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Analysis of Productive Pedagogies of Pre-Service Teachers in Teaching Mathematics at School

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Abstract. *This research aims to analyze the productive pedagogies of the pre-service teachers. Productive pedagogies are measured based on four dimension. This research involved three pre-service teachers in Universitas Negeri Makassar, Indonesia, who carry out teaching practices in schools. This research is a case study. The assessment of productive pedagogies was measured using a questionnaire, observation, and semi-structured interviews. The lowest average was found on the intellectual quality dimension of 79.6 (high category) based on the overall dimensions. This result suggests that, of all of the dimensions, Intellectual Quality was the least likely to be included in the classes. The highest dimension of the productive pedagogies of the pre-service teacher was connectedness, around 84.7, with a very high category. That means the pre-service teachers mainly focused on Connectedness during their teaching practice, followed by the Recognition of Differences around 82.2 (high category). Meanwhile, the Supportive Classroom Environment dimension is in the high category at about 79.9. Furthermore, for the Supportive Learning Environment dimension, two elements, academic engagement and self-regulation, were frequently observed in all pre-service teachers' classes. Still, student control, in which the teacher gives students chances to determine specific activities or outcomes of the lesson, was not very often.*

Keywords*: analysis, pre-service teacher, teaching practice, productive pedagogies*

Introduction

Universitas Negeri Makassar is one of the Teacher Training Institutes in Indonesia as the institution that produces professional teachers and is responsible for building professional and qualified teachers. The Mathematics Education Study Program of Universitas Negeri Makassar (UNM) is one of the mainstay study programs of UNM in Eastern Indonesia, particularly in South Sulawesi. This is characterized by a large number of enthusiasts every year. This is a challenge for the academic community of the Mathematics Education Study Program to maintain the quality of service to produce graduates with the best competencies. As an integral part of education, the study program prepares highly qualified specialists and organizes teaching internships. A teaching practice program (Praktek Pengalaman Lapangan/PPL) is a teaching internship program organized by Educational Institution. During the practice, the pre-service teacher is sent out from the university to the school. The unit begins with classroom observation. The first activity teachers do in preparing for their teaching process. During conducting the PPL, the student teachers can relate and differentiate the connection between theories and the reality of classroom practices.

PPL is an effort to increase the pedagogical competence of pre-service teachers to master good strategies to help them achieve the expected learning achievement. In addition, PPL

activities help the pre-service teachers increase their understanding of the material presented in class. Pre-service teachers with the teaching knowledge and content in lectures must be sensitive to the school culture built by policies, traditions, power, and personality. This is a special challenge for beginners trying to apply their knowledge (Zeichner & Gore, 1990). The pre-service teacher is prepared in the university with knowledge and methods for overcoming problems during the learning process. Although many obstacles may occur when teaching practicing programs, pre-service teachers will implement various strategies to deepen their teaching skills (Ardiyansah, 2021).

If mathematics learning is only obsessed with teachers' test scores, it limits the ability to serve the broader needs of students and their communities. The objectives of learning mathematics should include mathematical concepts, everyday contexts, and the world (Djam'an, 2014). Furthermore, the teachers are expected to develop a strong cultural and social identity in the mathematics learning process. This is relevant to the principle of productive pedagogies, which provides a different view of teacher teaching practice. It views teacher choices about content and strategy as fundamental and their main responsibility. It provides a context for pre-service teachers to prioritize pedagogy as they start their careers. Productive Pedagogy has gained worldwide recognition as a tool to improve students learning and a means for teachers to reflect critically on their practices (Tanko & Atweh, 2012).

One of the frameworks developed in Queensland in Australia, known as productive pedagogy, is an attempt to integrate the research findings of effective teaching from various research fields in education and classroom training. In particular, productive pedagogy is the product of a longitudinal study of school reform carried out in Queensland, Australia (Lingard, Ladwig, Mills, Hayes, Luke, Gore, & Christie, 2001). The basic objective of this framework is to improve the quality of classroom teaching. The ongoing investigation focuses on strong and important ideas and concepts connected to students' experiences and worlds (Atweh, 2014; Zyngier, 2005). Productive pedagogy is concerned with how to help students learn and how to improve their academic and social outcomes during classroom teaching. Developers of the productive pedagogies framework (Lingard, et al., 2001) postulate four dimensions that describe and mark what is called the quality of teaching (Atweh, 2014). These four dimensions are Intellectual Quality, Connectedness, Supportive Classroom Environment, and Recognition of Differences. Productive pedagogies can describe and examine how the learning process occurs. The study results can be useful for creating optimal learning by applying pedagogic skills considered appropriate through exploring productive pedagogies.

Rousseau (1889) defines pedagogy as an art, practice, or profession of teaching, systematic science, or teaching related to teaching principles and methods. Meanwhile, productive pedagogies are a normative framework consisting of four dimensions for improving classroom

teaching: Intellectual Quality, Connectedness, Supportive Classroom Environment, and Recognition of differences (recognition of differences). Each dimension is further elaborated by some elements that make up it (Lingard, et al., 2001), as in Figure 1 below:

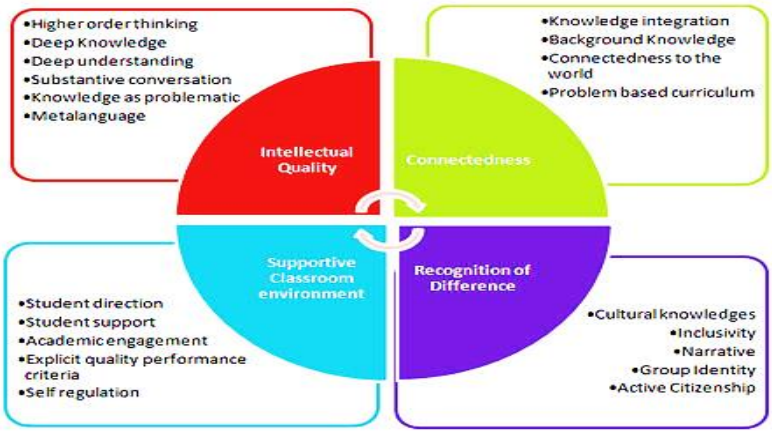

Figure 1. The framework of productive pedagogies

Productive pedagogies in this study illustrate the pros and cons of learning strategies used in the classroom environment. Productive pedagogies are described through the values obtained based on questionnaires, observation sheets in the learning process, lesson plan indicators, and learning implementation.

As an effort to integrate research findings into effective teaching, productive pedagogies allow teachers to reflect critically on their work. As Gore, Griffiths, and Ladwig (2001) identified, various benefits can be obtained, among others, to make the teacher or involve the teacher in personal reflection and substantive conversation about students.

Alsharif and Atweh (2012) used productive pedagogies as a framework to improve pre-service teachers' practices. In their research, the student participants were introduced to the framework in a unit on mathematics education and were observed during the following semester in their field experience to ascertain their level of understanding and use of the framework. The results showed that there was a high level of acceptance of the framework as an effective tool for planning and performing teaching. Faridah, Arismunandar, and Bernard (2017) also researched the challenge in the teaching practice of the pre-service teacher. In this study, they discussed how the concept of teaching practice is perceived and understood by mentor teacher (Guru Pamong). It also explores how this perception has shaped the role of a mentor teacher and prospective teachers' activities during their teaching practice program in teacher training schools. The difference between the previous research with this research is this research attempts to analyze the productive pedagogies of the pre-service teacher. The productive pedagogies are an observation instrument for measuring the intellectual quality, connectedness, supportive classroom environment, and valuing and working with the difference of the teacher.

Method

This research is a case study involving an intensive descriptive analysis of participants that focuses on the in-depth learning experiences of three pre-service teachers in the teaching practice program (PPL) course. They were selected because they practiced in the same State Junior High schools: pre-service teachers H, N, and Hd. Pseudonyms have been used to protect the identity of the pre-service teachers.

Pre-service mathematics teachers at Universitas Negeri Makassar undertake a four-year Bachelor of Education. The implementation of teaching practice for bachelor of education is usually in semester 7 and is known as PPL. To enroll in the PPL, a student should meet a minimum of 80 credits. Furthermore, they have taken several pedagogic courses as prerequisites for PPL. This course has a fieldwork component of about 14 weeks. During the unit period, the students are engaged in full-time field teaching experience in school. Each preservice teacher was observed by the supervisor (lecturer) and mentor teacher (Guru Pamong) as part of the university requirement. The activities of PPL consist of field observation, teaching practice, personal and social competence development, and non-teaching activities (Direktorat Pembelajaran, 2016). This research took place at the school where the PPL was implemented, which consisted of three different classes of grade 7^{th}, involving the three PPL students for the even Semester of the 2020/2021 school year as participants.

Data was collected using observation, a questionnaire from the productive pedagogies dimension, and semi-structured interviews (Lingard, et al., 2001) to measure the productive pedagogies (intellectual quality, connectedness, recognition of difference, and supportive classroom environment) for teachers during the learning activities. There are 17 questions in the questionnaire; each question item represents every indicator of the four dimensions of productive pedagogies. The questions were taken in week 14 of the study. The indicators of the four dimensions of productive pedagogies have been seen whether or not they appear through the data obtained from questionnaires and interviews.

The observation sheet on the implementation of learning is carried out by looking at the emergence of productive pedagogical aspects of teachers during learning. The analysis described all the findings in the field descriptively to get a complete picture of the teacher's productive pedagogical ability. Furthermore, data obtained based on observation and assessment has been coded and analyzed using productive pedagogy instruments. In addition, semi-structured interviews, including focus group discussions with the pre-service teachers, compiled, compared and analyzed the main themes concerning the objectives of this study.

According to Lingard, et al. (2001), teachers can consider learning strategies and present material to students through the productive pedagogies framework. Values in the range 1-29

indicate productive pedagogies that are not good, 30-39 (very low), 40-55 (low), 56-65 (moderate), 66-79 (high), and 80-100 (very good).

The results of the questionnaire answers regarding the productive pedagogies of teachers were analyzed using a Likert scale. The scales ask the respondent to select how much they agree or disagree with a particular statement on a continuum of attitude statements: strongly agree, agree, don't know, disagree, and strongly disagree. The overall score obtained is assessed by:

$$Score = \frac{\text{Total score}}{\text{Max score}}\ x\ 100$$

The scores obtained are interpreted as shown in Table 1:

Table 1. Interpretation of questionnaire answer scores

Score	Interpretation
30-39	*Very Low*
40-55	*Low*
56-65	*Average*
66-79	*High*
80-100	*Very High*

(Arikunto, 2012)

Results and Discussion

Productive pedagogies measured include intellectual quality, connectedness, recognition of difference, and a supportive classroom environment. Productive pedagogies were conducted on the pre-service teachers who attended the PPL course via a productive pedagogy questionnaire.

Intellectual Quality

The intellectual quality dimension relates to students' understanding of the mathematics material taught by the teacher. This includes a basic understanding of learning and a further understanding of issues that require high-level analysis and deep thinking (HOTS).

Table 2 shows the overview of productive pedagogies on the intellectual quality dimension. The lowest average was found on the intellectual quality dimension of 79.17 of the pre-service teacher Hd. The pre-service teacher Hd used the element of productive pedagogies on intellectual quality dimensions, but not often, especially in giving students chances to critically examine text, ideas, and knowledge. The pre-service teacher H got the lowest average in this knowledge problematic, but H generated mathematical knowledge, symbol, and concept consistently and successfully. While pre-service teacher N consistently successful provides challenging activities that foster deep knowledge.

During the implementation of PPL, N revealed in the interview that "PPL students experienced several obstacles. However, each of these problems was able to be overcome through the guidance of Pamong Teachers and supervisors. For example, consultation with Pamong Teacher in making lesson plans; After every teaching, we should consult with the Pamong teacher

and supervisor about what still needs to be corrected or the problems encountered in the teaching and learning process so that they are not repeated at the next meeting." By giving this responses, the participants showed that they had to prepare the material before teaching the students. After the class, they evaluated the process of teaching practice with the Guru Pamong and the academic supervisor. Therefore, it helps them in teaching in the current school.

Table 2. Value of pre-service teachers' productive pedagogies on intellectual quality dimensions

No	Intellectual Quality	Statement	Average		
			H	N	Hd
1	Deep knowledge	The teacher develops mathematics lesson that covers operational fields in any depth, detail, or level of specificity	80	88	82
2	Higher-order thinking	Teacher gives students opportunities to use higher-order thinking operations within a critical framework	80	81	80
3	Deep understanding	The teacher uses the mathematics work and responses of the students to demonstrate a deep understanding of concepts or ideas	75	80	79
4	Substantive conversation	The teacher keeps sustained conversational dialogue between students, between teacher and students, to create or negotiate an understanding of the mathematics topic	85	80	80
5	Knowledge problematic	The teacher gives students chances to critically examine texts, ideas, and knowledge	65	70	71
6	Metalanguage	The teacher prominently gives aspects of mathematics knowledge, symbol, and concept	90	85	83
		Mean	79.2	80.67	79.17
Average: 79.6					

Moreover, based on Table 2, the pre-service teacher has provided an understanding of learning to students. The interviews identified all the pre-service teachers' responses that students did the assignments well. However, pre-service teachers have difficulty applying problematic knowledge, deep understanding, and higher-order thinking to the dimension, inserting problems requiring high-level analysis in learning mathematics. However, according to Kristiyono (2018), learning with high-level analysis is directed at creating independent students, thinking critically, and answering all problems and problems in the surrounding environment. This is very important for students to adapt and compete in a global society. There are supporting research results in increasing student achievement using HOTS learning and assessment. HOTS learning can make students think systematically, learn to analyze a problem from various aspects, educate students to be confident, and improve critical and creative thinking skills.

Furthermore, Kristiyono (2018) found that using the HOTS-based Student Worksheet (LKS) positively and significantly affected the science learning motivation of 7th-grade students

in junior high school. Five things cause HOTS-based worksheets to increase student motivation, namely: (1) stimulating students' willingness to learn because the worksheet offered raises curiosity, (2) encouraging pleasure because it displays concepts that cannot be observed directly with other media, (3) helps students find mathematics concepts so that this media becomes a liaison between students' prior knowledge, (4) stimulates students' willingness to learn because the worksheet offered is not an answer from the object of observation but only implementation instructions so that students experience the process of finding themselves, (5) encouraging independence students because each student is allowed to do reinforcement in the form of critical thinking skills. These things show that the learning must not only provide a basic understanding of the learning objectives to be achieved. Mathematics learning also needs to include high-level analytical problems. Relevantly, challenging work is essential for students to achieve intellectual quality dimensions.

Connectedness

Table 3 shows the value of pre-service teachers‘ productive pedagogies on connectedness dimensions. In general, the connectedness dimension has a mean value of 84.7, which is in the very high category.

Table 3. Value of pre-service teachers' productive pedagogies on connectedness dimensions

No	Connectedness	Statement	Average		
			H	N	Hd
1	Knowledge integration	The teacher integrates the lesson in a range of subject areas	80	80	81
2	Background knowledge	The teacher explicitly creates the lesson links with students' background knowledge.	93.4	80	80
3	Connectedness to the world	The teacher applies activities or tasks connected to competencies or concerns beyond the classroom.	86.6	87	85
4	Problem-based curriculum	The teacher creates lessons focused on identifying and solving intellectual and/or real-world problems.	93.4	85	85
Mean			88.35	83	82.75
Average: 84.7					

Pre-service teachers score high on the relatedness dimension among the four dimensions of productive pedagogies. On indicators relating students' background knowledge to the material being taught in learning, the three teachers strongly agreed and applied these indicators in learning. Pre-service teachers H and Hd teach probability material and remind students of fraction simplification material. Pre-service teacher N, who leads the presentation of data in a pie chart, also relates it to the diagramming lesson that students have learned in elementary school.

Suherman (2003) suggest that "school mathematics as mathematics taught at the primary and secondary education levels is chosen based on or oriented towards educational interests and the development of science and technology." Basic mathematics is the basis of all subsequent mathematics learning. Some of the material taught is basic and closely related to other material taught at higher education levels. This causes teachers to need to remind students about learning materials that are required or have a relationship with the material to be studied.

Other indicators of the relatedness dimension, namely the existence of similarities or connections with the real world, have also been carried out in the teacher's learning. According to Van den Heuvel-Panhuizen and Drijvers (2014), relating the material taught to real life in ongoing learning is necessary. With a connection to real life, students feel the urgency or importance of learning. This can be a reason for students to learn the material being taught. Likewise, connecting the material being taught with students' real life in learning mathematics is necessary.

Teachers H and Hd also connected mathematics topics with real-life teaching and learning. The teacher takes examples of problems and questions related to real life. Especially in the probability material, students are expected to estimate which decisions should be taken based on the value of existing opportunities from the problems they face in the real world. Meanwhile, in learning mathematics conducted by Teacher N, there is a clear connection with real-life students. Students can find and see the presentation of data in diagrams in real life, such as in newspapers and electronic media, such as television. In solving real-world problems, students require literacy ability to solve them, including mathematical connection abilities by using links between concepts, procedures, and facts as the role of mathematical connections in mathematical problem-solving activities (Pambudi, Budayasa, & Lukito, 2020).

Supportive Classroom Environment

Table 4 shows the value of pre-service teachers' productive pedagogies in a supportive classroom environment. The mean value of productive pedagogies among PPL students in the supportive classroom environment dimension is in the high category, about 79.96, as shown in Table 4 below.

Based on Table 4, the indicators of this dimension have been carried out by pre-service teachers in teaching and learning mathematics. The Pre-Service Teacher gives students the freedom to ask questions and provide opinions during mathematics learning. In addition, the pre-service teacher also provides problems that require students to be active in solving them so that students can build understanding in learning.

Table 4. Value of pre-service teachers' productive pedagogies in supportive classroom environment

No	Supportive Classroom Environment	Statement	Average		
			H	N	Hd
1	Student control	The teacher gives students chances to determine specific activities or outcomes of the lesson	80	75	70
2	Academic engagement	The teacher engages students and gives them on-task during the lesson	80	85	83
3	Self-regulation	The teacher explicitly develops criteria for judging the range of students' performance.	86.6	80	80
		Mean	82.2	80	77.67
		Average: 79.9			

To maximize the learning process, students need a positive environment that supports student learning. If students feel they are cared for and allowed to participate actively and responsibly, they think the school climate is positive and supportive and helps students feel they belong at school (Monteiro, Carvalho, & Santos, 2021). Classroom management strategies are required to create a positive environment and make children want to work together. According to Alsharif and Atweh (2012), productive pedagogies can be a reference or framework for creating a supportive or conducive classroom environment. Learning is done by maximizing students' participation and freedom in determining the learning steps. This can be seen from the indicators on the dimensions of a supportive classroom environment. Various indicators, such as students having a voice in determining the direction and outcomes of learning, students participating actively in learning, and explicit assessments, have emerged in mathematics learning by pre-service teachers, even though the average score is only about 75.

Recognition of Difference

Table 5 shows the score of pre-service teachers' on recognition of difference. In general, the productive pedagogies of pre-service teacher participants in the dimension of recognition of differences is 82.2, meaning they are in the very high category.

Table 5. Value of pre-service teachers' productive pedagogies on recognition of difference

No	Recognition of Difference	Statement	Average		
			H	N	Hd
1	Cultural knowledge	Teacher values non-dominant cultures	86.6	85	85
2	Inclusivity	Teacher attempts to encourage active student citizenship within the classroom	80	80	80
3	Group identity	The teacher builds a sense of community and identity	80	82	81
		Mean	82.2	82.33	82
		Average: 82.2			

From the dimension of recognizing differences, the participants ensure that students know and appreciate cultural diversity, create positive relationships between students, respect

individuals, and help develop a sense of community. This applies cultural knowledge, inclusiveness, expository, group identity, and an active citizen role. The indicator involves diverse expertise and culture in the teaching and learning process. The insertion of moral messages related to culture can influence students directly or indirectly always to behave well. Inserting general knowledge into learning or given assignments can add insight into students' social life (Sadulloh, 2010). Thus, inserting cultural and moral messages into learning is a good thing to do. In addition, giving moral messages related to cultural values to students can also attract their attention if it is done at the beginning of learning and can motivate them to study hard.

Teachers must pay attention to time allocation when inserting messages related to culture. So this does not affect the learning material to be taught, especially in learning materials that are difficult to understand and require a lot of time allocation in teaching. The main priority in learning is to make students understand the topics and achieve the learning objectives (Komalasari, 2013).

The productive Pedagogies framework involves four overarching dimensions: intellectual quality, connectedness; supportive classroom environment; and recognition of difference. The framework requires teachers to move from a teacher-centered approach to connecting mathematics so that it is relevant to students. Gainsburg (2008) points out the importance of real-world connections in mathematics classes to help different kinds of students learn mathematics. Moreover, the teacher should understand mathematics topics from various perspectives and transform this knowledge into the best form of presentation and communication so that students can access it. Mills and Goos (2007) found that all students need the support of intellectually challenging classrooms to improve academic outcomes. Further, Anthony and Walshaw (2008) argue that mathematics teachers who produce effective classroom environments care about their students' engagement. Hayes, Mills, Christie, and Lingard (2006) suggest that knowledge from different cultures, beliefs, languages, practices, and ways of knowing should be presented in the classroom.

The result shows that, in Intellectual Quality Dimensions, Knowledge Problematic was not very often implemented by all the pre-service teachers, which refers to the teacher giving students chances to examine texts, ideas, and knowledge critically, but is more often concentrated on Metalanguage that the teacher prominently gives aspects of mathematics knowledge, symbol, and concept. Within the Connectedness dimension, the pre-service teachers tended to focus on the elements of a problem-based curriculum in which they created lessons focused on identifying and solving real-world problems rather than knowledge integration, which was not implemented as often. For the Supportive Learning Environment dimension, academic engagement and self-regulation were frequently observed in all pre-service teachers' classes. Still, student control, in

which the teacher gives students chances to determine specific activities or outcomes of the lesson, was not very often. The results also suggest that, of all of the dimensions, Intellectual Quality was the least likely to be included in the classes. While the pre-service teachers mainly tended to focus on Connectedness during their teaching practice, followed by the dimension of Recognition of Differences. In addition, Guru Pamong and Academic Supervisor's support during the teaching practice also promoted the development of pre-service teachers' productive pedagogies.

Conclusion

Based on the results of research and discussion, it can be concluded that: productive pedagogies of mathematics education students in teaching practice in schools (PPL) are in the very high category. Mathematics education students can apply productive pedagogies in their learning activities. Overall, the pre-service teachers in learning practices argue that they had to use the dimensions of Productive Pedagogy. The result shows that the average value of productive pedagogies for the dimensions of Intellectual Quality is in the high category. The pre-service teachers considered student-teacher and student-student interaction about the ideas in the mathematics topic in their classroom. In general, the dimensions of connectedness are in the very high category. The pre-service teachers introduce classroom activities relevant to student's needs and focus on identifying and solving real-world problems. Meanwhile, the mean value of productive pedagogies among PPL students in the Supportive Classroom Environment dimension is high. All the pre-service teachers had to engage students involves keeping students on-task. In addition, all pre-service teachers explicitly create a positive environment, make students want to work together, and maximize students' participation. The research findings also suggested that the average productive pedagogies of participants in the dimension of Recognition of Differences are in the very high category. Based on the result of the study, it was revealed that pre-service teachers values non-dominant cultures during their teaching practices. However, due to the research limitations, caution must be taken in generalizing the findings. The limitations include the time, the instrument used, and the mathematics topic of the PPL. This study was conducted for about 14 weeks in one semester. The period of fourteen weeks of implementation time is not long enough for the pre-service teachers to get maturity in teaching because the practice was something new for them. They need more time to conduct teaching more productive from the early weeks of the course.

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