

Priority Determination Analysis of Research Competencies in Building Engineering Preservice Teachers through the Analytical Hierarchy Process

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Abstract – The objective of this research was to obtain information on the priority ranking of superior research competence criteria in pre-service teachers. This study was designed with a quantitative descriptive research design using the Analytical Hierarchy Process (AHP) method. The AHP is a decision-making system for determining the priorities on predetermined criteria in the development of research competencies in pre-service teachers. The five main principles studied were: the skills in determining the topic and background of research, skills in developing theoretical foundations, skills in applying research methodologies, skills in discussing and concluding research results, and paper writing skills. The expert evaluated the priority weight scale for each aspect of research competence. The development of research competency stimulation on pre-service teachers will be more effective if the priority criteria are revealed. A model of stimulation based on a priority scale should be developed with AHP since the order of priority indicates which stimulation criteria should be optimized.

Keywords – research competencies, building engineering preservice teachers, analytical hierarchy process.

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1. Introduction

As a profession, teaching requires professional competence. The professional competence of teachers has a significant effect on performance. A teacher's most important task is classroom management skills, since they have to be able to cope with all kinds of school problems [1]. One of the standards of competence in the teacher's professional profession is to perform reflective actions on an ongoing basis. Taking reflective action is one of the core competencies of long-term professional development. Reflective actions include the ability to reflect on one's performance, the ability to apply reflection results, the ability to conduct classroom action research, and the ability to learn from a variety of sources. Writing reflective papers has the potential to improve the performance of civil engineering education students [2]. Pre-service teachers have to have the ability to pay attention to learners' thinking in the context of written work that involves disciplinary and non-disciplinary aspects [3].

Research is a systematic inquiry to increase knowledge and a systematic and organized effort to scrutinize specific problems that require answers [4]. Everyone has motivations, some of which are influenced by their objectives and occupations. However, the motivation and research objectives are essentially the same. Namely, research is a reflection of the human desire to know something. Research can improve problem-solving [5].

Research competence is the ability and skill to conduct scientific research in pursuing scientific truth using methods based on well-established scientific reasoning. The research process entails systematic planning, implementation, and reporting following scientific principles and methods, as well as scientific autonomy and academic culture.

Research competence is generally measured by summing the scores obtained from the assessment of the research competency indicator. The research competence of prospective teachers is also determined by mastery of material content, the ability to review research background, the ability to determine research methodologies, the ability to find research results and the ability to present [4]. The research skills are divided into six aspects, including the researcher's ability to conduct investigations and determine research needs, the researchers can find and produce information or data needed using the correct methodology, a researcher's ability to evaluate information (data critically), researchers can manage data, researchers can synthesize, analyze, and apply new knowledge by knowing and confirming information which he obtained, and the researcher is able to communicate on ethical, social, and cultural issues [6]. There is much more research that improves the indicator of research [7], [8]. In increasing academic success, especially in student research competencies, support is needed, especially in strengthening design skills, since only ten of the 12 research topics offered were successfully completed during the master's degree process [9]. The research did not reveal a research competency assessment that took into account the weight of the criteria for each research competency indicator.

In general, the higher the subject's score in the assessment of research competence, the greater the subject's research ability. The lower the subject's score, the lower the subject's research ability [10]. As a result, research is required to determine the priority of criteria based on their preferences because many researchers currently consider all of these criteria to be critical. The researching skills test instrument consists of 7 aspects having the same assessment weight [11]. In this study, a set of criteria will be established as the starting point for optimizing and stimulating student-teacher research competencies. The criteria for the research competence of student-teacher candidates are still very general, and it is unclear which criteria can provide the most significant contribution to the research competence of student-teacher candidates under certain conditions. As a result, it is critical to make the right decisions when carrying out stimulation steps.

It can be challenging to choose between the various options available. Decisions cannot be made solely on intuition but they have to be made systematically [10]. AHP (Analytic Hierarchy Process) is a decision-making framework. The analytical hierarchy process (AHP) is a layered hierarchical structure for decision-making [12].

In principle, AHP helps resolve complex problems by employing a hierarchy of criteria, assessed by interested parties (experts), and then incorporating all variables to formulate weights or priorities [13]. Many researchers in their research have used the method. It has been revealed that AHP decision-making is objective and rational. The AHP method's results were more accurate, scientific, calculating intuition and subjectivity than other methods [14]. AHP can create a supportive performance system and pinpoint the service elements that need to be improved the most [15]. AHP can also help improve one's literacy competencies [12]. The AHP is a decision-making system for determining the priorities of the major criteria that influence competency development. Determination of decision trees through fuzzy logic can also be used based on degrees of truth [6].

The objectives of the study are to determine priority criteria based on their preferences to optimize the stimulation of research competencies. The novelty of this study is the determination of priority weights by using a hierarchy analysis of processes among research competency indicators to measure the quality of teacher research competence. The priority weight of research competency indicators of student-teacher can be used for making appropriate decisions and measures to stimulate teacher research.

2. Method

2.1. Statements of the Problems

This study is a quantitative descriptive study designed to answer the following problem formulation: How should priority criteria be determined based on their preferences to maximize the stimulation of research competencies?

2.2. Research experts

Validation of research competency self-evaluation instruments involves a team of research experts from various universities in Central Java, Indonesia. The expert team includes experts in different substances, materials, and languages. The experts involved in this study were ten lecturers, with 20% holding the title of Professor and 80% holding the title of Doctor. The expert will validate the self-assessment instrument for pre-service teacher research competencies and evaluate the priority weight scale for each aspect of research competence.

2.3. Data Collection Method

The data collection technique was done by using a questionnaire. The questionnaire is developed to measure the ability of teachers to research. The questionnaire was adapted from various sources [4], [16]. Indicators developed include: (1) the skills to determine the topic and background of research, (2) the ability to formulate theoretical foundations, (3) the skills to apply research methodologies, and (4) the skills to discuss and draw the conclusion of the research results, and (5) the skills to compose publication manuscripts. Experts' questionnaires were sent in the form of document files.

2.4. Analytical Hierarchy Process (AHP)

The priority scale measurement, which was developed by Saaty using hierarchy program analysis, uses pairwise comparisons on a scale of 1 to 9, ranging from equally important to absolutely more important (AHP) [17]. The weights of the research competency priority scale were analyzed by Analytical Hierarchy Process (AHP) [12].

Analytical Hierarchy Process s (AHP) was used to calculate priority weight. The steps in the AHP method are as follows: 1. Define the problem; 2. Set priority elements; 3. Synthesize; 4. Calculate the consistency index (CI) with the formula:

$$CI = \frac{(\lambda_{max}-n)}{(n-1)} \dots\dots\dots(1)$$

where λ = multiplication matrix comparison with Eigen factor, n = the total criteria

Calculate Consistency Ratio (CR) with the formula: $CR = CI / RI$

$$CR = \frac{CI}{RI} \dots\dots\dots(2)$$

If $CR < 0.1$, then the value of pairwise comparisons in the given criteria matrix is consistent.

If $CR \geq 0.1$, the value of pairwise comparisons in the given criteria matrix is inconsistent.

So if it is not consistent, then filling in the values in the paired matrix on the criteria elements has to be repeated.

The result is a global priority as the value used by decision-makers is based on the highest score [13].

3. Result and Discussions

The findings of this research suggest priority weighting criteria for building engineering education teachers to optimize the stimulation of prospective students' research competencies.

The priority weight of prospective students' research competency criteria for Building Engineering Education teachers calculation using the Analytical Hierarchy Process (AHP) is carried out with the following steps: define the problem, matrix Preparation and Competency Test, arranging the comparison matrix, calculate the normalized Eigenvectors, consistency calculation, priority of research competencies can be found [13].

The main hierarchy is the main objective to be achieved. The second hierarchy is based on the criteria. A requirement is something that all alternatives have to meet in order to be considered an ideal choice. The five criteria for research competence are still very general, so the right decision is needed to determine the order of the highest criteria, which will later become the basis for optimal research stimulation given to Building Engineering Education pre-service teachers. Types of criteria research competencies can be presented in Table 1, and the normalization factor (Eigen factor) is presented in Table 2.

Table 1 Types of Criteria

Types of Criteria	Information
Criteria 1	Skills in determining the topic and background of research.
Criteria 2	Skills in formulating theoretical foundations
Criteria 3	Skills in applying research methodologies.
Criteria 4	Skills in discussing and concluding research results.
Criteria 5	Skills in writing for publishing manuscripts

Table 2 Normalization factor (Eigen factor)

	Content knowledge	Skills in reviewing research conditions	Research design skills	Skills in reflecting research findings	Communication Skills	Priority Factors
Skills in determining the topic and background of research	0.385	0.296	0.423	0.379	0.379	0.372
Skills in formulating theoretical foundations	0.180	0.139	0.092	0.198	0.166	0.155
Skills in applying research methodologies.	0.263	0.436	0.289	0.283	0.212	0.297
Skills in discussing and concluding research findings.	0.100	0.069	0.100	0.098	0.171	0.107
Writing skills for publishing manuscripts	0.072	0.060	0.097	0.041	0.071	0.068
Total	1.000	1.000	1.000	1.000	1.000	1.000

The consistency calculation has to be done using the Consistency Ratio (CR).

$$CI = 0.04$$

$$RI = 1.12 \text{ (Random indices table) [18].}$$

$$CR = 0.036$$

From the calculation, it is obtained that the value of $CR = 0.036$, which means the value is < 0.1 , and then the criteria are declared consistent. So based on the analysis above, the priority of research competencies can be presented in Table 3 below:

Table 3 Research Competency Criteria Based on Priority.

Criteria	Values	Rank
Skills in determining research topics and backgrounds	0.372	First
Skills in applying research methodologies.	0.297	Second
Skills in formulating theoretical foundations	0.155	Third
Skills in discussing and concluding research findings	0.107	Fourth
Writing skills for publishing manuscripts	0.068	Fifth

The priority weight of research competency criteria is obtained in the following order based on the results in Table 3: The ability to determine the topic and research background comes first in the component of research competence (0.372).

The research topic is the overarching theme that will be discussed throughout the study. The topic is related to the current topic and pertains to the researcher's knowledge and expertise. It is about scientific authority in the context of ethics. The problem's background is information systematically organized about phenomena and complicated problems worth studying. The context includes the following elements: ideal conditions, actual conditions, gaps, goals, and solution methods.

Getting research ideas is indeed the most challenging step. Accordingly, a successful researcher is usually determined by his accuracy in choosing a research problem, both from the aspect of implementation and the availability of methods to solve it [19]. Topic selection is based on FINER (Feasible; Interesting; Novel; Ethical; Relevant) [20]. Therefore, determining the topic and background of the research is a top priority in stimulating the research competencies of prospective teacher students.

Supporting skills in determining research topics and backgrounds include reviewing relevant research topics and preparing research introductions based on the field of study. This skill corresponds to research competency indicators used to evaluate research competence [4]. Finding phenomena and selecting significant research problems are indicators of the ability to review relevant research topics.

In contrast, the ability to develop background research problems, develop problem identification, formulate problem formulations, develop research objectives, and relate background problems and problem identification are indicators of the ability to prepare preliminary research. Research problems serve as the basis of research studies, and if adequately formulated, researchers can expect good studies to follow.

The second priority is knowledge of research methodology (0.297). The scientific process of gathering data for research is known as a research methodology. The fundamental principle of research methods used in the research process is research methodology. These skills require additional skills, including planning the research process and analyzing research data. Indicators of research process planning skills include designing, determining samples, determining data, and collecting data.

In contrast, indicators of research data analysis skills include testing instrument validity, instrument reliability, analyzing research data, and researching skills in line with the recommended guidelines for preparing essay tests and other performance tests [16]. Skills in applying research methodologies also have an essential role in research. The methodology is the ability to analyze changing socio-economic processes, search holistically process, and analyze heterogeneous information effectively [21]. So the research methodology has a level of importance. The ability to determine the topic and research background comes first in the component of research competence.

The third priority is the skills in developing theoretical foundations (0.155). The essence of the theory is to explain or predict a phenomenon. Theories can explain the findings and predict what will come as a result of the findings. Based on assessment instruments, these abilities require additional skills, such as identifying relevant literature sources and developing a thinking framework and research hypotheses. Skills in seeking the theory that provides the core of research and skills in finding relevant research findings are indicators of skills in searching for relevant literature sources to the field of study. In contrast, indicators of skills in developing a framework of thinking and research hypotheses include skills in developing a thinking framework and formulating hypotheses. Here are seven components of a literature review: (1) identifying keywords, (2) starting searching databases, (3) initially trying to search about 50 research reports, (4) looking above abstracts and reading articles to identify useful literature, (5) start

designing literature maps/visual images – helpful organizing tools, (6) write the most summary of relevant articles – including literary references, (7) appropriately or by essential concepts discussed in research [22].

The fourth priority is the skill to discuss and provide a conclusion (0.107). Based on assessment instruments, these skills require supporting skills such as reflecting on their research findings theoretically, empirically, and practically, as well as the skill to provide a conclusion for their research findings. Indicators of theoretical skills in reflecting research findings include the ability to interpret research findings concerning theories establishing the basis of the research topics. Interpreting research findings based on the results of other relevant studies is an indicator of the skills reflecting practically, as is the ability to formulate the implications of research findings. In contrast, providing research results indicates the skills in concluding the research findings.

The fifth priority is skills in writing scientific articles (0.068). These skills require supporting abilities because it requires data from research results or conceptual theory, namely the skills in writing academic writing for publications, this research competency indicator is the last stimulation step. Based on assessment instruments, the indicator of academic writing skills for publication is in line with national and international scientific writing standards.

Based on the analysis of the priority weight of research competency criteria, the gap in the research ability of prospective teachers is 50.16% which means that the research ability of prospective teachers has only obtained a score of 49.84%. Therefore, the research competence of prospective teachers has to be improved. One way is to provide stimulation, especially on research competency indicators with the highest priority weight optimally, and continue with the priority of research indicators below.

Determining the order of priority of research competency criteria from the most important in pre-service teachers can be used as an indifferent in determining the stimulation of research competency criteria that has to be optimized.

With known priority criteria, the development of literacy stimulation will be more effective [10]. This research is focused specifically on research methodology courses in the building engineering education study program. This finding can be adopted as a model for the development of stimulation with a priority scale in research learning according to the context of each field of study.

4. Conclusion

When developing priority criteria, the AHP method is effective and efficient. First, criteria skills to determine the topic and background of the research are the top priorities underlying the research criteria. It is the primary stimulation, then stimulation of skills in applying research methodology, skills in building foundation theory and skills in discussing research findings, and skills in writing academic writings for publication. Student-teacher research competencies have to be developed first to achieve optimal results, and then performance indicators for each criterion will be determined. To ensure that increased stimulation in developing research competencies for pre-service teachers in the future is possible, the relationship between the priority indicators for each criterion will be fascinating to follow up on.

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