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Effectiveness of literacy learning model to improve skills of scientific literacy learning plan for physics teacher candidates

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Abstract. The professionalism development of physics teacher candidates has been emphasized in their scientific literacy skills; so Skills of Scientific Literacy Learning Plan (SSLLP) is often ignored. Therefore, the purpose of this study was to analyze the effectiveness of the Literacy Learning Model (LLM) to improve the SSLLP for physics teacher candidates. This research used one group pre-test and post-test design toward 120 physics teacher candidates of Surabaya State University and Lambung Mangkurat University in academic year 2016/2017. The SSLLP was measured by using the Literacy Learning Plan assessment sheet and interviews. The data analyses used descriptive qualitative, n-gain, and Paired t-test / Wilcoxon test. The application of LLM in physics learning showed a significant increase in SSLLP at $\alpha = 5\%$; where the SSLLP was originally in the D / C criteria then became A and the mean n-gain value was in high criteria for each group. Thus, LLM is effective to be used to improve SSLLP for physics teacher candidates.

1. Introduction

The development of science and technology today provides its own challenges and opportunities for the Educational Institution of Education Personnel (LPTK) in Indonesia in producing students as future professional physics teachers [1]. Remembering that the professionalism development of physics teachers depends on the readiness of science, skills, positive attitude toward science, and practice ability in teaching heavily [2-4]; then physics teacher candidates need to have cognitive development before developing science literacy skills for their students in the future. This is to understand the key factors in the development of students' science literacy such as utilizing ICT media, teaching model, and selection of alternative learning methods to teach science literacy appropriately [5]. Thus, students are equipped with Science Literacy Skills (SLS) to be successful in their future life and careers and Skills of Scientific Literacy Learning Plan (SSLLP) to prepare for their successful lives and career later [6-7].

The development of scientific literacy content that is equipped with pedagogic is very important to create students as future professional physics teacher candidates. In fact, most of the learning process in Educational Institution of Education Personnel in Indonesia is still dominated by lectures and the limitations of the opportunity to reveal the physical material from real life make physics teacher candidates less understand the essence of scientific literacy and is still doubt in creating competent teacher candidates [8-9]. This is reinforced by previous research results [10-11] that the SSLLP of Physics Teacher candidates in Natural Science and Mathematics Faculty of Surabaya State University and Faculty of Teacher Training and Education of Lambung Mangkurat University are generally still low.

One of the efforts to improve the SSLLP for physics teacher candidates is the application of Literacy Learning Model (LLM). LLM as an innovative learning that seeks to facilitate the positive attitude of physics teacher candidates to act as students in constructing their own SLS through a process of scientific inquiry, decision-making, and solving real-life problems; then acting as a teacher in planning and implementing scientific literacy learning in class well [1][6-7]. The development of



LLM is supported by advanced organizer theory, discovery learning, cognitive process, metacognition, whole language learning, distributed cognition learning, self regulated learning, scaffolding; as well as the empirical support of the latest research and scientific publications of researchers. Therefore, the main objective of LLM development is to create future professional physics teacher candidates so that the students are need to be given the SLS, PATS and Lesson Plan [1][6-7]. The Lesson Plan includes: (1) formulating the learning indicators or the achievement of learning outcomes; (2) organizing the subject material, which includes the components of knowledge, processes, and values that are in accordance with the objectives to be achieved by the school; (3) organizing the learning resources or the guide book in learning; (4) creating scenarios of the learning activity (teacher manual) and student worksheet (student manual) in carrying out learning activities to achieve the stated objectives; and (5) creating an Assessment Sheet, as a process to determine the value of an object or event in the context of a particular situation [12-15].

Problem of Research

Previous research results have shown that LLM development meets valid and practical criteria to improve SLS, PATS, and SSLLP for physics teacher candidates [6][16]. In addition, LLM is also effective to improve SLS and PATS for physics teacher candidates [1][6-7][16]. As a follow up of the above research, the purpose of this study is to analyze the effectiveness of LLM in improving SSLLP for physics teacher candidates. The indicator of SSLLP involves formulating SLS and PATS indicators, organizing materials, selecting learning resources, developing the learning activity skeletons, preparing worksheet, and preparing the SLS assessments. The focus of the problem in this study includes: (1) gives SSLLP description before and after the application of LLM, (2) if there was a significant increase (statistically) of SSLLP before and after the application of LLM, and (3) how much the enhancement level of SSLLP before and after the application of LLM.

2. Methodology of Research

2.1. General Background of Research

This research was conducted at Surabaya State University and Lambung Mangkurat University. The scope of this research as on physics teacher candidates in academic year 2016/2017. This research was emphasized on the analysis of the fulfilment of the LLM model effectiveness by analyzing the improvement of SSLLP for physics teacher candidates before and after following the LLM. The effectiveness of the LLM was determined based on a significant increase in scores (statistically) between pre-test and post-test of SSLLP for physics teacher candidates, as well as the mean of n-gain that was determined by criteria: low, medium and high.

2.2 Sample of Research

The samples in this study were 120 physics teacher candidates from Surabaya State University and Lambung Mangkurat University; which was in the four groups, namely: Group-I (32 student of class A from Surabaya State University), Group-II (24 of class C from Surabaya State University), Group-III (32 students of class A ULM), and Group-IV (class B of Lambung Mangkurat University). The four classes were chosen based on the consideration that SSLLP for physics teacher candidates in all groups is still low.

2.3 Instrument and Procedures

The SSLLP data were obtained through pre-test and post-test for physics teacher candidates, which was emphasized on the ability to formulate SLS and PATS indicators, organize the material, select learning resources, arrange the learning activity scenario, prepare the worksheet, and arrange the SLS

assessment. Before the test instrument was used, it had been already validated and declared valid by 3 scientific literacy-learning experts [6].

This research used one group pre-test and post-tests design, which is O1 X O2 [17]. The learning process began by giving pre-test (O1); in which students are given preliminary tests to plan scientific literacy learning. After the pre-test, the lecturer applies the LLM and learning tools in each group (X). The learning began by motivating students to conduct scientific literacy, guiding the construction of scientific literacy in-group (Cycle I), producing and implementing scientific literacy learning (Cycle II), and then was ended by doing evaluation and reflection. The process of physics learning was ended by post-test (O2); in which the students were given a final test to plan the scientific literacy learning [6].

2.4 Data Analysis

The SSSLP data from the pre-test and post-test results were analyzed descriptively and qualitatively by using the Value (V) = (Maximum / Maximum score) x 4. According to the following criteria: (1) if $3.20 \leq V < 4.0$ (A), (2) if $2.60 \leq V < 3.20$ (B), (3) if $2.20 \leq V < 2.60$ (C), (4) if $1.60 \leq V < 2.20$ (D), and (5) if $0.00 \leq V < 1.60$ (E) [6]. The n-gain value was determined by the equation: n-gain = (post-test score-pre-test) / (maximum score - pre-test score) [18]. According to the following criteria: (1) if n-gain ≥ 0.7 (high), (2) if $0.3 < \text{n-gain} < 0.7$ (moderate), and (3) if n-gain ≤ 0.3 (low). Furthermore, to examine the significance of the LLM implementation impact on SSSLP improvement, the prerequisite normality and homogeneity test was begun with pre-test and post-test of SSSLP. When normality and homogeneity are met, Paired t-test can be used to test the impact of LLM implementation on SSSLP for physics teacher candidates. Conversely, if the data is not normally distributed / homogeneous, it can use Wilcoxon test.

3. Result of Research

The SSSLP data for physics teacher candidates were obtained from the pre-test and post-test results that are presented in Table 1.

Table 1. SSSLP for physics teacher candidates

Student	Group I		Group II		Group III		Group IV									
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test								
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria								
M1	1.88	D	3.77	A	2.00	D	3.79	A	2.14	D	3.77	A	2.28	C	3.65	A
M2	2.07	D	3.70	A	2.07	D	3.77	A	2.09	D	3.67	A	2.12	D	2.77	B
M3	1.98	D	3.72	A	1.95	D	3.86	A	2.02	D	3.70	A	2.26	C	3.67	A
M4	2.00	D	3.70	A	2.00	D	3.74	A	2.23	C	3.91	A	2.26	C	3.53	A
M5	1.98	D	3.91	A	2.09	D	3.84	A	2.14	D	3.79	A	2.09	D	3.26	A
M6	1.95	D	3.79	A	1.98	D	3.77	A	2.14	D	3.81	A	2.19	D	3.72	A
M7	1.91	D	3.81	A	1.91	D	3.84	A	2.05	D	3.91	A	2.09	D	3.77	A
M8	2.00	D	3.91	A	1.98	D	3.70	A	2.07	D	3.79	A	2.05	D	3.84	A
M9	1.95	D	3.79	A	2.07	D	3.84	A	2.21	C	3.72	A	2.09	D	3.74	A
M10	1.95	D	3.79	A	2.00	D	3.86	A	2.21	C	3.67	A	2.19	D	3.67	A
M11	1.95	D	3.86	A	1.91	D	3.77	A	2.05	D	3.70	A	2.16	D	3.65	A
M12	1.95	D	3.74	A	2.02	D	3.86	A	2.12	D	3.91	A	2.19	D	3.63	A
M13	2.07	D	3.81	A	2.09	D	3.77	A	2.12	D	3.91	A	2.02	D	3.53	A
M14	1.95	D	3.79	A	1.88	D	3.86	A	2.05	D	3.79	A	2.05	D	3.86	A
M15	2.05	D	3.81	A	2.00	D	3.77	A	2.14	D	3.77	A	2.12	D	3.63	A
M16	1.95	D	3.72	A	2.00	D	3.74	A	1.98	D	3.79	A	2.23	C	3.84	A
M17	2.05	D	3.81	A	1.93	D	3.86	A	2.09	D	3.86	A	2.05	D	3.63	A
M18	1.88	D	3.81	A	1.98	D	3.79	A	2.02	D	3.79	A	1.86	D	3.81	A
M19	2.00	D	3.79	A	1.93	D	3.84	A	2.07	D	3.86	A	2.09	D	3.65	A
M20	2.00	D	3.81	A	2.02	D	3.77	A	2.14	D	3.67	A	2.07	D	3.72	A

Student	Group I		Group II		Group III		Group IV									
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test								
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria								
M21	2.02	D	3.79	A	1.88	D	3.86	A	2.21	C	3.70	A	2.02	D	3.74	A
M22	2.02	D	3.81	A	1.98	D	3.79	A	2.05	D	3.77	A	2.02	D	3.91	A
M23	2.07	D	3.79	A	1.79	D	3.79	A	2.00	D	3.67	A	2.09	D	3.74	A
M24	1.95	D	3.77	A	2.05	D	3.77	A	2.26	C	3.70	A	2.07	D	3.70	A
M25	2.00	D	4.00	A					2.19	D	3.91	A	2.09	D	3.77	A
M26	2.00	D	3.79	A					2.14	D	3.79	A	2.07	D	3.74	A
M27	1.93	D	3.74	A					2.12	D	3.81	A	2.00	D	3.63	A
M28	2.02	D	3.77	A					2.19	D	3.72	A	2.05	D	3.79	A
M29	2.02	D	3.79	A					2.19	D	3.79	A	1.93	D	3.79	A
M30	1.98	D	3.74	A					2.14	D	3.77	A	2.07	D	3.70	A
M31	2.02	D	3.77	A					2.12	D	3.79	A	2.09	D	3.74	A
M32	2.00	D	3.74	A					2.07	D	3.86	A	2.28	C	3.79	A

Note: C = Enough, B = Good, A = Very Good

Table 1 shows that the SSLLP level of physics teacher candidates is initially still low, as almost all students were in Criteria D / C. There were indications that the majority of physics teacher candidates still had difficulty in designing the SLS and PATS indicators; organizing teaching materials and learning resources of scientific literacy; making Lesson Plan, Worksheet, and Assessment Sheet. Conversely, after the LLM had been applied; the SSLLP Criteria was in A. The average pre-test, post-test, and n-gain scores of physics teacher candidates' SSLP in all groups are presented in Table 2.

Table 2. The average score of pre-test, post-test and n-gain of SSLLP of physics teacher candidates in all groups.

School	Groups	Scores	The skill of scientific literacy Lesson Plan indicators							Average
			1	2	3	4	5	6	7	
Unesa	I	Pre-test	1.00	1.56	2.71	2.60	2.57	2.43	1.60	2.07
		Post-test	3.85	3.58	3.52	3.82	3.89	3.93	3.93	3.79
		n-gain	0.95	0.83	0.63	0.87	0.92	0.96	0.97	0.88
	II	Pre-test	1.04	1.65	2.53	2.53	2.47	2.51	1.60	2.05
		Post-test	3.71	3.78	3.50	3.81	3.90	3.94	3.85	3.78
		n-gain	0.90	0.91	0.66	0.87	0.94	0.96	0.94	0.88
ULM	III	Pre-test	1.00	1.89	2.62	2.58	2.46	2.38	2.00	2.13
		Post-test	4.00	3.63	3.52	3.83	3.85	3.74	3.90	3.78
		n-gain	1.00	0.82	0.65	0.88	0.90	0.84	0.95	0.86
	IV	Pre-test	1.00	1.89	2.53	2.51	2.35	2.52	2.00	2.11
		Post-test	4.00	3.60	3.49	3.80	3.86	3.63	3.54	3.70
		n-gain	1.00	0.81	0.65	0.87	0.92	0.75	0.77	0.82

Note: 1 = formulating the SLS indicators, 2 = formulating the PATS indicator, 3 = organizing the materials, 4 = choosing the learning sources, 5 = arranging the learning activity scenario, 6 = constructing the worksheet, 7 = compiling the LS rating

Table 2 shows the initial indicator average scores in the four groups respectively are 2.07, 2.05, 2.31, and 2.11; then increased to 3.79, 3.78, 3.78, and 0.82. This is reinforced by the n-gain value of each group of 0.88; 0.88, 0.86, and 0.82 with an elevated level in the High Criteria. Furthermore, to test the significance of the LLM implementation impact on SSLLP improvement, it began by the normality and homogeneity test; in which the pre-test and post-test data of SSLLP in all groups satisfied the homogeneity criteria, but data in group I and IV are not normally distributed [6]. Therefore, the significance test of LLM implementation impact on the increase of SSLP in groups I and IV used Wilcoxon Test; while groups II and III used Paired T-Test. The Wilcoxon Test and Paired T-Test results are presented in Table 3.

Table 3: Wilcoxon test and Paired t-test results of SSSLP for all groups.

Group	N	Paired t-test					Wilcoxon test	
		Mean	Std. error mean	t	df	p	Z	p
I	32						-4.94	<0.01
II	24	-1.82	0.19	-93.20	23	<0.01		
III	32	-1.66	0.19	-87.57	31	<0.01	-4.93	<0.01
IV	32							

***p < 0.05 (2-tailed)**

Table 3 shows that in group I and IV, Z gives value of -4.94 and -4.93 with significance $p < 0.05$ so it is significant; while in group II and III t score gives -93.20 and -87.57 with significance $p < 0.05$ so it is also significant. Since the calculation results of Z and t are negative value, it is clear that the impact of LLM implementation increased the SSSLP in all groups.

4. Discussions

Based on Table 1; the SSSLP of physics teacher candidates was still low in the first, because almost all of them were in D / C criteria. This is reinforced by researchers' interviews with some students that they find it difficult to distinguish science issues from academic problems; the difficulty of making science issues that raise scientific and unscientific questions; and difficulties in developing SSSLP (formulating SLS and PATS indicators, organizing teaching materials and learning resources, arranging learning activity scenario, worksheet, and assessment sheet). This is consistent with the result of previous research that the SSLP of Physics Teacher candidates in Natural Science and Mathematics faculty of Surabaya State University and the Teacher Training and Education Faculty of Lambung Mangkurat University are still low [10-11]. Some of the causes is that the most common trained innovative learning models are direct instruction, cooperative learning, problem-based learning, discussion learning, and discovery-based learning. The above models are commonly used to tap the scientific literacy skills of physics teacher candidates, but they have not be trained the skills of planning and implementing the scientific literacy learning well [6]. In contrast, post-test data showed that the SSLP after the implementation of LLM increased into A criteria. This improvement is supported by observational learning theory by Bandura [15] [19] that learning involves processing information in four stages, they are attention (learning from the model by paying attention to information which is relevant); retention (given the observed behaviour in order to imitate it in the future); production (converts mental representations that are created during coding for motor activity); and motivation (students are motivated to learn from the model and reproduce what is learned). Another support is self-regulated learning theory that the process of setting personal goals, which is combined with motivation, thought processes, strategies, and behaviour can lead to goal attainment [20]. Lecturers can help students understand pedagogical knowledge (specific teaching strategies for the taught content) and pedagogical content knowledge (making a topic understandable by students, and understand what makes learning a particular topic to be easy or difficult) [19-20]. Physics teacher candidates must understand the scientific literacy along with the key factors in the development of students' scientific literacy ability; such as the use of computers and Internet media, the selection of models or teaching methods, and learning media [5]. Thus, students are accustomed to make SLS and PATS indicators; organizing materials and learning resources of scientific literacy; making lesson plan, worksheet, and assessment sheet of scientific literacy well.

Table 2 shows that the impact of LLM implementation on the increased of SLLP level is in the high criteria for all groups. This increase in SLLP is influenced by the implementation of phases in LLM. Phase 1 Contribution: Motivating students to scientific literacy is able to cultivate students' self-awareness of the importance of positive attitude habits in supporting the success of physics activity in each model's phase. Students are able to ask scientific and unscientific questions. The student's

experience in studying and identifying such science issues can be an early start for students in making good science issues. Another phase 1 contribution is the availability of logistics (such as: Students' book, students' worksheet, assessment sheet, laboratory tools and materials / learning media) that are consistent with the lesson plan [6]. This is in line with the observational learning theory of Bandura [15] [19] on attention (students learn from the model by paying attention to the relevant information of the model) and retention (given the observed behaviour to imitate it in the future). Thus, Phase 1 provides hands-on experience for physics teacher candidates in recognizing current science issues, identifying concepts in science issues, identifying questions that may be investigated, and differentiate scientific and unscientific questions.

Phase 2 Contribution: Guiding the construction of scientific literacy as a group (Cycle I) is that students can feel the hands-on experience in constructing scientific literacy skills through 5 stages (identification, exploration, explanation, application, reflection) as an insight when planning and implementing scientific literacy learning [6]. This is in line with Vygotsky's constructivism theory, which emphasizes two main ideas: (a) students' intellectual development can be understood only in the cultural and historical context of their experience; and (b) intellectual development depends on the sign system of each developing individual. The sign system is a culturally created symbol to help students to think, communicate, and solve problems [15]. In addition, the development of the professionalism of physics teacher candidates depends on the readiness of knowledge, skills, positive attitudes toward science, and teaching practices [2-4]. Thus, this 2nd phase provides direct insight for physics teacher candidates to act as learners in constructing their own scientific literacy skills.

The main strengths of SSSLP development in LLM are very clear in Phase 3: Producing and implementing scientific literacy learning that students feel the experience of identifying and assessing SSSLP examples of SSSLP discussions and consultations, implementation through peer teaching / simulation, and SSSLP revision [6]. This phase is supported by four principles of Vigotsky constructivism [12] [15] that includes social learning (faculty facilitates social interaction to encourage knowledge construction and skill development); The Zone of Proximal Development (students work in ZPD when unable to solve their own problem, but it can be solved with the help of an adult or a capable friend); cognitive apprenticeship (the process of making students gradually acquire intellectual prowess through interaction with more skilled people, adults, or smarter friends); and scaffolding (students can overcome certain problems that are beyond their developmental capacity with the help of more capable friends or lecturers). Support from other research results is the integration of scientific inquiry with multiple learning modalities (read it, write it, do it, and talk it) supporting the teaching and learning of scientific literacy; and lecturers can guide laboratory practices based on investigation and pedagogical practice (planning and implementing scientific literacy learning) before being asked to work independently and providing feedback on learning progress [21-22] Thus, phase 3 provides a direct insight for physics teacher candidates to act as a physics teacher in producing and implementing scientific literacy learning for students.

The application of LLM has a significant impact on SSSLP level of physics teacher candidates in high criteria (Table 3) that lecturers' success in carrying out learning activities in each model phase contributes positivity to the skill development of scientific literacy learning plan. This is consistent with the results of previous studies [2-4] that the development of the physics teacher candidates' professionalism depends on the readiness of knowledge, skills, positive attitudes toward science, and teaching practices. This is reinforced by the interviews of researchers with some students that they feel the lecturers are guiding SSSLP production clearly so they feel that they are able to examine SSSLP examples, identifying and choosing topics, discussions and consultations on the preparation of SSSLP, peer teaching / simulation, having discussions and revisions of PPLS well [6].

Based on the results of the above discussion, it can be synthesized that LLM is proven effective not only to improve SLS and PATS, but also SSSLP for physics teacher candidates. Students actually

have the potential in planning scientific literacy learning well, if they are given the experience directly to act as a student in a positive attitude in constructing scientific literacy, then act as a teacher in producing and implementing scientific literacy learning in the classroom. This success cannot be separated from LLM support and learning tools that are valid and practical; the lecturers' professionalism, and the availability of inquiry and peer teaching needs [1] [6-7] [16]. Thus, LLM is feasible as an alternative model to improve the skills of scientific literacy learning of physics teacher candidates.

5. Conclusions

LLM implementation has been proven to be effective to improve SSLLP for physics teacher candidates; because the results of this study indicate: (1) the application of LLM in physics learning can increase SSLLP initially in D / C criteria into A; (2) the n-gain scores of each group are 0.88; 0.88, 0.86, and 0.82 with an elevated level in high Criteria; and (3) the increase of physics teacher candidates' SSLLP significantly after the application of LLM is at $\alpha = 5\%$. This is reinforced by previous research results that LLM has been proven to be effective to improve SLS and PATS for physics teacher candidates. Therefore, the fundamental implication of this research is that LLM can be used as an alternative model to improve the professionalism of natural science teacher candidates, especially physics teachers in Indonesia. Physics teacher candidates are equipped with the SLS and PATS as their own life and career success; as well as SSLLS are equipped as a provision to prepare their students' success in life and career in the future. Wider scale research are still needed to determine the consistency of LLM implementation impact in improving the ability to plan scientific literacy learning for natural science teacher candidates (physics, chemistry, biology, natural science).

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