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Development of Collaborative Learning and Programming (CLP): A Learning Model on Object Oriented Programming Course

Efan Efan*
Institut Teknologi Pagar Alam, Pagar Alam, South Sumatra, 31520, Indonesia
E-mail: efan@itpa.ac.id
ORCID iD: https://orcid.org/0000-0003-0545-2324
*Corresponding Author

Krismadinata Krismadinata
Universitas Negeri Padang, Padang, West Sumatra, 25132, Indonesia
Email: krisma@ft.unp.ac.id
ORCID iD: https://orcid.org/0000-0003-1485-4595

Chérifa Boudia
University Mustafa Stambouli of Mascara, Mascara, Oran, Algeria
Email: cherifa.boudia@univ-mascara.dz
ORCID iD: https://orcid.org/0000-0002-5190-9893

Muhammad Giatman
Universitas Negeri Padang, Padang, West Sumatra, 25132, Indonesia
Email: giatman@ft.unp.ac.id
ORCID iD: https://orcid.org/0000-0001-5896-9699

Mukhlidi Muskhir
Universitas Negeri Padang, Padang, West Sumatra, 25132, Indonesia
Email: muskhir@ft.unp.ac.id
ORCID iD: https://orcid.org/0000-0002-3885-9756

Hasan Maksum
Universitas Negeri Padang, Padang, West Sumatra, 25132, Indonesia
Email: hasan@ft.unp.ac.id
ORCID iD: https://orcid.org/0000-0003-1321-8888

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Abstract: There appears to be a tendency for the strategies and methods that have been offered in OOP course learning to affect the improvement of individual skills only. There is a significant need for learning strategies which are relevant and able of improving collaborative working skills. The purpose of this study is to develop a Collaborative Learning and Programming model suitable for Object-Oriented Programming courses and assess its validity, practicality, and effectiveness. The implementation of the CLP model was conducted using the ADDIE development procedure by involving 7 experts, 35 experimental class students, 23 control class students and 4 lecturers of the Object-Oriented Programming course. The survey results showed that the CLP model was valid, practical, and effective in achieving these goals. The validity test results were verified based on experts' assessment, indicating that the aspects contained in the CLP model were valid with an Aiken's value V =0.89. The practicality test results indicated that the model was highly practical with the practicality value of 89.95% from students and 89.67% from lecturers. Finally, using the CLP model demonstrated its effectiveness in reducing the abstraction and complexity of OOP courses and improving student collaboration, particularly in programming tasks. The significance of conducting this survey is that it provides evidence for the effectiveness of the CLP model in achieving its intended goals and can inform the development of future OOP courses and programming tasks. The survey was conducted well, as it used both expert assessment and student and lecturer feedback to assess the validity, practicality, and effectiveness of the CLP model.

Index Terms: CLP Model, Collaborative Learning, Collaborative Programming, Object-Oriented Programming, Teaching, Learning, Model, Method, Strategy.

1. Introduction

Over the past decade, the world has undergone a massive transformation as a result of the changing era. For the first time, Industry 4.0 was introduced at the Hannover Fair in Germany in 2011, which emphasized the digitization and integration of all production units [1]. This trend is driven by technological advancements in Information Technology (IT) both vertically and horizontally, including Big Data, Artificial Intelligence (AI), Internet of Things, Cloud Computing, and Augmented Reality (AR). Furthermore, starting before 2020 and for approximately two years, the world was dealing with Covid'19 pandemic era which has affected all aspects of modern life where almost all activities were suspended and diverted online as the application of lock down and social distancing rules [2]. In contrast to the industrial era 4.0, which was created due to the support of information technology, the pandemic era actually encourages an increase in information technology support. On the other hand, what is quite astonishing is the fact that the development of the metaverse, which is a virtual world where users are represented by avatars, able to socialize, shop, and learn, has been a priority for numerous technology companies, including Facebook and Microsoft [3]. Today, the metaverse has received high esteem globally thanks to the related technologies and the rapid evolution of IT capable of supporting it [4], making this new virtual world a big influence. This provides broad employment opportunities, particularly for graduated students with an IT background, where the world of employment has to rely almost entirely on products from the IT industry as anticipation of future changes in the work system. The results of a survey from McKinsey of 100 company executives from various countries and industries as respondents, indicated that nine out of ten companies planned to implement a hybrid work policy following the end of the pandemic [5]. Apart from McKinsey, Price Waterhouse Coopers (PwC) conducted a survey related to this and stated that one of the predicted trends in the world of work in 2022 is a work from anywhere, in fact 50% of companies researched by PwC have provided permanent remote working options for workers [6].

For vocational education practitioners, the previous conditions allow the realization of Prosser's theory, which still strongly influences the practices of vocational education in Indonesia [7], especially in courses in the computer science category. As it is known that the fundamental feature of the application of Prosser's theory in vocational education is a curriculum development, establish competency standards, provide tools and working procedures excavated from work competencies in the industry or at a minimum close to the standards of the world of work [7, 8]. The world of work that is about to be formed or is being formed directs the perpetrators to work with computer devices or the like connected to the internet network. It is evident that several sectors, including retailing, transportation, smart city, e-governance, supply chain management, online learning, logistics, cultivation, automotive, industrial enterprise, etc., have implemented the benefits of various IoT products [9]. These applications are developed using Personal Computers (PCs) that are connected to the internet, and are available for relatively affordble purchase.

The situation brings students and lecturers in OOP courses deal with two major problems: 1) the demands of the IT industry that require collaborative working skills and complexity and 2) the abstraction of the OOP concept within the course itself. Collaborative working skills are required due to the fact that software development requires effective collaboration between programmers [10]. Basically, programming works individually, but nowadays, the world of work and industry requires collaborative programming skills so that the main goal of programming is achievable [11]. In addition, in the world of computer science education, students are frequently assigned programming tasks in the form of working on applications or software in teams consisting of several students [12].

Various researchers have proposed various alternative strategies and methods related specifically to solve these problems. For example, by developing game-based learning models, designing virtual learning environments, developing web-based learning tools, nevertheless, the strategies and methods that have been provided usually have an impact solely on improving individual skills [13]. Furthermore, the learning design is made not only accommodating the basic objectives of the OOP course, but also accommodating the ability to work collaboratively. Boudia et al. [14] proposes collaborative learning model that is proven increased student involvement, commitment and motivation at each phase of the programming process. The model is also proven that the ollaborative study groups demonstrate new social skills in all students and the distribusion of tasks and roles makes the material less difficult and more enjoyable. However, the lack of ICT technology, time management, networks, and effective management often leads to a decrease in motivation for both lecturers and students. On the other hand, Lin et al. [15] proposed a collaborarative programming that used MediaWiki as ICT technology and is proven supported many aspects of collaborative work. This study aimed to develop Collaborative Learning and Programming (CLP) model on Object-Oriented Programming course and to determine the validity, practicality, and effectiveness. The model is developed by combining collaborative learning model [14] and collaborative programming model [15]. The ADDIE research and development model was applied during the development process.

2. Related Works

2.1. Collaborative Learning

Collaborative learning is a coordinated, student-oriented activity that involves students' interaction in working collectively to solve problems [16]. This requires students to work collaboratively to solve problems as a group. Group members are required to create a better product from shared knowledge [17]. Critical elements in this type of learning are active involvement and coordination among group members and the spread of individual expertise, resources and knowledge within the group [17, 18].

Literature references on collaborative learning frequently refer to the tenets of social constructivism. Dillenbourg [19] interprets this kind of learning as "An interaction between two or more individuals in which they learn or attempt to learn something together", two learners are called pairs, small groups (3-5), classes (20-30), communities of a several hundred or several thousand people, societies of several thousand or million people and all intermediate levels.

Some literatures consistently show that collaborative learning can be an effective way to improve student learning, but that it is important to carefully consider the factors that can affect its success. Suruchi and Dutt [20] reviewed the literature on collaborative learning, focusing on its effects on student learning and the use of various collaborative learning strategies, concluded that collaborative learning can be an effective way to improve student learning, but that the success of collaborative learning depends on a number of factors, such as the quality of the learning tasks, the composition of the groups, and the guidance of the teacher. Cheng et al. [21] investigated the impact of collaborative learning and personality on student satisfaction in an innovative teaching context. and found that collaborative learning was associated with higher levels of satisfaction, but that this effect was moderated by personality. Specifically, students who were more introverted and less agreeable were less satisfied with collaborative learning. Van Der Meer et al. [22] examined the use of virtual reality (VR) for collaborative learning and found that VR has the potential to support collaborative learning in a number of ways, such as providing a shared virtual space for collaboration, facilitating communication and interaction between learners, and providing opportunities for learners to practice skills in a safe and realistic environment. Erbil [23] examined the research on the use of flipped teaching, a pedagogical approach in which students learn the material outside of class and then applied it in class through activities and discussions, found that flipped teaching can be an effective way to promote collaborative learning, as it gives students time to work on problems and discuss their ideas with each other before class.

The key findings of the literatures above are: 1) collaborative learning can lead to higher levels of student achievement, retention, and motivation; 2) collaborative learning can help students develop critical thinking, problem-solving, and communication skills; 3) collaborative learning can help students build relationships with their peers and with their teachers; and 4) the success of collaborative learning depends on a number of factors, such as the quality of the learning tasks, the composition of the groups, and the guidance of the teacher. Overall, the research on collaborative learning is very promising. It suggests that collaborative learning can be a powerful tool for improving student learning and development. However, it is important to note that collaborative learning is not a magic bullet. It is important to carefully consider the factors that can affect its success in order to maximize its benefits.

One of the widely adapted collaborative learning models is pair programming. Pair programming entails two programmers working together on a single code [24]. Important researches have experimented this learning in their classes. Authors in [24–26]: 1) demonstrated that pair programming enhanced students' outcomes based on satisfaction, interactivity, and engagement in introductory courses; and 2) there appears to be considerable evidence that female students in particular benefited more from pair programming; 3) increased independence and reduced dependence on teaching; and 4) paired students demonstrated higher-order reasoning skills than those working themselves.

Nevertheless, several studies have revealed difficulties in the use of collaborative programming, especially related to planning and matching the right collaborators [25]. In addition, various level of Students' performance affects the effectiveness of pair programming [26]. According to [27], It can be asserted that students who are confident prefer collaborative learning over those who are less confident.

2.2. Collaborative Programming

The Incorporating collaborative programming into the process of learning can have a positive impact and reduce the problem of IT industry demands that require collaborative working skills as well as the complexity and abstraction of OOP concepts. Collaborative programming provides students the opportunity to interact with fellow students and utilizes each other's resources and skills, and facilitates better programming learning [15]. Collaborative programming, in addition to being able to generate a multitude of student ideas by observing other students' program code, also indirectly increases students' experience by seeing other students' mistakes when coding [15]. Collaborative programming also improves problem solving skills as a result of inherited metacognitive activities [28]. In addition, students are able to create better programs when using collaborative programming [29].

Since Computer Support Collaborative Learning (CSCL) is becoming increasingly popular, numerous researchers have argued that collaborative programming will not only enable students to interact with their mates, but will also facilitate a more effective learning of computer programming by utilizing each other's resources and skills [30], [31]. There are multiple reasons why collaborative programming is helpful in encouraging problem-solving and improving programming skills in learners. Firstly, students will be able to develop ideas and stimulate their thinking when they observe others programming [32, 33]. Moreover, they can gain experience from identifying mistakes others' programs. Lee [28] argued that collaborative programming engenders metacognitive activities that increase students' self-monitoring and subsequently advances problem-solving competences. Correspondingly [31] concurred that pair programming helped learners in their problem-solving activities. In addition, Bryant et al. [34] confirmed that students not only improve better problem-solving skills using collaborative programming, and proceeded to create more effective programs.

On other side, McGill & Volet [35] illustrated numerous nature of knowledge included in programming: declarative-conceptual, declarative-syntactic, procedural-conceptual, procedural-syntactic, and strategic knowledge where declarative knowledge is often used to specify the rules or constraints that govern the behavior of a system, without necessarily specifying how those rules are implemented. This can be contrasted with procedural knowledge, which refers to the knowledge of how to perform a particular task or procedure [36]. Soloway [37] mentioned that programming may be referred as a complex dynamic and nonlinear process. Furthermore, it is requiring careful planning that involves data [38]. When teachers emphasized only that programming's syntactic and semantic aspects, this conducts to teaching merely the programming process' outputs and final results. They should explain how to build mechanisms to students when they learn to program [37].

In prior researches, authors declared that there was no difference between collaborative and conventional learners involved in learning declarative knowledge. Nevertheless, in development of both procedural-syntactic and procedural-conceptual and strategic programming knowledge, it revealed positive impacts on students' collaborative learning [35]. As well, by participating in shared knowledge elaboration, students can develop their procedural flexibility by comparing the efficacy of alternative solution techniques [39]. In knowledge elaboration, new information is organized, restructured, linked, and integrated with existing information elements in order to expand and refine it [40]. Consequently, Students develop a fresh understanding of their information through knowledge elaboration. Effective collaboration programming activities can help to improve procedural knowledge acquisition [19].

Courses of Programming should be assumed in collaborative technique rather than propositional (declarative-conceptual) form to help students build their planning and algorithmic skills. Traditional education accentuates declarative knowledge while frequently overlooking procedural and strategic understanding. The defective or partial nature of programming training demands the development of new teaching approaches. Hence, Coaching and collaborative learning activities to improve students' shared knowledge elaboration should be integrated into programming teaching. Collaboration has also been demonstrated to improve student motivation, engagement, retention, and confidence. Jan & Hurlbutt [41] demonstrated that collaborative programming increased student confidence, retention, participation, and motivation.

As a result, learning media used for collaborative programming must be designed in an intentional and specific manner to encourage learner participation. It has been shown that students are more engaged and focused on programming activities when they have convenient and regular access to keyboard controls in learning media or can see and share visual information about their context. Hwang et al. [42] designed online learning system for collaborative programming aimed at enhancing the cognitive ability of students, via internet, this system enables students obtaining software, learning tools and diffusing information among them though sharing notifications and comments. An analysis of learners' collaborative behaviors was conducted using their participation in programming assignments. In their paper, Hwang et al. [42] elucidated that reviewing classmates' program and discussing it with them is challenging for high-achieving students. In contrast, students of varying abilities engaged to improve their peers' incomplete program code. Further, the large majority of learners concurred regarding the usefulness of wiki-based platform for collaborative programming. In meanwhile, numerous investigations published the collaborative platform benefits in assisting programming learning, conversely only few studies managed the way should the programming assignments strategies be conceived and integrated in collaborative learning platforms, or assessing these strategies' effectiveness on students' learning.

Recently, some present research publicized the technology effectiveness in its roles of assisting social constructivism and improving students' self-regulation regarding conceptual declarative knowledge [43], it is necessary to conduct further research to determine whether computer-assisted collaborative learning can enhance declarative and procedural knowledge [44]. There is a need in developing dynamic and nonlinear programming procedures that requires the development of additional collaborative instruments, systems, and works, particularly in the areas of procedural and strategic knowledge.

Current study tested various aspects of collaborative learning such as its importance, its use in online systems, and impacts of the effects of relations through collaboration. Nonetheless, despite all advances, it remains elusive gap of exploration about the way of deployments of the collaborative programs, and the assessment of collaborative programming effectiveness on students' outcomes and behaviors.

3. Methodology

To design and develop the CLP model, ADDIE development procedure was used which involved five phases including Analysis, Design, Implementation Development, and Evaluation [45]. See Fig.1.

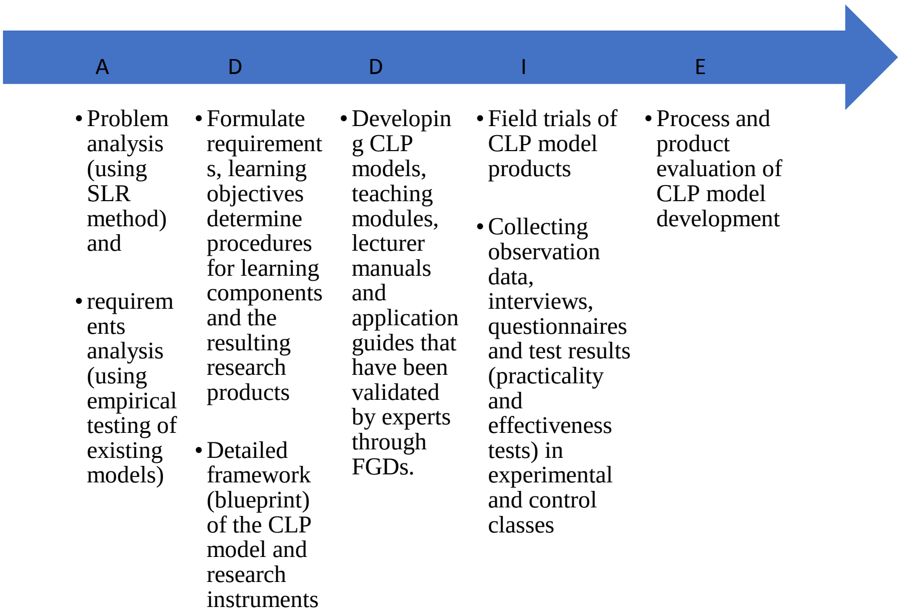

Fig. 1. ADDIE Development Procedure

The ADDIE can be used to help achieve research objectives in the development of learning models in OOP courses in a number of ways. First, the analysis phase can be used to identify the specific learning objectives that the research is trying to achieve. This can help to ensure that the learning model is designed to meet the specific needs of the learners. Second, the design phase can be used to create a learning model that is aligned with the research objectives. This can be done by carefully selecting the content, activities, and assessments that will be used in the learning model. Third, the development phase can be used to create high-quality learning materials that are effective in achieving the research objectives. This can be done by using evidence-based instructional methods and by carefully reviewing the learning materials for accuracy and clarity. Fourth, the implementation phase can be used to deliver the learning materials to the learners and to provide support as needed. This can help to ensure that the learners have the opportunity to learn effectively and that they are able to overcome any challenges that they may face. Fifth, the evaluation phase can be used to gather data to assess the effectiveness of the learning model in achieving the research objectives. This data can be used to make improvements to the learning model and to ensure that it is meeting the needs of the learners. Overall, the ADDIE methodology can be a valuable tool for researchers who are developing learning models in OOP courses. By following the five phases of the ADDIE model, researchers can increase the chances of developing a learning model that is effective in achieving their research objectives.

3.1. Product Trials

Product trials were carried out by conducting an experimental process for control group students and experimental groups using an experimental of two group design pre-test and post-test control [46]. See Table 1.

Table 1. Research Design Quasi Experiment of Two Group Pre-Test and Post-Test Control

Group	Pre-test	Treatment	Post test
Experiment	experimental class pre-test result	treatment provided to the experimental class.	experimental class post-test result
Control	control class pre-test result		control class post-test result

3.2. Test Subjects

The subject of expert testing is the validation of the construct and content of the CLP model through focus group discussion (FGD) activities. Table 2 shows the composition of the experts involvement and assessment of the construct and content of the model.

Table 2. List of experts

Fields	Quantity of experts
Technology and vocational education experts	3
Informatics engineering experts	3
Language experts	1

This trial aimed to evaluate the CLP model; three criteria are targeted: degree of practicality, efficiency, and students' learning results. The subjects of the trial application of the CLP model were students and lecturers in the OOP course class. The control class was OOP learning class without being treated; the experimental class was a class that was treated with the application of the CLP model. The collected data were analyzed using statistical tests and formulas with the help of SPSS and Microsoft Excel applications. Table 3 displays the data of the test subjects of the developed model.

Table 3. Data Of Trial Subjects

No.	Class	Amount of lecturers	Amount of students
1	Control	2	23
2	Experiments	2	35
	Total	4	58

3.3. Instruments of Data Collection

The instrument of validity was used to measure the construct and content validation of the CLP model through focus group discussion (FGD) activities. The validity instrument was developed according to 5-ranges Likert scale (from 1 = very irrelevant to 5 = very relevant). Table 4 shows the aspects and number of validity indicators of the CLP model.

Table 4. Aspects and indicators of the validity of the CLP model

No.	Aspect	Number of indicators
1	Rational model	3
2	Supporting theories	6
3	Characteristic	3
4	Sintax	6
5	Social system	6
6	Principal reaction	7
7	Supporting system	7
8	Instructional and accompanying impacts	5
	Total	43

For this practicality criterion, student and lecturer satisfaction questionnaire is intended to measure the effectiveness of CLP model's practicality. The purpose of practicality instrument is to evaluate the responses of students and teachers regarding the implementation of the collaborative CLP model. The practicality instrument was prepared using a 5-points Likert scale (1=strongly disagree, 2= disagree, 3=neural, 4= agree and 5 =strongly agree). The practicality instrument was prepared based on several aspects and indicators as on Table 5:

Table 5. Instruments of practicality framework

No.	Aspects	Number of statement
1	Practicality of learning model	18
2	Practicality of learning module	11
3	Practicality of the application guidebook	10
4	Practicality of the lecturer guidebook	7
	Total	46

The CLP model is deemed effective in improving student learning outcomes, if statistically, student learning outcomes determine a meaningful variation between students' initial understanding of the model and their understanding after learning it. This will justify that the CLP model is valid and practical and could be effective to improve student learning outcomes in OOP learning.

This criterion serves to measure CLP model's effectiveness across student learning achievements in term of multiple choice test questions. This instrument is explored through two time periods a pre-test and posttest of OOP learning using the CLP model in the experimental class. In the same time, in the control class, CLP model learning is skipped on purpose. At the end, this phrase emphasizes if there is a noteworthy and potentially important difference between the learning outcomes of both classes to determine the model's effectiveness.

3.4. Technique of Data Analysys

Descriptive analysis is an analysis conducted to assess the characteristics of a data, including: mean, median, variance, standard error, standard of mean, mode, range, minimal, skewness and kurtosis.

According to [47], an analysis of descriptive statistics involves describing the data collected as they are without making general conclusions about them. Description of collected data can be done through tables, graphs, circle charts, histograms, mode calculations, medians, averages, standard deviations, and percentage calculations.

Validity analysis of the CLP model and OOP teaching materials

The validation data are derived from results of a panel of experts filling out the validation instrument. Experts provide inputs, suggestions and information in order to improve the developed model. The validity test was carried out by calculating Aiken's V formula of the content validity coefficient. It is based on the results of several expert evaluation panels on ranged items which represents the construction being measured. If Aiken's V value is above 0.6 then it is declared valid. The Aiken's formula is illustrated in formula (1) and (2).

$$V = \sum S/[n(c-1)] \tag{1}$$

$$S = r - l_o \tag{2}$$

Notes: N = “The number of assessors”, lo = “Lowest validity score”, c = “Highest validity score i", and r = “The number given by the assessor”.

The assessment of the practicality of the CLP model was carried out by lecturers and students as respondents through filling out a questionnaire on the practicality of the learning model. The CLP model’s practicality analysis is the implementation level of the learning stages. The respondents' assessment results were analyzed to determine the CLP model’s practicality. CLP model’s practicality value is calculated using formula (3). Table 6 displays the practicality category based on the practicality value obtained.

$$\text{Practicality Score } = \frac{\text{number of scores obtained}}{\text{maximum score}} x100\% \tag{3}$$

Table 6. Practicality Category of CLP Model

Practicality score	Category
0.81-1.00	Highly practical
0.61-0.80	Practical
0.41-0.60	Practical enough
0.21-0.40	Less practical
0.00-0.20	Unpractical

Normality test is applied using Chi squared formula (4) to determine whether the variable's data distribution is normal. SPSS program on Kolmogorov Smirnov statistics is called up to test the normality of the data with a confidence level of 0.05. Regarding Kolmogorov Smirnov statistic, data’ sample distribution is normal, when the obtained value is higher than 0.05.

$$X^2 = \sum_{i=1}^{k} \frac{(f_o - f_e)^2}{f_e} \tag{4}$$

Notes: if X^2count >= X table, data distribution is abnormal; if X^2count <= X table, data distribution is normal

Homogeneity test aims to determine whether the two samples have homogeneous variances or not. Homogeneity of variance is tested based on the formula (5):

$$F = \frac{S_1{}^2}{S_2{}^2} \tag{5}$$

Notes: 1) $\boldsymbol{S_1^2}$ = value of the largest variant, $\boldsymbol{S_2^2}$ = value of the smallest variant; 2) Data have equal variance if f count < f table, and vice-versa, else data have unequal variance when f count > f table.

To compare the average of the experimental class and the control class, dependent sample t-test or paired sample t-test is employed. A substantive discrepancy is revealed if the t value is less than 0.05, otherwise there is no significant difference if the t value is above 0.05. The t-test formula (6) used for paired samples.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1{}^2}{n_1} + \frac{s_2{}^2}{n_2} - 2r\left(\frac{s_1}{\sqrt{n_1}}\right)\left(\frac{s_2}{\sqrt{n_2}}\right)}} \tag{6}$$

Notes: $\bar{x}_1$= sample 1, $\bar{x}_2$= sample 2, s_1= standard deviation of sample 1, s_2= standard deviation of sample 2, $S_1{}^2$= variance of sample 1, $S_2{}^2$= variance of sample 2, n_1= number of data of sample 1, n_2= number of data of sample 2.

4. Data Analysis and Findings

4.1. The Developed CLP Model

Collaborative Learning & Programming model is the development of a learning model that combines face-to-face collaborative learning and collaborative programming using the Github application that supports remote learning. Specifically, this learning model is a development of two existing models, namely: 1) collaborative learning model [14]; and 2) collaborative programming model [15]. Fig.2 shows the developed model.

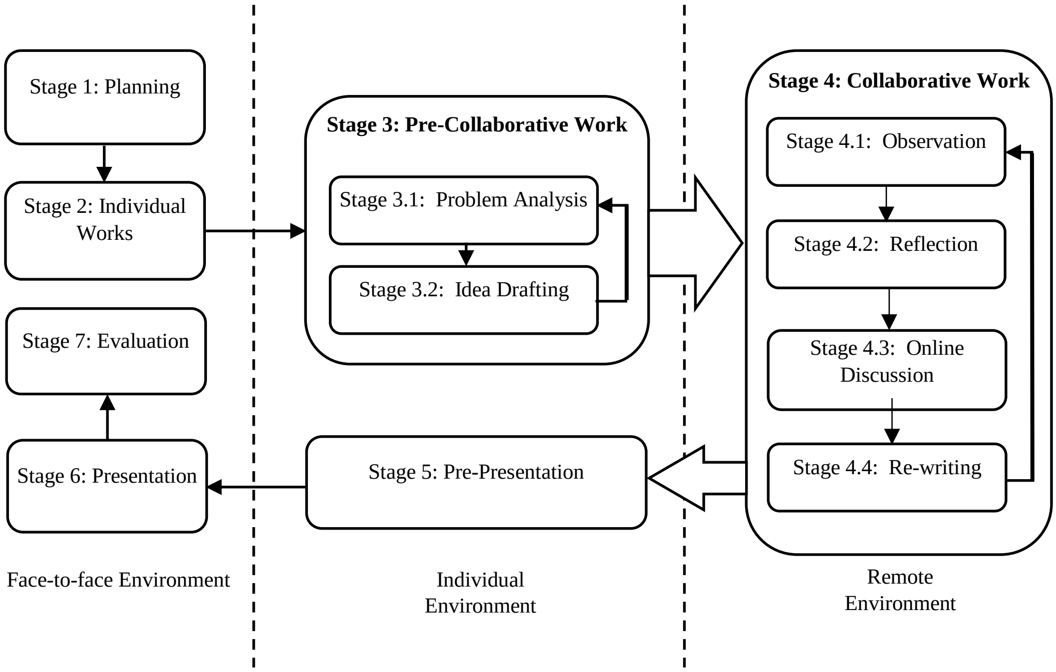

Fig. 2. The Developed Model

The combination was based on the consideration of the advantages and disadvantages of the two existing models. Table 7 describes the source of the syntax combination of the Collaborative Learning & Programming model.

Table 7. Source of Collaborative Learning and Programming syntax combination model

Collaborative learning & programming		Existing model	
		Collaborative learning	Collaborative learning
1	Planning		
2	Individual works	(p-2) individual works	
3	Pre-collaborative works	(p-3) collaborative works	
3.1	Problem analysis	(p.3.1) problem analysis	
3.2	Idea drafting	(p.3.2) conception	(p1) concepting ideas
4	Collaborative works		
4.1	Observation		(p2) observation
4.2	Reflection		(p3) reflection
4.3	Online discussion		(p4) discussion
4.4	Re-writing	(p.3.3) coding and (p.3.4) debugging and testing	(p5) rewriting
5	Writing presentation	P-4	
6	Presentation	(p.5) class discussion	(p6) performing a push
7	Evaluation	(p.6) individual work	
		Class environment	Wiki environment

The combination of the two existing models is based on the results of empirical trials by applying the existing learning model. The selection of the two existing models is based on the proposed solution at the problem analysis stage. The trial treatment follows the procedure applied to each learning model. This trial process was conducted to assess and evaluate the positive and negative aspects of each particular part in our proposed learning model. The purpose of this evaluation is to determine the areas of strength that can be leveraged to achieve goals and the areas of weakness that need to be addressed or improved upon. This learning model's advantages and disadvantages further form the basis of the combination in the design of the developed model. Fig.3 shows the stages of selecting the existing model up to the determination of requirement specifications.

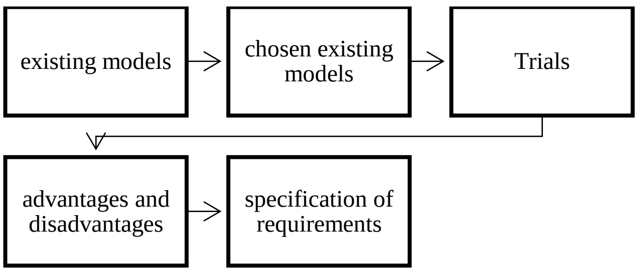

Fig.3. Empirical Test of Existing Model

4.2. Validity

Expert validation of the CLP model includes several aspects: model rationale, model supporting theory, model characteristics, model syntax, social system, reaction principles, support system, and instructional and accompanying impacts. The validators' assessment results of CLP model are displayed on Table 8.

Table 8. Validity Results of CLP Model

Assessed Aspects		**∑S**	**Aiken's V**
Rational Model	Idct. 1	22	0.79
	Idct. 2	26	0.93
	Idct. 3	22	0.79
Supporting theory Model	Idct. 4	26	0.93
	Idct. 5	25	0.89
	Idct. 6	27	0.96
	Idct. 7	28	1,00
	Idct. 8	25	0.89
	Idct. 9	24	0.86
Characteristics Model	Idct. 10	24	0.86
	Idct. 11	26	0.93
	Idct. 12	26	0.93
Syntax Model	Idct. 13	24	0.86
	Idct. 14	25	0.89
	Idct. 15	25	0.89
	Idct. 16	25	0.89
	Idct. 17	25	0.89
	Idct. 18	25	0.89
Sosial system	Idct. 19	28	1,00
	Idct. 20	24	0.86
	Idct. 21	26	0.93
	Idct. 22	23	0.82
	Idct. 23	26	0.93
	Idct. 24	25	0.89
Principal Reaction	Idct. 25	25	0.89
	Idct. 26	24	0.86
	Idct. 27	26	0.93
	Idct. 28	26	0.93
	Idct. 29	24	0.86
	Idct. 30	25	0.89
	Idct. 31	25	0.89
Supporting system	Idct. 32	26	0.93
	Idct. 33	25	0.89
	Idct. 34	27	0.96
	Idct. 35	24	0.86
	Idct. 36	24	0.86
	Idct. 37	25	0.89
	Idct. 38	26	0.93
Instructional and Accompanying Impact	Idct. 39	24	0.86
	Idct. 40	26	0.93
	Idct. 41	22	0.79
	Idct. 42	26	0.93
	Idct. 43	25	0.89
Total		1077	0.89
Description		**valid**	

Source: primary data processed using Excel

The results of data analysis obtained Aiken's V value of 0.89. Aiken's values ranged from 0 to 1. Based on this range, the number 0.60 means that the coefficient is significantly high. Thus, the V value of 0.89 can be considered in the valid category. Based on the suggestions obtained from the expert, the construct and content of the model were revised so that the CLP model construct was valid and suitable for testing.

4.3. Practicality

The CLP model's practicality test was conducted after the validity instrument was validated by experts and the results were declared valid. CLP model practicality analysis' results stated that the implementation of CLP model was carried out by conducting a model trial.

The implementation of all learning activities has been conducted in accordance with the stages of learning that have been designed. From the description of observation data, interviews by validators, students and lecturers comments indicate that the assessment instrument's practicality in the development of CLP model is highly practical. To justify the assessment instrument is practical, then: 1) The results of expert and practitioner assessments specified that the assessment instruments are applicable and ongoing throughout learning phases; 2) The field observations' results showed that learners and teachers were capable to implement activities in accordance with the activities listed in the CLP model.

In this research, the number of lecturers involved in the implementation of the CLP model amounted to four people (100%) and had responded to the instrument of practicality. While the number of students involved in the implementation of the model as a whole (both for pre-test and post-test) is 35 people (100%) and had responded to the instrument of practicality. Table 9 outlines the results of the practicality test given to lecturers and students who have conducted learning using the CLP model.

Table 9. Practicality Results of CLP Model

No.	Assested aspects		Students		Lecturers	
			Total	%	Total	%
1	Practicality learning model	Statement 1	163	93%	18	90%
2		Statement 2	156	89%	18	90%
3		Statement 3	152	87%	18	90%
4		Statement 4	163	93%	19	95%
5		Statement 5	164	94%	18	90%
6		Statement 6	151	86%	17	85%
7		Statement 7	153	87%	20	100%
8		Statement 8	152	87%	17	85%
9		Statement 9	164	94%	17	85%
10		Statement 10	161	92%	20	100%
11		Statement 11	167	95%	17	85%
12		Statement 12	152	87%	16	80%
13		Statement 13	155	89%	17	85%
14		Statement 14	161	92%	18	90%
15		Statement 15	151	86%	17	85%
16		Statement 16	150	86%	18	90%
17		Statement 17	160	91%	17	85%
18		Statement 18	153	87%	18	90%
19	Practicality learning modul	Statement 19	151	86%	18	90%
20		Statement 20	159	91%	19	95%
21		Statement 21	163	93%	18	90%
22		Statement 22	156	89%	18	90%
23		Statement 23	148	85%	16	80%
24		Statement 24	164	94%	18	90%
25		Statement 25	161	92%	19	95%
26		Statement 26	160	91%	17	85%
27		Statement 27	154	88%	19	95%
28		Statement 28	161	92%	17	85%
29		Statement 29	156	89%	17	85%
30	Practicality of the application guide book	Statement 30	165	94%	19	95%
31		Statement 31	153	87%	17	85%
32		Statement 32	154	88%	20	100%
33		Statement 33	155	89%	19	95%
34		Statement 34	158	90%	18	90%
35		Statement 35	161	92%	18	90%
36		Statement 36	156	89%	18	90%
37		Statement 37	156	89%	19	95%
38		Statement 38	161	92%	20	100%
39		Statement 39	163	93%	18	90%
40	Practicality of lecturer guidebook	Statement 40			17	85%
41		Statement 41			17	85%
42		Statement 42			19	95%
43		Statement 43			18	90%
44		Statement 44			16	80%
45		Statement 45			19	95%
46		Statement 46			17	85%
Total			6143	89.95%	825	89.67%
			Highly practical		Highly practical	

Source: primary data processed using Excel

Referring to practicality data, the average percentage of student assessment of the CLP model is 89.95%. Furthermore, the average percentage of lecturers' assessment of the CLP model is 89.67%. This condition means that students and lecturers rated the CLP model as highly practical when implemented.

4.4. Effectivenness

According to control and the experimental classes' effectiveness, data description's results are intended to provide an overview of the acquisition of OOP learning outcomes. The results of both pre-test and post-test data processing in control and experimental classes are presented in Table 10.

Descriptive analysis' results in the control class revealed that students' average (mean) pre-test score is 28.87. The median value is 29.00. The size of the distribution of statistical data (standard deviation) is 5.345. The scores are included in an interval [18, 42] with a range of 24. While the average (mean) student pre-test score in the experimental class is 29.48. The middle value (median) is 28.00. The size of the distribution of statistical data (standard deviation) is 6.243. The highest score is 40 and the lowest score is 19 with a range of 21.

Furthermore, descriptive analysis' results in the control class showed that the average (mean) student post-test score was 47.36 and middle value (median) is 46.00. The size of the distribution of statistical data (standard deviation) amounted to 15.311. The scores are included in an interval [28, 76] with a range of 48. While the mean of students' post-test scores in the experimental class is 71.69 and middle value (median) is 70.00. The size of the distribution of statistical data (standard deviation) is 13.427. The scores are included in an interval [48, 92] with a range of 44.

Table 10. Descriptive Analysis of Pre-Test and Post-Test Data

Class		Pre-test		Post-test	
		Experiment	Control	Experiment	control
Mean		29.48	28.87	71.69	47.36
95% confidence interval for mean	Lower bound	27.11	26.56	67.07	40.58
	Upper bound	31.86	31.18	76.30	54.15
5% trimmed mean		29.48	28.74	71.87	46.85
Median		28.00	29.00	70.00	46.00
Variance		38.973	28.573	180.281	234.433
Std. Deviation		6.243	5.345	13.427	15.311
Minimum		19	18	48	28
Maximum		40	42	92	76
Range		21	24	44	48
Interquartile range		10	5	24	27
Skewness		.296	.482	.023	.487
Kurtosis		-.876	1.001	-1.500	-1.039

Source: Primary Data Processed Using SPSS

Table 11 illustrated Normality test of pre-test and post-test scores' results for both control and experimental classes. For pre-test scores, the normality test results indicated marked contrast values equal to 0.200 and 0.072 for the control and experimental class respectively. In terms of post-test scores, the normality test results show marked contrast values equal to 0.051 and 0.000 for the control and experimental class respectively. Overall, the significant value is above 0.05. This amounts to saying that both tests scores are normally distributed, thus the data is applicable for the next test.

Table 11. the results of the normality test of the pre-test and post-test results

Class		Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre_Test	Control	.149	23	.200*	.965	23	.570
	Experiment	.155	29	.072	.932	29	.061
Post_Test	Control	.184	22	.051	.917	22	.065
	Experiment	.237	35	.000	.887	35	.002

a. Lilliefors Significance Correction
*. This is a lower bound of the true significance.
Source: primary data was processed using SPSS

Homogenity test defines whether some population variants are similar or not. As a prerequisite to the independent sample t-test and the anova analysis of variance, this test must be conducted. If the significance level exceeds 0.05, it is possible to assume that the variants of two or more groups of data are the same. In its most basic form, the homogeneity test is designed to show the similar variances of two or more groups of scaled sample data from the same population. This study used SPSS to analyze the pre-test and post-test results of students in the control and experimental groups. Using Lavene's test, the homogeneity test determines whether the data are homogeneous when the significance level exceeds 0.05. In Table 12, the pre-test and post-test homogeneity test results are presented for the control and experimental classes, respectively.

Table 12. Results of pre-test homogeneity test of control and experimental classes

	Levene Statistic	df1	df2	Sig.
Pre-Test	1.131	1	50	.293
Post-Test	.228	1	55	.635

Source: primary data was processed using SPSS

As a result of the data homogeneity analysis, the significance value of the pre-test results for the control and experimental classes is 0.293, indicating a significance level greater than 0.05. Therefore, it can be concluded that the data on the pre-test results of students in the control class and experimental class obtained have a similar variance. It amounts to saying that the pre-test data from the two classes are homogeneous and can be further examined. In addition, the results of the data homogeneity analysis show that the significance value of the post-test results for the control and experimental classes is 0.635 which suggests that it is higher than 0.05. Thus, it can be concluded that the data on the post-test results of students in the control class and the experimental class obtained also have similar variance. This means that the post-test data from the control class and experimental class are homogeneous and that the tests are applicable.

T-test is applied to affirm how the influence of each independent variable (independent variable) on the dependent variable (dependent variable). It is correspondingly used to determine whether or not there is a difference between two groups of unpaired samples. All results of the t-test for the two classes on the pre-test and post-test are in Table 13.

Table 13. T-test results of pre-test and post-test of control and experimental classes

		Levene's Test for Equality of Variances: F	Levene's Test for Equality of Variances: Sig.	t-test for Equality of Means: t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
Pre_Test	**Equal variances assumed**	1.131	.293	-.374	50	.710	-.613	1.638	-3.902	2.676
	Equal variances not assumed			-.381	49.672	.705	-.613	1.608	-3.844	2.617
Post_Test	**Equal variances assumed**	.228	.635	-6.306	55	.000	-24.322	3.857	-32.052	-16.593
	Equal variances not assumed			-6.118	40.381	.000	-24.322	3.976	-32.355	-16.289

Source: primary data was processed using SPSS

Based on the T-test pre-test's results, the significant values (2-tailed) of the two classes are 0.710 and 0.705. As a result, we can infer that the significance value is greater than 0.05. Consequently, it can be recognized that the students of the two classes do not have a significant average difference, or it can be stated that the two classes, both the control class and the experimental class, have almost the identical average ability. Based on these results, it can be concluded that in the initial condition there was no significant average difference between the pre-test results in the control class and the experimental class. It can be proven that in the initial condition in before the treatment, the condition of students in the control class and the experimental class has closely identical academic ability.

The t-test for post-test results in the control class and experimental class was conducted to determine whether there was a difference in learning outcomes between the control class which used a conventional learning model compared to the experimental class which was treated using the CLP model. Based on the results of the T-test post-test, the significant value (2-tailed) of the two classes is 0.000. This means that the significance value is less than 0.05. Based on this result, it can be seen that the students of the two classes have a significant average difference, or it can be stated that the two classes, both the control class and the experimental class, have different average abilities. The results can be concluded that in the final condition there exists a significant average difference between the post-test results between the control class and the experimental class. This justifies that in the condition after treatment, there is a change in the state of students in the experimental class in terms of academic ability.

4.5. Findings

Dataset is collected from X University's SET reports of computing students in three different online semesters. This data contains a total of 27,622 SET records of 701 sections for 35 different courses. Each section is filled with 36 to 42 students.

Students' learning outcomes in the control class and experimental class represent their learning outcomes in the OOP learning process. A post-test process is used to obtain cognitive learning outcomes as part of normative learning evaluation activities. On the basis of comparing the average value of OOP learning outcomes at the beginning and end of the lecture, it is possible to analyze the improvement in student learning outcomes in the control class and experimental class. By applying the CLP model to the experimental class, the analysis will examine how student learning outcomes develop before and after treatment.

At the beginning of the lecture, the average student learning outcomes were 28.87 for the control class and 29.48 for the experimental class. The average learning outcomes for the control class were 47.36, while the average learning outcomes for the experimental class were 71.69. Students in both classes were of the same academic ability at the beginning of the lecture and there was no significant difference in overall ability. Nevertheless, the experimental class showed a significant increase at the end of the lecture. This was a mean difference of 42.21. There was an increase of nearly 200% of the average obtained at the beginning of the lecture. Fig.4 illustrates the increase in student learning outcomes in the control class and the experimental class.

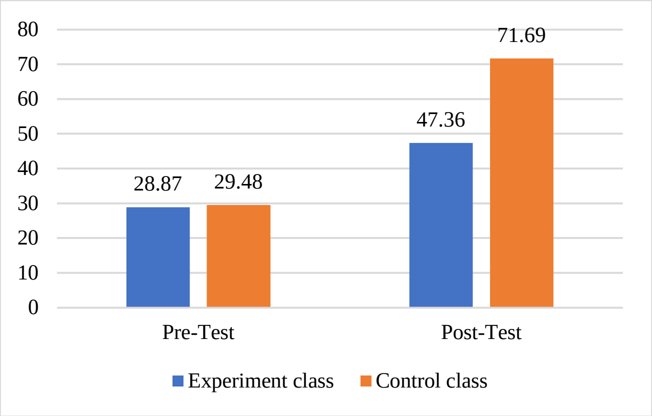

Fig. 4. Improvement of student learning outcomes

Fig.4 indicates that the average increase in learning outcomes (gain score) of control class students is 18.49 points compared to 42.21 points for experimental class. The results of the analysis indicate that OOP learning using the CLP model is significantly able to improve student learning outcomes. In addition, the CLP model is proven to be more effective than the conventional learning model.

CLP has several advantages over traditional methods of teaching OOP. First, it helps students to develop their problem-solving skills. When students work together to solve problems, they are forced to communicate and collaborate. This helps them to develop a deeper understanding of the material and to learn how to work effectively in teams. Second, CLP helps students to develop their programming skills. When students work together to code, they can learn from each other and share ideas. This helps them to improve their programming skills more quickly than they would if they were learning on their own. Third, CLP helps students to develop their communication skills. When students work together to discuss problems and code, they have to communicate effectively. This helps them to improve their ability to communicate their ideas to others.

Evaluation of the effectiveness of CLP found that students who participated in the CLP model had significantly higher achievement in OOP than students who did not participate in the model The results of this study suggest that CLP is a promising new learning model for teaching OOP. CLP can help students to develop their problem-solving, programming, and communication skills. This makes CLP a valuable tool for preparing students for the workforce and for lifelong learning.

5. Conclusion

The ability to work collaboratively with others is becoming increasingly important in today's interconnected and complex world. Collaborative skills refer to the ability to effectively communicate, cooperate, and work together with others in order to achieve a common goal. Many fields, including business, education, healthcare, and technology, have become dependent on collaboration.

This study developed a new learning model called the Collaborative Learning and Programming Model (CLP model) to enhance students' collaborative skills and reduce the obstacles of abstraction and complexity in Object-Oriented Programming (OOP) courses. The CLP model is a combination of the collaborative learning model proposed by Boudia et al. and the collaborative programming model proposed by Lin et al. It consists of seven stages: planning, individual work, pre-collaborative work, collaborative work, pre-presentation, presentation, and evaluation. The pre-collaborative work stage contains two sub-stages: problem analysis and idea drafting, while the collaborative work stage contains four sub-stages: observation, reflection, online discussion, and rewriting. The CLP model involves three learning environments: classroom or laboratory, independent, and remote.

The implementation of the CLP model was evaluated based on three criteria: validity, practicality, and effectiveness. The results showed that the CLP model is valid, practical, and effective in improving students' learning outcomes and collaborative skills in OOP courses. The findings of this study suggest that the CLP model can be a promising approach for enhancing students' collaborative skills and improving their learning outcomes in OOP courses. However, further studies are needed to investigate the effectiveness of the CLP model in other programming courses and non-programming courses.

The CLP model is a cyclical model, which means that it can be repeated as needed. This allows students to continuously improve their collaborative skills and learning outcomes. The CLP model is flexible and can be adapted to different learning contexts. This makes it a versatile tool that can be used in a variety of settings. The CLP model is supported by theoretical frameworks, such as the social constructivist theory of learning. This provides a strong foundation for the model and helps to explain its effectiveness.

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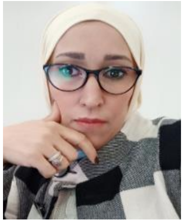
Authors’ Profiles

Efan Efan received the S.Kom. degree from Bina Darma University, Palembang, Indonesia, in 2007 and the M.Kom. degree from the University of Putera Indonesia YPTK, Padang, Indonesia, in 2013. In June 2023, He received the Dr. degree from Universitas Negeri Padang, Indonesia and become the best graduate on TVET Program. He is currently a Lecturer of the Department of Informatics Engineering, Sekolah Tinggi Teknologi Pagaralam (now reformed to Institut Teknologi Pagar Alam), Indonesia. His research interests include TVET, Information System, Artificial Intelligence, and Database.

Krismadinata Krismadinata was born in Padang Indonesia. He received the B.Eng. degree from Universitas Andalas, Padang, Indonesia, in 2000; the M.Eng. degree from the Institute of Technology Bandung, Indonesia, in 2004; and the Ph.D. degree from the University of Malaya, Kuala Lumpur, Malaysia, in 2012, and Post-doctoral at UMPEDAC within 2012–2014.

Dr. Kris was one of awardees ASEAN-INDIA Research Training Fellowship in 2019. He is currently with the Department of Electrical Engineering, Universitas Negeri Padang, where he is also a professional engineer and the Director of Center for Energy and Power Electronics Research Universitas Negeri Padang. He is also currently a lecturer in Post Graduate of Vocational Education and Training (VET) program. He has international patents and also as reviewer for many international journals in electrical engineering and energy fields. He is actively involved in consulting on renewable energy projects. He also wrote some articles and books related to teaching and learning method on Vocational Education and Training. His research interests are power electronics, control system, renewable energy, teaching and learning method, and vocational education and training.



Chérifa Boudia received her PhD degree in Computer Science from the University of Oran 1 Ahmed Ben Bella, Algeria in 2020. Her research is focused on methods of e-learning for Java programming language; collaborative e-learning; blended learning, developing a collaborative platform for e-learning at the university of Oran 1 Ahmed Ben Bella. Now, she is an associate professor at the University Mustafa Stambouli of Mascara, developed a passion for ICT educational tool, and students' assistance.

Muhammad Giatman was born in Bukittinggi January 21, 1959. Education, Doctoral Degree in Education with expertise in Technology and Vocational Education, Postgraduate UNP 2012, and Sandwich Program at Ohio State University USA 2009-2010. Became a Lecturer from 1983 at the Faculty of Engineering, Padang State University. Experienced in teaching various courses in the Department of Civil Engineering, Postgraduate FT UNP, and also in various private universities in the city of Padang. 2019 Professorship, Project Management expertise. Work experiences include: Initiator of the Establishment of the UBH Padang Industrial Engineering Department in 1991-1997. Head of D-3 Civil Engineering Study Program FT UNP 1997-2006. Coord. PLI Civil Engineering 2006-2007. Representative Management of QMS ISO 9001:2008 FT UNP 2008-2016. UNP Head of Quality Assurance 2017-2021. Ikip Padang P2T project Technical Team 1991-1995, UNP IDB Project Technical Team 2011-2016. Padang State University Development Project Technical Team 2017-2022. Writes a number of reputable books and scientific articles and National Journals.

Mukhlidi Muskhir graduated with a Bachelor in Electrical Engineering Vocational Education at Universitas Negeri Padang in 1998, continued his master's in 2001 with a Master of Computer Science at Universitas Gadjah Mada, graduating in 2003. He continued his doctoral in 2011 with a Doctoral of Vocational Technology Education at Universitas Negeri Yogyakarta, graduating in 2017. He is currently a lecturer in Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang.

Hasan Maksum is an professor at post graduate department of Technical and Vocational Education, Engineering Faculty, Universitas Negeri Padang, West Sumatera, Indonesia. His research interests include project based learning, problem based learning, teaching and learning technology, and design of learning evaluation.

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