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Research Article

Interaction between Scientific Attitudes and Science Process Skills toward Technological Pedagogical Content Knowledge

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Abstract

The purpose of this research aims to study the interaction between scientific attitudes and science process skills toward technological pedagogical content knowledge. A survey research with an ex post facto design is employed. Data collection is carried out by direct observation, learning outcomes documents, questionnaire sheets which covered by science process skills, and scientific attitudes questionnaires. Seventy eight students were taken randomly. The research instruments consisted of 14 items about basic science process skills, 18 items about integrated science process skills, and 28 items about scientific attitudes. Data analysis used descriptive statistics, regression analysis, and multiple correlations. The results showed that 1) positive interactions between basic science process skills in TPCK, 2) negative interaction between integrated science process skills in TPCK, 3) positive interactions between scientific attitudes towards TPCK, and 4) the presence of joint interactions -the same between science process skills and scientific attitudes toward TPCK. Further discussion needs to be carried out why this happens to help students understand scientific attitudes, scientific process skills, and TPCK as well.

Keywords:

TPCK, science education, interaction, scientific attitudes, science process skills

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Introduction

The world of knowledge in rapidly changed to all society, contents seem to be less important than those necessary skills and process of learning (Goldie, 2016; Schutt, 2018). The social world in the 21st century is very different from in the past. There are people moving media, technology, and resources. From all over the world, it is quickly and conveniently in economical, social, political, and social communities. The way of life and work in the 21st century is different from the past are open to accept and give priority to the information, knowledge, and a variety of news. People can't use their knowledge and skills, some in the past to resolve the problem in the current good. This era is not a process of transferring knowledge, but is to promote lifelong learning skills to people (Battistella, De Toni, & Pillon, 2016; Laar, Van Deursen, Van Dijk, & De Haan, 2017; Marta-Lazo, Frau-Meigs, Osuna-Acedo, 2019). Purposes of education tend to be transformed in learning management, students are active learners, teach less in recitation, and enhance process of learning. Students have several competencies such as knowledge competencies, skills competencies, and attitude competencies (Lin & Chuang, 2019).

Learning should made students meet the important goal in the way to development by individual abilities, as a citizen, a complete mind, body and soul. Knowledge with life balance skills is required, an emphasis on learning to inspire live means learning to nurture creativity (Karakas, Manisaligil, & Sarigollu, 2015; Gouthro, 2018). The ability to produce new things, learning to cultivate public spirit and seized a total of learning for implementation focused on ensuring the work causing the achievement, citizenship, quality self-reliance and life happily (Chapin III, Knapp, Brinkman, Bronen, & Cochran, 2016). Curriculum and methods of education and learning in 21st century should provide students learn and develop themselves continuously. Learning that arises from the needs of the learner and truly put into practice in order to directly experience and furthering knowledge of it oneself. Teachers must be able to create and design learning environments with atmosphere of prosperity and contributing to the learning targets (Fraser, 2015; Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2019).

The atmosphere in the 21st century, it is important that teachers need to create a learning-oriented action, students have learned, the actual situation in society, such as project learning with the base or the application to work, and to create a community of learning by Exchange of mutual learning between teacher learning skills (Häkkinen, Järvelä, Mäkitalo-Siegl, Ahonen, Näykki, & Valtonen, 2017). Technology for learning and individual support team and encouraging students to learn through resources and a variety of learning channels, both in the classroom and online learning, learning connection, and learning experiences inside and outside the classroom.

Additionally, the nature of science consists of scientific processes and scientific attitudes. Because science is related to all students find out the natural phenomena in systematically, so science is not only a collection of reliable knowledge in the form of facts, concepts, or principles but also includes scientific methods and scientific attitudes (Bonney, Phillips, Ballard, & Enck, 2016; Nuangchalerm & El Islami, 2018). This means that in science learning, students should be given direct experience through a learning process based on process skills and scientific attitudes. Curriculum and teaching skills to learn in the 21st century, teachers should give priority to skills-based learning (Prachagool, Nuangchalerm, Subramaniam, & Dostál, 2016; Ritter, Small, Mortimer, & Doll, 2018). Opportunity for students to have knowledge and skills in a wide variety of courses should focus on skills-based instruction management/performance. The innovative methods for learning by integrating technology in teaching, which emphasizes critical thinking and advanced thinking skills and using the issue as a learning base stimulate and engage the community.

Science process skills are one of the approaches to science learning that are very important for scientific investigation (Shahali & Halim, 2010; Kruea-In & Thongperm, 2014; Juhji, 2016; Alatas & Fachrunisa, 2018). Science process skills are interpreted as adaptations of skills used by scientists to compile knowledge, think about problems, and make conclusions (Karslı, Yaman, & Ayas, 2010). In another sense, science process skills are defined as insights to develop intellectual, social, and physical skills that are the source of the student's own self (Atmojo, 2012). In this approach, students are invited to learn to observe, classify, measure, use numbers, guess, conclude and communicate the object being studied. In addition, students are also invited to be able to identify variables, form hypotheses, define variables into operational forms, experiment, interpret data, and draw conclusions.

Some research results reveal that science process skills can help students learn, provide a way of research, improve achievement in learning, activate students, increase responsibility both personally and in groups, and help students understand practical lessons (Aktamış & Yenice, 2010; Juhji, 2016). The science process skills approach is an approach in science learning that involves mental and physical skills which include three aspects of psychomotor, affective, and cognitive skills that can be applied in scientific activity. In learning, the science process skills approach provides an opportunity for students to be actively involved so that interaction between process skills and facts, concepts, and principles of science can be formed that can foster students' scientific attitudes. The previous studies note that science process skills approach is very effective in science learning (Brotherton & Preece, 1995; Harlen, 1999; Beaumont-Walters & Soyibo, 2001; Wilke & Straits, 2005; Ergül, 2011)

Science process skills can be considered that its consistence category by basic and integrated science process skills. Basic science process skills provide an intellectual basis in scientific inquiry, such as observing, classifying, measuring, predicting (Beaumont-Walters & Soyibo, 2001), using numbers, using space relations and time, concluding communicating (Kruea-In, Kruea-In, & Fakcharoenphol, 2015). While integrated science process skills are terminal process skills for solving research problems in the form of scientific experiments, such as: identifying and defining variables, collecting and manipulating data, compiling data into tables and graphs, describing the relationships between related variables, interpreting data, manipulating materials, formulating hypotheses, designing investigations, drawing conclusions and generalizations.

Scientific attitude is that should be possessed by every scientist in carrying out their duties and functions in order to study, carry on, accept or reject and change or add to the knowledge they have learned. The scientific attitude in question consists of components of curiosity, respect for evidence and facts, desire to change paradigms, think critically, diligently, optimistically, creatively, honestly (Restami, Suma, & Pujani, 2013), responsibility, open, objective, tolerance, careful work, and positive thinking. The component of scientific attitude must be developed in the process of learning science at school. In other words, science learning in schools aims to develop students' personalities.

In the process of learning and teaching in the madrasa, the teacher should be able to convey the material well because learning is essentially a process of developing new knowledge, skills, and behavior in an individual as a result of his interaction with various information and environment. Therefore, the teacher should be able to convey the message he knows correctly, that is the material content/concept that is true through good pedagogical activities. However, there are still teachers who have not mastered the concept or teaching material correctly (Maulipaksi, 2016). Mastery of content is very important for a teacher so there is no misconception. While a positive contribution to mastery of the material to readiness to become a teacher (Murtiningsih, Susilaningsih, & Sohidin, 2014).

Pedagogical content knowledge or PCK is a form of content and pedagogic integration in understanding. Students need concepts that can be represented and adapted to meet their interests and abilities (Juhji, 2019). Content and pedagogical knowledge is the easiest category to distinguish the understanding of specialist contents from an educator (Koçoğlu, 2009). One form of technological pedagogical content knowledge application or abbreviated as TPCK in science learning is the use of technology by science teachers in teaching material or concepts of science lessons. The integration of technology in teaching is seen as important as the answer to the challenges of the globalization era which is marked by the rapid development of information and communication technology. Technology can also help teachers in their professional development, such as the presence of the internet teachers can find information or the latest issues regarding the world of education, learning strategies, and the development of science in accordance with the fields that they provide.

The interaction between scientific attitudes and science process skills are relevant to achievement in science learning. The initial point to engage students learn science in the suitable way is driven by scientific attitudes, so that, positive attitudes lead students to have much more achievement and science process skills. That why the study purposed to study the interaction between attitudes and process skills. New era of science teacher development and their professional training try to connecting technological pedagogical content knowledge for promoting students' achievement. The authors interested in how scientific attitudes and science process skills make its interaction with technological pedagogical content knowledge.

Problem of Study

The purpose of this study is to understand the interaction between scientific attitudes toward TPCK, the interaction between science process skills with TPCK, and the interaction of scientific attitudes and science process skills together on TPCK. This is an important report to TPCK, it is a knowledge that prospective teacher students in which must have to do so. They are able to teach science concepts correctly when they become professional teachers at school. Some literatures have not found any interaction between scientific attitudes and science process skills toward TPCK. To understand in the above recommendation, the problem of this study is as follows:

- Is there any correlation between scientific attitudes towards TPCK?
- Is there any correlation between science process skills with TPCK?
- Is there any correlation between scientific attitudes and science process skills together on TPCK?

Method

Research Design

This study discusses the interaction of processes between science and students' attitudes towards knowledge of pedagogical content. The study uses a survey method with expos facto survey research. Research conducted at the Tarbiyah and Teacher Training Faculty of State Islamic University of Sultan Maulana Hasanuddin Banten, Indonesia, which fully develops teaching skills for prospective teachers.

The stages of the research are as follows: (1) tracing information through print and electronic media reference studies of science process skills, scientific attitudes of students, and technological pedagogical content knowledge; (2) testing research instrument; (3) collecting data through interviews and direct observation of 78 students who are doing teaching practices in ten schools in Banten province, in Indonesia; (4) testing the regression analysis and multiple correlation of research hypotheses through SPSS 16.0.

Participants

Participants in this study were prospective madrasah teacher candidates in the Madrasah Ibtidaiyah Teacher Education Faculty of Tarbiyah and Teacher Training at the State Islamic University of Sultan Maulana Hasanuddin Banten, academic year 2018/2019 who took the job training program course in semester seven. Participants were determined using probability sampling techniques with the simple random sampling method (Arikunto, 2006; Sugiyono, 2017; Supardi, 2017). The sample was selected as many as 78 students who were spread into 10 schools where teaching practice was in Banten province, in Indonesia. The participants were asked to express their science process skills, scientific attitudes, and technological pedagogical content knowledge in freely opinions.

Research Instruments

The data were collected through non-test methods, namely closed questionnaire sheets with 5-Likert scale, direct observation, and learning outcomes documents. The instrument of science process skills consisted of 32 items which include items about basic science process skills as many as 14 items and integrated science process skills as many as 18 items. While the scientific attitudes questionnaire consisted of 28 items.

The closed questionnaire of technological pedagogical content knowledge consisted of 70 items which include 14 items of Technological Knowledge (TK), 14 items of Pedagogical Knowledge (PK), 14 items of Content Knowledge (CK), 7 items of Pedagogical Content Knowledge (PCK), 7 items of Technological Content Knowledge (TCK), 7 items of Technological Pedagogical Knowledge (TPK), and 7 items of Technological Pedagogical Content Knowledge (TPCK). Questionnaires were adapted from (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009; Sahin, 2011; Kabakci Yurdakul, Odabasi, Kilicer, Coklar, Birinci, & Kurt, 2012).

The questionnaire was validated before being used as a standardized instrument. Testing is done through Cronbach alpha coefficient (Cronbach, Schoneman, & McKie, 1965). Based on the calculation, the alpha Cronbach coefficient is 0.889, thus the questionnaire items in this study are reliable. Then research instrument was used for data collection.

Data Analysis

The analysis used in this study is the analysis of regression and multiple correlations. There are three hypotheses in this study. First, there is a significant correlation between scientific attitudes with TPCK. Second, there is a significant correlation between science process skills and TPCK. Third, there is a significant correlation between scientific attitudes and science process skills together with TPCK. Before conducting hypothesis testing, researchers conducted normality and homogeneity tests. The data normality test uses the Kolmogorov-Smirnov test, while the homogeneity test uses the Levene's test with a significance level of 5% ($\alpha = 0.05$). All statistical reasons were performed using SPSS 16.0 for Windows.

Results

Scientific Attitudes of Pre-service Teachers

Students had scientific attitudes ranges between moderate and excellent. The average component of student scientific attitudes can be represented in Table 1.

Table 1

Scientific Attitudes Score of Pre-service Teachers

Components of scientific attitudes	Average	SD	Level
Curiosity	2.39	0.83	good
Respect for evidence and facts	2.50	0.81	good
Desire to change the paradigm	2.40	0.80	good
Critical thinking	2.37	0.79	moderate
Persevere	2.40	0.95	good
Optimistic	3.10	0.48	good
Creative	2.58	0.69	good
Honest	2.76	0.72	good
Responsible	2.50	0.78	good
Open-minded	2.66	0.79	good
Objective	3.01	0.65	good
Tolerance	3.25	0.61	excellent
Careful at work	2.50	0.78	good
Positive thinking	2.32	0.86	moderate

They had excellent in terms of tolerance, but positive thinking and critical thinking in moderate level. Other components were at good level and it listed in the following i.e. curiosity, desire to change the paradigm, persevere, careful at work, responsible, creative, open-minded, honest, objective, and optimistic. Scientific attitudes can underlie the process of science. Scientific attitudes can be explained as values and norms which held by students in science. These norms are expressed in the form of rules, prohibitions, choices, and abilities. These norms and values must be internalized with scientific habits. The scientific attitude includes curiosity, respect for evidence and facts, the desire to change paradigms, think critically, diligently, optimistically, creatively, honestly, responsibly, openly, objectively, tolerance, careful in working, and thinking positively.

That is, learning outcomes and learning achievements can improve through providing students had science process skills. The intended learning outcomes include aspects of verbal information, intellectual skills, regulation of cognitive activities, motor skills, attitudes (Gagne, 1983), knowledge, understanding, application, thinking skills, general abilities, attitudes, interests, appreciation, and adjustments (Gronlund & Linn, 1990). Learning outcomes are a number of abilities possessed by students after receiving learning experiences. Thus, basic science process skills have an influence on student TPCK skills.

Science Process Skills of Pre-service Teachers

Basic science process skills of students were explored that it ranges between moderate and excellent level. The average component of the basic and integrated science process skills can be represented in Table 2.

Table 2

Science Process Skills Score of Pre-service Teachers

Science Process Skills	Average	Standard Deviation	Level
Basic Science Process Skills			
Observe	2.40	0.82	good
Classify	2.02	0.70	moderate
Measure	3.17	0.51	good
Predict	2.71	0.70	good
Using numbers	2.61	0.65	good
Using the relationship between space and time	2.44	0.76	good
Summarize and communicate	2.29	0.76	Moderate
Integrated Science Process Skills			
Identify and define variables	2.39	0.83	good
Collect and change data	2.40	0.95	good
Arrange tables and graphs	3.10	0.48	good
Describe relationships between variables	2.58	0.69	good
Interpret data	2.72	0.72	good
Manipulation materials	3.01	0.65	good
Formulate a hypothesis	3.25	0.61	excellent
Designing an investigation	2.50	0.78	good
Summarizing and generalizing	2.32	0.86	moderate

Basic science process skills of students ranges moderate to good level, the moderate level can be listed on the skills for classifying, and summarizing and communicating. Other skills expressed in good level in which observing, using the relationship between space and time, predicting, using numbers, and measuring in the follow. While integrated science process skills of students ranges moderate to excellent level, summarizing and generalizing was at moderate level. The good level of skills can be listed in identifying and defining variables, collecting and manipulating data, designing an investigation, describing relationships between variables, interpreting data, and manipulating materials. While formulate a hypothesis was at excellent level.

Technological Pedagogical Content Knowledge of Pre-service Teachers

Technological Pedagogical Content Knowledge (TPCK) of students ranges between moderate to good level. The average of TPCK can be shown in Table 3 below.

Table 3.

TPCK Score of Pre-service Teachers

TPCK	Average	SD	Level
TK (Technological Knowledge)	2.94	0.75	good
PK (Pedagogical Knowledge)	2.86	0.71	good
CK (Content Knowledge)	2.65	0.82	good
PCK (Pedagogical Content Knowledge)	3.02	0.67	good
TCK (Technological Content Knowledge)	2.41	0.76	good
TPK (Technological Pedagogical Knowledge)	2.63	0.73	good
TPCK (Technological Pedagogical Content Knowledge)	2.38	0.75	moderate

TPCK was at moderate level, but other components were at good level, including TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge), CK (Content Knowledge), PK (Pedagogical Knowledge), TK (Technological Knowledge), and PCK (Pedagogical Content Knowledge) in the following. To confirm results of study, multiple linear regression analysis was used and analyzed.

Table 4.

Multiple Linear Regression Analysis of Pre-service Teachers' TPCK between Scientific Process Skills and Scientific Attitudes

Variable	Unstandardized Coefficients		t	Sig.	Correlations	
	B	Std. Error			Zero-order	Partial
(Constant)	1.569	1.260	1.245	0.217		
Basic Science Process Skills (X_1)	0.647	0.048	13.407	0.000	0.795	0.842
Integrated science process skills (X_2)	-0.404	0.084	-4.807	0.000	0.348	-0.488
Scientific attitudes (X_3)	0.162	0.049	3.287	0.002	0.369	0.357

Dependent Variable: TPCK (Y)

Source: Data processed, 2018

The regression equation obtained is as follows. $Y = 1.569 + 0.647X_1 – 0.404X_2 + 0.162X_3$. The value of the basic science process skill variable (X_1) of 13.407 at the significance level of 0.000, integrated science process skills (X_2) of -4.807 at the 0.000 significance level, and scientific attitude (X_3) at 3,287 at the significance level of 0.002. The results of the t-test using a level of significant (α) 0.05, obtained basic science process skills and scientific attitudes of students partially have a significant positive effect on TPCK skills, while integrated science process skills partially have a negative effect on TPCK skills. This is based on the t count value of all these variables significantly below than 5% (0.05).

The results of the significance test of basic science process skill variables, integrated science process skills, student scientific attitudes, and TPCK can be shown in the following Table 5.

Table 5.

Multiple Regression Analysis of TPCK Model for Pre-service Teachers

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	249.439	3	83.146	73.340	0.000[a]
Residual	83.894	74	1.134		
Total	333.333	77			

Predictors: (Constant), Scientific attitude, basic science process skills, integrated science process skills

Dependent Variable: TPCK

The results of data processing using a significance level, statistical testing showed an F value of 73,340 with a value of sig 0,000. Thus, the basic science process skills, integrated science process skills, and scientific attitudes of students simultaneously showed positive value and significant influence on the TPCK. The coefficient of determination can be shown in Table 6.

Table 6.

Model of Significance Test for Double Correlation Coefficients

		Model
		1
R		0.865
R Square		0.748
Adjusted R Square		0.738
Std. *error* of the Estimate		1.065
Change Statistics	R Square Change	0.748
	F Change	73.740
	df1	3
	df2	74
	Sig. F Change	0.000

Source: Data processed, 2018

The determination coefficient is 0.748 with the meaning of basic science process skills, integrated science process skills, and scientific attitudes which able to influence TPCK skills by 74.8%. While its remaining 25.2% influenced by other variables outside. The finding also showed that scientific attitudes had a significant positive effect on the abilities of TPCK skills. The correlational coefficient was 0.357 at the statistical significance level of 0.002. This is in line with the results of several studies which scientific attitudes have a positive correlation with students' natural science learning achievement (Simpson & Steve Oliver, 1999; Papanastasiou & Zembylas, 2004; Kirikkaya, 2011). TPCK is a crucial part of learning achievement and learning achievement for 21st century science classroom, it can be achieved students in many domain not separated from the learning process carried out.

Discussion and Conclusion

The results of data analysis show that scientific attitudes have positive interactions toward the ability of TPCK. This is indicated by the correlation coefficient of 0.357 at the significance level of 0.002. This is justified because curiosity and confidence can affect one's learning outcomes (Ameliah & Munawaroh, 2016). Therefore, components of scientific attitudes such as curiosity have interactions with TPCK. While, the other components such as respect for evidence and facts, desire to change the paradigm, critical thinking, persevere, optimistic, creative, honest, responsible, open-minded, objective, tolerance, careful at work, and positive thinking do not shown the intended interaction. Therefore thus, lecturers and teachers are advised to always develop students' curiosity and confidence so that they are able to have a good scientific attitude so that it has implications for the ability of TPCK.

The results of data analysis showed that basic science process skills had a significant positive effect on the ability of the TPCK. This is indicated by the correlation coefficient of 0.842 at the significance level of 0.000. The results of this study are in accordance with the findings of previous researchers who stated that there is an influence of science process skills on learning outcomes (Markawi, 2013), there is an interaction between science process skills on cognitive and affective learning achievement (Deta & Widha, 2013), science process skills can improve learning outcomes and students' creative thinking skills (Rahayu, Susanto, & Yulianti, 2011). This reinforces the view that basic science process skills such as observe, classify, measure, predict, use numbers, use the relationship between space and time, summarize and communicate need to be developed continuously in learning science in the classroom because can interact with TPCK.

Information can be shown in Table 4. The results of data analysis showed that integrated science process skills had a significant negative effect on the ability of

TPCK students. This is indicated by the correlation coefficient of -0.488 at the significance level of 0.000. The results of this study indicate that the lower the acquisition of integrated science process skill variable scores, the higher the TPCK score, and vice versa.

This is because the components of the integrated science process skill variable are: 1) identifying and defining variables, 2) collecting and changing data, 3) compiling tables and graphs, 4) describing relationships between variables, 5) interpreting data, 6) manipulating materials, 7) formulating hypotheses, 8) designing investigations, and 9) drawing conclusions and generalizations in stark contrast to the TPCK component, namely: 1) using strategies that combine technology, learning approaches, and primary school science content, 2) providing exemplary in helping others to coordinate the use of technology, the school teaching approach, and content, 3) choose the use of technology in the classroom that can improve the quality of the learning process, how I teach, and what learners learn, 4) teach appropriate material content by integrating technology, methods, and lesson content, and 5) teach material content that is in accordance with pedagogic competencies and can use learning technology in teaching material to students. Different components of these two variables can cause negative interactions between the two. That is, the interaction of the two variables can be determined by the elements attached to the variable.

Recommendation

Scientific attitudes and basic science process skills interact positively with technological pedagogical content knowledge. This must be improved and developed in the process of learning science in the classroom by teachers and lecturers, also in the development of science curricular and learning strategies for prospective student teachers. Thus, in order to improve the ability of students in TPCK it can also be balanced with the development of scientific attitudes and basic science process skills.

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