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Lecturer professionalism: Local problems with the help of teaching aids to make students understand Prim's, Cruscal's, and Djiksra's algorithms

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Abstract

This study aims to design case-based learning with lesson study learning trajectory with the help of teaching aids to make students understand Prim's, Cruscal's, and Djiksra's Algorithms. The validation study was selected because it is a suitable method for this research. The research subjects were 41 Mathematics Education Study Program Students at Universitas Negeri Padang. This research data were collected using Interview guidelines, journals, and observation sheets. Data analysis was carried out by transcribing interviews, reducing, presenting, and drawing conclusions from the data. A lesson study was chosen as an alternative to improve and reflect on the learning process. Moreover, two expert lecturers supervised the groups during the learning process. A proper design of case-based learning with lesson study learning trajectory with the help of teaching aids development process is obtained. Using a case-based learning method can make students understand Prim's, Cruscal's, and Djiksra's Algorithms. This design can be used by the other lecturers to provide a learning process of Prim's, Cruscal's, and Djiksra's Algorithms or other topics.

Keywords: Case-Based Learning, Lesson Study, Teaching Aids, Tourist Attractions, Validation Study

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One of the Lecturers' responsibilities is to provide a learning process that will make students understand the topic and improve students' higher-order thinking ability. To provide the best learning process, applying various learning methods is necessary; one of the methods is case-based learning. Case-based learning techniques have been popular in education for a long time (Srinivasan et al., 2007). This technique can encourage students to understand the learning topics deeply (Crowther & Baillie, 2016; Noy, Patrick, Capetola, & McBurnie, 2017). According to Scott (2007), learning with case-based learning aims to illustrate learning practically and theoretically. Furthermore, case-based learning enables the students to contextualize an object without memorizing the studied concept. Moreover, this method can improve students' problem-solving, logical thinking, critical skills, and analytical skills (Chung, Chou, Hsu, & Li, 2016). Case-based learning can also involve students with various abilities in a group, develop students' analysis, synthesis, and decision competencies, and enable them to study different alternatives and solving-problems by sharing academic knowledge and previous experiences. A case-based learning learning consists of positive interdependence, direct interaction between group members, individual responsibility, development of individuals' essential abilities, and evaluation on the results of group work (Gartland, Field, Gartland, & Leadership, 2014; Pozo, Durbán, Salas, & del Mar Lázaro, 2014).

Several studies have reflected on the effectiveness of learning with a case-based learning method. Imhanlahimi and Imhanlahimi (2008) have revealed that learning with a case-based learning method is more effective than that with an expository method because a case-based learning allows students to discuss and ask questions about the completion of a given case. Meanwhile, Marfisi-Schottman, Labat, and Carron (2013) have discovered that the case-based learning method stimulates students' critical thinking and provide them with unstructured forms of problem-based learning. Ruiz-Gallardo, Castaño, Gómez-Alday, and Valdés (2011) have also found that the participatory method is one of the case-based learning methods that can increase students' average retention. Meanwhile, Chen, Shang, and Yu (2005) conducted a case-based learning on learning methods in the asynchronous online learning process and have revealed that the case-based learning method helps students achieve higher cognitive learning outcomes even in the online learning process.

On the other research, Pillai Nair, Shah, Seth, Pandit, and Shah (2013) have found that 98% of students consider that the case-based learning method is exciting to gain knowledge; meanwhile, 84% of the students argue that the experience of logical application of the knowledge gained in a given case will significantly help them in the future. In addition, learning with a case-based learning can increase students' learning independence (McMahon & Christopher, 2011). Meanwhile, Farahani and Heidari (2014) compare a case-based learning method with a traditional learning method. They have revealed that the case-based learning brings more significantly independent effects than the traditional learning. Kiessling and Henriksson (2002) have proved that learning with case-based learning provides very useful changes in practice for students. Learning with case-based learning can also provide authentic experiences for students so that they can interpret learning more effectively (Kazama & Guo, 2010).

This current study presents learning using a case-based learning method to learn Prim's, Cruscal's, and Dijkstra's algorithms in universities. This topic was chosen based on the survey to 80 students that 95% of them said that this topic is difficult to understand. The local problems of tourist attractions are chosen as a learning trajectory. This learning trajectory also uses teaching aids to assist the learning process. These tourist attractions refer to the attractions in Pariaman, a city in West Sumatra in Indonesia that has many tourist attractions. Moreover, this case-based learning was also influenced by a lesson study.

The lesson study is developed to improve teachers' pedagogy, develop students' learning (Kanauan & Inprasita, 2014; Norwich & Ylonen, 2013; Sudirman, Samsudin, & Darman, 2007), and allow teachers to reflect on their teaching strategies. The teachers' reflections show that the collaborative environment during the study allows them to find out how to improve their teaching strategies. The lesson study comprises three main objectives: (1) to promote the professional development of teachers, (2) to foster a collaborative teaching environment, and (3) to improve student learning outcomes concerning learning objects (Lee, 2008). Furthermore, the designs of lesson plans, students' participation, the realization of lesson objectives, and mathematical thinking work effectively when receiving suggestions from an evaluator. Therefore, a lesson study is needed to build good learning (Bandung, Langi, & Hutabarat, 2013; Dossey, 2020; Dotger, 2011; Endris, 2008; Ross, 1998). The lesson study allows Lecturers not only to develop the learning process but also to learn (Huang, Su, & Xu, 2014; Kartal, Ozturk, & Ekici, 2012; Nesusin, Intrarakhamhaeng, Supadol, Piengkes, & Poonpipathana, 2014). The lesson study usually follows eight steps of activity as follows (Fernandez, Cannon, & Chokshi, 2003).

1. Defining general problems to arouse students' interest in a particular science.
2. Planning the lesson which begins by considering how other teachers deal with similar problems and aims to understand why and how a lesson can encourage students to learn.
3. Teaching the lesson
4. Evaluating the lesson and reflecting on its effects, including sharing views
5. Revising the lesson and making changes, including resolving certain misunderstandings shown by students during the lesson
6. Teaching the revised lesson to another class
7. Conducting further evaluation and reflection
8. Sharing the results with other teachers to improve the quality of student learning.

The lesson study was conducted, starting from planning the learning process until evaluating the learning process. In the planning phase, the learning process(problems, teaching aids, and other learning tools) was planned. The lesson study in this phase was standing alone. Next, in doing the plan, case-based learning was observed by expert lecturers(lesson study). Then, after the learning process is done, the expert lecturers will also evaluate the learning process that was done.

This study aimed to design case-based learning with lesson study learning trajectory with the help of teaching aids. Specifically, all of the process of case-based learning, lesson study and the teaching aids are presented clearly.

METHODS

This research is a validation study with three parts: preliminary design, experimental design, and retrospective analysis (Hadi, 2021; Rahayu & Putri, 2021). The validation study process can be seen in Table 1.

Table 1. The Validation Study Process

Validation Study Process	
Preliminary Design	Examines the literature on discrete mathematics course (Prim's, Cruscal's, and Djiksra's Algorithms), the learning method which is case-based learning, and Lesson Study. The researchers and expert lecturers collaborated to make learning trajectory through case-based learning methods using the tourist attractions case with the help of teaching aids. The lesson study was conducted during the planning.
Experimental Design	In this phase, there is two stages, namely, pilot experiment and teaching experiment. The pilot experiment is conducted to trial the learning design. Then, the teaching experiment stage is conducted to evaluate the learning process. During the learning process the expert lecturers observe the learning activity that students did(lesson study).
Retrospective Analysis	All data collected are analyzed.

Participants

Participants of this study were 2nd semester students of the mathematics education study program at Universitas Negeri Padang that are 41 students. These students are in different class, the first class consists 23 students as a class for pilot experiment and 18 students as a class for the teaching experiment stage. In the trial or learning process, each class is divided into three groups because there are three subtopics(Prim's, Cruscal's, and Djiksra's Algorithms). The pilot experiment class were divided into 8, 8, and 7 students and teaching experiment class were divided into 6 students for each group. Moreover, there are 2 expert lecturers that doing the lesson study collaborated with the researchers.

Instruments and Data Analysis

The instrument and data analysis of this research can be seen in Table 2.

Table 2. The Instruments and Data Analysis

Stage	Instrument	Description	Data Analysis
Preliminary Design	Interview guidelines	These guidelines consist of open questions about the proper learning process that can be used.	Transcript interview, then the data were reduced, presented, and concluded.
	Journal	This journal was used to note the important thing while the designing of the learning tools.	The data were reduced, presented, and concluded.
Experimenta l Design	Observation sheet	The observation sheet consisted of three forms of learning observation: positive and negative of the learning process(by the students), students' needs(by the students), and analysis of their learning process(by the expert lecturer).	The data were reduced, presented, and concluded.

RESULTS AND DISCUSSION

Preliminary Design

The learning process for the Prims', Cruscal's, and Djiksra's algorithms topic was carried out using case-based learning. The case-based learning trajectory was using local problems namely tourist attractions problems in Pariaman(A tourist city in West Sumatera, Indonesia). Moreover, the process also uses teaching aids that consist of tape, cardboard, nails, and styrofoams.

Experimental Design

In the pilot experiment, minor revisions are necessary. These revisions are conducted on the local problem that was used. In addition, the description about the pilot experiment can be seen in the teaching experiment stage. Next, the result of the teaching experiment stage is the proper learning process. The activities of the learning process are described as follows.

Step 1: Deepening materials and concepts

The materials and concepts are done by providing the learning module about the Prims', Cruscal's, and Djikra's algorithms on Universitas Negeri Padang e-learning. The learning module consists about how to find minimum spanning tree and shortest path of a graph. Figure 1 is a snippet of the material uploaded on the e-learning.

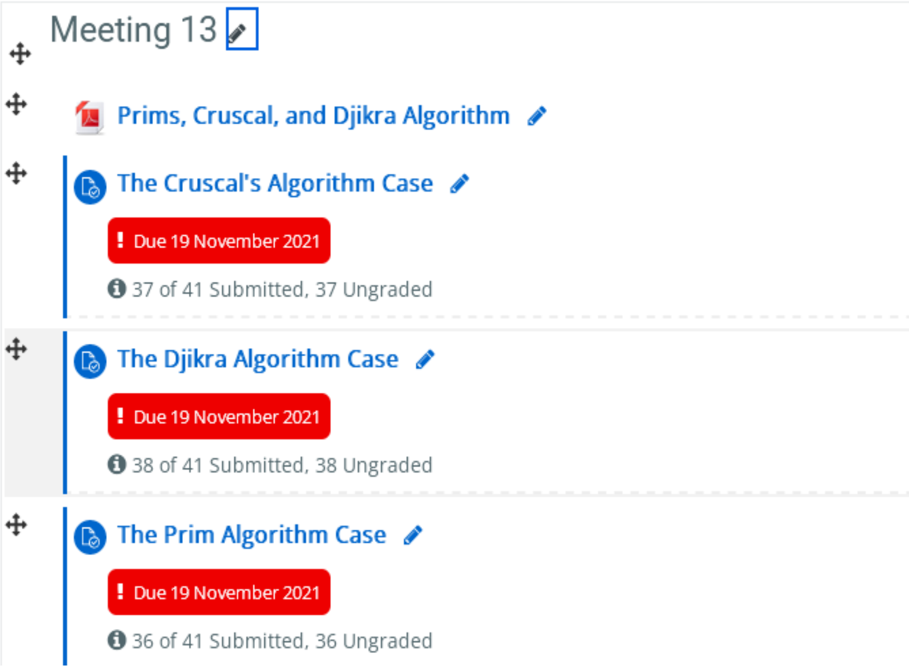

Figure 1. Snippets of Material on E-Learning

Step 2: Presenting Cases

The cases are about a tourist attractions in Pariaman City. The cases were given to the three groups. The form of the presented cases is as follows.

Anny wants to go around several tourist attractions in Pariaman City. The names of the places are shown on the map in Figure 2.

Figure 2. Map of Tourist Attractions in Pariaman

Meanwhile, the names of tourist attractions Anny wants to visit are listed in Table 3.

Table 3. Names of Tourist Attractions in Pariaman City

No	Names of Tourist Attractions
a	Pantai Belibis
b	Pulau Kasiak
c	Anso Duo
d	Pantai Sanur
e	Pasar Baru
f	Pasar Ampalu

The tourist attractions and several connecting roads are illustrated in Figure 3.

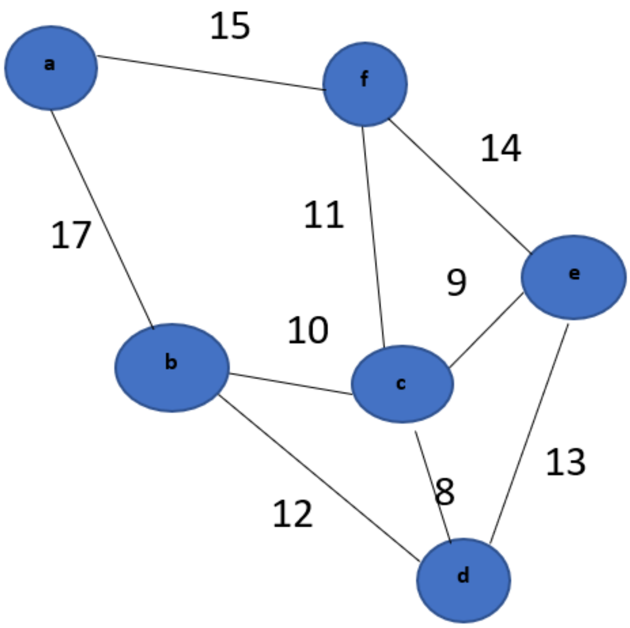

Figure 3. Representation of the City's Tourism Attractions

Based on the illustration in Figure 3, the problem is divided into each groups, as shown in Table 4.

Table 4. Description of Problems for Each Group

Group	Problem Description
1	1. Finding the minimum distance connecting each tourist spot (minimum spanning trees) using Prims' Algorithm 2. Illustrating the invention process using tape, cardboard, nails, and styrofoams
2	1. Finding the minimum distance connecting each tourist spot (minimum spanning trees) using the Crucal's Algorithm 2. Illustrating the invention process using tape, cardboard, nails, and styrofoam
3	1. Finding the shortest path from Pantai Belibis to Pantai Sanur using Djikstra's Algorithm 2. Illustrating the invention process using tape, cardboard, nails, and styrofoam

Step 3: Solving Cases

The case-solving consists of several steps to search for data and information, theories and materials, tools and resources, and proposed ideas, discussion and validation, formulation of solutions, and writing of work results. The expert lecturers observed each group by adapting the lesson study. The following is a form of problem-solving from each group.

Episode 1: Group 1 Creating Prims' Algorithm

Group 1 was given red styrofoam, green ribbon, yellow cardboard, small scissors, markers, madding nails, and other equipment. Each member of Group 1 wore a name tag with a yellow strap. The name tag consisted of information about their full names, nicknames, and student numbers. Therefore, the observers could easily observe the activities of each student. Figure 4 shows how Group 1 solves Problem 1.

Figure 4. Group 1 solving case Problem 1

Group 1 cut the ribbon shape according to the form in the case. Then they looked for information to find the minimum spanning tree. Figure 5 shows the algorithm made by Group 1 on cardboard.

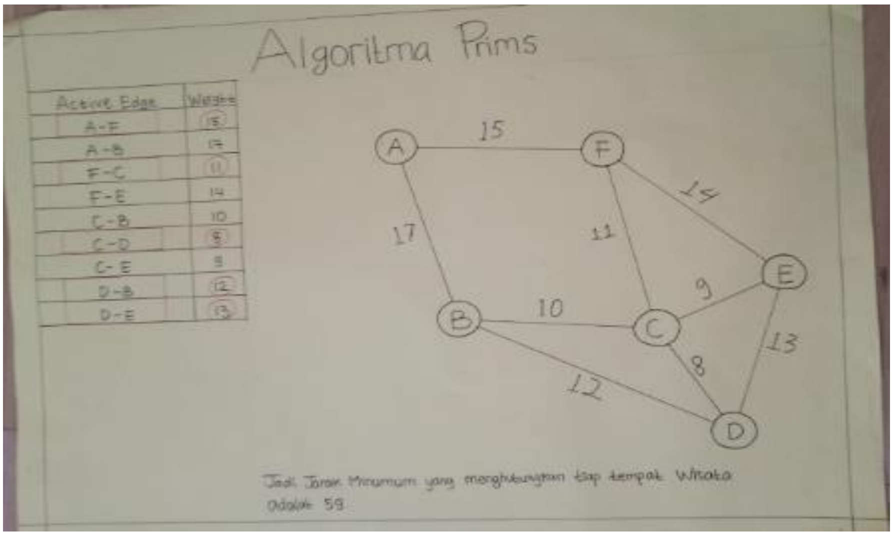

Figure 5. Prim's Algorithm Created by Group 1 on Cardboard

Figure 5 shows that Group 1 used the Prim's algorithm and determined which side had the minimum weight and did not form a cycle. Moreover, Group 1 should not draw the graph in the answer sheet based on the instruction.

Episode 2: Group 2 Creating Cruscal's Algorithm

Group 2 was given green styrofoam, yellow ribbon, pink cardboard, small scissors, markers, madding nails, and other equipment. Each member of Group 2 wore a name tag with a green strap. Figure 6 demonstrates how Group 2 solves Problem 2.

Figure 6. Group 2 Solving Case Problem 2

Group 2 also cut a ribbon and made sketches that fit the problem. Furthermore, Group 2 made an algorithm to find the minimum spanning tree using Cruscal's algorithm. Figure 7 shows that the Group 2 has written an algorithm on a cardboard.

ALGORITMA KRUSKAL

TERPILIH (SISI)	BOBOT	SIMPUL MASUK
CD	8	CD
CE	9	CDE
CB	10	BCDE
CF	11	BCDEF
BD	12	—
DE	13	—
EF	14	—
FA	15	ABCDEF
AB	17	—

BOBOT TOTAL w(e) = 8 + 9 + 10 + 11 + 15
= 53

Figure 7. Cruscal's Algorithm Made by Group 2 on Cardboard to Solve Problem 2

Figure 7 shows that Group 2 wrote the Cruscal's algorithm on cardboard without repeating the graph like Group 1.

Episode 3: Group 3 Creating Djiksra's Algorithm

Group 3 was given yellow styrofoam, red ribbon, blue cardboard, scissors, madding nails, and red cardboard. Figure 8 presents that the students are solving a given problem using Dijkstra's algorithm.

Figure 8. Group 3 Solving a shortest path problem Using Dijkstra's Algorithm

Furthermore, Group 3 has found a solution to Problem 3 by making Djiksra's algorithm and finding the shortest path from Belibis Beach to Sanur Beach. Figure 9 shows the algorithm to solve the problem.

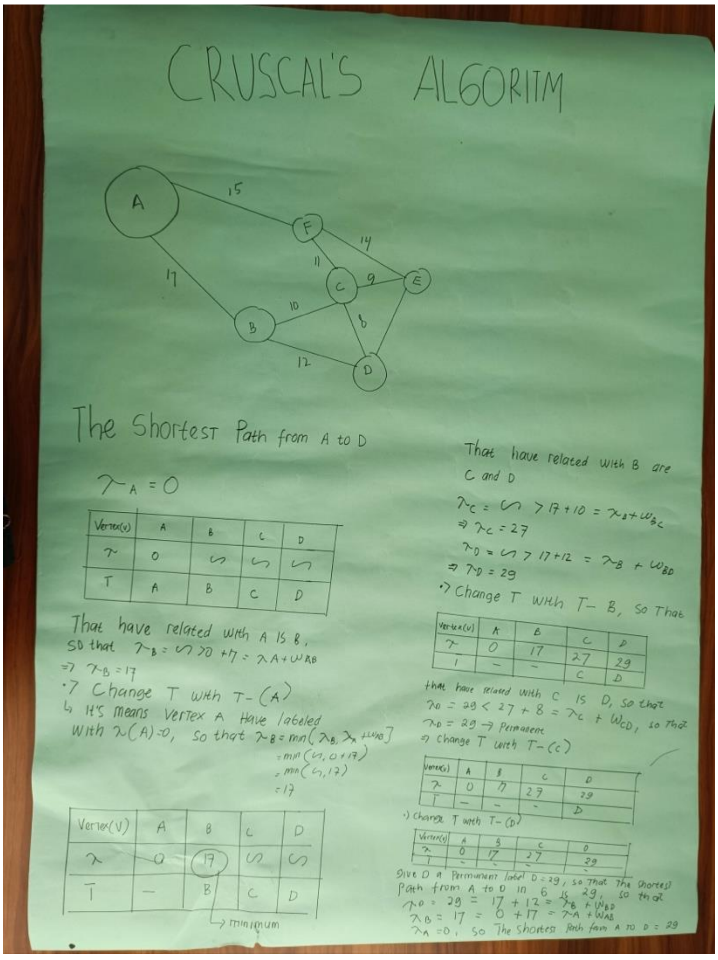

Figure 9. Dijkstra's Algorithm Created by Group 3 to Solve Problem 3

[Figure 9](#) shows that Group 3 has developed Dijkstra's algorithm to solve Problem 3. Moreover, Group 3 repeated the graph that is already available on the aids.

Step 4: Presenting Group or Individual Work Results

In this step, each group presented the results of the group work. Moreover, they presented the material solved using their own developed teaching aids.

Episode 1: Group Presentation 1

Group 1 presented the stages to obtain the minimum spanning tree using Prim's algorithm. One group member was holding the algorithm on cardboard while the other members were trying it on the teaching aids. The presentation of Group 1 can be seen in Figure 10.

Figure 10. Group 1 Presenting Stages to Find Minimum Spanning Tree Using Prim's Algorithm

Group 1 explained the smallest weights and did not form a cycle. At the end of the exhibition, Group 1 opened the unused sides and showed the minimum spanning tree constructed. These findings are presented in Figure 11.

Figure 11. Group 1 demonstrates the shape and weight of the spanning tree obtained and solve the problem using the Prim's algorithm

Episode 2: Group Presentation 2

Group 2 also presented how to find the minimum spanning tree using Cruscal's algorithm. Group 2 explained the algorithm on the cardboard with the help of the teaching aids they have made. Moreover, Figure 12 demonstrates that Group 2 has presented the results of solving Problem 2.

Figure 12. Group 2 Presenting Solution for Problem 2 by Finding Minimum Spanning Tree Using Cruscal's Algorithm

At the end of the presentation, Group 2 showed the obtained minimum spanning tree, as shown in Figure 13.

Figure 13. Group 2 Presenting The Minimum Spanning Tree Obtained

At the end of the presentation, Group 2 also cut the ribbon with a large weight that connects the tourist attractions.

Episode 3: Group Presentation 3

Group 3 presented strategies to solve Problem 3 and find the shortest path from Pantai Belibis to Pantai Sanur by using Dijkstra's algorithm. Figure 14 shows the presentation of Group 3 in solving Problem 3.

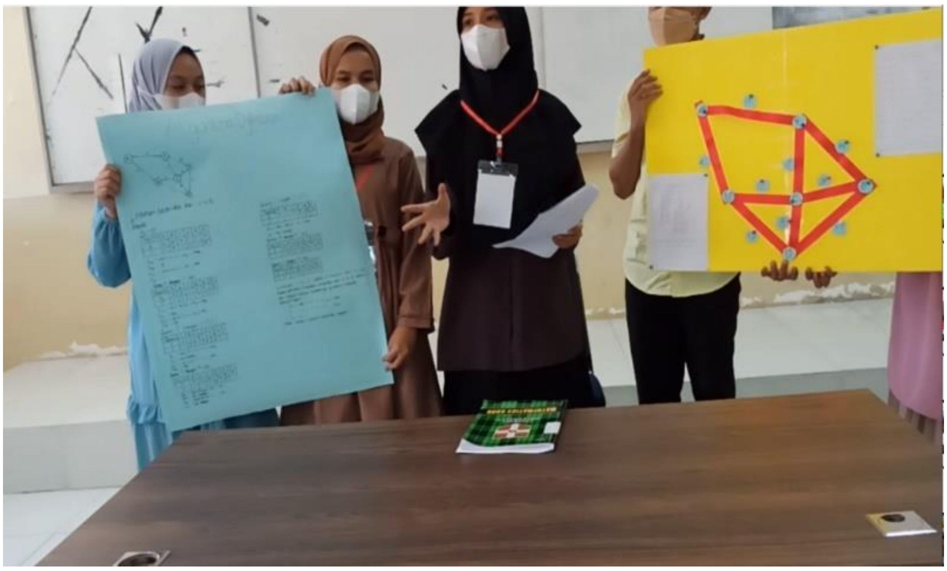

Figure 14. Group 3 Presenting Solution for Problem 3 to Find the Shortest Path Using Dijkstra's Algorithm

Group 3 presented the shortest path from Pantai Belibis to Pantai Sanur but did not demonstrate the final shape of the path by breaking the ribbon as done by the other groups.

Step 5: Class or Group Discussions

During class discussions, all students were allowed to ask questions about the material presented by each group. So that, every students comprehensively understood each algorithm.

Step 6: Rating and Feedback

Assessment or feedback was done at the end of the lesson. Each expert lecturer monitored each group to examine the adapted learning process or lesson study. The observers submitted the redesign after the observations. Figure 15 show that the observers were examining the problem-solving process in each group.

Figure 15. Observer Monitoring and Reviewing the problem-solving process.

The snippet of the dialogue of one of the expert lecturers while doing the observation is (E=expert lecturer, S=Student)

E: How do you solve the problem of finding the minimum spanning tree?
S1: We are just did a trial and error, for example starting from the Pantai Belibis we find the closest tourist attraction that can be seen in the teaching aids. There are two spots Pasar Ampalu and Pulau Kasiak. We found that Pasar Ampalu is closer and choose that tourist attraction. Furthermore, we cut the Pantai Belibis-Pulau Kasiak ribbon.
E: Impressive, why you cut that ribbon?
S2: Soo, in our opinion, we cut that ribbon to ensure the other do not confuse us.
E: GOOD, anyway, do the teaching aids help you to solve the problem?
S2: Yeah, of course.

Based on the snippet, Students can understand the topics by using the learning trajectory with the help of the teaching aids. After observing each group, the observers proposed the redesign as follows.

1. Each group should show its process in the presentation. Moreover, group members should cut off the ribbon one by one according to the algorithm steps, not just breaking the ribbon at the end.
2. Group 1 should not redraw the graph on the cardboard. They should only write algorithms based on the teaching aids on the cardboard.
3. Group 3 should show the shortest path from Pantai Belibis to Pantai Sanur by breaking the ribbon as well as the other groups.

The results of the observation signify that all students feel positive in the learning process because they can understand all the materials effectively. These findings agree with the previous research discovering that learning using the case-based learning method can improve students' understanding of concepts and help them solve problems because they will solve cases by searching for various sources (Campbell, Powers, & Zheng, 2016; Stjernquist & Crang-Svalenius, 2007). Students could meet their learning needs starting from understanding, solving, and presenting cases; as a result, they can understand the material comprehensively. This statement is supported by several experts stating that learning using case-based learning helps students understand the material better and improves their critical and creative thinking skills (Mumford, 2005; Sarah, Prihatmanto, & Rusmin, 2012). The problem faced by students during learning is insufficient time to understand and find solutions for problems. This postulation is supported by several previous studies proposing that case-based education demands the teacher to be able to manage time effectively (Anggraeni, 2012; Putri et al., 2021; Wafi, Wuryadi, & Haryanti, 2020; Yuna, 2006).

This research has revealed that cases given are related to learning materials for discrete mathematics courses in universities. Unfortunately, only a few studies have applied the case-based learning method in mathematics courses in universities. In general, learning using a case-based learning is more easily applied in sciences, such as biology, physics, social, and medicine. This conclusion is derived from various scientific journals and refers to several scientific experts' opinions that cases are more accessible to design (Urban & Keys, 1994).

Furthermore, the learning process using a lesson study has made a significant contribution. The expert lecturers provide inputs to reflect the learning process. This step is in line with the experts' opinion that lesson study aims to reflect the learning process (Dudley, 2013; Lewis, 2009; Matanluk, Johari, & Matanluk, 2013; Zorofi, 2010). The redesign proposed by expert lecturers for this research will increase teachers' professionalism, beliefs, reflections, and attitudes (Harisman, Kusumah, & Kusnandi, 2018, 2019a, 2019c; Novikasari & Dede, 2021). Specifically, a lesson study brings several impacts, including changing the learning process, taking the contexts of learning, offering best experience for teachers who apply this method, and assisting colleagues (Isoda, 2010; Parks, 2008; Post & Varoz, 2008; Sims & Walsh, 2009). The lesson study simultaneously increases teachers' professionalism in teaching. The professionalism of a good teacher will influence students' learning achievement (Armiati et al., 2020; Harisman, Kusumah, & Kusnandi, 2019b; Harisman, Noto, Hidayat, Habibi, & Sovia, 2021; Subhan et al., 2020).

CONCLUSION

A proper design of the case-based learning with lesson study learning trajectory with the help of teaching aids development process is obtained. Learning using a case-based learning method can make students understand materials of certain subjects. This study has designed problems close to the students that are tourist attraction problems in Pariaman City. In the learning process, they play an active role. Moreover, the students feel positive about the learning, meet their needs, and can overcome their difficulties. Problem-solving is done creatively using teaching aids, such as ribbons and styrofoams provided by the course lecturer. Furthermore, the suggestion of the expert that observed the learning process from the start was well deserved.

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