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Application of Science Integrated Learning in Practicum Assessments to Improve Science Student Teachers' Creative Thinking

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Practicum requires lecturers or practicum assistants' presence like in laboratories. When the practicum is carried out remotely, lecturers and assistants need to be replaced by an assessment system to report the practicum progress. The study aims to determine the impact of implementing the Science Integrated Learning (SIL) model with digital tools in an assessment in practicum on the science student teachers' creative thinking skills. The research applied quantitative methods through hypothesis testing to discover the differences in new practicum strategies as an adaptation in remote practicum and causal relationships to models and assessment of creative thinking skills. The independent t-test obtained sig < 0.05 (H0 was rejected), meaning that there was a difference between the average learning outcomes of the experimental and control classes. This study concludes that the online assessment system developed in this study has been tested and can be used by science student teachers to input practicum stages. The advantage of the assessment system lies in the content that leads to the reporting of independent practice activities integrated with creative thinking skills. Although the impact of the SIL model in this study was only moderate on improving creative thinking skills, it has become a solution to the obstacles of distance science practicum. For science student teachers, it is recommended to apply an assessment in accordance with the skills to be measured and use the right learning model.

Keywords: assessment, digital, higher-order thinking skills, science integrated learning

INTRODUCTION

The educational administration for student teachers must continue, although with modifications due to restrictions on face-to-face meetings. Learning is held remotely

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with various online applications making it easier to do. However, it is different from science practicums, which were previously carried out in a laboratory. Problems occur when the practicum is carried out at home with inadequate facilities and infrastructure. The preliminary study that analyzed the science practicum problems on student teachers showed severe obstacles. It was found that the most significant difficulties for students during practicum were when preparing materials and tools and modifying the practicum guide. Practicums cannot be held without materials, tools, and guides. The limited materials and tools can cause errors in practicum findings that result in misconceptions (Papadimitropoulos et al., 2021; Raviv et al., 2019). Weaknesses that result in erroneous test results can become more comprehensive obstacles due to conceptual errors. The main obstacle to the practicum is also caused by students' dependence on the assistance of lecturers and practicum assistants. It can be then concluded that the students' independence in learning is low.

Low students' independence is a major factor in the occurrence of obstacles in online practicum. The practicum has not used adaptive strategies to implement distance learning because student teachers still use the practicum method commonly used in the laboratory. Therefore, the new adaptation of remote practicum strengthened with the students' independence becomes a rational solution. The remote practicum system requires a strict assessment mechanism using the correct application program because the lecturer cannot supervise the process directly. Remote practicum also requires an adaptive application system for monitoring and evaluation needs (Aljuhani et al., 2018; Efstathiou et al., 2018; Kolil et al., 2020). Besides, online remote practicum requires the preparation of an application assessment system that follows the learning objectives. However, the current application program has not been specifically designed to assess practicum implementation but is limited to distance learning. Therefore, a new application assessment program that is adaptive to practicum needs and oriented towards students' independence is needed.

Science learning activities that emphasize learning independence are found in the Science Integrated Learning (SIL) model. The model developed by Parmin et al. (2017) aims to create self-awareness in each individual to carry out the stages of scientific work independently. The SIL model is under the needs of remote practicum because it is developed from constructivism theory, oriented towards the differences in each individual's learning style. The SIL model has six syntaxes whose learning activities are oriented towards independence: exploration, concept integration, experimentation, analysis, action-taking, and reflection. The syntax of the SIL learning model starts from the first step of exploration in the form of observing by presenting facts in the student environment or using image media by facilitating students to ask questions or give opinions and then share experiences gained in everyday life as well as from discussions by reading textbooks. Second, on concept integration, students are given worksheets. The third is experimentation; at this stage, students are faced with real environmental conditions by expecting to take samples to be used as material for conducting an experiment and how students can have critical thinking skills by paying attention to existing conditions. Together with their friends, students prove problem-solving ideas, developing communication skills. After that, students are made media to pour what they get in simple experiments; thus, meaningful learning can take place, thereby bringing creativity.

The use of this model needs to be supported by an appropriate assessment system for distance learning activities. Without an adaptive assessment application system, the use of this model will undoubtedly experience obstacles. Distance learning requires learning strategies that combine learning methods with online learning application systems following learning objectives (Liang et al., 2021; Ray & Srivastava, 2020; Rusydiyah et al., 2021). The required application program can assess the quality of the science student teachers' independence in practicum.

The implementation of distance learning assessment also requires an online application tailored to the learning strategy. In this case, the stages of the SIL model have independent activities in practicum, starting from exploring resources in the environment around students' residences to identifying and collecting practicum materials and tools, modifying worksheets referring to existing practical worksheets independently, doing outdoor practicum, analyzing, reporting, and reflecting on the stages of practicum. Independence in this practice further requires an applicable assessment system to collect data on students' independence level and the practicum's effectiveness. The assessment in contextual science learning is used to reveal learning activities following actual activities in learning (When et al., 2021; Zhai, 2021). So far, no assessment instrument has been developed from the SIL model, so a development stage is needed to determine the level of learning success of science student teachers in detail.

Moreover, practicum needs to be done to continue learning science theory, mainly to produce science student teachers. They are scientists who will prepare young scientists in schools. The way scientists work is in every stage of practice. According to de Groot et al. (2021), Gotian and Andersen (2020), and Leigh (2020), scientists work through the maximum use of natural resources. Modifying practice tools and engineering practicum materials is an integrated activity in the practicum. An effective practicum is known from the final results, and an assessment of all processes carried out. The suitability of work procedures determines the success of the practicum. In this study, the main problem of distance practice is students' low independence on the initial study results. This study then applied the SIL model, equipped with an assessment application according to the learning syntax. Thus, online assessment is needed as a substitute for lecturers and practicum assistants through online practice monitoring filled by students at each practicum stage. Also, obstacles in practicum were experienced in preparing science student teachers in Indonesia from the initial research studies at three universities in Indonesia. Therefore, the impact of the experimental findings in this study is confirmed to be fundamental to finding the right science practicum strategy on the science student teachers' higher-order thinking skills.

Higher-order thinking skills (HOTS) are thinking skills developed in science through a practicum process. The HOTS-oriented practicum aims for students to think critically about receiving all the information obtained, solve practicum problems both technically and substantively, and make decisions in complex situations. Preparation of practicum reports orally and in writing requires the ability to analyze, synthesize, and evaluate. Achieving HOTS through remote practicum is needed because students' thinking skills are required, from collecting information directly from the environment and the community to finding practicum materials and tools, thinking in modifying practice tools, and communicating the results orally and in writing. Liu et al. (2021) and Lu et al. (2021) reveal that 21st-century learning demands the quality of the learning process that requires thinking skills. Creative thinking skills have become the center of attention of educators in the 21st century which demands student activity and participation (Saputro, 2022).among others so called soft skills, is supposed to get students equipped for their active and positive engagement in the ongoing transformations of society/professions towards technical, economic, social and environmentally sustainable Goals (Silva, et. al. 2022). The results of the study indicate that the empowerment of creative thinking skills in Indonesia is still low (Zubaidah & Corebima, 2021). The implementation of HOTS in learning is carried out through activities that emphasize the discovery process (Lu et al., 2021). The aforementioned concerns show that it is crucial to develop new initiatives to foster students' creative thinking skills in learning science (Simanjutak, et.al., 2021). Some experts refer creative thinking to a whole set of cognitive activities used by individuals in certain conditions to react to the object of the problem based on their capacity (Birgili, 2015). The research conducted by Yusnaini et al. (2017) reported that the average creative thinking skills of the students taught by using traditional learning were 36.18%, classified as low criteria.

Barton and Dexter (2020) suggest that students' learning independence is determined by the stimulus to foster self-awareness. Awareness of doing practicum following learning objectives needs to be built so that student teachers have internal motivation to do the practicum. Learning independence is the impact of the space given when studying. Cotner et al. (2020) state that self-confidence will undoubtedly grow through the vast opportunities given to students to do practicums according to their respective learning styles. The success of the practicum is determined by the quality of the process or the activeness in the practicum. During the pandemic, the challenges of learning science are caused by scientific testing activities that cannot occur in the laboratory to be better understood theoretically. Salta et al. (2021) and Hsiao (2021) find that material presentation innovation is needed in distance learning so that content is presented through application programs under the needs and suitable supporting devices.

In this study, the science practicum applied the SIL model and was supported by an online assessment application oriented towards students' independence. The stages of learning following the chosen learning model require online monitoring, indicating that an integrated assessment is needed in the application program. Hence, this study aims to determine the impact of implementing Science Integrated Learning (SIL) through activities with digital tools in practicum assessments for science student teachers on HOTS. Higher-order thinking skills in this study were limited to aspects of creative thinking.

METHOD

Research Design

The research design used in this study was One Groups Pretest-Posttest. This design was chosen because it was given a pretest before treatment and a posttest after treatment. Comparison of test results was collected to know both groups more accurately before and after treatment.

The research applied a quantitative method that refers to Onwuegbuzie et al. (2008). The quantitative method was used because hypothesis testing was carried out to determine the differences in the new practicum strategy as an adaptation in remote practicum and the causal relationship to the model and assessment of creative thinking skills. This study developed a new assessment method to determine the effect of implementing the SIL model on the science student teachers' creative thinking skills. The new assesment method combines learning models for distance learning that involve practical activities This study used two target groups: the experimental and control groups. The difference in treatment was in the experimental group, which carried out practical activities with the SIL model, while the control group did not. Both groups were equally assessed using the application developed in this study.

Sample and Data Collection

The sample of this research was science student teachers from three state universities in Indonesia (Universitas Sebelas Maret, Universitas Negeri Semarang, and Universitas Mataram). All samples carried out practicum in the same subject, became students in the same year, and were taught by the same lecturer in practicum. There were 83 science student teachers as samples consisting of 58 women and 25 men. The experimental group consisted of 38 students, and the control group had 45 students.

Data for both groups were collected using pretest and posttest instruments for practicum independence assessment. Pretest and posttest assessments are used to determine the difference in creative thinking before and after using the Science integrated learning model in practical learning. The instrument was developed in the form of an online application, this is a novelty in research. The instrument consists of ten items of seven aspects of practicum independence: environmental exploration, determining materials, modifying tools, compiling practicum worksheets, implementing practicum, compiling reports, communicating results, and reflecting on practicums.

The instrument used also contains HOTS aspects (creative thinking), consisting of fluency, originality, elaboration, evaluation, and presentation, with the following outline:

Table 1
Indicator of instruments

Aspects	Indicators
Fluency	Generating many relevant ideas
	Generating learning motivation
	Smooth flow of thought
Originality	Thinking of unconventional ways to express themselves Generating expressions or something new and unique
Elaboration	Developing, adding, and enriching an idea Breaking down the details
Evaluation	Providing an assessment according to predetermined criteria Providing suggestions or input on the object being assessed
Presentation	Able to communicate ideas fluently Giving perspective on something objectively

Before being used, the instrument was validated on each indicator using content validity, assessed by two experts in the related material field. Then, it was calculated using Gregory's formula. The following is a tabulation of Gregory's formula:

Table 2
Tabulation of Gregory's formula

Tabulation 2 x 2		Validator 1	
		Less Relevant (Score 1 – 2)	Relevant (Score 3 – 4)
Validator 2	Less Relevant (Score 1 – 2)	A	B
	Relevant (Score 3 – 4)	C	D

Based on the table above, content validity can be found using the Gregory formula as follows:

$$VC = \frac{D}{A+B+C+D}$$

Description:
VC : Content validity
A : Both validators disagree.
B : Validator 1 agrees, while Validator 2 disagrees.
C : Validator 1 disagrees, while Validator 2 agrees.
D : Both validators agree.
The coefficient criteria from 0 – 1 are as follows:
0.9 – 1.0 : Very high
0.6 – 0.89 : High
0.4 – 0.59 : Moderate
0.2 – 0.39 : Low
0.0 – 0.19 : Very low

Furthermore, it is necessary to test the validity of the data obtained by increasing persistence. Increasing persistence means making careful and detailed observations on an ongoing basis to salient factors (Moleong, 2014). The instrument was validated by an assessment expert until it was declared suitable for use. The points of validation of the assessment instrument included construct and content.

Analyzing of Data

Before testing the hypothesis, the data first passed the normality and homogeneity tests. The data normality test was conducted to show that the sample data came from a normally distributed population. The technique used to test for normality was the Kolmogorov-Smirnov test. The results of the normality test are presented in Table 3.

Table 3
Normality test results

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Score	Statistic	df	Sig.	Statistic	df	Sig.
Score	Control	.163	39	.174	.850	39	.382
	Experiment	.195	40	.008	.982	40	.067

The test results for the control class had a calculated sig value of 0.382 ≥ 0.08 sig table; then, the data were normally distributed. The calculated sig value was 0.067 ≥ 0.08 sig table in the experimental class, meaning that data were normally distributed. Based on the normality test, the data used were normally distributed so that the next step was parametric statistical analysis.

A homogeneity test was also carried out to show that two or more sample data groups came from populations with the same variance. Based on the Levene homogeneity test, sig 0.958 > 0.050 means that the data were homogeneously distributed. In other words, the data group came from a population with the same variance (homogeneous).

Hypothesis testing used an independent sample t-test to test the significance of the average difference between the experimental group and the control group. This test was also employed to test the effect of the independent variable (the implementation of practicum with the SIL model) on the dependent variable (science student teachers' independence). The coefficient interpretation criteria refer to the coefficient and interpretation interval, with the lowest interval of 0%-19% as low interpretation and 80%-100% as high interpretation.

FINDINGS

Inferential statistical tests to test the research hypothesis were conducted on the pretest and posttest data in the experimental and control classes. The test results are presented in Table 3.

Table 3
Inferential statistical test: Independent sample t-test

Class	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Conclusion
Control vs Experiment	-4.632	79	.000	-12.280	2.530	H0 is rejected.

In the research hypothesis, H0 is that the average control class learning outcomes are the same as the experimental class learning outcomes, while Ha is that the control class learning outcomes are not the same as the experimental class learning outcomes. The independent t-test with equal variance assumed obtained sig < 0.05 (H0 was rejected), meaning that there was a difference between the average learning outcomes of the experimental class and the control class. The follow-up test was a left-tailed t-test since the t-value was negative. Besides, the average learning outcomes for the experimental class were more significant than the control class with sig < 0.025.

The test results using Smart PLS through several stages are:

The evaluation of the measurement model consists of three stages: convergent validity test, discriminant validity test, and composite reliability test.

1. Convergent Validity Test

Testing the validity of the reflective indicators can be done by using the correlation between the indicator scores and the construct scores. Measurements with reflective indicators show a change in an indicator in a construct when other indicators in the same construct change. The following are the calculation results utilizing the PLS 3.0 smart computer program:

Table 4
Output result for outer loading

	SIL	HOTS
X1	0.769	
X2	0.833	
X3	0.754	
X4	0.745	
X5	0.762	
Y1		0.786
Y2		0.729
Y3		0.714
Y4		0.725
Y5		0.747

According to Chin (1998) in Ghozali (2012: 25), a correlation can be said to meet convergent validity if it has a loading value greater than 0.5. The output shows that the loading factor gave a value above the recommended value of 0.5. Thus, the indicators used in this study have met convergent validity.

2. Discriminant Validity Test

For reflective indicators, it is necessary to test discriminant validity by comparing the values in the cross-loading table. An indicator is declared valid if it has the highest loading factor value to the intended construct compared to the loading factor value to other constructs.

Table 5
Cross loading output

	SIL	HOTS
X1	0.769	0.139
X2	0.833	0.217
X3	0.754	0.179
X4	0.745	0.123
X5	0.762	0.028
Y1	0.195	0.786
Y2	0.081	0.729
Y3	0.127	0.714
Y4	0.198	0.725
Y5	0.157	0.747

Composite Reliability Test

Sarwono and Narimawati (2015: 18) state that a latent variable can be said to have good reliability if the composite reliability value is greater than 0.7 and the Cronbach's alpha value is greater than 0.7.

Table 6
Reliability test on latent variables

Construct	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	Description
SIL	0.827	0.900	0.601	Reliable
HOTS	0.816	0.902	0.621	Reliable

The table above presents that all latent variables measured in this study had Cronbach's Alpha and Composite Reliability values greater than 0.7; hence, it can be said that all the latent variables were reliable.

Structural Model Evaluation (Inner Model)

The significance test on the SEM model with PLS aims to determine the effect of exogenous variables on endogenous variables. Hypothesis testing with the SEM PLS method was carried out by performing a bootstrapping process with the help of the smartPLS 3.0 computer program to obtain the relationship between the influence of exogenous variables on endogenous variables, as follows:

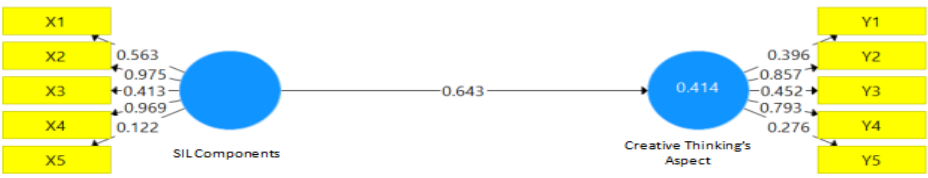
Table 7
Significance test (Bootstrapped)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)
SIL -> HOTS	0.189	0.229	0.093	2.082

Before testing the hypothesis, it is known that the T-table value for the 95% confidence level (α 5%) and the degrees of freedom (df) = n-2 = 79 – 2= 77 was 1.911. Hypothesis testing for each latent variable relationship is shown as follows:

$H_{01}\ X_1 \rightarrow Y$

$H_{11}\ X_1 \not\rightarrow Y$



SIL Components: environmental exploration (X1), compiling practicum worksheets (X2), determining materials (X3), modifying tools (X4), presentation (X5)

HOTS Aspects (Creative Thinking): fluency (Y1), originality (Y2), elaboration (Y3), evaluation (Y4), presentation (Y5)

Based on the statistical T table output results and the figure above, the variable Effect of SIL Learning Model (X1) on the HOTS variable (Y) of 2.082 was > T-table (1.911). The original sample estimate value revealed a positive value of 0.189, indicating that the direction of the relationship between the SIL variable (X1) and the HOTS variable (Y) was positive. Thus, H11 in this study was accepted. It signifies that in this study, the latent variable SIL (X1) with its indicators significantly affected the latent variable HOTS (Y) with its indicators.

In this research, there were differences in learning outcomes between the experimental and control classes. The comparison of pretest and posttest average scores is in Table 3.

Table 8
The average score of pretest and posttest in the experimental and control classes

Class	Pretest	Posttest
Experiment	68.55	86.40
Control	67.50	74.80

Based on the R-square results, it can be concluded that the SIL model had an effect of 0.414 and was included in the moderate category on the HOTS aspect. The measurements or tests on the relationship between variables showed that the SIL variable and HOTS had a path coefficient value of 0.643, with the t-count value of 4.307 each. This value was more significant than the t-table (1.697), with a significance level of 95% and an alpha of 5%. These results indicate that SIL had a positive relationship to HOTS.

DISCUSSION

The application of the SIL model has a moderate effect on the science student teachers' higher-order thinking skills. After exploring the data and facts from applying the model, it was found that the effects on thinking in fluency, originality, elaboration, evaluating, and presentation skills were found. The practicum resource exploration activities led to the emergence of faster performance to find practicum materials and tools. Students can prepare practicum materials from exploration results in their home environment. Fluent thinking skills impact the design of the practicum tools made. A stimulus is needed in actual scientific work activities to trigger thinking skills in science (Chen et al., 2020; Park et al., 2019). Modifying tools into student sizes has a strategy in preparing practicum tools that have the same function as tools in the laboratory. Fluent thinking was observed from applying the model to the fast way of working, and the ideas developed through the questions submitted in this study's virtual practicum monitoring system.

The SIL model impacts the student teachers' skills to provide information to solve problems beyond the lecturers' expectations. The information includes different practicum environmental factors because it is carried out from their respective homes, for example, differences in weather that affect practicum results on specific topics. Different learning situations in science provide learning opportunities according to learning styles (Galamba & Matthews, 2021). Practicum is usually carried out in the laboratory so that the environmental conditions are the same, in contrast to the practicum carried out at home from various regions. Unexpectedly, some students found a practicum method under environmental conditions so that the practicum time was different. The temperature control and environmental conditions in outdoor practicums are the new or original value of findings.

From analyzing the differences in the answers to the essay questions in pretest and posttest, student teachers in the experimental class can elaborate answers more coherently and correctly because it uses the stages of a detailed learning model for practical activities. They can elaborate the answers to the questions asked to present the process during the practicum. The elaboration skill positively impacts the model stage of preparing a practicum plan. Macgilchrist (2021) mentions elaboration skills as the indicator of higher-order thinking skills created through systematic activities in science learning. When students are asked to elaborate on the preparation, implementation, and analysis of results, they are better prepared because they have compiled their worksheets. The independence in scientific work is the strength of the SIL model, which is applied during the practicum. When students present their results, they present them coherently and systematically because they have experience carrying out activities according to plans that have been prepared themselves.

Using digital learning with the practicum assessment application, the SIL Model has become a new practicum way in distance learning. The syntax of the model prioritizes the independence of learning for student teachers to plan and report the practicum results. Each practicum activity with this model improves higher-order thinking skills by creating a learning situation that develops student teachers' thinking skills. The learning model applied to stimulate thinking in science has learning stages that allow them to choose their learning style (Suyatman et al., 2021). Student teachers' thinking in remote practicum can be improved by using an assessment application system as a substitute for lecturers at the practicum location. The assessment system in research to input the development of actual practice implementation impacts the seriousness of student teachers in practicum.

CONCLUSION

The online assessment system developed in this study which is a novelty in conducting assessments for distance practicum learning has been tested and can be used by science student teachers to input practicum stages from preparation to reporting. The advantage of the assessment system lies in the content that leads to the reporting of independent practice activities integrated with creative thinking skills. The entries in the assessment system reveal thinking skills in fluency, originality, elaboration, evaluation, and presentation. Although the impact of the SIL model in this study was only moderate on improving creative thinking skills, it has become a solution to the obstacles of distance science practicum. For future science student teachers, it is recommended that they apply online assessments for remote practicum using the SIL learning model. The assessment used must be adapted to the skills being measured and applied using an appropriate learning model. In this distance practicum learning, it is highly recommended for teachers who want to create creative and innovative learning.

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