1. Teachers' teaching results in the previous year

	Class 1 (n = 31)		Class 2 (n = 32)		Difference	
Course	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**Sig. (2-tailed)**
Theoretical Mechanics Scores	62.2	16.2	67.5	14.0	–5.3	0.164
Mechanics of Materials Scores	65.6	14.6	68.2	13.1	–2.6	0.461
Difference between the Two Scores	3.5	12.1	0.7	14.0	2.8	0.403

Table 2. Differences in the teaching process between the two classes

	Experimental class	**Control class**
Grouping rules	By student ID	No grouping
Problem-based learning	The teacher explains and analyzes the material when needed after mutual teaching	Teacher explains and analyzes all the questions
Homework	Doing homework in class	Doing homework after class
Discussion and assistance	Within the group	People sitting around
Marking of homework	One sample from each group is taken and graded on the spot	Everyone is graded after class
Feedback on homework	One-on-one feedback provided on the spot	Explanation of common errors in the following class
Benchmark process score	By group	By individuals
Bonus points	Lesson notes, active group interaction, actively asking the teacher questions	Actively asking the teacher questions
Penalty points	Late arrival and absenteeism	Absenteeism

3. Research Tools and Instruments

The purpose of this study is to determine whether PL learning offers significant benefits with regard to students' level of academic performance, character education, mental health, and curriculum evaluations. A psychological scale is used to measure the benefits with regard to mental health, structured interviews are used to measure the benefits with respect to character education, teaching evaluations, curriculum evaluations, etc., and final examination scores are used to measure academic benefits.

3.1 Questionnaire

The questionnaire contains many scales, and this study directly cites or translates scales that have been used in other studies. These questionnaires or scales have been widely used in related studies and have exhibited good reliability and validity. This study includes the Study Process Questionnaire [23, 24], the Academic Motivation Scale [25, 26], the California Critical Thinking Disposition Inventory [27–29], the Basic Empathy Scale [30–32], the Relatedness Scale [22, 33], the General Self-efficacy Scale [34, 35], and the Social Avoidance and Distress Scale [22, 36]. In addition, inspired by the relevant research on bullying in primary and secondary schools and workplaces [37–39], a campus soft bullying questionnaire for college students was developed.

The pretest and posttest of the questionnaire were conducted in the first and final weeks of the course, respectively. All scales in the questionnaire are 5-point Likert scales. The reliability of and usage instructions for the questionnaire are shown in Table 3.

3.2 Structured Interviews

Although semistructured interviews are commonly used in academia to collect data [40], structured interviews are relatively effective with respect to mitigating discrimination and bias [41, 42]. This study featured a structured interview that included 9 themes and a total of 85 questions, specifically including knowledge gain, character gain, course evaluations, evaluations of peer learning method, social avoidance alleviation, cooperation, seeking help, evaluations of assessment methods, and teacher evaluations. The entire interview process was recorded, and the interviewees sat alone in the middle of the room. The interviewees first read out the questions themselves and then answered them.

3.3 Final Examination

The final examination is a closed book exam that features a total score of 100 and was designed by the third author. The test paper includes 6 types of questions, i.e., Q1: multiple-choice questions, Q2: short answer questions, Q3: internal force diagrams, Q4: stress calculation for tension and compression bar, Q5: a strength and stiffness check of a single span beam, and Q6: a strength check of compression bending combined deformation.

According to Bloom's Taxonomy [43, 44], all questions are divided into six levels, which are listed from low to high as follows: knowledge, comprehension, application, analysis, synthesis, and evaluation. The specific distribution of scores is shown in Table 4. The reliability coefficient α of the final examination is 0.80 according to the results of a reliability analysis conducted using SPSS software.

3.4 Data Analysis

In this quasi experimental study, the experimental and control classes completed the same questionnaire survey, interview and final examination simultaneously, and a large amount of quantitative data featuring a small number of open answers were obtained; thus, both quantitative and qualitative analyses are needed.

3.4.1 Quantitative Analysis

Statistical analysis, analysis of variance, t tests, reliability analysis, and nonparametric testing were performed using SPSS 18 software to obtain the means, variance, significance, reliability, and other aspects of the data.

Table 3. The reliability and usage instructions of the questionnaire

Scale	Cronbach's α	N of Items	Score range	Usage instructions
The Study Process Questionnaire	0.818	20	20–100	>60: Positive
The Academic Motivation Scale	0.934	30	30–150	>90: Positive
The California Critical Thinking Disposition Inventory	0.881	20	20–100	>60: Positive
The Basic Empathy Scale	0.745	20	20–100	>60: Positive
The Relatedness Scale	0.912	20	20–100	>60: Positive
The General Self-Efficacy Scale	0.873	10	10–50	>30: Positive
The Social Avoidance and Distress Scale	0.920	28	28–140	>84: Positive
The Campus Soft Bullying Scale	0.936	25	25–125	>25: Positive

Table 4. Scores on the final examination were classified according to Bloom's taxonomy

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Sum
Q1	6		3			6	15
Q2		15					15
Q3			20				20
Q4				15			15
Q5					20		20
Q6					15		15
Sum	6	15	23	15	35	6	100

Note: the numbers in the table represent the full scores on the questions.

3.4.2 Qualitative Analysis

The first author completed the preparation, organization, implementation, and coding of the interviews to eliminate errors caused by different implementers. First, the initial thematic framework was roughly determined based on the process of peer learning. The questions under each theme were listed as much as possible with brainstorming methods, and 85 questions were ultimately determined and retained. After the research objectives and issues were further clarified, inductive analysis was used to ultimately summarize all of the questions into 9 themes, which are still within the initial thematic framework.

4. Results

4.1 Questionnaire

Thirty and thirty-one questionnaires were distributed to the experimental and control classes, respectively; twenty-six and twenty-eight valid questionnaires were collected in the pretest, while twenty-nine and twenty-three in the posttest, and twenty-five and twenty-one questionnaires could be paired, respectively. Only paired questionnaires were used for the analysis to ensure the comparability of the results, and the results are shown in Appendix A.

4.2 Structured Interviews

Twenty-eight and twenty-three participants from the experimental and control classes, respectively, were interviewed. Respondents were encouraged to provide open-ended answers, and the results of the qualitative analysis are shown in Appendix B. However, most respondents responded with simple answers of 'yes' or 'no'. After the answers were digitized, with 0 representing no, 1 representing neutral, and 2 representing yes, the quantitative research and analysis were conducted, and the results are shown in Table 5.

4.3 Final Examination

Overall, 27 and 30 students took the final examination for theoretical mechanics, and 30 and 31 students took the final examination for MMC. The results of the t test for the scores and pass rates of the two courses are shown in Table 6. The specific score shown in Table 6 is the final examination score, and whether the students passed depends on the overall evaluation score.

5. Findings

The research objective of this paper is to determine whether the academic, character, mental health, and satisfaction benefits of peer learning in the mechanics of materials course exhibit significantly improvements over the benefits obtained by the control class. For the convenience of indexing, Table 7 presents a matrix of all tools and data supporting all the research questions in this study.

5.1 Academic Benefits

The results of the quantitative analysis of the inter-

Table 5. Quantitative analysis results of the interview

				Experimental		Control		Difference	
Item	Cronbach's α	N of Items	Positive	Mean	SD	Mean	SD	Mean	sig.
Knowledge gain	0.662	15	>15	20.5	4.4	18.1	5.5	2.38	0.093
Character gain	0.823	10	>10	16.6	3.9	14.0	5.4	2.60	0.052
Learning method	0.829	10	>10	18.4	2.4	9.3	2.5	9.10	0.000
Relieving social avoidance	0.741	5	>5	9.2	1.1	8.1	2.6	1.05	0.058
Interactive discussion	0.384	5	>5	7.4	2.2	7.9	1.9	–0.48	0.416
Evaluation of teachers	0.806	10	>10	23.0	6.6	24.3	3.4	–1.36	0.377

Note: the significance in the table is 2-tailed.

Table 6. Results regarding the final examination scores and pass rate

Item	Experimental		Control		Difference	
	Mean	SD	Mean	SD	Mean	sig.
Mechanics of materials						
Q1	8.5	3.7	7.9	3.8	0.56	0.557
Q2	8.7	4.6	10.7	4.9	–2.01	0.104
Q3	13.4	4.3	15.4	4.4	–1.95	0.086
Q4	9.2	2.9	9.5	2.6	–0.32	0.658
Q5	9.6	5.7	8.6	6.9	1.02	0.534
Q6	7.0	4.6	6.4	5.1	0.68	0.587
Total score	56.5	18.6	58.5	21.6	–2.02	0.698
Pass	0.90	0.30	0.84	0.37	0.06	0.487
Theoretical mechanics						
Total score	50.5	18.8	63.1	20.2	–12.62	0.018
Pass	0.70	0.47	0.83	0.38	–0.13	0.252
Progress between two courses	9.3	14.5	–3.6	12.7	12.89	0.001

Note: the significance in the table is 2-tailed.

Table 7. Matrix of Data Supported Research Problems

		Academic benefits	Character benefits				Mental health benefits		Evaluations benefits
			Moral	Civic	Behavioral	Intellectual	Bullying	Social Avoidance	
Questionnaire	1. Study Process					○√			
	2. Academic Motivation					○√			
	3. Critical Thinking					○√			
	4. Basic Empathy							○	
	5. Relatedness						○		
	6. Self-Efficacy				○				
	7. Social Avoidance						○√		
	8. Campus Soft Bullying							○√	
Interviews	1. Knowledge benefits	○√							
	2. Character benefits			○√			○√		
	3. Course experience								○√
	4. Teaching methods		○√						○√
	5. Social avoidance						○√	○√	
	6. Interactive discussion							○√	
	7. Seeking help		○√	○√					
	8. Group assessment								○√
	9. Teacher evaluation								○√
Final examination		○√			√				

Note: ○ – designed tools, √ – ultimately adopted tools.

views (Table 5) show that the academic benefits obtained by the experimental class are significantly higher than those obtained by the control class ($p = 0.093$). Although no significant differences were observed in the total final examination scores, given that the scores attained by the experimental class in the theoretical mechanics course were 12.6 points lower than those attained by the control class ($p = 0.018$), these findings indicate that the experimental class made great progress by eliminating this difference. The experimental class exceeded the control class by 12.89 points in terms of score growth between the theoretical mechanics course and the mechanics of materials course ($p = 0.001$). This finding proves that the peer learning method can significantly improve the academic benefits of the mechanics of materials course.

Furthermore, the experimental class scored higher on Q1, Q5, and Q6, which pertain to high-level knowledge, and lower on questions Q2, Q3, and Q4, which indicate low-level knowledge according to Bloom's Taxonomy as shown in Table 4.

5.2 Character Benefits

Character education has rich connotations, which can be divided into moral character, civic character, behavioral character and intellectual character [45].

This research studies mainly the integrity (moral character), cooperation and dedication (civic character), self-discipline and struggle (behavioral character), and curiosity and critical thinking (intellectual character) that peer learning can promote. Overall, the experimental class achieved more moral gains than the control class ($p = 0.052$), as shown in Appendix B.

5.2.1 Integrity

Searching for information online is indeed a convenient, fast, and effective learning method; however, copying answers from online sources to obtain better process scores is a form of academic misconduct. This behavior is prohibited but difficult to detect. The interview results (Appendix B.) show that 60% of the students in one class and 90% of the students in the other class searched for answers online, thereby exhibiting significant differences ($p = 0.024$). On the one hand, these differences are due to the fact that a focus on completing homework in class allows teachers to supervise students effectively and prevent them from having the opportunity to cheat. On the other hand, in this context, it is convenient to ask questions of team members or teachers in peer learning; thus, there is no need to cheat. In summary, peer learning indeed had significant benefits for students' moral character.

5.2.2 Cooperation and Dedication

Teamwork is one of the most important non-technical skills for civil engineering students [46]. The randomly selected collective scores method is a way to implement shared responsibility for consequences, which may lead to difficulties from the perspective of personal interests. However, according to the interview results, more students in the experimental class believed that their teamwork skills had improved ($p = 0.060$), thus implying that effective interaction was more frequent in the experimental class. In addition, when they encountered difficulties, more students in the experimental group first sought help from their teammates ($p = 0.052$). This finding indicates that the experimental class exhibited higher teamwork ability and dedication.

5.2.3 Self-Discipline and Struggle

Behavioral character is a valuable quality that promotes success. If a person is anxious, has an inferiority complex, or experiences self-doubt, it is difficult for them to control their life. In contrast, if a person is disciplined, confident, self-satisfied, and exhibits a spirit of struggle, they can often achieve their goals in their work. The interview results show that in terms of alleviating anxiety as well as promoting confidence and self-satisfaction, the experimental class attained slightly better results than the control class.

5.2.4 Curiosity and Critical Thinking

The experimental class scored significantly lower in deep approach ($p = 0.020$) and learning motivation ($p = 0.089$) in the pretest than the control class, while no differences between the two groups were observed in the posttest. After peer learning, the improvements in deep approach ($p = 0.005$) and critical thinking ($p = 0.011$) attained by the experimental class were statistically higher than those attained by the control class. This finding shows that the experimental class improved significantly in terms of deep approach, learning motivation and critical thinking.

5.3 Mental Health Benefits

Mental health issues are a broad concept, and the aforementioned character education is essentially also a part of mental health. This article discusses only campus soft bullying and social avoidance in this section.

5.3.1 Campus Soft Bullying

The experimental class scored significantly higher than the control class in the pretest with regard to campus soft bullying ($p = 0.041$), but no significant difference between the two classes was observed in the posttest, thus indicating that peer learning significantly alleviated campus soft bullying. This impact may be due to the fact that peer learning promoted mutual understanding among classmates and changed their impression of others ($p = 0.036$), improved communication ($p = 0.075$), and made new friends ($p = 0.002$), as shown in Appendix B.

5.3.2 Social Avoidance

According to the interview results, the consensus between the two classes indicated that social avoidance was the most common reason that prevented students from participating more actively in collaborative discussions. The topic of social avoidance was investigated in both questionnaires and interviews. According to the results of the questionnaire survey, the social avoidance situation in the experimental class improved slightly, while that of the control class remained almost unchanged. More specifically, the pretest scores of the experimental class were slightly higher than those of the control class, while their posttest scores were slightly lower. According to the interview results, the experimental class was more able to express their true meaning ($p = 0.013$), thus also indicating that their social avoidance had improved. Finally, the experimental

class performed significantly better in relieving social avoidance ($p = 0.058$), as shown in Table 5.

5.4 Satisfaction Benefits

The two classes exhibited some common satisfaction benefits, as shown in Appendix B. Most students in both classes are satisfied with the overall process of the course, the amount of homework, and the evaluation of the teacher. According to the interview results, although there were almost no differences between the two classes in terms of in teacher evaluations, more students in the control class preferred classes from other teachers ($p = 0.016$), which in turn indicates that more students in the experimental class preferred this course. In addition, the experimental class believed that their efficiency in class was high ($p = 0.089$), indicating that the experimental class was able to solve most problems in class, while the control class needed to spend more time performing work outside class. Finally, the control class preferred independent learning ($p = 0.072$), which in turn indicated that the experimental class was more satisfied with the interactions and mutual teaching associated with the peer learning experience. In summary, the experimental class outperformed the control class in terms of overall satisfaction, teaching methods, teacher evaluations, and course evaluations.

6. Discussion

To answer the four questions raised in the introduction of this paper, this study employed a quasi experimental approach featuring the peer learning method in a mechanics of materials course. The final examination, questionnaire survey, and structured interviews were used as research tools to obtain answers to the questions.

Answer 1: Academic Benefits

Peer learning exhibited significant improvement in the experimental class, confirming its significant academic benefits. The improvement of the experimental class between the theoretical mechanics course to the mechanics of materials course was 12.89 points ($p = 0.001$) higher than that of the control class and reached an equal score in the mechanics of materials course given that the experimental class's score in the theoretical mechanics course was 12.6 points lower than that of the control class ($p = 0.018$).

Answer 2: Character Benefits

The experimental class achieved more significant progress than the control class in terms of integrity (moral character), cooperation and dedication (civic character), self-discipline and struggle (behavioral character), and curiosity and critical thinking (intellectual character) as revealed by the interviews and the comparison between the pre - and posttests of the questionnaire survey.

Answer 3: Mental Health Benefits

The experimental class achieved greater success in the task of eliminating and reducing campus soft bullying and social avoidance than the control class. Specifically, the gap between the experimental class and the control class was eliminated after peer learning ($p = 0.041$), social avoidance was reduced ($p = 0.058$) and members of the class were more able to express their true meaning ($p = 0.013$).

Answer 4: Satisfaction Benefits

The experimental class achieved great success in terms of satisfaction, with more students believing that learning in class is more efficient than learning outside class ($p = 0.089$), and the design of the learning process made them more responsible ($p = 0.013$) and efficient ($p = 0.004$). Fewer students in the experimental class claimed that they preferred courses taught by other teachers ($p = 0.016$).

Nevertheless, one of the limitations of this article is that, more effective methods are still needed for measuring abstract personality traits in the future, such as self-discipline and struggle, whereas only interview and final exams were used in this article. This article assumes that all other factors of the same person can be considered to be basically stable in the short term, and the self-discipline and struggle are positively correlated with academic performance, when one is compared to themselves rather than to others. When one study hard, the grades will improve, otherwise, the grades will deteriorate. Some people may claim to study very hard but still not as well as others, which may be a bluff (they are not working as hard as they said); however, it may also be true because there are many other factors that affect them (such as intellectual level, learning disabilities, or mental illness). Therefore, it is hoped that more appropriate methods can be used for more in-depth research in the future.

7. Conclusions

The experimental class achieved 12.89 points more progress than the control class in academic performance, more effective in the promotion of integrity, cooperation and dedication, self-discipline and struggle, and curiosity and critical thinking than the control class, better response in reducing campus soft bullying and social avoidance than the control class, and more satisfaction about the teacher and the course than the control class. Overall, peer learning in this study has significantly

improved students' academic, character, mental health, and satisfaction benefits.

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Appendix A

T test results of the questionnaire

Item	Pretest						Posttest						Advances					
	Treatment		Control		Difference		Treatment		Control		Difference		Treatment		Control		Difference	
	Mean	SD	Mean	SD	Mean	sig.	Mean	SD	Mean	SD	Mean	sig.	Mean	SD	Mean	SD	Mean	sig.
Deep approach	60.2	9.5	66.7	8.7	–6.5	0.020	64.4	7.5	65.1	7.6	–0.7	0.743	4.2	7.1	–1.6	6.2	5.8	0.005
Motivation	97.1	14.8	104.2	12.7	–7.1	0.089	108.7	12.0	112.4	12.4	–3.7	0.311	11.6	13.2	8.1	8.6	3.4	0.314
Critical thinking	73.6	9.2	76.2	4.7	–2.6	0.252	81.6	8.6	78.3	5.6	3.3	0.139	8.0	8.3	2.1	6.3	5.9	0.011
Empathy	71.2	10.1	70.7	4.0	0.4	0.849	70.5	7.2	70.7	6.4	–0.1	0.943	–0.6	6.5	0.0	4.4	–0.6	0.725
Relatedness	76.6	11.9	78.7	11.1	–2.1	0.546	77.6	11.8	79.8	9.2	–2.2	0.497	1.0	9.9	1.0	8.3	–0.1	0.974
Self-efficacy	32.6	5.4	32.5	5.6	0.1	0.940	35.4	4.9	35.8	5.5	–0.4	0.789	2.8	4.4	3.3	4.6	–0.5	0.690
Soft bullying	46.0	14.6	38.1	10.1	7.9	0.041	48.8	13.0	46.1	10.4	2.7	0.454	2.7	12.2	8.0	12.1	–5.3	0.149
Social avoidance	83.9	18.8	81.4	13.1	2.5	0.605	81.1	10.4	81.6	13.5	–0.5	0.879	–2.8	12.6	0.2	6.0	–3.1	0.311

Note: the significance in the table is 2-tailed.

Appendix B

Identified themes and interview transcripts

	Consensus (sig. > 0.1)		**Difference (sig. ≤ 0.1)**	
Theme	**Category (sig.)**	**(Percentage) Particulars**	**Category (sig.)**	**(Percentage) Particulars**
Theme 1: Knowledge benefits	Basic deformation (NA); Strength (0.138); Stiffness (0.742); Internal force diagram (0.753); Pressure bar stability (0.751).	**(100, 82, 82, 96, 32)**; *(100, 70, 78, 96, 43)*;	Stress of T-shaped section (0.009); Hollow design (0.000); Complex stress state (0.059); Stress-circle (0.030); Combined deformation (0.099).	**(71, 82, 68, 68, 54)** *(39, 22, 43, 30, 74)*
Theme 2: Character benefits	Expression (0.285); Listening (0.295); Relieving anxiety (0.285); Self-confident (0.158); Self-satisfaction (0.255); Interest in learning (0.143).	**(86, 96, 79, 89, 79, 89)**; *(70, 87, 61, 70, 65, 70)*	Communication situation (0.075); Teamwork (0.060); New friends (0.002).	**(82, 100, 68)**; *(57, 89, 30)*
Theme 3: Course experience	Challenging (0.189); Exhausted (0.824). Reasons for learning or not	**(74, 19);** *(59, 17)* Useful, n = 13; Graduation, n = 12; Interested, n = 7; Postgraduate studies, n = 5; Boring, n = 8	Effective in class (0.089).	**(86)**; *(65)*
Theme 4: Teaching methods	Overall process (0.802); Workload (0.986); Hoping that other courses follow (0.350).	**(89, 89, 82)**; *(87, 87, 65)*	Sequential grouping (0.000); Collective scores (0.000); Seating by group (0.000); Homework in class (0.000); Face-to-face correction (0.000); Bonus points (0.000); Penalty points (0.000).	**(79, 96, 93, 89, 89, 100, 93)**; *(0, 43, 35, 26, 26, 61, 0)*
Theme 5: Social avoidance	More relaxed (0.136); Treated in a kindlier manner (0.837); Courageous expression (0.362).	**(96, 54, 86)**; *(87, 57, 74)*	Changing perceptions of others (0.036); Expressing true meaning (0.013).	**(96, 100)**; *(74, 78)*
Theme 6: Interactive discussion	Prefer discussion over lectures (0.268); Being taught (0.795); Teaching others (0.778). Reasons for preventing interaction	**(82, 79, 29)**; *(70, 83, 22)* Social avoidance n = 9; Poor academic performance n = 8; Good academic performance n = 6; Lack of interest n = 5	Prefer independent learning (0.072)	**(46)**; *(70)*
Theme 7: Seeking help	Problem solved (0.940); Encouraged to seek help (0.753)	**(93, 96)**; *(91, 96)*	Prefer team member (0.052); Searching for homework answers online (0.024); Seeking help from teachers/team members/friends;	**(32, 60, 21, 32, 46)**; *(9, 90, 22, 9, 65)*
Theme 8: Group assessment	Urging everyone to work harder (0.137)	**(100)**; *(91)*	Enhancing a sense of responsibility (0.013); Increasing efficiency (0.004); Social loafing (0.000); Unable to team up with friends (0.008).	**(100, 93, 0, 0)** *(78, 61, 39, 26)*
Theme 9: Teacher evaluation	Academic level; Teaching skills; Humanistic care	Both Positive	Prefer classes from other teachers (0.016)	**(7)**; *(30)*

Note: 1. the percentages in bold black font pertain to the experimental class, while the italicized blue percentages pertain to the control class; 2. the significance in the table is 2-tailed.