Profile of senior high school in-service physics teachers’ technological pedagogical and content knowledge (TPACK)

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Abstract. This research is aimed to find out TPACK of high school in-service Physics teachers in North Maluku by using TPACK survey instrument that consist of 7 components, namely Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and TPACK in Likert scale. The data of TPACK perceptions were analysed using descriptive statistics, whereas teachers’ TPACK differences in gender and experience of teaching were analysed using Mann Whitney test by SPSS 20 because the samples were small samples. The result of data analysis shows that TPACK perception of senior high school in-service Physics teachers is still in the low category. The components are TK, TCK, TPK, and TPCK that related to technology. Based on gender data analysis, it is known that there is significant difference only on TCK component, whereas based on teachers’ experience of teaching, significant differences were found in components of PK, PCK, and TPCK. Based on these research result can be conclude that TPACK of teachers are still constrained on components related to technology so that the ability of teachers in integrating technology in learning is still not maximized.

1. Introduction
Technological Pedagogical and Content Knowledge (TPACK) is a framework that introduces the relationships and complexities between all three basic components of knowledge, namely technology, pedagogy, and content [1,2]. The developing of 21st century teacher competencies related to technology, pedagogical, and learning content, known as Technological, Pedagogical, and Content Knowledge (TPACK) [3]. Therefore, TPACK framework is very useful for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge. Teachers need to improve their knowledge and skills continuously to teach their students in TPACK mindset in order to teach their students effectively. In realizing the skills of the 21st century, it is necessary innovations in learning, whether related to approach, model, strategy, and
media or learning technology. Teachers should have an intuitive understanding of teaching content with appropriate pedagogical methods and technologies.

The study of TPACK has been widely practiced and generally the result concluded that TPACK perception is essential for teachers to prepare for 21st century education. The fact on the ground that many beginner and pre-service teachers do not have the knowledge or experience necessary to incorporate technology into their classes [4,5]. It is agree with the research results stated that teachers often learn about technology, content and pedagogy in separate course work giving them an incomplete description of how technology can support student learning [6]. In order to teachers make good in teaching, they need to develop themselves in the areas of pedagogy, content and technology. By using information and communication technology, teachers can follow the developments in their fields, transfer approaches and contemporary applications of teaching methods into their teaching in order to they are still up-to-date. The main reasons for their incapacity in educational technology are the lack of training for teachers [7,8]. The appropriate solution to overcome the challenge of using ICT by teachers is knowledge of content pedagogical technology or known as TPACK [9].

The perception of TPACK is also important to be possessed by teachers in Indonesia in order to prepare for the 21st century learning. Teachers are required to have the Information and Communication Technology (ICT) skills in order to create meaningful learning because the using of ICT give students the opportunity to work collaboratively and independently as demands 21st century skills. It is according to the demands of teacher competency standards that require teachers to be able to utilize information and communication technology in communicating and for self-development. Therefore, the study related to TPACK of senior high school Physics teachers need to be done. The results of this study can be used as a reference in an effort to develop pedagogical and professional competence of teachers.

2. Methods
The aim of this research is to measure perception of Technological, Pedagogical, and Content Knowledge (TPACK) of senior high school in-service Physics teachers from several schools in North Maluku Province. The participants in this study are 30 Physics teachers (14 male and 16 female) ranging from the age of 23-46 years that chosen by purposive sampling technique. They are chosen as representation of population based on consideration of teaching experience, type of school, and by region. Measuring perception of TPACK using TPACK survey instrument developed by Schmidt that consist of seven components, namely: Technological Knowledge (TK); Content Knowledge (CK); Pedagogical Knowledge (PK); Pedagogical Content Knowledge (PCK); Technological Content Knowledge (TCK); Technological Pedagogical Knowledge (TPK); and Technological Pedagogical Content Knowledge (TPACK) [10]. The instrument as a whole consists of 29 items in Likert scale with 5 choices of answers, namely Strongly Disagree (SD) given 1 score, Disagree (D) given 2 score, neither agree nor disagree (N) given 3 score, Agree (A) given 4 score, and Strongly Agree (SA) given 5 score. The tests of content and empirical validity were did of the instrument used and the result showed that there are 6 items from 29 items are invalid so that only 23 items were used. TPACK perception data obtained then analyzed using descriptive statistics in the form of percentage [11,12]. While the analysis to determine the difference TPACK teachers by gender and experience of teaching using Mann Whitney test by SPSS.20 because the sample of research is small sample.

3. Result and discussion
This study has identified TPACK perceptions through self-assessment of senior high school in-service Physics teachers in seven knowledge domains within the TPACK framework.

3.1. Physics teachers' perception of TPACK
The results of the research were Technological, Pedagogical, and Content Knowledge (TPACK) data of senior high school in-service Physics teachers identified using TPACK survey instrument for all components can be shown in Table 1.

**Table 1. Percentage of in-service physics teachers’ perception of TPACK.**

| Component of TPACK                      | SD | D  | N  | A  | SA | Total Score | Percentage (%) | Category |
|-----------------------------------------|----|----|----|----|----|-------------|----------------|----------|
| Technological Knowledge (TK)            | 37 | 104| 294| 92 | 0  | 527         | 50             | Low      |
| Content Knowledge (CK)                  | 0  | 0  | 30 | 80 | 0  | 110         | 73             | High     |
| Pedagogical Knowledge (PK)              | 0  | 0  | 36 | 284| 35 | 355         | 79             | High     |
| Pedagogical Content Knowledge (PCK)     | 0  | 0  | 0  | 24 | 120| 144         | 96             | High     |
| Technological Content Knowledge (TCK)   | 3  | 24 | 36 | 12 | 0  | 75          | 50             | Low      |
| Technological Pedagogical Knowledge (TPK)| 33 | 134| 150| 0  | 0  | 317         | 42             | Low      |
| Technological Pedagogical Content Knowledge (TPACK) | 21 | 100| 198| 52 | 0  | 371         | 49             | Low      |

The results of the analysis of the research data (Table 1) showed that TPACK perception of senior high school in-service physics teacher in four components is still in low category, which is in TK component (50.1%), TCK (50%), TPK (42.3%), and TPACK (49.5%). These components are related to technology so that it can be stated that the ability of teachers related to the using and integration of technology into learning is still not maximized. This result aligned with the research that the ability to integrate ICT into teaching and learning in the classroom continues to be a challenging task for many teachers [13,14]. Although the Government has effort to improve the ICT skills of teachers through ICT training activities, but the effort still need to be done continuously so that every teacher will have the opportunity to follow it, considering the geographical position of Indonesia which is an archipelago country can be one of the constraints of time and cost limitation, even if not all of teachers have the opportunity to follow these activities.

3.2. Physics teachers’ perception of TPACK by an open questionnaire

The result of data analysis obtained using open question in the form of essay showed that from 30 teacher respondents there are 6 teachers (20%) who did not master computer technology so do not use technology in their learning, 9 teachers (33%) only use simple technology laboratory equipment, 10 teachers (50%) use PowerPoint technology that contains text, animation and picture, 5 teachers (16.7%) use technology in the form of internet.

Furthermore, the results of interviews on 6 teachers who did not master computer technology obtained information that the six of teachers did not master computer technology because they never get the lectures or training related to the use of computers. While the information obtained through interviews of 9 teachers who only use modeling tool/laboratory tool that the teachers experienced obstacles related to the limitations of school infrastructure such as electricity, laptop and LCD.

The results showed that from 30 respondents of Physics teachers who participated in this study, only 15 people (50%) are able to use computer technology and internet, and others do not use technology in learning. These results are according to the results study that found if there are still four TPACK components still in the low category [10].
This phenomenon is very ironic if it is associated with the demands of 21\textsuperscript{st} century skills that must be owned by Physics teachers to be able to teach 21\textsuperscript{st} century skills to their students. How can we prepare 21\textsuperscript{st} century skills on students if teachers are still teaching with 19\textsuperscript{th} century skills [15]. The 21\textsuperscript{st} century education emphasizes that every teacher should know how to use technology, pedagogy and subject areas effectively in their classroom teaching every day. Teachers should understand their role in technology-oriented classrooms because when teachers integrate technology into teaching, students become more interested in learning [16,17]. The knowledge about using of educational technology effectively has become an important aspect of the educational base of educators for the 21\textsuperscript{st} century [18-20]. Based on these findings, the improvement of teachers’ ICT skills is very important to be done because it can help teachers to utilize ICT in the learning. Teacher need to continuously improve their knowledge and skills in order than to make students learn effectively.

3.3. Physics teachers’ perception of TPACK by gender

The Mann Whitney test by SPSS.20 was conducted to compare TPACK perceptions of teachers on all TPACK components (TK, CK, PK, PCK, TCK, TPK, TPACK) for male and female teachers. Participants in this study consist of 14 male and 16 female. The results of the analysis contained in Table 2 indicate that there is a significant difference for the CK and TCK component between male and female teachers with p value (0.042 and 0.032) with a significance level of 0.05. Furthermore, there was no significant difference between TPACK perceptions of male and female teachers in TK, PK, PCK, TPK, and TPACK components.

| Table 2. Perception of TPACK physics teachers by gender. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Component       | Male            | Female          | Male            | Female          |
| Mean rank       | 17.96           | 13.34           | 21.35           | 14.77           | 0.150           | no difference   |
| Sum of ranks    | 251.50          | 213.50          | 77.50           | 65.00           |                  |
| CK              | 18.36           | 13.00           | 208.00          | 72.000          | 0.042           | difference      |
| PK              | 16.46           | 14.66           | 234.50          | 98.500          | 0.546           | no difference   |
| PCK             | 16.36           | 14.75           | 236.80          | 100.000         | 0.472           | no difference   |
| TCK             | 18.89           | 12.53           | 200.50          | 64.500          | 0.032           | difference      |
| TPK             | 18.82           | 12.59           | 201.50          | 65.500          | 0.052           | no difference   |
| TPACK           | 18.25           | 13.09           | 209.50          | 73.500          | 0.106           | no difference   |

In terms of gender-based analysis, there was a significant difference for the CK and TCK component where TPACK perceptions of male teachers were higher than female teachers. This result aligned with the research results that significant differences are found between male and female pre-service teachers’ TPACK of TK component [21]. In addition, the research found that significant difference between male and female pre-service teachers’ TPACK in favor of male students [22]. Moreover, based on this research result we found that the gender variable is not too affecting the TPCK perception of teachers.

3.4. Perceptions of TPACK based on experience of teaching

The results of the analysis using Mann Whitney by SPSS.20 conducted to compare TPACK perceptions of teachers on all components TPACK (TK, CK, PK, PCK, TCK, TPK, TPACK) based on teachers’ experience of teaching can be shown in table 3. The results showed that there are significant differences in the component PK (p = 0.017), and TPACK (p = 0.039) with level of significance is 0.05. Furthermore, there was no significant difference between perceptions of teachers that have experience of teaching more than 10 years and less than 10 years in term of TK, CK, PCK, TCK, and TPK component (table 3).
Table 3. Physics teachers’ perception of TPACK based on experience of teaching.

|            | More than 10 years | Less than 10 years |
|------------|--------------------|--------------------|
|            | Mean rank          | Sum of ranks       | Mean rank | Sum of ranks | U    | P      | Result      |
| TK         | 11.25              | 112.50             | 17.63     | 352.50       | 57.500| 0.061  | no difference |
| CK         | 19.00              | 190.00             | 13.75     | 275.00       | 65.000| 0.073  | no difference |
| PK         | 20.55              | 205.50             | 12.98     | 259.50       | 49.500| 0.017  | no difference |
| PCK        | 18.50              | 185.00             | 14.00     | 280.00       | 70.000| 0.057  | no difference |
| TCK        | 13.65              | 136.50             | 16.43     | 328.50       | 81.500| 0.378  | no difference |
| TPK        | 11.90              | 119.00             | 17.30     | 346.00       | 64.000| 0.111  | no difference |
| TPACK      | 10.85              | 108.50             | 17.83     | 356.50       | 53.500| 0.039  | difference   |

Furthermore, research results found that there are significant differences TPACK perceptions on components PK, and TPCK based on experience of teaching. TPACK perceptions of teachers who have more than 10 experience of teaching in the PK components are higher than teachers who have taught less than 10 years. While on the TPACK component, the perception of teachers with experience of teaching less than 10 years is higher than teachers who have more than 10 years. This result is according to the research results that stated TPACK perceptions of pre-service teachers who have longer study periods are higher for some TPACK components [21,23].

4. Conclusion
The result of data analysis shows that TPACK perception of senior high school in-service Physics teachers is still in the low category. The components are TK, TCK, TPK, and TPCK that related to technology. From these research result can be conclude that TPACK of teachers are still constrained on components related to technology so that the ability of teachers in integrating technology in learning is still not maximized. While we know that 21st century learning requires teachers to be able to teach content with appropriate pedagogical methods and technologies. In realizing the skills of the 21st century requires innovations in learning, whether related to approach, model, strategy, media or learning technology. Teachers should have an intuitive understanding of teaching content with appropriate pedagogical and technologies methods. Therefore, ICT training activities for teachers still need to be done continuously so that all teachers have the same opportunity to follow these activities. In addition to training activities, other efforts are also needed that can help improve the ICT skills of teachers through the providing the teacher guide book based on TPCk that teachers can access wherever they are located so that all teachers have same opportunities to improve ICT integration skills in their learning. The using of quality teacher guide book is a more appropriate solution to do other than the form of trainings. The using of teacher guide book appropriately will give profound direct effect on the learning process. Providing the quality teacher guide book is relatively easy, cheap and quick compared to other activities [24].

Moreover, when we analyzed the TPCK perception data based on gender, it was found that there was significant difference only on CK and TCK component, whereas in other component there is no difference. So we can conclude that the gender variable is not too affecting the TPCK perception of teachers. While based on teachers’ experience of teaching, the significant differences were found of PK and TPCK components.

5. References
[1] Koehler M J and Mishra P 2008 Introducing TPACK. In AACTE Committee on Innovation and Technology (Ed.), Handbook of technological pedagogical content knowledge (TPACK) for educators (New York, Routledge) p 329
[2] Mishra P and Koehler M J 2006 Teachers College Record 108 10171054
[3] Sahin 2011 TOJET: The Turkish Online Journal of Educational Technology 10 97
[4] Buckenmeyer and Freitas 2005 (Paper presented at the National Educational Computing Conference, Philadelphia PA)
[5] Niess M L 2005 Teaching and Teacher Education 21 509
[6] Mouza C and Klein K 2013 Journal of Education Computing Research 48 127
[7] Angeli C and Valanides N 2005 Journal of Computer Assisted Learning 21 292
[8] Koehler M J, Mishra P and Yahya K 2007 Computers and Education 49 740
[9] Chai C, Koh J and Tsai C 2013 Educational Technology and Society 16 31
[10] Schmidt D S 2009 Journal of research on technology in education (International Society For Technology In Education) 42 123
[11] Depdiknas 2003 Pedoman Khusus Pengembangan Silabus dan Penilaian Mata Pelajaran Fisika (Jakarta, Depdiknas) p 18
[12] KemenPAN dan RB 2009 PermennegPAN dan RB Nomor 16 Tahun 2009 tentang Jabatan Fungsional Guru dan Angka Kreditnya (Jakarta, KemenPAN dan RB)
[13] Shafer G K 2008 Contemporary Issues in Technology and Teacher Education 8 27
[14] So H and Kim B 2009 Australasian Journal of Educational Technology 25 101
[15] Martin B 2015 International Journal on Integrating Technology in Education (IJITE) 4 17
[16] Schrum L, Thompson A, Maddux C, Sprague D, Bull G and Bell L 2007 Contemporary Issues in Technology and Teacher Education 7 456
[17] Sweeder J and Bednar R 2001 Contemporary Issues in Technology and Teacher Education 1 421
[18] Ann E B, Kate K, Christine H and Kimberly K 2003 Journal of Research on Technology in Education 35 489
[19] Partnership for 21st Century Skills 2003 Learning for the 21st century: A report and mile guide for 21st century skills. Washington, DC: Author. Available from http://www.21stcenturyskills.org
[20] Berber D and Erdem A 2015 Computers 4 234
[21] Erdogan A and Sahin I 2010 Proc. Soc. Behav. Sci. 2 2707
[22] Chuang H and Ho C 2011 J. Coll. Educ. 12 99
[23] Chingos M and Whitehurs 2012 Choosing Blindly Instruction Material, Teacher Effectiveness and the Common Sense (Brown Centre on Education Policy at Brookings) p 1

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