WaPFi (Wahana Pendidikan Fisika)
Vol. 7 No. 2 (2022) pp. 104-112
https://ejournal.upi.edu/index.php/WapFi
p-ISSN: 2338-1027 e-ISSN: 2685-4414

The Development of Concept Development-Collaborative Decision-Making Problem Solving (CD-CDMPS) to Improve The Prospective Physics Teachers' Decision Making Skills

Yulianti Yusal[1*], Andi Suhandi[2], Ida Kaniawati[3]

[1]Program Studi Tadris Ilmu Pengetahuan Alam, Fakultas Tarbiyah, Institut Agama Islam Negeri Kediri
[2,3] Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia
*Email: yuliantiyusal@iainkediri.ac.id

Article Info

Recieved:
17/05/2021

Revised:
09/08/2022

Accepted:
26/09/2022

Abstract
Developing a concept development model - collaborative decision making problem solving (CD-CDMPS) to improve the prospective physics teachers' decision-making skills has been carried out. This study aims to develop a teaching model that is effective in improving the decision-making skills of student-teachers. The method used in this research is R & D (research and development), which includes the following stages: (1) needs analysis; (2) product development (design, development, and product validating); (3) field test of the products produced; and (4) product improvement based on the results of the field test. The research subjects were 23 prospective physics teachers on a limited-scale trial and 76 prospective physics teachers on a large-scale attempt at a university in Makassar, South Sulawesi. The research instrument used was a 5-point decision-making skill test in the form of a description. The results showed that after applying the CD-CDMPS lecture model, most students achieved improved decision-making skills in the high category. Thus, the CD-CDMPS model developed can be effectively used to improve students' decision-making skills.
Keyword: *CD-CDMPS model, Decision-making Skills, Prospective Physics Teachers*

Introduction

Decision-making skills are needed to face the challenges of the 21st century [1]. Students are expected to be able to make decisions about what to do when the needs and living standards are getting higher while natural resources are increasingly limited [2]. Decision-making skills are skills that everyone must learn, possess, and develop in depth.

The learning process plays a role in supporting students' decision-making skills [3]. This is because the decision-making depends on personal experience or what he learns in classroom learning activities. Therefore, the orientation of decision-making skills training is carried out by including it in the designed lesson content instruction [4]. Meanwhile, subjects that play a role in developing decision-making skills--besides helping to understand content are science courses [5], [6]. Students agree that decision-making skills can be led by science courses [7].

The learning that has been used so far is not enough to practice decision-making skills among students. Learning that does not involve students in the decision making causes low decision-making skills [7]. Evidence that the learning that has been used so far is not enough to practice decision-making skills among students is shown by the results of the investigation of decision-making skills among students conducted by the

researchers. The results of the investigation show that the average decision-making skills possessed by students are still in the low category [8].

Problem solving and decision making are related to one another. Decision-making is the thought of producing a choice of several alternative actions and that selection activity occurs in the problem-solving process. Decision making is generally associated with the first five steps in problem-solving [9]. Thus, problem solving oriented learning is recommended to be applied in learning in order to provide students with decision-making skills because problem-solving activities include the decision-making process. Decision-making skills can be improved by teaching a series of structured decision-making steps [10]. However, not all activities in problem solving contain decision-making processes or steps. Therefore, the application of the problem solving model that has been developed cannot be generalized depending on the type of problem used [11]. The problem-solving framework used is influenced by the types of problems faced by students [12]. Thus, in the context of providing decision-making skills, not all types of problems are used as a stimulus in problem solving learning. Indeed, not all types of problems, if solved, take steps to make decisions in it. Different types of problems require different skills, so learning methods must also vary [11]. The type of problem that takes decision-making steps in solving it is the decision making problem because this type of problem presents various alternative problem solving solutions and students are asked to choose the most profitable one so that the solution must take decision-making steps [11]. Decision making problem is a problem that requires problem solvers to choose a solution from a series of alternative solutions [11]. Thus, learning problem solving by using decision making problems as a type of problem can lead to decision-making activities to build students' decision-making skills.

The setting of activities to facilitate interaction between fellow students is needed in decision making so that students can exchange ideas or exchange opinions so as to obtain an agreement as a solution to the decision. Collaborative is a group activity where students in groups are encouraged to interact and learn together [13]. Through collaboration, students in groups are encouraged to interact and learn together in order to obtain mutual agreement. Knowledge is built as a result of mutual discussion and reaching agreement. Problems given as decision-making tasks should be done collaboratively [4][14]. Thus, a collaborative activity setting is suggested in facilitating the provision of students' decision-making skills.

A complete understanding of students' concepts optimizes their decision-making skills training. Students' understanding of science concepts is used and influential in decision making [15]–[19]. Understanding the concept is the basis for building students' decision-making skills in solving problems [20]. Therefore, students' understanding of the concept needs to be formed first before carrying out decision-making activities in solving problems. Thus, in the context of providing decision-making skills, the concept formation stage needs to be presented in learning and positioned at the initial stage of the core learning activities.

Research on problem solving learning or collaborative problem solving has often been carried out. However, most of the previous studies examined problem solving learning or collaborative problem solving, for example integrated with technology, namely computerized science problem-solving [21], collaborative problem-solving with multi-touch technology [22], and concept mapping for computer-supported collaborative problem solving [23]. There has not been any problem solving or collaborative problem solving learning that develops the types of problems, for example using decision-making problems.

A study that can practice students' decision-making skills needs to be developed. In order for learning that is developed to really facilitate the development of decision-making skills, it is necessary to consider the content and activities of relevant learning. Several things that need to be considered in the learning developed include: **first**, there is a need for learning that presents problems to be solved; it can be done by applying problem solving learning; **second**, there is a need of activities in stages that teach a series of structured decision-making steps; **third**, there is need of problems that involve decision-making skills, exposing the student to decision making problems; **fourth**, the adjustment of the orientation of the learning, namely the direction of applying basic physics concepts in problem solving; **fifth**, there is a need of a setting to facilitate interaction between students in the implementation of learning activities, through collaborative group work; and **sixth**, there is a need of a concept formation stage that is positioned at the initial stage of the core learning activities.

The learning developed by having the six characteristics above is closely related to problem solving learning, where the problems used are decision making problems, the problem solving activities are carried

out collaboratively, and there is a concept development stage positioned at the initial stage of learning. Thus, the learning developed can be called as a learning model of concept development - collaborative decision making problem solving (CD-CDMPS).

Based on the background that has been stated above, the researchers are interested in conducting research and development activities to produce a model product for concept development - collaborative decision making problem solving (CD-CDMPS) which can train the skills of taking prospective physics teachers. This study aims to produce a valid and tested concept development - collaborative decision making problem solving (CD-CDMPS) model product in improving decision-making skills of prospective physics teachers. This research is very important to equip the decision-making skills of prospective physics teachers to face the challenges ahead.

Methods

Research design

The method used in this research was the Research and Development (R & D) developed by Borg and Gall which includes the following stages: (1) needs analysis; (2) product development (designing, developing and validating); (3) field testing of the products produced; and (4) product improvement based on the results of field test [24]. Figure 1 shows the research and development method used.

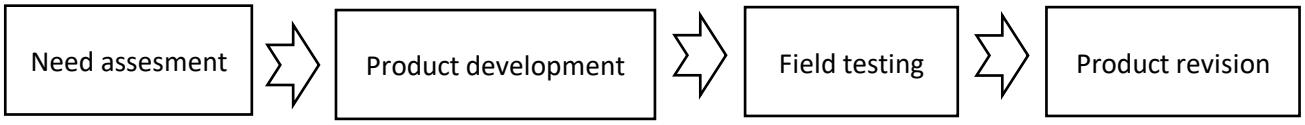

Figure 1. Development Model of CD-CDMPS

The initial product of the resulting CD-CDMPS model was validated by experts. After that, it was revised in accordance with suggestions and input by experts. The expert validation stage (expert judgments) is focused on assessments to obtain product improvement suggestions from the experts. Validation was carried out by three expert validators who came from universities that run Physics education study programs.

Field tests of the CD-CDMPS model product produced at the product development stage were carried out twice, namely limited-scale field trial and large-scale field trial. From this field testing, it is expected to obtain an overview of the strengths and limitations of the CD-CDMPS model which was developed as a feedback material for material improvements and product refinement of the CD-CDMPS model based on its implementation so that the resulting CD-CDMPS model product has a better performance. Another purpose of the trial product implementation of this model is to determine the effectiveness of the CD-CDMPS model product produced in facilitating the achievement of better decision-making skills for prospective physics teachers.

The limited and larger field test of the CD-CDMPS model product was conducted at a state university in South Sulawesi province. The research subjects were the student-teachers taking Basic Physics courses. The number of students in the limited field test of the CD-CDMPS model product was 23 students. Meanwhile, in a larger test, the number of research subjects consisted of 76 students.

Research instrument

For the purposes of data collection, a research instrument has been constructed in the form of an essay test on decision-making skills [25]. The instrument used in the research on the effectiveness test of the CD-CDMPS model is a test of decision-making skills which consisted of 5 questions in the form of description for all basic physics material taught, namely static fluid, sound waves, heat transfer, kinetic theory of gases and direct current circuits.

Data analysis

The improvement of decision-making skills in limited-scale trials and large-scale trials were analyzed using the concept of normalized gain <g> based on the normalized pretest and posttest scores data. The normalized gain describes the increase that occurs in the competency of learning outcomes between before

and after learning is carried out. The calculation of the normalized average gain (<g>) is carried out using equation (1) [26]:

$$< g >= \frac{<S_{pos}> - <S_{pre}>}{100 - <S_{pre}>} \quad (1)$$

To describe the normalized gain average value <g>, the following criteria as shown in Table 1 are used [26].

Table 1. Criteria of normalized average gain score <g>

Normalized Gain Average	**Interpretation**
<g> > 0,70	High
0,30 ≤ <g> ≤0,70	Middle
<g> < 0,30	Low

Findings and Discussion

The CD-CDMPS model developed was validated in advance by three experts in the field of Physics education before being tested in Basic Physics lectures which were oriented towards provision of decision-making skills to ensure their use in Basic Physics lectures. From the validation results of the three validators, it can be concluded that the scenario for the application of the CD-CDMPS model developed has met the feasibility criteria.

Table 2 shows the data on the improvement of decision-making skills achieved by students who were involved in the limited-scale trial of the CD-CDMPS model.

Table 2. The Improvement of decision-making skills of students following the CD-CDMPS model in a limited-scale field trial

Materials	**Average <g>**	**Category**
Static Fluid	0,58	Middle
Sound Waves	0,67	Middle
Heat Transfer	0,56	Middle
Kinetic Theory of Gases	0,66	Middle
Direct Current Circuits	0,55	Middle

In Table 2, it can be seen that the average improvement in student decision-making skills on all materials is classified as an increase in the *medium* category. This shows that the CD-CDMPS model has the potential to be applied in providing and practicing the decision-making skills of prospective physics teachers.

Furthermore, table 3 shows the percentage of the number of students who employed the CD-CDMPS learning model in each improvement category of students' decision-making skills.

Table 3. The percentage of students in the CD-CDMPS model class in each improvement category of decision-making skills

Materials	**Number of students (%)**		
	***High* Category**	***Middle* Category**	***Low* Category**
Static Fluid	57	30	13
Sound Waves	60	31	9
Heat Transfer	52	35	13
Kinetic Theory of Gases	60	31	9
Direct Current Circuits	60	27	13

From Table 3, it is known that the number of students who perform high improvement in static fluid material is 57%, those in sound waves are 60%, those in heat transfer is 52%, those in the kinetic theory of gas is 60%, and those in direct current circuits material is 60%. This shows that the field trials of the CD-CDMPS model on a limited scale have resulted in satisfactory improvement in decision-making skills, however, the improvements have not achieved the expected targets. For this reason, before the CD-CDMPS model is used in further trials on a larger range of subjects, it is necessary to improve the CD-CDMPS model, especially the elements that still need to be strengthened so that the achievement of decision-making skills

is more optimal. On the basis of the limited trial results, the CD-CDMPS model was further refined. Table 4 shows the activities of lecturers and students at each stage of the CD-CDMPS model after completing the CD-CDMPS model.

Table 4. The activities of lecturers and students at each stage of the revised CD-CDMPS model

Stages of CD-CDMPS	Lecturer's Activity	Students' Activity	Supporting Media
Pre-Activities			
Student orientation session in decision making problems	• Checking students' attendance	• Responding the attendance checking	
	• Proposing apperception related to the concept of physics being studied	• Responding to the apperceptions presented by lecturers	• *PPT slides*
	• Describing the purpose of the lecture	• Listening to the description of the course objectives	• *PPT slides*
	• Presenting decision making problems related to the concepts covered in the topic being studied	• Listening to the decision making problems presented by the lecturer	• *PPT slides*
Main Activities			
Session of *Concept development*	• Presenting an interactive demonstration, followed by a question and answer discussion so that students can understand the concepts being studied	• Listen to and respond to interactive demonstrations, as well as question and answer discussions so that they can understand the concepts being learned	• *PPT slides* • Animation video • Virtual simulation
	• Presenting videos of relevant phenomena to strengthen students' concepts	• Listening to and responding to the reinforcement of the concept in the presented phenomenon video	• Video of relevant phenomena
Session of introducing *decision making problem solving*	• Describe problem solving decision making strategies related to the concepts studied.	• Listening and asking questions when the lecturer describes the decision making strategy problem solving related to the concept so that they have a good understanding of the problem solving decision making strategy related to the concept.	• *PPT slides*
Session of practicing *collaborative decision-making problem solving*	• Facilitating each group of students to do collaborative decision making problem solving exercises using the strategies that have been introduced. Problems that are solved are problems that are presented by the lecturer at the beginning of the lesson related to the concepts being studied	• Doing collaborative decision making problem solving exercises using the strategies introduced by the lecturer until a solution is mutually agreed upon by the group members	• Problem sheets for decision making
Session of presenting *collaborative decision-making problem solving*	• Facilitating each group of students to present the results of collaborative decision making problem	• As a group, presenting the results of collaborative decision making problem solving	• *PPT slides*

	solving related to the concepts learned in front of other groups followed by a question and answer discussion.	related to the concepts learned in front of other groups which is followed by a question and answer discussion.	
Post-Activities			
Session of reflection and lecture follow-up	• Reflecting and following up on lectures in the form of giving homework assignments, namely looking for examples of decision making problems that use the concepts studied and their solutions	• Listen to and respond to lecture reflections conducted by the lecturer and make notes on the follow-up assignments given by the lecturer	• *PPT Slides*

Table 4 shows the data on the improvement of decision-making skills achieved by students who were involved in the CD-CDMPS model trial on a larger scale.

Table 4. The Improvement of decision-making skills of students following the CD-CDMPS model in a larger-scale field trial

Materials	Average <g>	Category
Static Fluid	0,73	High
Sound Waves	0,74	High
Heat Transfer	0,73	High
Kinetic Theory of Gases	0,73	High
Direct Current Circuits	0,74	High

In Table 4, it is found that the average increase in student decision-making skills of all materials is classified as *high* category. This shows that the CD-CDMPS model has the potential to be applied in providing and practicing the decision-making skills of prospective physics teachers.

Meanwhile, table 5 shows the percentage of the number of students who utilized the CD-CDMPS learning model in each improvement category of students' decision-making skills.

Table 5. The percentage of students in the CD-CDMPS model class in each improvement category of decision-making skills

Materials	Number of students (%)		
	***High* Category**	***Medium* Category**	***Low* Category**
Static Fluid	76	24	0
Sound Waves	77	23	0
Heat Transfer	76	24	0
Kinetic Theory of Gases	76	24	0
Direct Current Circuits	76	24	0

In Table 5, it is found that the number of students who are in the *high* category for static fluid material is 76%, those of in sound waves are 77%, those of in heat transfer is 76%, those of the kinetic theory of gas is 76%, and those of in direct current circuits is 76%. This shows that the field trials of the CD-CDMPS model on a large scale have resulted in the achievement of improved decision-making skills that are effective as expected.

The improvement of students' decision-making skills occurs in the application of the CD-CDMPS model because it is facilitated by a concept-development session which is positioned at the beginning of the main activity section of the lecture. As explained earlier, conceptual understanding is used and influences decision making. Students' concepts understanding is formed first at an early stage, then the concept that has been understood is used to optimize students' retrieval skills training which is placed in the next stage. Decision makers must be able to understand the knowledge gathered to help the selection process for decision making [11].

In addition, the improvement also supported by a stage session that introduces and teaches the steps of decision-making skills to build students' decision-making skills. Decision-making skills can be improved by

teaching a series of structured decision-making steps [10]. Considering that the steps for decision-making skills are structured and complicated, they must be taught in the introduction to problem-solving decision-making strategies before carrying out problem-solving exercises that involve the decision-making process in collaborative decision-making problem-solving training sessions.

The collaborative decision-making problem-solving training session is a session to practice students' decision-making skills, and provision of students' decision-making skills is emphasized in this session. In this collaborative decision making problem solving training session, students carried out collaborative decision making problem solving activities together with their respective group friends based on the decision-making steps taught in the previous session, namely the introduction to problem solving decision making strategies. Decision making problems were presented in the form of contextual stories that contain real-world problems that are often encountered in everyday life. Decision making problems offer various alternative solutions to the problems in the story, and students must choose the best solution from these various alternative solutions as problem solving to the problem. Therefore, in collaborative decision making problem solving, students must take decision-making steps and it must be carried out collectively so that there is an exchange of ideas between group friends and in the end a mutual agreement is obtained in the form of the best solution to the problem. Solving the decision making problem goes through systematic decision-making steps [11]. Problems given as decision-making tasks should be done collaboratively [4], [14].

Furthermore, students' decision-making skills can be provided through a presentation session on the results of collaborative decision making problem solving contained in the CD-CDMPS model. In this session, representatives from each group in the collaborative decision making problem solving training session came forward to present their collaborative results and other groups responded to the results of their presentations. In this session, there were an exchange of ideas and an exchange of opinions among groups about the results of decision making problems solutions, the steps taken by each group in solving decision making problems that are carried out collaboratively, and what collective agreement is obtained. Students can be involved in decision-making situations in small groups, then explain the results of small group discussions in class discussions.

In addition, decision-making skills are also trained in the last session on the CD-CDMPS model, namely reflection and lecture follow-up sessions. In this session, students were given a homework assignment, namely looking for examples of decision making problems so that students' decision-making skills could be trained further.

Students' answers show that students who are able to take the steps of making decisions well will get the best decisions. This result is supported by the results of data analysis which shows that most (about 69%) students experienced an improvement in the high category from the initial step to the final step, which indicates that they gained the best decision. These results are consistent with those reported by [27] and [28] that good decision-making steps influence the selection of the best decisions.

Conclusion

The CD-CDMPS model developed is effective in improving the decision-making skills of prospective physics teachers. This is indicated by the majority of students achieving improved decision-making skills in the high category after they attend Basic Physics lectures using the CD-CDMPS model. The developed CD-CDMPS model product can be used by lecturers in the Basic Physics lecturing process which is oriented towards developing students' students' decision-making skills

References

[1] M. Binkley *et al.*, "Defining Twenty-First Century Skills. In P.Griffin, B. Mc Gaw, & E. Care (Editor)," *Assesment and Teaching of 21st Century Skills,* pp. 17-66, New York: Spinger, 2012.

[2] T. Gok and I. Silay, "Effects of Problem-Solving Strategies Teaching on The Problem- Solving Attitudes of Cooperative Learning Groups in Physics Education," *J. Theory Pract. Educ.*, vol. 4, no. 2, pp. 253–266, 2008.

[3] A. Kaşkaya, Ş. Calp, and O. Kuru, "An evaluation of factors affecting decision making among 4th grade elementary school students with low socio-economic status," *Int. Electron. J. Elem. Educ.*, vol. 9, no. 4, pp. 787–808, 2017.

[4] R. J. Swartz, "Thinking About Decision. In Costa, Arthur (Editor)," *Developing of Minds,* pp. 58-66. Alexandria: Association for Supervision and Curriculum Development, 2001.

[5] H. Jho, H. G. Yoon, and M. Kim, "The Relationship of Science Knowledge, Attitude and Decision Making on Socio-scientific Issues: The Case Study of Students' Debates on a Nuclear Power Plant in Korea," *Sci. Educ.*, vol. 23, no. 5, pp. 1131–1151, 2014, doi: 10.1007/s11191-013-9652-z.

[6] B. Covitt, C. Harris, and C. Anderson, "Evaluating Scientific Arguments With Slow Thinking," *Sci. Scope*, vol. 037, no. 03, 2013, doi: 10.2505/4/ss13_037_03_44.

[7] R. Soobard and M. Rannikmäe, "Upper secondary students' self-perceptions of both their competence in problem solving, decision making and reasoning within science subjects and their future careers," *J. Balt. Sci. Educ.*, vol. 13, no. 4, pp. 544–558, 2014, doi: 10.33225/jbse/14.13.544.

[8] Y. Yusal, A. Suhandi, W. Setiawan, and I. Kaniawati, "Profile of pre-service physics teachers' decision-making skills related to electric circuit," *J. Phys. Conf. Ser.*, vol. 1157, no. 3, 2019, doi: 10.1088/1742-6596/1157/3/032071.

[9] F. Basyaib, *Teori Pembuatan Keputusan*. Jakarta: Grasindo, 2006.

[10] J. L. Arvai, V. E. A. Campbell, A. Baird, and L. Rivers, "Teaching Students to Make Better Decisions About the Environment: Lessons From the Decision Sciences," *J. Environ. Educ.*, vol. 36, no. 1, pp. 33–44, 2004, doi: 10.3200/JOEE.36.1.33-44.

[11] D. H. Jonassen, *Learning to Solve Problems*. Newyork: Routledge, 2011.

[12] A. E. Leak, S. L. Rothwell, J. Olivera, B. Zwickl, J. Vosburg, and K. N. Martin, "Examining problem solving in physics-intensive Ph.D. research," *Phys. Rev. Phys. Educ. Res.*, vol. 13, no. 2, pp. 1–13, 2017, doi: 10.1103/PhysRevPhysEducRes.13.020101.

[13] C. H. Barkley, Elizabert E., Cross, K., P. and Major, *Collaborative Learning Techniques: Teknik-teknik Pembelajaran Kolaboratif*. Bandung: Penerbit Nusa Media, 2012.

[14] A. Tekbiyik, "The Use of Jigsaw Collaborative Learning Method In Teaching Scocioscientific Issues: The case of Nuclear Energy," *Journal of Baltic Sci. Edu.,* pp. 237–253, 2013, doi: 10.33225/jbse/15.14.237.

[15] M. Evagorou, M. P. Jimenez-Aleixandre, and J. Osborne, "'Should We Kill the Grey Squirrels?' A Study Exploring Students' Justifications and Decision-Making," *Int. J. Sci. Educ.*, vol. 34, no. 3, pp. 401–428, 2012, doi: 10.1080/09500693.2011.619211.

[16] I. K. Asha and A. M. Al Hawi, "The impact of cooperative learning on developing the sixth grade students decision-making skill and academic achievement," *J. Educ. Pract.*, vol. 7, no. 10, 2016, [Online]. Available: http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1099599&site=ehost-live.

[17] D. Paraskeva-Hadjichambi, A. C. Hadjichambis, and K. Korfiatis, "How Students' values are intertwined with decisions in a socio-scientific issue," *Int. J. Environ. Sci. Educ.*, vol. 10, no. 3, pp. 493–513, 2015, doi: 10.12973/ijese.2015.256a.

[18] M. G. Lindahl and C. Linder, "What's natural about nature? Deceptive concepts in socio-scientific decision-making," *Eur. J. Sci. Math. Educ.*, vol. 3, no. 3, pp. 250–264, 2015, doi: 10.30935/scimath/9435.

[19] Y. Yusal, A. Suhandi, W. Setiawan, and I. Kaniawati, "The Effectiveness of Collaborative Problem-solving Using Decision-making Problems to Improve the Pre-service Physics Teachers' Critical Thinking Skills," *J. Pendidik. Fis.*, vol. 9, no. 2, pp. 107–116, 2021, doi: 10.26618/jpf.v9i2.5059.

[20] Y. Hadzigeorgiou, P. Fokialis, and M. Kabouropoulou, "Thinking about Creativity in Science Education," *Creat. Educ.*, vol. 3, no. 5, pp. 603–611, 2012, doi: 10.4236/ce.2012.35089.

[21] Z. Fund and N. Madjar, "The influence of scaffolded computerised science problem solving on motivational aspects," *Int. J. Sci. Educ.*, vol. 40, no. 18, pp. 2265–2291, 2018, doi: 10.1080/09500693.2018.1528644.

[22] E. Mercier and S. Higgins, "Creating joint representations of collaborative problem solving with multi-touch technology," *J. Comput. Assist. Learn.*, vol. 30, no. 6, pp. 497–510, 2014, doi: 10.1111/jcal.12052.

[23] T. Engelmann and F. W. Hesse, "How digital concept maps about the collaborators' knowledge and information influence computer-supported collaborative problem solving," *Int. J. Comput. Collab. Learn.*, vol. 5, no. 3, pp. 299–319, 2010, doi: 10.1007/s11412-010-9089-1.

[24] M. D. Gall, and W.R Borg, *Educational reseach: An Introduction 4th Ed*. New York & London: Longan,

Inc, 1983.

[25] Y. Yusal, A. Suhandi, W. Setiawan, and I. Kaniawati, "Construction and testing of decision-problem solving skills test instruments related basic physics content," *J. Phys. Conf. Ser.*, vol. 1521, no. 2, 2020, doi: 10.1088/1742-6596/1521/2/022007.

[26] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.*, vol. 66, no. 1, pp. 64–74, 1998, doi: 10.1119/1.18809.

[27] H. Gresch, M. Hasselhorn, and S. Bögeholz, "Enhancing Decision-Making in STSE Education by Inducing Reflection and Self-Regulated Learning," *Res. Sci. Educ.*, vol. 47, no. 1, pp. 95–118, 2017, doi: 10.1007/s11165-015-9491-9.

[28] H. Gresch and S. Bögeholz, "Identifying Non-Sustainable Courses of Action: A Prerequisite for Decision-Making in Education for Sustainable Development," *Res. Sci. Educ.*, vol. 43, no. 2, pp. 733–754, 2013, doi: 10.1007/s11165-012-9287-0.