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Development of Professional Learning Communities Model to Improve Digital Pedagogy Skills of Elementary School Teachers in Science Learning: Effectiveness Test

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ABSTRACT

Science learning in the 21st century requires teachers who are skilled at integrating technology functions into interactive science learning by utilizing multimedia to support students' scientific mastery of science concepts. However, the digital pedagogical skills of primary school teachers are still weak. This study aims to determine the effectiveness of the professional learning communities (PLC) model developed to improve the digital pedagogy skills of elementary school teachers in science learning. This research is research and development at the stage of operational field testing. The study applied the pretest posttest control group design method. The research data was collected through tests of teachers' digital pedagogical skills in terms of learning tools. The research sample was 52 elementary school teachers in Surakarta City. The results of the study obtained a sig score. (2-tailed) of 0.002 <0.05 so it was concluded that the digital pedagogy skills of teachers in the experimental group were better than the control group. It can be concluded that the developed PLC model has been effective in improving the digital pedagogy skills of elementary school teachers in learning science.

Introduction

The 21st century science learning is characterized by learning based on the use of digital-based media. The preparation of science learning tools and their implementation is inseparable from multimedia integration (Kruger & Bodemer, 2022; So et al., 2019; Syawaludin et al., 2019). The integration of digital technology in the development of science learning must continue to guarantee the fulfillment of science needs as a product, process, and scientific attitude (Kurniawan et al., 2019). Therefore, teacher skills in developing 21st century science learning tools have a very important role (Bedir, 2019; Dakhi et al., 2020; Kim et al., 2019). This is because the integration of technology in learning requires a digital pedagogy foundation. Digital pedagogy skills are easily understood as engaging in learning practices that utilize digital technology facilities. The term digital pedagogy arose from pedagogical practice and an understanding of curriculum design approaches suitable for 21st century learners based on problem solving and higher order thinking and creation skills (Beeson & Byles, 2020; Robertson, 2020). Digital pedagogy is a teacher's skill in using ICT in a professional context with good didactic pedagogical assessment and awareness of its implications for students' digital learning strategies that are relevant to the learning needs of the 21st century (Olofsson et al., 2020; Marta-Lazo et al., 2019). Preliminary studies through observation and questionnaires (conducted December 2020-January 2021 in Surakarta City) found that the digital pedagogical abilities of elementary school teachers are currently still in the poor category (mean score of 1.27 on a scale of 5). Measurements are made on indicators of the application of pedagogical principles in curriculum development, learning strategies, use of learning technology, and evaluation techniques. The weakness of teachers in digital pedagogy has a real impact on technology-based learning as in the conditions of the covid pandemic which is carried out with online policies proving that the role of digital pedagogy is very important and the current abilities of

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elementary school teachers are not satisfactory.It is known that previous research has made many efforts in the form of training on the use of technology in learning (Puryono, 2020; Tirtoni, 2020; Yusron et al., 2020), but has not found effective results. This is because continuity conditioning is needed, that is, not only during training or immediately after training, it needs to be continuously applied and developed on a regular basis. This research seeks to accelerate the transformation of digital pedagogical abilities for elementary school teachers in science learning through the development of the Professional Learning Community (PLC) model. PLC as a forum for teachers to exchange ideas, share experiences, and reflect on professional practice (Azorin et al., 2020; Goodyear et al., 2019; Powell & Bodur, 2019).

The developed PLC model is applied to the teacher working group forum (KKG). The steps involved in implementing PLC consist of: (1) orientation, namely the shared perception of the urgency and agreed program goals; (2) Sharing and analysis, namely sharing teaching experiences and analyzing the problems faced by the majority of teachers in learning science; (3) collaboration, namely in groups the teachers analyze learning tools and determine problem solving; (4) design and develop, namely in groups each teacher gets assistance from resource persons who have expertise in developing learning media based on digital technology, (5) reflection, namely product presentation and product improvement through group presentations. This stage is carried out in the form of a cycle so that the teacher's digital pedagogy skills continue to be developed sustainably. The developed PLC model has gone through several improvements at the previous research stages through limited and broad tests. After going through improvements according to input from teachers and students, this study aims to determine the effectiveness of the PLC model developed in improving teachers' digital pedagogical skills in science learning in elementary schools.

Research Methodology

This research is part of the research and development phase, namely the testing phase of the model's effectiveness. Product Test is the stage of testing the efficacy of the product produced, in this study it is testing the effectiveness of the PLC model in improving teachers' digital pedagogical abilities in science learning in elementary schools. Model testing uses a pretest-posttest control group design. The research design is presented in figure 1.

Samples	The Beginning Condition	The treatment	The End condition
The Experiment Class	O_1	X	O_2
The Control Class	O_3	Y	O_4

Figure 1. Pretest-posttest control group design (Budiman, 2016)

In this design, two groups were randomly selected, and the experimental group was teachers from Laweyan District, and the control group was SD KKG forum teachers from Banjarsari District. Both groups were given a pretest to determine their initial abilities. Furthermore, the experimental group used the developed PLC model, while the control group used the commonly used PLC. After that, measurements were taken in two groups through a post test to measure the digital abilities of elementary teachers.

Sample and Sampling Method

The population of this research is elementary school teachers in Surakarta. In order to obtain a representative research sample, this research uses the cluster random sampling method because it deals with a large population (Berndt, 2020). Sampling using the cluster random sampling method is a collection of clusters that do not overlap each other. The research sample was obtained by 26 teachers from the Laweyan sub-district and 26 teachers from the Banjarsari sub-district in Surakarta City.

Data Collection Technique

The data was obtained through a test of the teacher's digital pedagogical skills in terms of learning tools. The learning tools assessed consisted of lesson plans, teaching materials, and student worksheets. The indicators measured include: skills in understanding student characteristics, skills in presenting material, and skills in developing student worksheets. These three aspects are measured through learning device products made by each research sample.

Data Analysis

Data analysis techniques in this study used quantitative methods with independent sample t-tests. The hypothesis test in this study was preceded by an analytical prerequisite test consisting of a normality test, homogeneity test, and balance test. After the prerequisite tests are met, an independent sample t-test can be carried out to determine the effectiveness of the developed PLC model.

Results and Discussion

The effectiveness test of the PLC model is carried out by means of an experimental design. In this design, two groups of KKG were randomly selected and the Karangasem KKG group was obtained as the experimental group and the KKG Banjarsari group as the control group. The experimental group applied the developed PLC model, while the control group's KKG carried out the KKG routine as usual. Both groups were pretested. After carrying out the pretest. After the KKG activities were held for one month, a post-test was carried out to find out changes in the digital pedagogical skills of elementary school teachers. Data descriptions of pretest and posttest values of teachers' digital pedagogy skills in science learning are presented in Table 1.

Table 1. Distribution of teacher pedagogical skills data in experimental and control groups

Class	Data	n	Min	Max	Mean
Experiment	Pretest	26	55	80	65,92
	Posttets	26	60	96	79,68
Control	Pretest	26	58	78	65,92
	Posttets	26	55	82	79,68

Based on the results of the acquisition of pre-test and post-test scores in the two groups, then analysis of the prerequisite test and independent sample t-test was carried out to determine the effectiveness of the developed PLC model product. However, before entering this stage, a balance test analysis was carried out to ensure that the two groups had a balanced initial ability. Analysis prerequisite tests and balance tests are presented in Table 2.

Table 2. Prerequisite test results

No	Test	Method	Score	Conclusion
1	Normality	Kolmogorov-Smirnov	Sig. =0,128 (Pretest)	Data is normally distributed
			Sig. =0,116 (Posttest)	Data is normally distributed
2	Homogenity	Levene's test	Sig. = 0,428	Homogeneous data
3	Balance test	T-test	t_{value}= 0,537 > 0,05	Balanced initial abilities

The data in table 2 shows that the normality of the data tested with the Kolmogorov-Smirnov method has a significance level of 0.128 which is greater than α = 0.05 (sig. > 0.05) so that it can be concluded that the pretest data for the experimental class and the control class are distributed normal. As for the posttest data obtained by 0.116 greater than α = 0.05 (sig. > 0.05) so it can be concluded that the posttest data for the experimental class and the control class are normally distributed.

The homogeneity of the pretest data for the experimental class and the control class tested by Levene's test yielded a significance level value of 0.428 greater than α = 0.05 (sig. > 0.05), so it can be concluded that the research data came from a homogeneous population or the variance of each sample The same. The balance test obtained t was 0.537 (p > 0.05), so there was no significant difference between the initial abilities of the two classes. Thus, the two groups had a balanced initial ability so that they could proceed to independent t-test analysis. The results of the independent t test are presented in Table 3.

Table 3. Result of independent sample t-test

Test	Score	Conclusion
Independent Sample t-tes	Sig. (2-tailed) = 0,002 < 0,05	There are differences in the digital pedagogical skills of elementary school teachers in learning science in the experimental and control groups

Table 3 shows that the sig. (2-tailed) was obtained by 0.002 <0.05, so there was a significant difference between the teacher's digital pedagogical skills between the control group and the experimental group. Teachers who apply the PLC model developed in the KKG activities show better results than those who do not use the regular PLC model.

This research shows that a common perception of the urgency and agreed program goals is necessary so that teachers have a strong commitment to improving their professionalism. In addition, sharing and analysis activities provide opportunities for teachers to be able to express themselves regarding the problems they face and the solutions that have been made (Louis & Leithwood, 2021; Schaap et al., 2019). As for the problems raised by some teachers, one problem can be drawn from the majority of teachers in science learning. This is very effective in setting targets for increasing teacher professionalism, especially digital pedagogical skills of elementary school teachers in learning science. Meanwhile, collaboration activities provide opportunities for teachers to analyze learning devices and determine problem solving. This is useful for improving teacher skills in the aspects of developing learning tools, teaching materials, and student worksheets. The development of student worksheets in this study measured very well in terms of content, language, and presentation (Felitasari & Rusmini, 2022; Haryati et al., 2019; Nainggolan et al., 2020). Therefore, design and develop activities accompanied by the assistance of resource persons who have expertise in the development of instructional media are very beneficial for media development skills. The developed media includes interactive functions such as power points, audiovisual animations, and digital worksheets. This research shows that all stages of the PLC developed have supported the improvement of effective teacher digital pedagogy skills.

Conclusion

The effectiveness test using an independent sample t-test obtained that sig score. (2-tailed) of 0.002 <0.05 so it was concluded that the digital pedagogy skills of teachers in the experimental group were better than the control group. It can be concluded that the developed PLC model has been effective in improving the digital pedagogy skills of elementary school teachers in learning science. This study recommends that teachers apply the stages of the PLC model which were developed according to the majority problems experienced by teachers in each cluster. Thus, it is expected that every teacher can be skilled in developing 21st century science learning well.

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