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The flipped-classroom effect on vocational high school students' learning outcomes

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ABSTRACT

The flipped-classroom instructional model is considered suitable for teaching procedural knowledge. Apart from flipped-classroom, it turns out that another instructional model, namely direct instruction, is also designed to teach procedural knowledge. Therefore, this study aimed to examine differences in procedural knowledge learning outcomes between flipped-classroom and direct instruction learning models in the cognitive and psychomotor domains and to determine the effect of flipped-classroom on students' procedural knowledge learning outcomes. This type of research is a true-experimental design with a randomized pre-test post-test control group design for the cognitive domain and a randomized post-test only control group design for the psychomotor domain. The research instrument used a written test (pre-test and post-test) for the cognitive domain and a performance assessment for the psychomotor domain. The flipped-classroom is better than direct instruction regarding procedural knowledge learning outcomes. Furthermore, flipped-classroom significantly affects the students' procedural knowledge learning outcomes, both cognitive and psychomotor domains. The effect of flipped-classroom implementation on the psychomotor domain ($t(50)=23.62$; $p<0.01$; $d=6.56$) is greater than the impact of performance on the cognitive domain ($t(50)=2.35$; $p<0.05$; $d=0.65$).

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1. INTRODUCTION

Several research results have proven that flipped-classrooms have a tremendous impact on a variety of student learning outcomes [1]–[5]. Many studies related to flipped-classrooms have been carried out but are still dominated by case studies in medical subjects [6]–[9]. The condition is reasonable because medical subjects are synonymous with practical activities, so flipped-classroom can cut the duration of learning concepts and increase the period of learning for practice [10]–[12]. Several studies also mention the potential of flipped-classroom to increase the attractiveness of learning in engineering [13], [14]. The field of technical or vocational education in secondary education rarely pays attention to implementing flipped-classroom, even though the substance of the subjects is dominated by procedural knowledge. Several flipped-classroom studies highlight the learning process related to computer science. However, the computer science question is for higher academic institutions, not vocational or secondary education [15], [16]. Flipped-classroom has the potential to help the vocational instructional process, especially for vocational high schools.

Limited teacher resources and equipment are among the administrative problems in Indonesian public vocational schools, especially in information technology majors [17]. The limited resources cause several problems, such as difficulties in serving all students, where teachers have to repeat exactly the material presented in the first and the next class, which can drain the time and energy of the teachers. The quality of learning received by students is not the same, and the limited learning time makes the curriculum target difficult to achieve and negatively affects student learning outcomes. In addition, productive subjects (subjects that contain much procedural knowledge) in information technology majors require practice. They are carried out face-to-face with guidance from the teacher because they focus on skills [18]. On the other hand, some productive subjects, such as computer network subjects, require devices in the learning process. While these devices can only be used in schools, optimizing the limited learning time is crucial.

Looking at the conditions, one of the learning models that can be used as a solution is the flipped-classroom instructional model [18]. The flipped-classroom is an instructional model in which the theoretical material is studied by students independently at home [19]–[21]. Then face-to-face learning in the class focuses on practical activities [22]. The flipped-classroom is divided into three stages, namely: i) Pre-class is used so that students learn independently at home; ii) In-class for practical activities in the class; and iii) Post-class for giving evaluations or assignments [23]–[25]. Thus, the limited time in the class can be optimized for practical activities, and the teacher has the opportunity to guide learners in practical activities one by one [26], [27].

Therefore, the flipped-classroom is very promising for learning, especially procedural knowledge or skills [28], [29]. However, more research is needed to assess its wide application [30], [31]. Flipped-classroom for procedural knowledge or skills is a significant research problem for further investigation. Procedural knowledge is how to do something, including knowledge of skills, methods, and techniques and determining when to do something based on existing criteria [32]. A meta-analysis research revealed that the flipped-classroom is more suitable for practical learning, such as productive subjects in vocational schools [33]. The flipped-classroom’s potential and identified research gaps make flipped-classroom an exciting area of research and still needs further investigation [34].

In addition to the flipped-classroom, direct instruction is another instructional model often used to teach procedural material that requires practice. Direct instruction is one of the instructional models specifically designed to teach systematic procedural and declarative knowledge and needs to be introduced gradually [35]. In this instructional model, there are five instructional phases, namely: i) explaining learning objectives and preparing students; ii) explaining knowledge and demonstrating skills; iii) guiding training; iv) studying understanding and providing feedback; and v) provide opportunities for advanced training. This instructional model is suitable if students are expected to have specific skills because learners will gradually be guided in carrying out practicum procedures. Based on the background and theoretical studies that have been carried out, this study aims to explain the differences in procedural knowledge learning outcomes between the flipped-classroom and direct instruction instructional model in the computer network subject for public vocational schools.

2. RESEARCH METHOD

Figures 1 and 2 show the flow or stage during the research activity. The experimental research design used is true experimental, and the selection of experimental and control groups is random [36]. The design form used for the cognitive domain is the randomized pretest-posttest control group design, where the selected group will be given pre-test and post-test. The design form used for the psychomotor domain is the randomized post-test only control group design, where the selected group will be assigned post-test only. This research was conducted at public vocational high school in Bombana, Southeast Sulawesi, Indonesia. Data was collected using random sampling techniques to obtain the research sample from 52 students taking the network infrastructure administration lesson in computer network subject. Two groups are used as subjects in the study: i) XI-TKJ-1 Class as an experimental group of 26 students; and ii) XI-TKJ-2 Class as a control group of 26 students. The number of each group member is less than 30 students.

This limitation causes some things to be considered by readers in addressing the results reported in this study. First, even though the sample size for each group is less than 30 students, researchers are still guided that researchers can use a parametric test to test the differences between two groups of data as long as the assumption of the normal distribution is met, namely using the dependent t-test or independent t-test. That is, the results of the reported study still have the urgency to be generalized to other cases regardless of the sample size used. Second, if the normal distribution assumption is unmet, the researcher will use a non-parametric test to test two data groups. It means that the results of the reported study cannot be generalized to other cases and only to the issue of this study. Third, sample sizes for experimental research range from at least 15-30 per group. The sample size in this study still meets these guidelines. The selection of sample members in this study was controlled using a random technique so that it is still possible to generalize if the normal distribution assumptions are met.

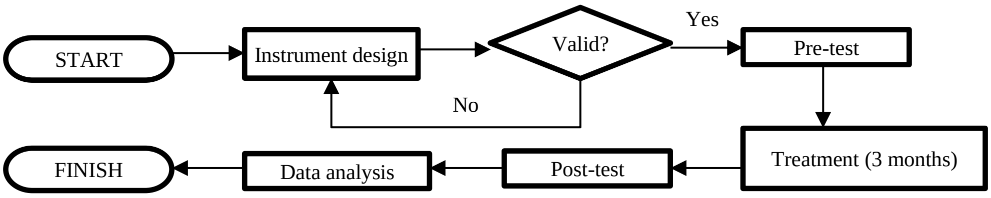

Figure 1. Cognitive domain research process

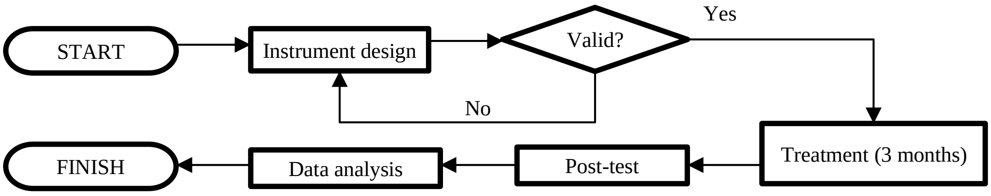

Figure 2. Psychomotor domain research process

Data was collected using research instruments such as written tests and performance assessments. Written tests are used to measure learning outcomes in the cognitive domain during the pre-test and post-test, while performance assessment is used for the psychomotor domain of students during in-class learning. The creation of test instruments includes teacher-made tests with 30 multiple-choice questions. Instrument validity testing uses "content validity" or validation tests by experts. The validated and declared valid instruments are the lesson plan, student worksheets, and test items. Instrument validity analysis using Aiken's V and obtaining high validity criteria for all research instruments. This study began with giving a pre-test to both groups to measure students' initial knowledge and performance. Then in the experimental group, treatment was given by implementing the flipped-classroom instructional model, while the control class used the direct instruction instructional model. Post-test activities were conducted to measure student learning outcomes in every group after treatment implementation. Tables 1 and 2 show that there are differences in the research design for the cognitive domain and the psychomotor domain. The cognitive domain uses random selection, two groups, and pre-test and post-test for each group. The psychomotor domain uses random selection, two groups, and only uses a post-test for each group.

Table 1. Randomized pre-test post-test control group design for the cognitive domain

Group	Pre-test	Treatment/Duration	Post-test
Control (Randomized, 26 students)	O_1	DI (3 months)	O_2
Experiment (Randomized, 26 students)	O_1	FC (3 months)	O_2

O=Observation (1: pre-test, 2: post-test); FC=Flipped-classroom; DI=Direct instruction

Table 2. Randomized post-test only control group design for the psychomotor domain

Group	Treatment/Duration	Post-test
Control (Randomized, 26 students)	DI (3 months)	O
Experiment (Randomized, 26 students)	FC (3 months)	O

O=Observation (post-test/performance test); FC=Flipped-classroom; DI=Direct instruction

The application of flipped-classroom is carried out in three stages, namely pre-class, in-class, and post-class. Pre-class, learning is carried out outside the classroom (online), where teachers will upload learning materials in modules and videos through the learning management system (LMS). The teacher will assign students to answer the questions to ensure that students learn the material given. In-class is a face-to-face learning activity in the classroom or computer laboratory. In this stage, students will apply the concepts learned in the previous setting. The limited learning time in class can be maximized for practicum activities. Students can interact and ask the teacher directly if some obstacles and concepts are not yet understood in practicum activities. Post-class, the teacher gives students assignments as evaluation material and reinforcement related to the material that has been studied.

Direct instruction instructional implementation has five stages [35]. In the first phase, the teacher explains the learning objectives to be achieved, the reasons for the importance of learning the material, motivation, and preparing students to learn. In the second phase, the teacher explains the concepts and demonstrates the ways or steps that must be done in the learning activities on a step-by-step basis. In the third phase, learners try to practice the steps that have been demonstrated, and the teacher must accompany and guide the learners if they experience problems. The fourth phase is reviewing comprehension and providing feedback, where the teacher checks the results of the learner's work and whether they have successfully performed the task well. Then it gives feedback regarding errors found during the learning activity. In the last phase, teachers allow learners to carry out advanced training. The research data analysis techniques used are descriptive statistical analysis and inferential statistics. The descriptive analysis calculates the minimum, maximum, and average scores. Testing the assumptions of the normality of the data distribution was carried out first before the researcher decided whether to use a parametric or non-parametric type difference test.

3. RESULTS AND DISCUSSION

3.1. Cognitive domain learning outcomes

Data collection of cognitive learning results was obtained through pre-test and post-test activities. Table 3 shows the results of the cognitive domain score analysis using descriptive statistics. Table 4 shows the results of the normal distribution test using the Kolmogorov-Smirnov test. If the p-value generated by the Kolmogorov-Smirnov test is more than 0.05, then the data has a normal distribution.

Table 3. Cognitive domain score descriptive analysis

Data test	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Pre-test (CG)	45.00	20.00	65.00	40.77	2.74	13.98	195.39
Post-test (CG)	45.00	30.00	75.00	52.31	2.71	13.80	190.46
Pre-test (EG)	20.00	25.00	45.00	36.92	1.21	6.18	38.15
Post-test (EG)	65.00	30.00	95.00	63.65	4.00	20.42	417.12

CG: Control group; EG: Experiment group

Table 4. Cognitive domain Kolmogorov Smirnov test result

Group	p-value	Baseline	Condition
Pre-test (CG)	0.70	0.05	It is normally distributed.
Post-test (CG)	0.20	0.05	It is normally distributed.
Pre-test (EG)	0.08	0.05	It is normally distributed.
Post-test (EG)	0.20	0.05	It is normally distributed.

CG: Control group; EG: Experiment group

Difference tests between pre-tests in the control and experiment groups were conducted to determine whether the two groups had differences in initial knowledge before being treated. The test uses an independent T-test and produces a p-value of 0.21, greater than 0.05, so it can be ascertained that the initial conditions in both groups are not different. Difference tests between pre-tests and post-test in the control groups were conducted to determine whether the two groups had differences. The test uses a dependent t-test and produces a p-value of 0.00, less than 0.05, so it can be ascertained that both groups are different. Difference tests between pre-tests and post-test in the experiment groups were conducted to determine whether the two groups had differences. The test uses a dependent t-test and produces a p-value of 0.00, less than 0.05, so it can be ascertained that both groups are different. Difference tests between post-tests in the control and experiment groups were conducted to determine whether the two groups differed after treatment. The test uses an independent t-test and produces a p-value of 0.04, less than 0.05, so it can be ascertained that the initial conditions in both groups are different. Cohen's d calculation based on the post-test conditions in the control and experimental groups is 0.66. The effect size for this analysis (d=0.65) exceeded Cohen's convention for a medium effect (d=0.5). Based on the conditions in Table 5, it can be concluded that there is a significant difference in cognitive domain learning outcomes scores between the control group and the experimental group after the treatment activities in each group. This condition means that the application of flipped classroom has a more significant effect than the application of direct instruction on cognitive learning outcomes in the procedural knowledge context.

3.2. Psychomotor domain learning outcomes

Data collection of psychomotor learning results was obtained through post-test activities. Table 6 shows the results of the psychomotor domain score analysis using descriptive statistics. Table 7 shows the results of the normal distribution test using the Kolmogorov-Smirnov test. If the p-value generated by the Kolmogorov-Smirnov test is more than 0.05, then the data has a normal distribution.

Table 5. Cognitive domain difference test result

Group	p-value	Baseline	Condition
Pre-test (CG) and Pre-test (EG)	0.21	0.05	There is no difference.
Pre-test (CG) and Pre-test (CG)	< 0.01	0.05	There is a difference.
Pre-test (EG) and Post-test (EG)	< 0.01	0.05	There is a difference.
Post-test (CG) and Post-test (EG)	0.04	0.05	There is a difference.

CG: Control group; EG: Experiment group

Table 6. Psychomotor domain score descriptive analysis

Data Test	Range	Minimum	Maximum	Mean	Std. Error	Std. deviation	Variance
Post-test (CG)	11.76	47.06	58.82	53.73	0.70	3.58	12.83
Post-test (EG)	20.59	79.41	100.00	90.61	1.39	7.11	50.55

CG: Control group; EG: Experiment group

Table 7. Psychomotor domain Kolmogorov-Smirnov test result

Group	p-value	Baseline	Condition
Post-test (CG)	0.07	0.05	It is normally distributed.
Post-test (EG)	0.10	0.05	It is normally distributed.

CG: Control group; EG: Experiment group

Difference tests between post-tests in the control and experiment groups were conducted to determine whether the two groups differed after treatment. The test uses an independent t-test and produces a p-value of 0.00, less than 0.05, so it can be ascertained that the initial conditions in both groups are different. Cohen's d calculation based on the post-test conditions in the control and experimental groups is 6.56. The effect size for this analysis (d=6.55) exceeded Cohen's convention for a large effect (d=0.8). It can be concluded that there is a significant difference in psychomotor domain learning outcomes scores between the control group and the experimental group after the treatment activities in each group. This condition means that the application of flipped-classroom has a more significant effect than the application of direct instruction on psychomotor learning outcomes in the procedural knowledge context.

3.3. Differences in learning outcomes of flipped-classroom and direct instruction instructional models

The data analysis results show differences in procedural knowledge learning outcomes between the flipped-classroom and direct instruction from both the cognitive and psychomotor domains. The difference in learning outcomes is influenced by the treatment received under the applied learning model. The experimental group implements the flipped-classroom while the control group implements direct instruction. In the experimental group, students are asked to study learning materials and answer questions uploaded in the school's LMS (pre-class) before participating in face-to-face classroom learning activities. So that during face-to-face activities (in-class), students already have basic knowledge related to the material, and the teacher does not need to explain the concept of the material from the beginning but only ensures and recalls the knowledge students obtained through questions and answers. When learners are given questions related to the material, learners become more confident and active in answering the questions [37]–[39]. While in the control group, there are no pre-class activities, so students do not have basic preparation and knowledge related to the material during face-to-face learning. Therefore, the teacher must explain the material from the beginning, and students listen more and listen to the material presented by the teacher through the lecture and demonstration method. The learners missed some important lesson points due to decreased concentration and focus [27], [30].

Flipped-classroom was possible to make the students learn the lesson repeatedly at any time according to the needs of students and able to serve different learning curves that vary according to students' abilities [40], [41]. Direct Instruction cannot help students with different learning styles, abilities, and levels of understanding [35]. If students take longer to understand a lesson or do not participate in face-to-face learning activities, they will find it difficult to access and relearn the material taught, allowing learning loss to occur and impacting students' cognitive abilities.

Furthermore, during practical activities, students in the direct instruction class cannot complete all practicum tasks because lectures and demonstrations have cut off the learning time at the beginning of learning. The more learning time used to explain concepts, the less time is left for practical activities [11], [26]. Meanwhile, in the flipped-classroom group, students can complete all practicum tasks even with the same learning time as the direct instruction group. The face-to-face learning time in the flipped classroom group can be used optimally for practical activities, questions-answer, and guiding students if they experience difficulties during practical activities rather than just delivering a lesson that will drain learning time [42]–[44]. Therefore, the psychomotor learning outcomes of the flipped classroom group are higher than the direct instruction group based on performance assessments during practicum.

Flipped-classroom is student-centered, where learners play an active role in learning and constructing their knowledge and support the current policy of the Indonesian national curriculum, which is required to be student-centered. In the direct instruction group, learning is still teacher-centered, so teachers become the main actors in learning activities, which can hinder their ability to learn independently [35]. In this learning model, teachers act more actively in delivering material and demonstrations as learners passively listen to lectures and occasionally note and answer when given questions. Therefore, in the conclusion of this discussion, the author states that applying flipped-classroom is better than direct instruction when viewed from the procedural knowledge learning outcomes, especially in the information technology program of public vocational high school at computer network subject.

3.4. Effect of flipped classroom learning model on procedural knowledge learning outcomes

The data analysis results show that flipped-classroom positively affects students' procedural knowledge learning outcomes. The result is in line with the theory presented by some research which states that flipped classroom is suitable for teaching procedural knowledge or skills [27], [45]–[47]. This study's results also support Chen's research [48].

In the flipped-classroom group, before participating in classroom learning (pre-class), students gain knowledge and understanding at a lower cognitive level, namely, remembering and understanding [49], [50]. The knowledge gained during pre-class serves as a basis and guide that will be used during practical activities in the classroom [22], [24], [51]. In addition, utilizing the LMS or information technology tools to upload learning materials can make it easier for students to access and learn material according to their needs [44], [52], [53]. The utilization plays a reasonably significant role because students have varying speeds in understanding a material [54], [55]. Pre-class learning efforts can complement in-class activities since procedural knowledge usually results from applying abstract knowledge to manual techniques [56]–[59]. In other words, procedural knowledge requires integrating theory and practice.

After passing the pre-class, the next step is the in-class stage. In the in-class stage, learners focus on higher cognitive levels (applying and analyzing) by using the knowledge gained in the previous setting [49]. The condition is in line with McCormick [14] that learning procedural knowledge or skills is acquired through hands-on practice (learning by doing) [60]–[63]. Since learners have grasped the concept of material at home, the limited learning time can be optimized to provide more individualized reflective learning time [11], [26]. So that students have the opportunity to learn to apply or apply the knowledge they have gained, and teachers have more opportunities to guide students one by one if they experience difficulties in the learning process in class [48], [50].

In addition, it should be noted that in the computer network subject, students need a device, namely a router, to practice. Meanwhile, the device can only be used in a school environment, so students cannot use it when studying independently at home. Thus, the face-to-face learning time in the classroom should be optimized for practical activities because learners only have the opportunity to practice using a router when configuring. Moreover, technical errors sometimes occur in practical learning, which can drain learning time. Therefore, flipped-classroom is excellent for use in practical subjects, as presented by Zhao and Cao [33], and supports research that flipped-classroom provides excellent benefits to computer science education [27], [64].

In this study, there were several obstacles experienced. The students did not have an internet connection to access learning materials, so the solution provided by students was asked to download the material using the school's internet connection. Still, some students ended up unable to collect the assignments given. In addition, some students come from lower-middle families (social disparity) where, when at home, they have to help their parents work. Some other students come from outside the area and live with families, which causes them not to have the same opportunities to study at home as other students. It can also affect the learning outcomes of students [17], [34].

Several things need to be considered in the implementation of flipped-classroom. Teachers must ensure students have learned the material online through the school's LMS. For example, students must watch learning videos by linking them to quizzes completed before the in-class session. If students do not follow the directions for independent learning, it will impact the learning process during face-to-face learning and affect their learning outcomes [24], [34]. In addition, teaching materials can also affect the success of this learning. Teachers can provide material in the handbook and videos to equip students before participating in face-to-face classroom learning activities [24].

4. CONCLUSION

This study concludes that the flipped-classroom learning model is better than direct instruction regarding learning outcomes on students' procedural knowledge in both cognitive and psychomotor domains. The effect of flipped-classroom implementation on the psychomotor domain is greater than the impact of performance on the cognitive domain. In addition, applying the flipped-classroom learning model has also been proven to positively affect learning outcomes in the procedural knowledge of computer network subjects at information technology major public vocational high school. The suggestion for future research is to measure the learning outcomes of another knowledge type, such as factual, conceptual, and metacognitive knowledge. In addition, it can measure other aspects, for example, learning motivation. In implementing flipped-classroom, students' motivation can affect the learning experience and success of implementing this instructional model. Then it can develop new flipped-classroom instructional model procedures and teaching or learning resources that effectively support the learning outcome of computer network subjects in vocational high schools.

The results of this study have limitations, especially on psychomotor learning outcomes. It is because the research design used still uses only the post-test without involving pre-test activities in both the control and experimental groups. Hopefully, future research can improve the research design carried out in this study by adding a pre-test to the experimental procedure used.

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