Flipped Direct Instruction (FDI): Optimization of Practicum Learning Models

Akrimullah Mubai, Ambiyar*, and Dedy Irfan

***Abstract*—Selecting an accurate learning model plays a big part in determining the quality of the implemented learning process. The Flipped Direct Instruction (FDI) learning model is introduced as a new learning model to increase the effectiveness of the implementation of learning through practicums. Therefore, the purpose of this study is to examine the effectiveness level of the FDI learning model application. This research is carried out during the Computer Network Installation practical lesson in the July-December 2022 semester at the Electronic Systems Engineering Study Program, Universitas Negeri Padang, Indonesia. This study is conducted using a quasi-experimental design with a control class and an experimental class as the research samples. The Direct Instruction (DI) model was applied in the control class and the FDI model was utilized for the experimental class. This study uses quantitative and primary data types. Data were obtained using test instruments through the application of a pre-test and a post-test. The data is calculated using the N-Gain method to measure the level of effectiveness of the FDI model implementation. In utilizing the N-Gain method, the requirements for the normality test, homogeneity test, and t-test were applied. The results of the research on the implementation of the pre-test for the control class were a value of 36.11 and 34.01 for the experimental class. Whereas for the post-test, a value of 71.27 and 86.80 were the results for the experimental class. The experimental class post-test scores were used in the N-Gain test. The results of the N-Gain test obtained a percentage of 79.11% with a minimum value of 62.76% and a maximum value of 90.89%. The value of 79.11% in the N-Gain value range can be categorized as a notably high outcome. This portrays that the FDI learning model is effective in improving practicum learning outcomes.**

***Index Terms*—Flipped Direct Instruction (FDI), practical learning models, simulator**

I. Introduction

The type of learning model used in class is an important point in education. Learning models have several phases according to the type of learning implementations [1]. In the type of practicum learning, the Direct Instruction (DI) learning model is the oldest model. However, it is still widely used until this day. This is based on the results of Stockard's research which reviewed more than 500 articles on the DI learning model [2].

The DI model is a learning model that focuses on thinking skills and behaviours in practical learning. The DI model was initiated by Bropy and Weil in 1986 [1]. The DI learning model consists of orientation, presentation, structured practice, guided practice, and independent practice phases. In its implementation, the current DI model has several weaknesses. The most prominent weakness of the DI model is that it is less effective in increasing students' prior knowledge, critical thinking, and creative thinking which has an impact on student learning outcomes [3–5].

This issue was also found in the results of observations carried out in the Pendidikan Teknik Informatika (PTI) study program, Universitas Negeri Padang (UNP) Indonesia. Observations were carried out in four classes of the second year (2F) PTI study program in the January-June 2022 semester in practical learning of Computer Network Installation. The implementation of this practical learning used the DI learning model. The learning outcomes of the practicum implementation are presented in Table I.

TABLE I: THE LEARNING OUTCOMES USING THE DI LEARNING MODEL

Class	Learning outcomes
2F1	63.92
2F2	65.36
2F3	75.63
2F4	73.05

Based on the learning outcomes in classes 2F1, 2F2, 2F3, and 2F4, the quality of the learning outcomes of the Computer Network Installation Practicum needs to be improved. It is important to further observe this increase according to the DI learning model used. This study can be supported by looking for other alternatives to the DI learning model or using the development of the DI model. The DI model in its development has attempted to implement various types of techniques to increase students' initial knowledge, critical thinking, and creativity [3–5].

Taking Winarno and Muthu *et al*. [5] and Winarsih *et al*.'s [4] research as an example that collaborates the DI model with the Problem-Based Learning model to improve student's critical thinking skills. Warju and Ariyanto *et al.* [3] use Real Condition Video in the DI model to increase students' initial knowledge and understanding. Budiman *et al.* [6] combines the DI model with Contextual Learning and Winarno and Andono *et al*. [7] utilize multimedia in the DI model to increase student creativity. Recently, we have combined the DI model with the Flipped Classroom (FC) learning model advancing it to the Flipped Direct Instruction (FDI) model.

The FDI learning model is built based on the combination of the DI and Flipped Classroom (FC) models. The use of the FC model is intended to obscure the shortcomings of the DI model in increasing students' initial knowledge, critical thinking, and creativity. This is due to how the FC model as part of blended learning is aimed to increase the students' thinking skills and creativity [8–12]. The advantages of the FC model are suitable for the DI model which is specifically aimed to increase the students' practical abilities [1, 9]. For

Manuscript received March 1, 2023; revised April 18, 2023; accepted May 22, 2023.

Akrimullah Mubai, Ambiyar, and Dedy Irfan are with the Faculty of Engineering, Universitas Negeri Padang, Indonesia.

*Correspondence: ambiyar@ft.unp.ac.id (A.)

doi: 10.18178/ijiet.2023.13.11.1985

this reason, this study uses the FDI model in researching and proving the advantages of the FDI learning model. The description of the FDI learning model is presented in Fig. 1.

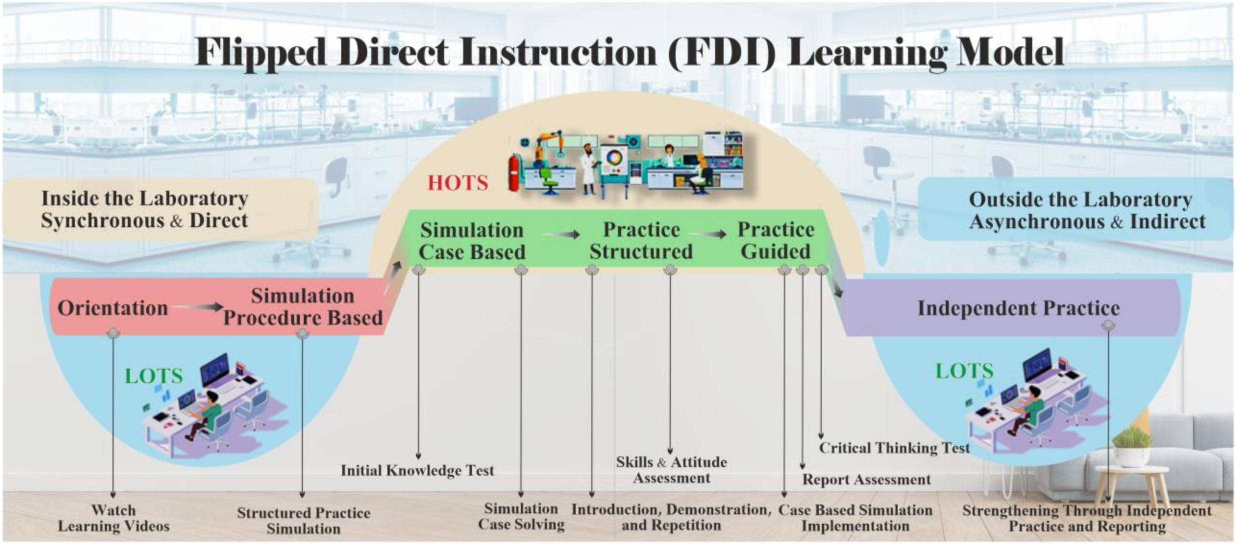

Fig. 1. FDI learning model.

Based on Fig. 1, the FDI learning model has six learning phases. The first and second phases are the orientation and the basic procedure simulation phases. Both phases are designed so that students' initial knowledge is good. The construction of this knowledge is carried out asynchronously and indirectly outside the laboratory in controlled independent learning. Independent learning is carried out by using videos as a part of learning media, simulators, and social media which are expected to improve students' Low Order Thinking Skill (LOTS) abilities [1, 13, 14].

Following that, the third, fourth, and fifth phases are the case-based simulation phase, structured practice, and guided practice. These three phases aim to shape students' skills, creativity, and critical thinking skills at the Higher Order Thinking Skill (HOTS) level. For this reason, the implementation of the three phases is carried out directly and synchronously in the laboratory with the lecturers. Student HOTS skills are shaped in the FDI model through learning by solving cases, discussions, simulations, demonstrations, and direct practice along with testing prior knowledge, practical skills, and critical thinking skills [13, 15, 16].

The sixth phase is an independent practice carried out asynchronously and indirectly outside the laboratory. The independent practice phase is intended to strengthen students' memories who have just acquired new knowledge [1]. This reinforcement of the memory is in the form of repetition of simulations and documentation of making practicum reports by each student. The advantages of the FDI model are aimed to increase the effectiveness of practicum learning which has an impact on improving student learning outcomes. Therefore, this research aims to test the level of effectiveness of the FDI learning model in improving student learning outcomes as a newly proposed learning model.

II. Method

This study uses a Quasi-Experimental design. The research was conducted in the Computer Network Installation Practicum course in the July-December 2022 semester at the Electronic Systems Engineering study program, Universitas Negeri Padang, Indonesia. The final decision of conducting this research in the Computer Network Installation Practicum course is based on the argument that it is a mandatory and fundamental subject to be mastered by every student of the study program in the fields of computers, informatics, and electronics.

Computer Network Installation Science majors with competency and expertise in network transmission media installation, IP Address, Subnetting, Supernetting, VLSM, NAT, DNS, DHCP, Wireless, Hotspot, and Proxy are urgently needed at this time in the industry. Consequently, this research was carried out during the Computer Network Installation course to answer the research hypothesis. The research hypothesis is as follows:

Ha: A significant effect of the use of the FDI learning model on the learning outcomes of the Computer Network Installation practicum is present.

H0: Any significant effect of the use of the FDI learning model on the learning outcomes of the Computer Network Installation practicum is not visible.

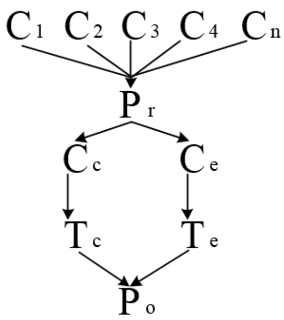

Fig. 2. Research subject design.

An intact-group comparison method was used to answer the research hypothesis. The intact-group comparison method implements the experimental and control groups as the research sample. The model of the intact-group comparison in this study is presented in Fig. 2.

C_1, C_2, C_3, C_4, C_n = First class (1), second (2), third (3), fourth (4), and so on (n)
P_r = Control and experimental class selection tests (Pre-test)
C_c = Control class
C_e = Experiment class
T_c = Treatment in the control class
T_e = Treatment in the experimental class
P_o = The final test of control and experimental classes (Post-test)

The research subjects were determined based on the number of classes that are available. Each class is given the symbol 'C', followed by the order of the class. The group that has been labeled is then given a class selection test (P_r) as a pre-test to measure the ability of each student in the class. The test results were used as the basis for selecting the control class (C_c) and the experimental class (C_e) which were the samples in this study. The selection of the two classes is based on students who have the smallest difference in their average scores. This is used as grounds to state that the class chosen is a class with students that have relatively equal or similar abilities.

The control and experimental classes that have been selected are then given treatment. The treatment for the control class (T_c) was in the form of using the DI learning model and the FDI learning model was used in the experimental class (T_e). After the treatment was carried out for one semester, a final test (P_o), also referred to as the post-test, was carried out. The results of this final test will be calculated using the N-Gain test. The N-Gain test was used to determine how big the treatment given affected the experimental class.

The outcome will then be a benchmark in answering the research hypothesis. In using the N-Gain method, several analysis requirements are needed. The requirements are presented in Table II.

TABLE II: N-GAIN TEST REQUIREMENTS [17, 18]

Requirements	Purpose	Method	Benchmark
Normality test	To test whether the distribution of data is normal or not	Shapiro-Wilk	Sig. > 0.05
Homogeneity Test	To test the data samples taken from populations that have the same variance	Homogeneity of Variance	Sig. > 0.05
T-Test	To test whether there is a significant difference between groups	Independent Samples Test	Sig. (2-tailed) < 0.05

Each requirement must be implemented in using the N-Gain test. After each requirement is met, the N-Gain method (1) can then be used properly.

$$N\ Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score} \quad (1)$$

N Gain = Gain Value
Post-test Score = Value after being given treatment
Pre-test Score = Value before being given treatment
Ideal Score = Minimum completeness value

In determining or finding out the level of effectiveness of the N-Gain calculation, Hake uses the N-Gain category guidelines. The N-Gain category is presented in Table III.

TABLE III: CATEGORY GAIN-SCORE [18]

N-Gain Value	Category
N-Gain > 0.7	High
0.3 ≤ N Gain ≤ 0.7	Medium
N Gain < 0.3	Low

TABLE IV: RESEARCH INSTRUMENTS

Instrument	Instrument Type	Number of Items	Validity test	Reliability test
Pre-test instrument	Objective Test	20 questions	Product Moment Pearson	Kuder-Richardson (KR-20)
Post-test instrument	Essay and Practice Tests	3 questions	PHI correlation	Cronbach Alpha

The types of data this study uses are primary and quantitative data. Each data test utilizes the Excel application and IBM SPSS Statistics 25. During data collection, test instruments are used in the pre-test and post-test. The instruments used are presented in Table IV.

The standard for testing the validity of the instrument is by viewing the value of countable *r* and the *r* table, where if the value of countable *r* is greater than the *r* table, then the instrument is declared valid and vice versa. Furthermore, for reliability, the interpretation of the *r* value is used as in Table V.

TABLE V: INTERPRETATION OF THE VALUE OF *R* [17, 19]

r value	Interpretation
0.81 – 1.00	Very High
0.61 – 0.80	High
0.41 – 0.60	Medium
0.21 – 0.40	Low
0.00 – 0.20	Very Low

III. FINDINGS AND DISCUSSION

A. Research Outcome

The research outcome begins with the presentation of the results of the research instrument testing. The results of this test are presented in Table VI.

TABLE VI: INSTRUMENT VALIDITY AND RELIABILITY TESTS

Instrument	Validity			Reliability	
	countable *r*	*r* table	Status	Value	Status
Pre-test instrument	0.798	0.444	Valid	0.994	Very high
Post-test instrument	0.634	0.602	Valid	0.617	High

The results of the pre-test and post-test research instruments obtained a countable *r* value that was greater than the *r* table value. This symbolizes that the instrument used is valid. Continuing, the reliability test on the pre-test instrument showed very high reliability as a result and the post-test instrument obtained high reliability as a result. Instruments that are valid and reliable are then used in the implementation of the pre-test and post-test. The pre-test was carried out in three classes of Electronic Systems Engineering (TRSE) batch 3 (3TRSE). The results of the pre-test are presented in Fig. 3.

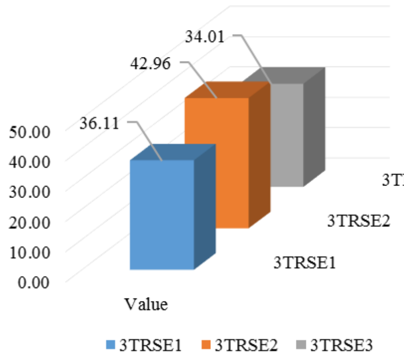

Fig 3. Pre-test results.

The results of the pre-test were used as the basis for selecting the control and experimental classes. For the chosen control class, 3TRSE1 was the result, and as for the experimental class, 3TRSE3. The control and experimental classes that have been selected are given different treatments. The control class was given the DI learning model and the experimental class uses the FDI learning model. The results of applying this variable were then tested in a post-test at the end of the semester. The results of the implementation of the post-test are presented in Fig. 4.

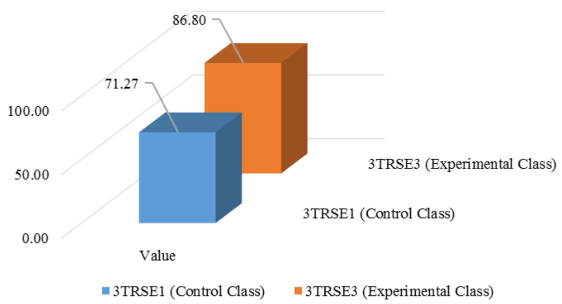

Fig. 4. Post-test results.

The results of the implementation of the post-test illustrate that the value for the control class was 71.27 and the experimental class was 86.80. Based on the comparison of these two values, the application of the FDI learning model is more effective to be applied. However, this alone has not yet answered the hypothesis in this study. In answering the research hypothesis, testing is still carried out by using the N-Gain method. The description of the N-Gain test results is presented as follows.

1) N-Gain test

Normalized gain (N-Gain) Score aims to determine the effectiveness of using a method or model in a study. The N-Gain test was carried out in the experimental class using the pre-test and post-test data. The results of the Gain-Score test are presented in Table VII.

Based on the results of the calculation of the N-gain score test in the experimental class using the FDI learning model, it is 79.11 or 79.11% with a minimum value of 62.76% and a maximum value of 90.89%. The N-Gain value can only be used to answer the research hypothesis if the T-Test test value produces significant data calculations [18]. Meanwhile, the T-test requires normal and homogeneous data [17]. The following is an explanation of the Normality, Homogeneity, and T-Test tests.

TABLE VII: N-GAIN TEST RESULT DATA

Student	Experiment Class Data				N Gain Score (%)
	Pre test (A)	Post test (B)	B-A	100-A	
Student 1	20.0	92.71	72.71	80.00	90.89
Student 2	33.3	84.53	51.23	66.70	76.81
Student 3	26.7	87.47	60.77	73.30	82.91
Student 4	26.7	87.63	60.93	73.30	83.12
Student 5	26.7	87.12	60.42	73.30	82.43
Student 6	40.0	81.10	41.10	60.00	68.50
Student 7	53.3	82.61	29.31	46.70	62.76
Student 8	40.0	86.79	46.79	60.00	77.98
Student 9	26.7	86.38	59.68	73.30	81.42
Student 10	46.7	91.62	44.92	53.30	84.28
Average	34.01	86.80			**79.11**
Minimum			**62.76**		
Maximum			**90.89**		

2) Normality test

The normality test in this study applied the Shapiro-Wilk method since the data obtained was less than 50 [16, 17]. The data used are the pre-test and post-test results in the control and experimental class. The results of the calculations are presented in Table VIII. Based on Table VIII, the significance values were obtained sequentially, respectively 0.296, 0.656, 0.286, and 0.798. The value of the four data>0.05 which means that all data is normally distributed and can be processed with parametric statistics.

3) Homogeneity test

The homogeneity test utilizes post-test data from the experimental class and the control class to test the variance of the two sets of data. Variable testing is carried out to ensure that the data obtained is of the same type, produced by the same process and the same instrument. The results of the homogeneity test are presented in Table IX. Based on Table IX, the test obtained a significant value of 0.567. The value of 0.567 > 0.05 interprets that the variance of the post-test data for the experimental class and the control class is homogeneous.

4) Independent T-test

The Independent T-Test in this study uses post-test data from the control and experimental classes. The results of the homogeneity test are presented in Table X. Based on Table X, it is clear that the post-test data for the control class and the experimental class have a Sig (2-tailed) value of 0.002, which is <0.05, means that there is a significant difference in the average value of learning outcomes in the post-test data of the control class and the experimental class. This interprets that what type of learning model is being implemented plays a big part in learning outcomes.

In addition, the significant T-Test value allows the N-Gain test results to be used in answering the research hypothesis. Based on the N-Gain value in Table VII, the value obtained is 79.11%. A value of 79.11% interprets that the N-Gain value is in the *High* or *Effective* category. The effective N-gain value answers the hypothesis in this study, where the Alternative Hypothesis (Ha) is accepted and the Null Hypothesis (H0) is rejected. The Ha hypothesis is that there is a significant effect of the use of the FDI learning model on the learning outcomes of Computer Network Installation practicum.

TABLE VIII: NORMALITY TEST RESULTS DATA

Class		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Learning outcomes	Experiment Class Pre-Test	0.254	10	0.066	0.912	10	**0.296**
	Experiment Class Post-Test	0.208	10	.200*	0.949	10	**0.656**
	Control Class Pre-Test	0.212	12	0.144	0.920	12	**0.286**
	Post-Test Control Class	0.120	12	.200*	0.960	12	**0.782**

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

TABLE IX: HOMOGENITY TEST RESULT DATA

		Levene Statistic	df1	df2	Sig.
Learning outcomes	Based on Mean	0.339	1	20	**0.567**
	Based on Median	0.334	1	20	0.570
	Based on Median and with adjusted df	0.334	1	19.777	0.570
	Based on trimmed mean	0.337	1	20	0.568

TABLE X: DATA ON INDEPENDENT T-TEST RESULTS

		Levene's Test for Equality of Variances		t-test for Equality of Means			Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)			Lower	Upper
Learning outcomes	Equal variances assumed	0.339	0.567	3.57	20	**0.002**	5.71	1.598	2.378	9.043
	Equal variances not assumed			3.6	19.74	**0.002**	5.71	1.586	2.399	9.021

B. Research Discussion

The practice of the Flipped Direct Instruction (FDI) learning model has a good impact on student practicum learning outcomes. This is based on the results of the study where the experimental class obtained a post-test score of 86.80 which was significantly higher than the control class score of 71.27. This positive impact has a high level of effectiveness with an N-Gain value of 79.11%. The results of the N-Gain prove the hypothesis of this study that there is a significant influence of the use of the FDI learning model on the results of practical learning carried out in the Computer Network Installation Practicum course.

The implementation of the FDI learning model is not fundamentally tied to a specific subject or course. This is because the FDI learning model is specifically designed to increase the effectiveness of practicum learning which has an impact on improving student learning outcomes. The increase in student learning outcomes is due to the implications of applying the FDI model after observing the deficiencies of the DI model. This advantage lies in the implementation of indirect asynchronous learning and direct synchronous learning in the FDI learning model phase.

The FDI learning model starts from the Orientation phase. This phase contains independent learning activities carried out by students themselves by watching videos of practical learning indirectly and asynchronously outside the laboratory. It is different from the orientation phase of the DI model which contains activities explaining learning orientation by the lecturer directly in the laboratory through lectures [1, 20]. Independently learning through videos allows students to learn self-sufficiently and be able to construct their knowledge. This is also very much due to how learning using videos can be repeated and implemented dynamically [21, 22]. This is in line with the development of the DI model initiated by Warju and Ariyanto *et al.* [3] which uses Real Condition Video in the DI model. The use of video materials in learning is backed up by its plus points in the flexibility of learning processes and is proven to have an impact on increasing student learning outcomes by 77%.

This approach is then followed by the Base Procedure Simulation phase as the second phase. This phase contains simulation activities from the learning material that has been obtained in the learning videos during the orientation phase. The Base Procedure Simulation Phase is carried out indirectly and asynchronously outside the laboratory using a media simulator. The advantage of this media simulator is that it can provide a better understanding to students since observation is a key point in its implementation of the simulation [14, 15]. These observations can represent reality with a complexity of events that can be controlled and can be transferred to the real world [1].

Activities in the Procedure-Based simulation phase will form students' foundational knowledge in the form of Lower Order Thinking Skills (LOTS). Orientation and procedural-based simulation phases are proven solutions to the weaknesses of the DI model. This weakness was in strengthening students' initial knowledge [3, 5, 7]. The problem of increasing students' primer knowledge in the DI model had been proposed by various previous researchers.

Warju and Ariyanto *et al* [3] proposed providing real video conditions in the DI model and Winarno and Andono *et al.* [7] utilized multimedia in the DI model. This is indeed, a feasible approach, however, it would be much more adaptive if the FDI learning model learning videos are also accompanied by media simulation. Media simulation is used to prove concepts that have just been obtained from learning videos. This is very helpful in directing students who are completely new to a specific learning material [23].

The next phase is the Case-Based simulation which is carried out directly and synchronously in the laboratory. This phase consists of an initial knowledge test activity and completing a learning case activity. These tasks aim to foster students' critical thinking skills in the form of Higher Order Thinking Skills (HOTS) [1, 24]. Providing cases that are relevant to current conditions and issues provides an overview for students to find out the benefits of the practicum studied in the industry later. This can also bring students closer to the real world that they will encounter [25, 26].

The Case-Based simulation phase is carried out in groups of 2–6 students. Collaboration and teamwork in groups foster cooperation skills as a single team to solve cases with theoretical and practical evidence [27]. This is a solution to the weaknesses of the DI model in aspects of increasing students' critical and creative thinking [5, 28]. An attempt by previous researchers to address the solution to this obstacle is already present. For example, Winarno and Muthu *et al.* [5] and Winarsih *et al.* [4] proposed problem-based learning in the DI model. The implementation of the DI model development proposed by Winarno and Muthu *et al.* [5] increased learning outcomes by 25.9% and the increase in Winarsih *et al.* [4] research increased by 12.8%. This is inevitably a favorable idea, but in the FDI model, the problems given are more complex than those contained in a case. All of this is due to how the case is a collection of problems that have a more complex pattern [29].

After carrying out the simulation, the next phase is Structured Practice which is carried out directly and synchronously in the laboratory. The structured practice phase contains practical activities that are imitative as well as the assessment of work skills and attitudes. The structured practice phase is based on the principle to shape [1]. This formation is intended so that students can possess skills that can be used independently with little or no mistakes at all. Furthermore, the structured practice phase is targeted to prove realistically and directly step by step the procedure-based simulation material that has been carried out in the second phase. In achieving independent practice with a high degree of accuracy, practicums are carried out in the structured practice phase, the guided practice phase, and the independent practice phase [1].

The Guided Practice phase is the fifth phase. In this phase, students carry out their activities in the form of self-practice under the monitoring of the lecturer. The purpose of this practice is to provide a wider space for students to practice and be creative as well as to prove the case-based simulation that was carried out in the third phase. The previous case-based simulation's objective is to strengthen students' understanding and to reduce the level of risk of accidents that might occur during the Guided Practice phase. At the end of the Guided Practice phase, an assessment to examine students' critical thinking skills is carried out.

The Independent Practice Phase is the sixth phase of the FDI model. This phase is repetitive in nature and is carried out by each student indirectly and asynchronously outside the laboratory. Independent practice is made in the form of assignments in the form of repetition of simulations and preparation of practicum reports. Repetition of simulations and preparation of practicum reports will be able to strengthen students' memories of newly acquired learning information. These things are the advantages of the FDI model in optimizing the practicum learning model. On that account, the FDI learning model is expected to be a breakthrough in practicum learning for various levels of education.

IV. Conclusion

The implementation of the FDI learning model has a remarkable impact on increasing the effectiveness of learning the Computer Network Installation practicum. The effectiveness of practicums that are carried out has a significant impact on improving student learning outcomes. The increase in learning outcomes is supported by an increase in the ability to construct foundational knowledge, critical thinking, creativity, and practical abilities which is facilitated in the FDI learning model. This is following the post-test results in the experimental class with a value of 86.80 which is visibly higher than the control class score of 71.27. This beneficial impact has a high level of effectiveness with an N-Gain value of 79.11%. The results of the N-Gain value prove that there is a significant influence of the use of the FDI learning model on the results of practicum-method learning. This is a novelty in practicum learning which is expected to contribute to the improvement of graduates who will be ready to face the challenges of the 21st century and the 4.0 industrial revolution.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

This research was conducted by several researchers. Akrimullah Mubai contributed to data collection and paper writing. Ambiyar contributed to the creation of the research instrument, approved the final version of the paper, and was responsible for conducting the research. Dedy Irfan contributed to processing research data and helping improve papers. All authors had approved the final version.

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