A Systematic Mapping Review on Cooperative and Collaborative Learning in Engineering and Computing

José Antonio Pow-Sang, Ph.D. in Informatics Engineering, Dennis-Cohn-Muroy, Msc. in Informatics, and Natali Flores-Lafosse, Msc. in Informatics
Pontificia Universidad Católica del Perú, Peru, {japowsang, dennis.cohn, natali.flores}@pucp.edu.pe

***Abstract*– Cooperative or collaborative learning is a type of active learning in which students have to work in groups. This paper aims to identify and to present the current research on cooperative and collaborative learning in Engineering and Computing that is available since 2012. A systematic mapping study was therefore performed to classify the selected studies using the following criteria: learning technique, undergraduate or graduate program, and research type. A total of 2999 studies were identified, of which only 112 studies were selected for this review. According to the analysis, problem-based learning is the technique with more studies published in Engineering and Computing.**

***Keywords*-- systematic mapping; cooperative learning, collaborative learning, engineering education, computing education.**

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I. INTRODUCTION

Cooperative and collaborative learning focuses on the premise that the students can learn better by doing and working with each other [9]. This kind of learning techniques is applied in engineering and computing education. Although the terms "cooperative" and "collaborative" have similar meanings, there is debate or discussion about when to apply one term or another about learning techniques, but both are types of group work. Agawa [1] points out that both cooperative and collaborative learning are based on two essential elements: positive interdependence and individual responsibility.

A systematic literature review is a method to analyze, evaluate and interpret all relevant studies to a particular research question, or specific area, or phenomenon of interest [6]. A systematic mapping review is a variant of this technique in which the evidence is plotted at a high level of granularity. Its main focus is rather on classification, conducting a thematic analysis and identifying publication fora [7].

This paper presents the results of a mapping study to identify and categorize a set of primary studies covering cooperative and collaborative learning in engineering and computing education.

The remainder of the paper is organized as follows: Section 2 describes the review process followed for the systematic review; Section 3 discusses our findings; and finally, conclusions and future work are included.

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II. REVIEW PROCESS

This study was conducted according to the guidelines established by Petersen et. al [7] and was based on the PICO (Population, Intervention, Comparison, Outcomes) method [1]. The definition of the general concepts through the use of PICO is detailed in the following table.

TABLE I
DEFINITION OF THE GENERAL CONCEPTS USING PICO

Criterion	**Description**
Population	Undergraduate or postgraduate students in engineering and computing
Intervention	Cooperative or collaborative learning technique
Comparison	Traditional lecture or laboratory
Outcomes	Experiences in the application of cooperative or collaborative learning techniques in lectures or laboratories

The purpose of this study is to know if cooperative or collaborative learning techniques are being applied in engineering and computing courses at undergraduate or postgraduate level. The research questions that were defined for this review are:

RQ1.Which publication channels (journals or conferences) are the main targets for cooperative and collaborative learning research?

RQ2. Which cooperative or collaborative learning techniques are applied in Engineering in Computing?

RQ3. In which areas of engineering and computing have cooperative or collaborative learning techniques been applied?

RQ4. What research method was used in the evaluation of the application of these learning techniques?

A. Search strategy

The search terms used in this study were developed using the following criteria, similar to a systematic review study [8]:

(i) Besides the term "computing", we considered the five defined sub-disciplines of the computing curricula proposed by IEEE and ACM [5] "software engineering", "computer science", "information systems", "information technology", and "computer engineering".

(ii) Include "informatics" as a synonym of "computing."

(iii) Include "software development" because is a term widely used in computing.

The search string that was employed in this review was:

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("cooperative learning" OR "collaborative learning") AND (engineering OR informatics OR computing OR "software engineering" OR "computer science" OR "information technology" OR "software development" OR "information systems" OR "computer engineering").
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B. *Search process*

The search process was conducted using the following databases: Scopus, Web of Science (WOS), and IEEE Xplore. WOS database used in this SLR contains the main collection of Web of Science, BIOSIS, Current Contents Connect, Derwent Innovations Index, Inspec, KCI, Medline, and SciELO.

C. *Selection of studies*

The following inclusion and exclusion criteria were applied to the select publications:

Inclusion Criteria. (i) The abstract of the study must indicate the application of one of the cooperative or collaborative learning techniques included in Appendix I (the list of learning techniques were obtained in [2][4])

Exclusion Criteria. (i) Studies with experiences not related to higher education (undergraduate or graduate) in engineering or computing (ii) Publications without peer-review (e.g. prefaces, books, editorials, etc.) (iv) Studies that shows the utilization of a software tool that supports a cooperative or a collaborative learning technique without the evaluation of the jigsaw technique.

The search process was conducted during July 2016. We obtained 2999 results from the three consulted databases. After deleting the duplicates, we select the articles that had the terms of Appendix I in their abstracts, and we finally selected 348 papers.

We applied inclusion and exclusion criteria in those 348 papers in two iterations. In the first iteration, each author reviewed 146 papers (only titles and abstracts) and extract relevant information according to our defined research questions. After a meeting to discuss our findings, in the second iteration, each author checked the 146 papers (titles and abstracts) reviewed by another author. Finally, we selected 112 studies (The appendix shows the list of selected papers).

III. FINDINGS

This section shows our findings according to the defined research questions.

A. *RQ1. Publications chanels*

The selected studies were published in conferences (59 papers), journals (51 articles) and books (2 book chapters). Table II reports the top-five channels with more publications.

TABLE II
JOURNALS AND CONFERENCES WITH MORE PAPERS

Journal/Conference	Type	Number of papers	Percentage
ASEE Annual Conference and Exposition	Conference	10	8.93%
International Journal of Engineering Education	Journal	7	6.25%
IEEE Transactions on Education	Journal	6	5.36%
Tecnologias Aplicadas a la Ensenanza de la Electronica (Technologies Applied to Electronics Teaching)	Conference	3	2.68%
International Technology, Education and Development Conference (Inted)	Conference	3	2.68%

We could find the selected studies were published in 40 conference proceedings, 36 journals, and 2 books. Table III shows the top-nine conferences with more papers, and Table IV shows the top-eight journals with more articles.

TABLE III
CONFERENCES WITH MORE PAPERS

Conference	Number of papers	Percentage
ASEE Annual Conference and Exposition	10	16.95%
International Technology, Education, and Development Conference (Inted)	3	5.08%
Tecnologias Aplicadas a la Ensenanza de la Electronica (Technologies Applied to Electronics Teaching)	3	5.08%
IEEE Global Engineering Education Conference (EDUCON)	2	3.39%
SIGCSE - ACM Technical Symposium on Computer Science Education	2	3.39%
SEFI Annual Conference	2	3.39%
International Conference on Teaching and Learning in Higher Education	2	3.39%
International Journal of Engineering Education	2	3.39%
The Annual Hawaii International Conference on System Sciences	2	3.39%

TABLE IV
JOURNALS WITH MORE PAPERS

Journal	Number of Articles	Percentage
IEEE Transactions on Education	6	11.76%
International Journal of Engineering Education	5	9.80%
Journal of Universal Computer Science	2	3.92%
Journal of Korea Academia-Industrial cooperation Society	2	3.92%
Computers in Human Behavior	2	3.92%
Science and Engineering Ethics	2	3.92%
International Journal of Applied Engineering Research	2	3.92%
Wireless Personal Communications	2	3.92%

B. RQ1. Publications chanels

We could observe that some studies referred to more than one learning technique. Table IV reports the number of times a technique has been applied.

TABLE V
LEARNING TECHNIQUES APPLIED IN ENGINEERING AND COMPUTING

Learning technique	Number of times reported	Percentage
problem-based learning	54	43.20%
game	20	16.00%
problem-solving	12	9.60%
project-based or project-oriented	11	8.80%
jigsaw	8	6.40%
team-based	6	4.80%
case studies	5	4.00%
peer instruction	3	2.40%
collaborative writing	2	1.60%
role-play	1	0.80%
case-based	1	0.80%
think-pair-share	1	0.80%
pogil	1	0.80%
Total	**125**	**100.00%**

As can be observed in Table V, the most applied technique is problem-based learning, following by game.

C. RQ3.Areas of engineering or computing

We could observe that one of the studies referred to more than one area. Table VI reports the number of times a learning technique was applied in an area.

TABLE VI
AREAS WHERE LEARNING TECHNIQUES WERE APPLIED

Areas	Number of times reported	Percentage of articles
Engineering	63	55.26%
Computing	36	31.58%
Not specified	15	13.16%
Total	**113**	**100.00%**

In Table VI, "not specified" means that it cannot be determined whether the study is in engineering or computing. Table VII shows the top-five programs (undergraduate or graduate) in which were applied those learning techniques.

TABLE VII
AREAS WHERE LEARNING TECHNIQUES WERE APPLIED

Program (undergraduate or graduate)	Number of articles	Percentage of articles
Computer Science	12	30.00%
Civil Engineering	5	12.50%
Mechanical Engineering	3	7.50%
Aerospace and Mechanical Engineering	2	5.00%
Chemical Engineering	2	5.00%

D. RQ5. Research methods used

Unfortunately, most articles included very little information in their abstract about the research method employed.

IV. Conclusions and Future Work

This paper presents the results of a systematic mapping review of the application of cooperative or collaborative learning techniques in engineering and computing. 112 studies were selected, and they show cooperative and collaborative learning techniques were applied in laboratories and class-rooms. Three of the four research question could be answered with the information of the abstracts. Unfortunately, the question about the applied research methods in those studies could not be answered because many of the abstracts did not include information about them.

It is planned as a future work include other databases to find more papers related to the application of cooperative or collaborative learning. It remains as future work to check introductions and conclusions of the selected papers in order to respond RQ4.

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APPENDIX I: NAMES OF LEARNING TECHNIQUES

think-pair-share, role-play, jigsaw, problem-solving, case studies, structured problem solving, group investigation, dyadic essays, collaborative writing, team games tournaments, tandem, discussion-based, project-oriented learning, project-based learning, problem-based learning, think aloud pair problem solving, round table, rally table, note-taking pair, three-step interview, round robin, buzz groups, talking chips, critical debate, learning cell, fishbowl, test-taking team, send-a-problem, affinity grouping, group grid, team matrix, sequence chains, world webs, dialogue journal, dyadic essay, peer editing, team anthology, paper seminar, team scavenger hunt, quizo, team jeopardy, friendly feud, game, pogil, team-based

APPENDIX II: LIST OF SELECTED PAPERS

1. Abdullah, Siti Rozaimah Sheikh; Takriff, Mohd Sobri; Anuar, Nurina; Ismail, Manal; Harun, Shuhaida(2012). JKKP Experience in Conducting Integrated Project since Session 2006/2007. Universiti Kebangsaan Malaysia Teaching and Learning Congress 2011, VOL II
2. Aburas A.A., Rustempasic I., Muhic I., Yildiz B.G.(2012). New proposed structure for communication engineering curriculum. International Symposium on Telecommunications, BIHTEL
3. Adewoyin O., Wu K., Vassileva J.(2015). Exploiting the use of wikis to support collaborative writing: A case study of an undergraduate computer science class. International Workshop on Groupware
4. Agrifoglio R., Metallo C., Varriale L., Ferrara M., Casalino N., De Marco M.(2013). Assessing individual learning and group knowledge in a wiki environment: An empirical analysis. IASTED International Conference on Web-Based Education, WBE
5. Agudo J.E., Rico M., Sánchez H., Vaca J.M.(2015). Enhancing e-learning: Problem based learning supported in moodle. Project Based Learning on Engineering: Foundations, Applications and Challenges
6. Akili W.(2014). On implementation of classroom-based pedagogies of engagement: Relevant measures and general outcomes. ASEE Annual Conference and Exposition, Conference Proceedings
7. Arboleya, A.; Las-Heras, F.(2014). Improving independent learning and communication skills of students in last year of engineering degrees through the use of project-based learning methodologies. Tecnologias Aplicadas a la Ensenanza de la Electronica (Technologies Applied to Electronics Teaching) (TAEE)
8. Azmi S., Iahad N.A., Ahmad N.(2015). Gamification in online collaborative learning for programming courses: A literature review. ARPN Journal of Engineering and Applied Sciences
9. Banerjee R.K., D'Souza G.A., Rylander C., Devireddy R.(2014). A review of biotransport education in the 21st century: Lessons learned from experts. Journal of Biomechanical Engineering
10. Barchino R., Gutiérrez J.M., de-Marcos L., Martínez J.J., Jiménez L., Otón S., Gutiérrez J.A., Hilera J.R.(2012). Experiences in the use of mobile games to improve programming skills in computer engineering. International Journal of Innovative Computing, Information and Control
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12. Borras-Gene O., Martiñez-nunez M., Fidalgo-Blanco A.(2016). New Challenges for the motivation and learning in engineering education using gamification in MOOC. International Journal of Engineering Education
13. Carroll J.M., Jiang H., Borge M.(2015). Distributed collaborative homework activities in a problem-based usability engineering course. Education and Information Technologies
14. Cavalli-Sforza, Violetta(2012). Experiences In Problem-Based And Cooperative Learning. International Conference Of Education, Research And Innovation (ICERI)
15. Chance S.M., Bowe B.(2015). Influence of collaborative learning on women's experiences of engineering education. Research in Engineering Education Symposium, REES
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17. Chaparro-Peláez J., Iglesias-Pradas S., Pascual-Miguel F.J., Hernández-García Á.(2013). Factors affecting perceived learning of engineering students in problem based learning supported by business simulation. Interactive Learning Environments
18. Chen C.(2013). Immersive learning: A creative pedagogy. International Journal of Pedagogy and Curriculum
19. Cheng X., Li Y., Sun J., Huang J.(2015). Application of a novel collaboration engineering method for learning design: A case study. British Journal of Educational Technology
20. Cheng X., Li Y., Sun J., Zhu X.(2014). Easy collaboration process support system design for student collaborative group work: A case study. The Annual Hawaii International Conference on System Sciences
21. Cheng X., Li Y., Zhao Y.(2015). Can we solve low participation, distraction, and inefficiency? A case study of distributed collaborative learning in industries. The Annual Hawaii International Conference on System Sciences
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28. Dunaway M.M.(2013). Is learning: The impact of gender and team emotional intelligence. Journal of Information Systems Education
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