Mastery of Technological Pedagogical And Content Knowledge (TPACK) Prospective Teacher In ICT Expertise Brawijaya University

Luluk Latifah¹, Admaja Dwi Herlambang², Satrio Hadi Wijoyo³
¹,²,³Brawijaya University, Malang
luluklatifah@student.ub.ac.id¹, {herlambang,satriohadi}²,³@ub.ac.id
*Corresponding Author

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Abstract. The Information Technology Education (ITE) study program, Faculty of Computer Science, Universitas Brawijaya requires its students to take part in Pengenalan Lapangan Persekolahan (PLP) 2 according to Permenristekdikti No. 55 of 2017 in order to be able to produce prospective teachers who have the competence of educators. This study describes the gap in mastery of competencies with the TPACK framework based on the results of PLP 2 activities which are compared with standard values using a discrepancy evaluation model. The results of the gap are mapped using the method Importance Performance Analysis (IPA) to determine the priority scale for improvement of variables according to positions in certain quadrants. Through the IPA method, the variables that are prioritized to improve their mastery are TPK and PCK because they have very small gaps. Recommendations are given for the TPK variable to be given a pretest and posttest on the material for preparing teaching tools and training in the preparation of lesson plan. For the PCK variable, should be given pretest and posttest to the study material for theoretical and practical learning scenarios, the activities are needed lesson study which is carried out at least twice.

Keywords: technological pedagogical and content knowledge, prospective teachers, gap, information technology

1 Introduction

The development of a country and nation is seen in the most important element, is education. Because the progress of education continues to grow and its existence is needed in the context of fulfilling the goals of the Republic of Indonesia. In fact, the condition of education in Indonesia is experiencing quite serious obstacles, because the results of the report Human Capital Index (HCI) presented by the World Bank [1] positioned Indonesia at 87th in the low category based on the accumulated assessment of the probability components of life, education, and health. The level of quality of education is influenced by the teaching staff as the main actor implementing education [2]. Through the results of the Ujian Kompetensi Guru (UKG) which only obtained an average value of five, it indicated that the competence possessed by teachers in Indonesia was low [3]. Faculty of Computer Science Brawijaya University has an Information Technology Education (ITE) study program whose role is to prepare graduates as prospective teachers in the field of Information and Communication Technology (ICT) expertise who master competencies in accordance with Law no. 14
of 2005 concerning Teachers and Lecturers. Mastery means understanding or a person's ability to use his knowledge, intelligence, and so on [4]. Efforts made by Faculty of Computer Science Brawijaya University to prepare graduates to master competencies by arranging activities through the design of certain conditioning arrangements. The activity is Pengenalan Lapangan Persekolahan (PLP) 2 which is based on the Permenritedikti No. 55 of 2017 concerning Teacher Education Standards and PLP Program Guidelines for Undergraduate Education Programs. Through activities, PLP 2 ITE students are fostered and prepared to carry out apprenticeship and observation activities to learn aspects of learning and education management in certain educational units [5].

To measure the competency mastery of prospective educators, a special assessment standard is needed through a framework. Framework Technological Pedagogical and Content Knowledge (TPACK) which has been developed by Mishra, P., & Koehler [6] and Cox & Graham [7] can be used to analyze a teacher's knowledge in an effort to integrate technology into learning. In line with Omoso and Odindo [8], Vivian and Falkner [9], Chai et al., [10], Ramakrishnan et al., [11], and Furqon et al., [12] they adopted the TPACK framework to compare seven domains of knowledge of prospective teachers on each subject of his teaching. Chai, Koh and Tsai [13] add that the seven knowledge domains have a positive and significant relationship.

Based on the activities of developing learning tools and guided teaching and learning exercises, it will describe mastery of technological, pedagogic and content knowledge. Therefore, the TPACK framework is suitable to be used in identifying a teacher's knowledge. The purpose of this study is to describe the real condition of mastery of knowledge of prospective teachers in the field of ICT expertise at Brawijaya University based on PLP 2 activities using a discrepancy evaluation model so that it can be used as a reflection reference for the implementation of PLP 2 activities by the ITE Faculty of Computer Science study program, Brawijaya University based on the value of the gap obtained. Discrepancy evaluation model is an evaluation activity that compares actual performance with standards or provisions [14]. Priority assignment of TPACK domains carried out using the method Importance Performance Analysis (IPA). Importance Performance Analysis (IPA) is a method used to identify the level or order of priority of the variable importance [15][16]. With this evaluation, it is hoped that it will be able to help education policy makers, planners, and developers to review, make decisions in improving or maintaining performance based on the TPACK domain priority scale and setting recommendations in the realm of improving or maintaining the PLP 2 curriculum.

2 Method

This research is included in quantitative descriptive research that adapts the sequence of stages of Sugiyono’s [17] quantitative research. Figure 1 shows the stages of the research carried out.

This research took place at Faculty of Computer Science, Brawijaya University from February 2021 - May 2021 with the research sample being 79 ITE Faculty of Computer Science students at Brawijaya University who had passed the PLP 2 course. The research stage begins at the time of planning the research by identifying the problem through initial interviews which then utilizes the problem by determining the formulation of the problem.
Then the literature study activities to study previous studies and examine several theories in order to answer the question formulation of the problem. The next stage is compiling questionnaires and tests. The starting point for the questionnaire is based on the Omoso and Odindo [8] and Hayati, Rahmadi and Nursyifa [18] research questionnaire indicators which were adapted from the research of Chai et al., [13], Sahin, [19], and Schmidt et al., [20]. Several indicators in the questionnaire were also used as indicators in the preparation of the test. Questionnaire and test indicators are summarized on the research instrument grid.

After the questionnaires and tests have been prepared, the next step is testing the research instrument for its validity and reliability. The validity test on the questionnaires and tests includes construct tests and empirical tests. The construct test is carried out to experts or education experts with a minimum number of three people. The education experts who conducted the test were Faculty of Computer Science Lecturers, Brawijaya University. Empirical tests were carried out on the research sample as test respondents. If it is declared valid and reliable, questionnaires and tests are distributed for the data collection process.

The stage of processing data and analyzing data using descriptive statistical calculations. At this stage, it is also identified the gaps that occur between the results of the implementation of the PLP 2 program when viewed from the TPACK aspect and the graduation standards of the PLP 2 curriculum of ITE Faculty of Computer Science Brawijaya University based on the gap analysis of the discrepancy evaluation model. Then the gap is mapped using the IPA method. Through the results of domain mapping, recommendations are given to improve or maintain the performance of a domain. The last stage is drawing conclusions and suggestions for further research development.
3 Results

Mastery of prospective teachers in the field of ICT expertise at Brawijaya University through a questionnaire with statistical calculations using the mean formula can be seen in Figure 2.

![Questionnaire Descriptive Statistics Results](image1)

Fig. 2 Questionnaire Descriptive Statistics Results

The results of calculating the domain mastery of the TPACK framework through a questionnaire based on Figure 2 show that the value of mean the domain Technological Knowledge (TK) is 4.00, which is in the good category. The Value of mean the domain Pedagogical Knowledge (PK) is 3.57 in the good category. Meanwhile, the domain Content Knowledge (CK) obtained a value mean of 3.66 in the good category. Furthermore, the domain Pedagogical Content Knowledge (PCK) obtained a value of mean 3.70 in the good category. Domain Technological Content Knowledge (TCK) obtained a value of mean 3.86 with a good category. Then, the domain Technological Pedagogical Knowledge (TPK) gets a value mean of 3.60 with a good category. Last domain Technological Pedagogical and Content Knowledge (TPACK) obtained a value of mean 3.53 with a good category.

![Test Descriptive Statistics Results](image2)

Fig. 3 Test Descriptive Statistics Results

The results of the calculation of the domain mastery of the TPACK framework through tests based on Figure 3 show that the percentage value of the domain Technological Knowledge (TK) is 51% which is in the sufficient category. The percentage value of the domain Pedagogical Knowledge (PK) is 64% in the good category. Meanwhile, the domain Content Knowledge (CK) obtained a percentage value of 72% in the good category. Furthermore, the domain Pedagogical Content Knowledge (PCK) gets a value of the percentage of 39% in the lesser category. Domain Technological Pedagogical and Content Knowledge (TPACK) obtained a value of mean 3.53 with a good category.
Technological Content Knowledge (TCK) obtains a percentage value of 46% with a sufficient category. Then, the domain Technological Pedagogical Knowledge (TPK) gets a percentage value of 39% in the lesser category. Last domain Technological Pedagogical and Content Knowledge (TPACK) scores a percentage 73% with a good category.

Table 1. Gap of Expectations and Actual Performance Variable Acquisition

| Variables | Expectations | Actual Performance | Gap |
|-----------|--------------|---------------------|-----|
| TK        | 3            | 3,3                 | -0.3|
| PK        | 3            | 3,38                | -0.08|
| CK        | 3            | 3,58                | -0.58|
| PCK       | 3            | 2.82                | 0.18|
| TCK       | 3            | 3,08                | -0.08|
| TPK       | 3            | 3,77                | 0.23|
| TPACK     | 3            | 3.59                | -0.59|

Through Table 1 the combination of calculation and test results is calculated on average, previously the percentage value of the test was converted so that it could be calculated with the value of the mean questionnaire. The gap or gap that occurs only in the PCK and TPK variables has a very small gap category. Meanwhile, in the variables TK, PK, CK, TCK, and TPACK there is no gap because it gets a negative value (-) or smaller than 0 which means that the actual result is greater when compared with the expected value. The values of the expectations and reality attributes in the mastery of each TPACK domain are mapped using a Cartesian diagram as shown in Figure 4 through the method Importance Performance Analysis (IPA). This value will later describe the order of the priority scale of variables that need to be addressed or have options to be addressed in order to increase or defend a actual performance value or reality.

Figure 4 is a Cartesian IPA diagram for each TPACK domain. In quadrants I and II there is no domain occupying that quadrant. For the TPK domain, PCK and TCK are in quadrant III. Quadrant III itself describes variables whose reality value or performance is already high but there are still a few gaps so that they can be considered for recommendations so that these gaps no longer exist. If sorted, the domains that require improvement options are in quadrant III is TPK, PCK and the last TCK. The variables considered to be recommended for improvement are TPK and PCK, while
TCK is not considered for an increase to be recommended. This is because the actual performance value of the TCK variable is 3.08, which means it exceeds the expected value of 3, although with a very small difference. Meanwhile, quadrant IV is occupied by the TK, PK, CK and TPACK domains. Quadrant IV has shown that the variables that get high reality or performance values are even considered excessive. Therefore, the variables occupying quadrant IV don’t need to be increased on the variables.

4 Discussion

4.1 Technological Knowledge (TK)
TK indicators include basic knowledge of software computers, specific use of technology, technological developments, solving technological problems, and knowledge of self-existence as users of digital technology that have been well mastered. Obtaining the value mean of this study is in line with the research of Hayati et al., [18] because they both get the good category. However, in the research of Omoso and Odindo [8] the value of mean TK is only 3.54, so if in this study the value of mean TK is the highest gain which is inversely proportional to the research of Omoso and Odindo [8] which pocketed the lowest gain. The PK domain has no gaps because the mastery of this domain has been mastered to the maximum. If viewed based on the Cartesian diagram of the IPA method, the PK domain is in quadrant IV, which means that mastery of this domain based on reality is considered very good, therefore there is no need to worry about the ability of the PK domain.

4.2 Pedagogical Knowledge (PK)
Mastery of PK through learning planning indicators, problem-based teaching contexts, application of learning approaches, management of learning problems, understanding types of evaluation, knowledge of learning theory and learning planning and the overall learning process have been mastered by prospective teachers in the field of ICT expertise. Pedagogic knowledge includes lesson planning, general classroom management, and student assessment [21]. Because the pedagogical mastery is mastered well, the prospective teacher is said to be a professional teacher candidate. Because, professional teacher candidates are those who always apply their pedagogical knowledge in teaching because pedagogy is the basis for all teaching and learning processes [22]. The results of this study are commensurate with those conducted by Pradana [23] because the results of the biology teacher's test scored 69.6% in the good category. The PK domain has no gaps because the mastery of this domain has been mastered to the maximum. If viewed based on the Cartesian diagram of the IPA method, the PK domain is in quadrant IV, which means that mastery of this domain based on reality is considered very good, therefore there is no need to worry about the ability of the PK domain.

4.3 Content Knowledge (CK)
Mastery of the CK domain with indicators of subject subject knowledge about Software Development Life Cycle (SDLC), editing video, internet protocols, then understanding of increasing knowledge capacity, knowledge of scientist figures, and development of learning resources has been well mastered. The implication of good content mastery will affect the teacher in listening and responding to students with their questions. It also affects the teacher's ability to explain clearly and ask good questions to students [24]. If we look back at the research conducted by Schmid, Brianza and
Petko [25] because the acquisition of value mean CK of 4.20 ranks first, in this study the mean CK value obtained a value of 3.66 in the fourth position. The CK domain has no gaps because the mastery of this domain has been mastered to the maximum. If viewed based on the Cartesian diagram of the IPA method, the CK domain is in quadrant IV, which means that mastery of this domain based on reality is considered very good, therefore there is no need to worry about the ability of the CK domain.

4.4 Pedagogical Content Knowledge (PCK)

In the PCK domain, there are indicators for selecting teaching approaches, preparing lesson plans, making material linkages, mastering complex and simplifying materials, lattices and test questions, suitability of materials with learning media, characteristics of students with learning models, and suitability of strategies. with student characteristics. In general, there are still indicators that have not been mastered thoroughly because the mastery of the PCK domain has a very small gap value when viewed based on the IPA method which positions this domain in quadrant III. The problem faced by prospective teachers in the field of ICT expertise at Brawijaya University is that they are unable to adapt learning models that are able to facilitate students' thinking skills to be critical and logical to solve problems by involving all senses, and determine the use of strategies with different characteristics of students in learning. In fact, PCK is conceptualized as the foundation of knowledge needed to change content so that it is taught in various forms that can be understood by students [26]. Overall, 39% of the test results in the category of not describing prospective teachers do not fully understand how to link pedagogic and content elements properly [23].

Recommendations that can be given to improve the PCK domain are increasing understanding of the suitability of the material with learning media and the suitability of strategies with student characteristics that can be done during the orientation and debriefing period of the PLP 2 program based on the PLP 2 curriculum material, namely a study of theoretical and practical learning scenarios, needed pretest is and posttest so that participants are better prepared to carry out the PLP 2 program. Because, through the pretest and posttest the progress and development of learning participants can be seen [27]. Not only material that is theoretical in nature, but prospective teachers in the field of ICT expertise at Brawijaya University can also improve pedagogic competence in their teaching subjects through practical activities, namely lesson study at least twice with observers, supervisors and students. Because in the 2019/2020 school year, many experienced problems in carrying out lesson study, even based on interviews with PLP students for the 2019/2020 academic year, there were students who only carried out lesson study once. Emphasized by Wuryandari, [28] the efforts made by schools to develop teacher pedagogic competencies such as making Classroom Action Research (CAR) by several teachers, holding lesson study, supervision, workshops and seminars.

4.5 Technological Content Knowledge (TCK)

Through the indicators of knowledge of materials and supporting technology, the use of technology variations, critical thinking in the use of technology, and the suitability of the application of technology, the prospective teachers in the ICT field of expertise Brawijaya University have mastered well because the results of the mean questionnaire obtained a value of 3.86 with a good category. In line with Margerum-Leys, J., & Marx [29] who said that mastery of a good teacher's TCK will help teaching staff to visualize effective integrated learning materials.
Mastery of the TCK domain indicates that prospective teachers are proficient in using ICT as a learning medium and are even able to choose learning media according to their learning content. Pramono [30] explains that by using ICT as a teaching aid, material that was originally abstract or material that is just dreamy can become more concrete or real so that students understand it in real terms and are not easily forgotten. Also supported by the opinion of Kurniawati [31] an educator must be good at choosing learning media in the form of visual, audio, audio visual and multimedia media because the impact will make it easier for students in the teaching and learning process. The TCK domain does not have a gap because the mastery of this domain has been mastered to the maximum. If it is reviewed based on the Cartesian diagram of the IPA method, the TCK domain is in quadrant III, which means that mastery of this domain based on reality is assessed already and this domain is given the option not to be increased because the gap that occurs is relatively small.

4.6 Technological Pedagogical Knowledge (TPK)

In mastering the TPK domain, prospective teachers are able to master technology selection indicators, use technology for discussion, use computer applications, evaluate new technologies, and process technology-supported learning activities with appropriate models, approaches, methods that have not been fully mastered. This is because the prospective teacher in the field of ICT expertise at Brawijaya University scored 39% in the lesser category. Prospective teachers are still not able to design learning media as a supporter in delivering material with the right pedagogy mastery. According to Majumdar [32] the use of ICT in pedagogy helps students not only to access information in various communication styles but also helps students to benefit from collaborative learning which as a result enhances creative thinking and problem-solving skills.

The gap category that is pocketed is very small, through the IPA method the TPK domain is positioned in quadrant III. Recommendations that can be given are focused on the material in the PLP 2 curriculum regarding the preparation of teaching tools held into theory and practical classes. In theory, the material on the preparation of teaching tools serves as the basis for making teaching tools in general. In the preparation of teaching tools, it is necessary to give pretest and posttest so that participants are better prepared to carry out the PLP 2 program. Because, through the pretest and posttest, the progress and development of learning participants can be seen [27].

Then in the practical class, a kind of training was made for the manufacture of specific teaching tools is lesson plans with a note of the need to think about the use of technology in it. Thus the ability of prospective teachers in the field of ICT expertise will be seen, whether he uses technology in his planning or not. Because, one indicator of teacher professionalism is to use Information and Communication Technology (ICT) to communicate and develop themselves [33].

4.7 Technological Pedagogical and Content Knowledge (TPACK)

Through indicators of integration of methods, technology, and content, combined teaching, coordination of the use of content, technology with teaching approaches, and the appropriate use of technology with materials, models, approaches, methods, media in learning, prospective teachers have mastered this domain well. Mastery of TPACK is the end result of various combinations of the three larger domains of content, pedagogy, and technology to create teaching using effective educational technology [34]. The test score obtained by 73% indicates that the prospective teacher really mastered the TPACK domain in the realm of learning. The TPACK domain does not
have a gap because the mastery of this domain has been mastered to the maximum. If viewed based on the Cartesian diagram of the IPA method, the TPACK domain is in quadrant IV, which means that mastery of this domain based on reality is considered very good, therefore there is no need to worry about the ability of the TPACK domain.

5 Conclusions

Mastery of PK, CK, and TPACK domains for prospective teachers in the field of ICT expertise at Brawijaya University is included in the good category through the distribution of questionnaires and tests, thus mastery in this domain has been mastered and is able to equip students to become prospective educators. Then, the TK and TCK domains are included in the good category for questionnaires and sufficient for tests, meaning that mastery in this domain has been mastered and is able to equip students to become prospective educators but still needs a little improvement so that mastery of this domain reaches the highest category. Finally, the PCK and TPK domains achieved a good category for the questionnaire and bad for the test, this indicates the need for improvement in this domain, especially in indicators that are still lacking so that the highest mastery category can be achieved.

There is a very small gap between ideal conditions and real conditions related to mastery of the TPK and PCK domains. This is due to the lack of optimization of domain mastery, which results in the value category being below the standard, resulting in a gap. Recommendations that can be given to the organizers of the PLP 2 program at PTI FILKOM Universitas Brawijaya are in the form of improvements in the implementation of their activities. In the realm of TPK, it is necessary to give pretest and posttest during the orientation and briefing of the PLP 2 program with materials for preparing teaching tools and training activities for making the required lesson plans. Meanwhile, the recommendation for increasing PCK mastery is the provision of pretest and posttest during the orientation and briefing of the PLP 2 program in the study of theoretical and practical learning scenarios. Then the implementation of lesson study activities at least twice in order to increase the competence of prospective teachers in the realm of pedagogic content.

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