

The Application of Cooperative Project-Based Learning in Engineering Drawing Course to Enhance Students' Teamwork Skills

Lina Indawati

Department of Civil Engineering, Faculty of Engineering, Universitas Sebelas Maret, 57126,
Surakarta, Indonesia

linainda@staff.uns.ac.id

Abstract

Social skills are a serious concern because that are gaps between corporates and academic engineering when engineering graduates lack adequate social skills. One of the most important social skills is teamwork skills. The development of teamwork skills among students can be gained from a learning activity of a course. The objective of this study is to identify the challenge and impact of cooperative project-based learning in engineering drawing course to enhance students' teamwork skills. Several students who had experience cooperative project-based learning in engineering drawing course were interviewed using a questionnaire. The results show how cooperative project-based learning develops students' teamwork skills and the challenge of its application during the engineering drawing course to prepare them for the real world.

Keywords

Cooperative project-based learning, engineering drawing course, teamwork skill

1. Introduction

One of the important skills that must be owned by engineering students besides technical skills is social skills when they come to actual practices. Social skills include the abilities such as to represent a team, to succeed as a team, to share team goals, decision-making, to control emotion among a team, to construct and to maintain relationships in a team (Apte and Gudipudi 2020, Wu et al. 2021). Social skills are a serious concern because work problems do not only from technical part. Those become a gap between corporate and academic when graduates do not have sufficient social skills (Apte and Gudipudi 2020). One of the most important social skills needed by engineering students is teamwork skills (Aranzabal et al. 2022). Teamwork skill is the ability to cooperate with others in a team. Collaboration between technical skills and teamwork skills is necessary in the future to create social-economic development (Ananiadou & Claro 2009, Binkley et al. 2012) (Veldmen et al. 2020). Engineers must have teamwork skills because most engineering projects involve many expertise areas in one team. If the collaboration in a team does not go well, the project handled also does not go well. The development of teamwork among students can be gained from the learning activities of a course. Learning methods that introduce teamwork skill are cooperative learning (Azizan et al., 2018) and project-based learning (Ricaurte and Vilorio 2020). Cooperative learning is a learning approach that improves cognitive learners' achievement (academic learning) and social-emotional outcomes (social learning) (Veldmen et al. 2020, Liebech-Lien 2021). Project-based learning is learning approach designed as an ended project which develops critical analysis skills and deeper learning such as effectively self-monitoring and self-regulating for group tasks (Butterfield et al. 2015, Viguri et al. 2020). By combining both cooperative learning and project-based learning in engineering drawing, students are guided to enhance their technical skill and teamwork skill. In engineering drawing courses, it can be arranged by forming groups and accompanied by case study projects that reflect the actual practices. However, it is necessary to know how cooperative project-based learning enhance the students' teamwork skill in engineering drawing course besides the challenges and the impact of applying it.

1.1 Objectives

The objective of this study is to identify the challenge and impact cooperative project-based learning in engineering drawing course to enhance students' teamwork skill

2. Literature Review

2.1 Cooperative Learning

Cooperative learning is another method of learning which reduce an individualistic behavior among the students (Del C. et al. 2015). Cooperative learning is developed with a team who has goal and has to complete learning task together. Each member of a team must support each other to achieve a successful goal. There is promoted interactions to improve team work, build trust and encourage communication. In cooperative learning, each learner must learn from each other and able to reflect upon own group-learning experiences, then, the social skill will be developed (Johnson & Johnson 1989). Moreover, a lecturer has role as an instructor in organization and facilitation, including assigning groups, coordinating the learning progress, and evaluating student productivity (Johnson et al. 1998). There several factors that determine effective cooperative learning such as cooperation each learner among group members; development a cooperative learning environment; (1) positive interdependence, (2) individual accountability, (3) quality of group processing, (4) teaching of cooperative skills, and (5) teaching of social skills. Positive interdependence was a condition which develop learners to have responsibility sharing unique contribution in a team. Individual accountability was the element, which provided for each student believing that it was important for him/her to learn the material. Quality of group interaction process was the process to develop interaction among students where activeness in expressing opinions and mutual support for each other is very important in cooperative learning. Teaching interpersonal and small group skills was placing unskilled student in groups and instructor support them to learn the task, maintain groups skill and teach them explicitly how to cooperate with others. The cooperative learning environment is developed to assist students to decrease their reliance on authority, improve recognition of peers as legitimate learning source, and increase students' self-confidence levels. (Muellerjoseph & Nappodattoma 2013) (Zhang et al. 2021). Teaching of the social skills is an activity which encourage student to have leadership, communication skill, teamwork skill and motivation in learning by themselves. (Azizinezhad et al. 2013). However, the implementation of cooperative learning will be fail if the instructor is not being to implement the cooperative structure carefully and just put the students into groups to learn and didn't structure the positive interdependence and individual accountability. Moreover, cooperative learning more concern about social skill than technical skill (Turco and Elliott 1990). Another cooperative learning limitation resided in the differences of opinion regarding driving conflict or pursuing consensus among team members (Tsai 1998, Azizinezhad et al. 2013)

2.2 Project based learning

Project based learning was learning approach that engages learner knowledge construction by giving them accomplish meaningful projects based on real problem and develop real-world product (Yague et al. 2010) (Brundiens and Wiek, 2013, Guo et al. 2020). In project based learning, instructors engage learners through a structured identification, authentic questions and carefully designed projects and task (Markham et al. 2003, Pan et al. 2021). First step of project based learning development among learners was heterogeneous team formation. Instructor gives project assignments which contains team work basic material with limited time. these assignments contain learning objectives, grading criteria, team policies, a peer rating form of team members' contributions to the team, and the required tasks. Each assignment consists of planning, scheduling, discussion, collaboration, writing report, and presentation. Then individual performance and team performance were evaluated and graded (Younis et al. 2021).

3. Methods

In this part, several steps was contrived to carried out cooperative project based learning in engineering drawing course. The steps consisted of course introduction, team formation, project briefing, grading criteria and policy, course engagement (Fig. 1). The detail steps can be seen below.

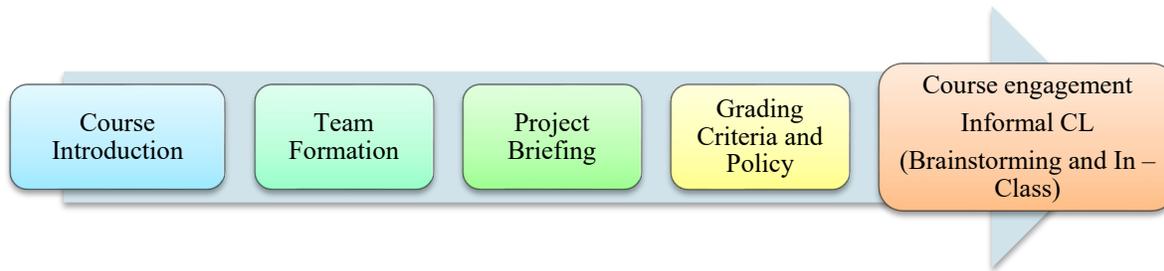


Fig. 1 Several steps in cooperative project based learning in engineering drawing course

3.1 Course Introduction

A lecturer was mentioned here as instructors. The instructor introduced the course by explaining the lesson plan. The instructor explained the learning objectives to be achieved as well as the benefits of the course for real life when students entered the community. The instructor explained what material will be studied during the lecture.

3.2 Team Formation

Students who attended lectures were asked to introduce themselves to the instructor then the instructor identified the learner's ability from the GPA obtained. Teams were formed by instructors based on various GPA scores. After the teams were formed, each team was given motivation that each individual had the ability and opportunity to successfully master the subject being studied. Every learner had to trust and support each other.

3.3 Project Briefing

At this stage the learners were explained the rules during the lecture and how the learners were assessed. The instructor explained that she was a facilitator who helped students master the subject being studied. At this stage, it was explained what projects they would work on during the lecture. Each team that had been formed was considered as a consultant who provided drawing services for housing equipped with sanitation.

3.4 Grading Criteria and Policy

There were two assessment criteria, namely the assessment of individual and team performance. Each individual was judged by his activeness in a team, discipline in how to express opinions, support his friends, and his team. In addition, each individual was tested with several interview questions in the middle semester and final semester related to their project. Team assessment was based on the success of working on the project starting from the concept, neatness of the image and teamwork. Each individual had not to have an individualistic nature and had to support each other. If one member has an individualistic nature, the team value was reduced. If there were team members who were not active, the assessment points were deducted. In addition, if the teams had good cohesiveness, they were given an award or more points.

3.5 Course engagement

Each team was given the freedom to express design ideas based on what they learn in the real world and technical drawing theory. Each person was given their respective responsibilities according to their part and is responsible for explaining to other members who have different responsibilities. Tasks were sequential series so that if the first one was not completed then the next sequence cannot work on the next task. The team was conditioned as if it were a consultant handling a house design project. The instructors here act as advisors, facilitators during project consultations and also clients during project demonstrations. There were two types of activities, namely activities that must be completed in class and projects that were assigned to the team. Activities in the classroom were in the form of mastery processes related to the basic theory of drawing and basic drawing exercises for each individual in the team. In this activity, there were discussions related to theory and drawing skills between instructors and learners, each learner with other each learner. This activity was a learning process that supports learners in

completing project assignments. Brainstorming and In-class team as informal cooperative learning activities methods (Yusof et al. 2016) were used in the class. This activity was carried out in the first and third weeks. The second activity was the assignment of the team to complete the project. Each team consulted the instructor in the second and fourth weeks. In the middle of the semester, each team will present their project progress. At the end of the semester, each team presents their final project. In addition, each individual is evaluated by interview in the middle and end of semester.

4. Data Collection

There were 31 students who had experienced cooperative project-based learning were given a questionnaire via a google form. The questionnaire contained several questions related to their learning experiences in cooperative project based learning. The questionnaire consisted of 11 closed questions and 2 open questions. Then the results of the questionnaire were analyzed statistically. The questions can be seen in Table 1 and Table 2.

Table 1. The detail closed questions of survey via a google form

No	Questions	Strongly disagree	Disagree	Slightly agree	Agree	Strongly agree
		1	2	3	4	5
1	Cooperative project-based learning in the engineering drawing course helped me to understand the basics and applications it when I got into actual practice					
2	Cooperative project-based learning in the engineering drawing course improved my learning ability.					
3	Cooperative project-based learning in engineering drawing courses improves my technical skill of civil engineering.					
4	Cooperative project-based learning in the engineering drawing course sharpened my ideas, logic-thinking skills when working in a team.					
5	Cooperative project-based learning in the engineering drawing course improved my social skills (communication, leadership, and decision making) when working in a team.					
6	Cooperative project-based learning in the engineering drawing course improves the ability to work in teams (team work skills).					
7	Cooperative project-based learning in the engineering drawing course helps me to respects the others' opinions when working in a team.					
8	Cooperative project-based learning in the engineering drawing course trained me to be able to discuss in an academic manner when working in a team.					
9	Cooperative project-based learning in the engineering drawing course helps me manage my time and respect other people's time when working in a team.					
10	Cooperative project-based learning in the engineering drawing course helps my team to complete project assignments well.					
11	Cooperative project-based learning in the engineering drawing course provided a challenge and a valuable experience for me.					

Table 2. The detail open questions of survey via a google form

No	Questions	Answer
1	Mention the challenges when taking engineering drawing lectures with cooperative project-based learning methods?	
2	Mention the obstacles when participating in engineering drawing lectures with cooperative project-based learning methods?	

The close questionnaire was analyzed statistically using eq. 1-3 and validated using eq. 4.

Mean equation

$$\bar{x} = \frac{f_1x_1 + f_2x_2 + f_3x_3 \dots + f_nx_n}{f_1 + f_2 + f_3 + \dots + f_n} \quad (1)$$

$$\bar{x} = \frac{\sum_{i=1}^n f_i x_i}{\sum_{i=1}^n f_i} \quad (2)$$

Standard deviation

$$S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}} \quad (3)$$

Reability

$$r_x = \left(\frac{n}{n-1}\right) \left(1 - \frac{\sum \sigma_t^2}{\sigma_t^2}\right) \quad (4)$$

Where x_i is all samples of the x-values, \bar{x} is sample mean, n is the number of item in sample, \sum is summation notation, f_i is frequence of samples, S is standard deviation, r_x is reability, σ_t^2 is population variance (Hidayati et al. 2019).

5. Results and Discussion

The respondents were students at the civil engineering vocational school who had experience cooperative project-based learning in engineering drawing course. Some of the respondents were students who took an engineering drawing course before pandemic. Others respondents were students who studied engineering drawing during pandemic. The survey results show that 52%-65% of student agree, 32%-48% student strongly agree and 3.2%-12.9% slightly agree if cooperative project-based learning helps them to understand basic and applications when they get in actual practice, to improve their learning ability, to improve their social skill especially team work skill, to train them communication in academic manner, to improve their technical skill in engineering drawing, and time management. The improvement of social skill such as communication, leadership, decision making and also others skills enhance their team work skill and help them to accomplish the assigned project. However, 3% of student feel

if it do not give them a challenge and a valuable experience (Fig. 2). As such, the instructor should be more paying attention each student especially in online learning to challenge and encourage them.

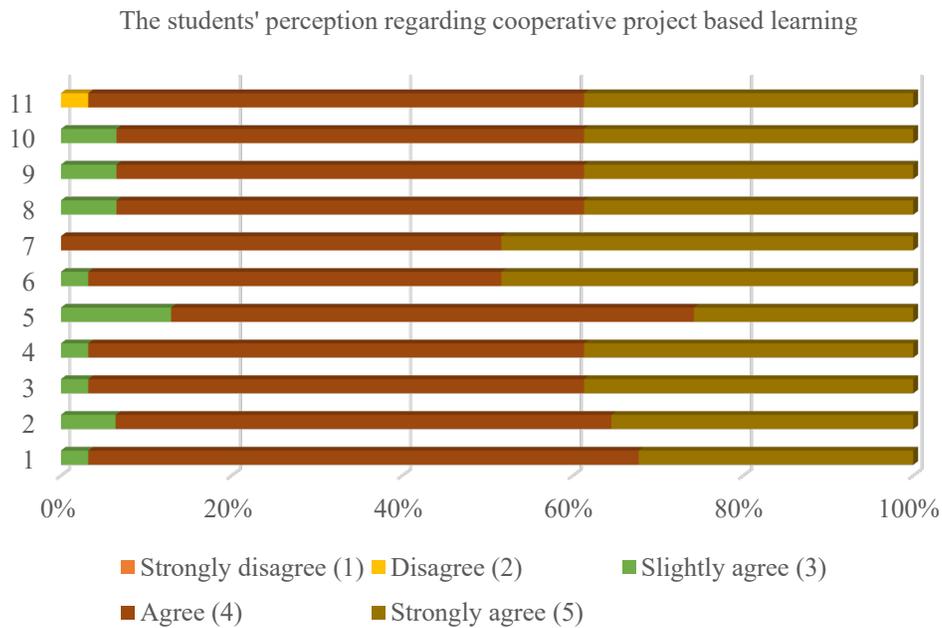


Fig. 2 The students' perceptions regarding cooperative project-based learning

Most of the students are very enthusiastic about cooperative project-based learning. In the initial phase of introducing this learning system, not only students experienced difficulties but also they are challenged. Their biggest challenge is related to social skills such as the ability to communicate between members in the team, dividing tasks fairly, respecting the opinions of others, and motivating friends to take responsibility. The next challenge is self-study motivation while they had to work well in a team and to gained technical skills related to the accuracy and precision of drawing (technical skill). In addition, it is related with time management because they must share their time with other subjects (Fig.3).

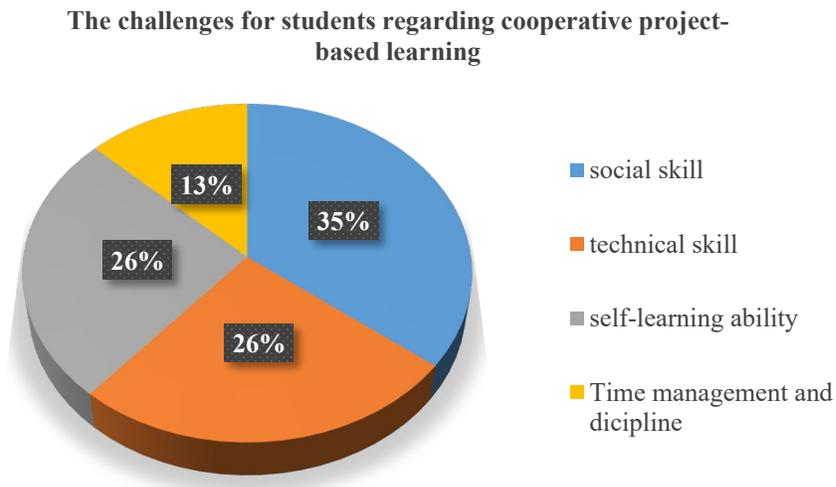


Fig. 3 The students' challenges for learners regarding cooperative project-based learning

At the beginning of the introduction of cooperative project-based learning, many difficulties are faced by students. The main difficulty experienced was the disruption of communication (social skill), especially during a pandemic due to network disruption when the system was online. They also had difficulty managing time with other subjects. Others obstacles were adaptation and lack of basic knowledge related to civil engineering because they were still in the first year of college (technical skill) (Fig. 4). Some students also felt less guided. Based on these obstacles, in the future, instructors must improve the online learning methods and tools so that cooperative project-based learning runs well.

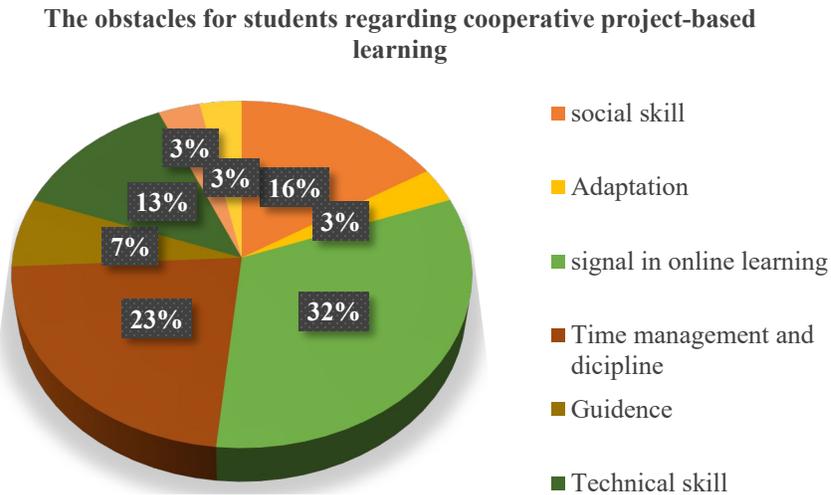


Fig. 4 The students' obstacles for learners regarding cooperative project-based learning

5.1 Validation

To find out students' perceptions regarding the challenges and impacts of cooperative project-based learning in engineering drawing courses to enhance students' teamwork skills, a close questionnaire with 11 questions was distributed to 31 civil engineering vocational school students who had experienced cooperative project-based learning in engineering drawing courses. The results of the questionnaire can be seen in table 3 showing a mean value of 4.13-4.35. This value shows that the students agree that these activities have an impact and challenge in improving on their team work ability. Then it is proven again by the standard deviation value with a range of 1.57-1.59 which the result of questionnaire tends to the right side (agree to strongly agree). Cronbach's α amount for the reliability of the questionnaire was 0.94. the reability value was very high. Thus, it indicated that the questionnaire result was reliable consistency (Parsazadeh et al. 2018)

Table 3. The validation result of close questionnaire proofed with mean value and standard deviation

No	Questions	Mean	Standar deviation
1	Cooperative project-based learning in the engineering drawing course helped me to understand the basics and applications it when I got into actual practice	4.29	1.57
2	Cooperative project-based learning in the engineering drawing course improved my learning ability.	4.29	1.57
3	Cooperative project-based learning in engineering drawing courses improves my technical skill of civil engineering.	4.35	1.59
4	Cooperative project-based learning in the engineering drawing course sharpened my ideas, logic-thinking skills when working in a team.	4.35	1.59

No	Questions	Mean	Standar deviation
5	Cooperative project-based learning in the engineering drawing course improved my social skills (communication, leadership, and decision making) when working in a team.	4.13	1.51
6	Cooperative project-based learning in the engineering drawing course improves the ability to work in teams (team work skills).	4.45	1.63
7	Cooperative project-based learning in the engineering drawing course helps me to respects the others' opinions when working in a team.	4.48	1.64
8	Cooperative project-based learning in the engineering drawing course trained me to be able to discuss in an academic manner when working in a team.	4.32	1.58
9	Cooperative project-based learning in the engineering drawing course helps me manage my time and respect other people's time when working in a team.	4.32	1.58
10	Cooperative project-based learning in the engineering drawing course helps my team to complete project assignments well.	4.32	1.58
11	Cooperative project-based learning in the engineering drawing course provided a challenge and a valuable experience for me.	4.32	1.58

6. Conclusion

Cooperative project-based learning can enhance teamwork skills. Based on the survey results, the challenges faced are uniting various opinions in a team, coordinating the team, and making detailed pictures, especially during a pandemic. Meanwhile, the obstacles faced are communication between teams especially during the pandemic, time management, adaptation to the learning system that had to coordinate and understand each other. Cooperative project-based learning also gives a positif impact on students' learning skill, technical skill dan social skill when their teamwork skill improved. Moreover, instuctor must concern methods and tools when cooperative project-based learning is implemented in online learning, so that it can run well. Therefore, further researchs regarding implementation of cooperative project-based learning in online learning and blended learning are needed.

References

- Ananiadou, K., & Claro, M. 21st century skills and competences for new millennium learners in OECD countries. Paris: OECD, 2009.
- Apte, Manoj and Gudipudi Dr. AsawariBhave. "Cooperative Learning techniques to bridge gaps in academia and." *Procedia Computer Science* 172 (2020): 289–295.
- Ananiadou, K., and Claro, M., *21st century skills and competences for new millennium learners in OECD countries*. OECD, Paris, 2009.
- Azizinezhad, M., Hashemi, M., Darvishi, S., Application of cooperative learning in EFL classes to enhance the students' language learning, *Procedia - Social and Behavioral Sciences* 93, 138 – 141, 2013.
- Azizan, M.T., Mellon, N., Ramli, R.M., Yusup, .S., Improving teamwork skills and enhancing deep learning via development of board game using cooperative learning method in Reaction Engineering course, *Education for Chemical Engineers* 2 2, 1–13, 2018.
- Aranzabal, A., Epelde, E., Artetxe, M., Team formation on the basis of Belbin's roles to enhance students' performance in project based learning." *Education for Chemical Engineers* 38 ,22–37, 2022.
- Butterfield, A.E., Branch, K., Trujillo, E., First-year hands-on design course: implementation & reception. *Chem. Eng. Educ.* 49, 19–26, 2015.
- Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., Defining twenty-first century skills. In P. Griffin, & E. Care (Eds.). assessment and teaching of 21st century skills, *Methods and approach* (pp. 17–66). 2012.

- Brundiers, K., and Wiek, A., Do we teach what we preach? an international comparison of problem-and project-based learning courses in sustainability, *Sustainability*, 5(4), 1725–1746, 2013.
- Del C, Martínez, R.R., Benítez C.L., Villanueva, I. M, Cooperative learning in the implementation of teaching chemistry, *Procedia - Social and Behavioral Sciences*, 174, 2920 – 2925, 2015.
- Guo, P., Saab, N., Post, L.S., Admiraal, W., A review of project-based learning in higher education: student outcomes and measures, *International Journal of Educational Research* , 02, 101586, 2020
- Hidayati, T., Handayani, I., Ikasari, I.H. *Fundamental Statistics*, CV. Pena Persada, 2019.
- Johnson, D. W., & Johnson, R. T, *Cooperation and competition: theory and research*. Edina, Interaction Book Company. MN, 1989.
- Johnson, D. W., Johnson, R. T., & Holubec, E., *Cooperation in the classroom*, 7th edition, Edina, Interaction Book Company, MN, 1998.
- Liebech-Lien, B. "Teacher teams- A support or a barrier to practising cooperative learning?", *Teaching and Teacher Education*, 106, 103453, 2021.
- Pan, G., Shankararaman, V., Koh, K., Gan, S., Students' evaluation of teaching in the project-based learning, *The International Journal of Management Education*, 19, 100501, 2021.
- Parsazadeh, N., Ali, R., Rezaei, M. A framework for cooperative and interactive mobile learning to improve online information evaluation skills, *Computers & Education* 120, 75–89, 2018.
- Muellerjoseph, L. J., & Nappodattoma, L., Collaborative learning in pre-clinical dental hygiene education, *Journal of Dental Hygiene*, 87 (2), 64–72, 2013.
- Markham, T., Larmer, J., and Ravitz, J., *Project based learning handbook: a guide to standards-focused project based learning* , 2nd edition, Novato, CA, Buck Institute for Education, 2003.
- Ricaurte, M., and Vilorio, A., Project-based learning as a strategy for multi-level training applied to undergraduate engineering students, *Education for Chemical Engineers* 33, 102–111, 2020.
- Turco, T., and Elliott, S. Acceptability and effectiveness of group contingencies for improving spelling achievement, *Journal of School Psychology*, 28, 27-37, 1990.
- Tsai, S., *The effects of cooperative learning on teaching English as a foreign language to senior high school students (Master's Thesis)*. National Kaohsiung Normal University, 1998
- Veldmen, M.A, Doolaarda, S., Boskera, R.J., Sniijdersb, T.A.B., Young children working together. cooperative learning effects on group work of children in grade 1 of primary education, *Learning and Instruction* 67, 101308, 2020.
- Viguri, J.R., Cifrian, E., Andrés, A., Galán, B., Javier R., Integration of different assessment approaches: application to a project-based learning engineering course, *Education for Chemical Engineers* 31, 62–75, 2020.
- Wu, H., Wang, C., Hu, B.Y., Li, Y., Vitiello, G., Preschool teachers' self-efficacy, classroom process quality, and children's social skills: a multilevel mediation analysis, *Early Childhood Research Quarterly* 55, 242–251, 2021.
- Yague, J.L., Diaz-Puente, J.M., Cazorla, A., Ríos, I., "Project-based learning in engineering higher education: two." *Procedia Social and Behavioral Sciences* 2 : 1368–1378, 2010.
- Younis, A., Sunderraman R., Metzler, M., Bourgeois, A.G. Developing Parallel Programming and Soft Skills: A Project Based Learning Approach, *Journal of Parallel and Distributed Computing*, 2021.
- Yusof, K.M., Hassan, S.A.H.S., Sadikin, A.N., Mustaffa, A.A., *Effective Implementation of student centred learning, part 1: engaging learners through active learning*, Center for Engineering Education Universiti Teknologi Malaysia, 2016.
- Zhang, J., and Chen, B., The effect of cooperative learning on critical thinking of nursing students in clinical practicum: a quasi-experimental study, *Journal of Professional Nursing* 37 , 177–183, 2021.

Biography

Lina Indawati is a lecturer in Civil Engineering in Faculty of Engineering at Universitas Sebelas Maret. Ms. Lina holds a Bachelor of Engineering degree in Environmental Engineering from Institut Teknologi Sepuluh Nopember and a Master of Engineering in Institut Teknologi Sepuluh Nopember and Asian Institute of Technology. She has been recognized as a professional environmental consultant with over 8 years of experience in working. She has taught courses in engineering drawing, environmental engineering, hydrology, hydraulics, and sciences. Her research interests include water and wastewater management, water and wastewater design, environmental management, hydrology, sewerage system, solid waste management, and LCA.