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Scientific Inquiry Perception and Ability of Pre-service Teachers

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ABSTRACT

The research purpose was to assess the inquiry perception and ability of biology pre-service teachers. This research used mixed methods, with embedded design drawing on instruments adapted from the Principle of Scientific Inquiry – Teacher (PSI-T), inquiry ability test, and open questions list. Data analysis used descriptive statistics technique and independent sample t-test. The results showed high scientific inquiry perception and ability of pre-service teachers who used structure inquiry learning strategy in the classroom. There are no significant differences among scientific inquiry perception and the ability of pre-service teachers with respect to gender, but there are differences according to university. Pre-service teachers need to improve inquiry strategies in the classroom to the next levels, i.e., guided inquiry and open inquiry, which provides positive implications for students to be more independent and creative.

Keywords: Inquiry perception, Inquiry ability, Pre-service teachers.

INTRODUCTION

The acquisition of scientific inquiry has been one of the main goals of science education since 1960 (NRC, 2001). NSES (National Science Education Standard) since 2002 has drawn up standards at every level of inquiry, from the level of basic education to higher education. The inquiry is considered a very important strategy to encourage the learning of science (AAS, 1993; Çimer, 2007) and has become a major part of a teaching science reformation (Balim, 2009; Bulunuz, 2011). The practice of inquiry helps students develop knowledge concepts and understand scientific processes more clearly and deeply (NRC, 2000; Sahin, 2007). Some studies of the practice of inquiry have investigated the components of this, including hypothesis, theory, and interpretation of a phenomenon, which is critical to developing an understanding of science concepts (Muukkonen, Lakkala Hakkarainen, 2005; Llewellyn, 2002).

Inquiry-based teaching encourages students to exercise the thinking processes and creative activities conducted by scientists (Rutherford, 1960; Aktamış, Hiğde, Özden, 2016; Rees, Pardo & Parker, 2013). Inquiry provides an opportunity for students to conduct investigations and develop scientific concepts and ideas from their own experience (Parmin,

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Sajidan, Ashadi, Sutikno, & Maretta, 2016). It also encourages students to observe scientific empiricism (Edward & Mercer, 1987, in Chen & She, 2015). For scientists, some of these components become important, especially in formulating research questions, designing and conducting informative investigations, and formulating persuasive opinions.

Scientific inquiry was a keyword in Indonesia's 2013 National Curriculum, referring to the scientific inquiry-based learning processes as the core of commonly known inquiry. The stages of inquiry include the ability to formulate problems, design experiments, collect data, and draw conclusions. Inquiry activities engage students in meaningful, creative, critical, and problem-solving-based learning. The 2013 National Curriculum necessitated the implementation of the scientific inquiry approach or scientific attitude in the learning process in the classroom (Kemdikbud, Indonesia Ministry of National Education, 2013). This learning process focuses not only on developing students' knowledge (cognition) and skills (psychomotor), but also their spiritual and social attitudes, and metacognition.

There have been a number studies looking at how to develop competence in teaching inquiry learning and pre-service teachers' perceptions of inquiry learning (Varma, 2007; Reaume, 2011). Varma (2007) studied teaching science using multi-methods inquiry-based learning integrated with teaching practice (field experience). She found that, through lectures, she was able to develop an inquiry understanding of pre-service teachers as well as its implications, and develop appreciation and confidence to create an inquiry environment in teaching. Related research by Reaume (2011) used an alternative instrument, open-ended semi-structured interviews, to investigate the development of perception inquiry of pre-service teachers. She reported a positive increase in perception in accordance with the increase of the teacher's education level and revealed time and classroom management to affect the success of inquiry learning.

In the Indonesian context, research over a teacher's efforts to develop inquiry ability was conducted by Anggraini (2005). She used a research and development method to find a form of lecture for General Biology of Inquiry Based Learning (BUBI) which effectively provides pre-service teachers the ability to inquire and master the concepts of the subject. Similarly, Amprasto (2016) developed an inquiry-based field trip program to improve the scientific ability and problem-solving skills of biology pre-service teachers. Nevertheless, both these studies have not clearly described how pre-service teachers can apply inquiry ability in the class, unlike other studies, which have provided pertinent information about the application of inquiry learning in the school context as well as at the level of inquiry being carried out.

One of the variables related to the application of the inquiry method is teacher perception of inquiry. This is because their level of inquiry perception will determine how effectively they can apply a method in the classroom. Campbell, Abd Hamid, & Chapman (2010) have developed an instrument of teacher's inquiry perception PSI-T in order to assess teacher competence in implementing inquiry learning in the classroom. Another research finding, MCLIC (McGill Classroom Level of Inquiry Checklist), offers quick reference criteria for the procedures to assess the level of inquiry in the classroom. This research recorded the application of inquiry learning directly in the classroom (Nuako, Shore, Saunders-Stewart, Gyles, 2015).

Both instruments above are able to measure perception inquiry, but are not equipped to measure the inquiry ability of pre-service teachers. Scientific inquiry capability is interpreted holistically not only as a positive perception in order to ensure the implementation of inquiry learning and comprehensive information. The implementation of scientific inquiry learning process, both in terms of quality and quantity in the classroom, can be shown through the acquisition of teachers' perceptions of inquiry. With respect to quality, we can measure the level of inquiry profiles that teachers enact in the classroom. With respect to quantity, the

levels of inquiry enacted by teachers in the classroom can be classified using a numerical score (see Table 2). So far, there is no empirical data describing the perception of scientific inquiry and inquiry ability that is actually held by a biology pre-service teacher.

Purpose

This paper goes beyond Campbell et al. (2001) by providing an opportunity to interpret and elaborate on the level of inquiry demonstrated by teachers. We do this by aligning perception scores with NSES inquiry levels, such as structured/discovery inquiry, guided inquiry, and free inquiry. Furthermore, it provides preliminary data on pre-service teachers' perceptions and inquiry ability, which is very important to teacher education curriculum reform.

The research questions addressed are: 1. What are the scientific inquiry perception and inquiry ability of pre-service teachers? 2. Do scientific inquiry perception and inquiry ability of pre-service teachers show a meaningful difference depending on gender and university? 3. Do scientific inquiry perception and ability of a pre-service teacher of a particular gender show meaningful difference depending on different university? All the information was required synergistically as initial data for developing the biology teacher education courses that integrate the ability of inquiry. The data simultaneously describes the capacity of biology pre-service teachers undertaking the teacher education program to implement the 2013 Indonesian National Curriculum, in particular, the inquiry learning process.

METHODS

a) Methodology of Research

This research used mixed methods with embedded data. The researcher has been embedding secondary data (qualitative) into the primary data (quantitative) in one study, the secondary database supporting role in this research (Creswell & Plano Clark, 2011). A quantitative study was conducted by disseminating the PSI-T instrument and the inquiry ability test, then a qualitative study was conducted purposively for a number of students to be interviewed.

b) Sample of Research

The research subject was 90 biology pre-service teachers from the Biology Education Department of two state universities in Jakarta, namely University A (49) and University B (41). They are in the 8th semester, and had completed all courses and followed the Teaching Practice (PPL). Both programs require students to do a teaching internship in school for about 4 months under the guidance of the teacher tutors and lecturers. The teaching internship included some apprenticeship stages, such as classroom observation, consultation, real teaching, and feedback provision by the teacher tutors and lecturers. Pre-service biology teachers who wish do this internship should have already taken prerequisite courses related to the content and pedagogy.

c) Data Collection Tool

The research instrument was distributed to all students at each university in the classroom setting simultaneously for each instrument. Questionnaire PSI-T and inquiry ability test were distributed to pre-service teachers. The time allocated for the questionnaire would be 30 minutes and the inquiry ability test for 60 minutes.

Furthermore, in-depth interviews were conducted with 12 pre-service teachers from both universities (Table 1) to identify and confirm the answers they provide when filling out the questionnaires and tests. Determination of students' acquisition based on inquiry ability

with three levels is categorized as high, medium, and low level. The interview was audio taped for about 100 minutes for all student in each university.

Table 1. The distribution of biology pre-service teachers according to gender and inquiry ability score from two universities (University A & University B)

University A	Gender	University B	Gender	Inquiry ability score
X1	Woman	Y1	Woman	High Category
X2	Woman	Y2	Woman	High Category
X3	Woman	Y3	Woman	Middle Category
X4	Woman	Y4	Woman	Middle Category
X5	Woman	Y5	Woman	Low Category
X6	Man	Y6	Woman	Low Category

Question on Interviews

Three questions were asked at the interview, i.e:
Question 1: Explain the meaning of Inquiry Learning Model.
Question 2: Which parts of inquiry ability item are considered difficult?
Question 3: Give your opinion: is your practical experience with themes on the item required when you graduated and taught at school?

Instrument

Principle of Scientific Inquiry Teacher (Psi-T) Instruments

PSI-T instruments developed by Campbell et al. (2001) consist of 20 statements that include five principles of inquiry: (A) framing research questions, (B) designing investigations, (C) conducting investigation, (D) collecting data, and (E) drawing conclusions. The PSI-T has been adapted and validated both linguistically by language experts and science education experts. The pilot study of 30 biology teachers obtained 20 valid statement which were tested with Cronbach alpha test values (r = 0.83). PSI-T has used a Likert scale with a description: 1 = almost never, 2 = seldom, 3 = sometimes, 4 = often, 5 = almost always. The adjustment scale discussed has been validated by a science education expert to describe the information as meaningful. The maximum score for PSI-T was 100.

Inquiry Ability (Ia) Test Instruments

Inquiry ability instruments in the form of 10 items described the biology concept integrated with IA. The IA in this study was limited to (1) define a problem, (2) identify the variables, (3) develop a hypothesis, (4) plan trial (drafting tool materials, making research procedures and predicting data obtained). Instruments were validated by the science education experts. The maximum score for IA was 100.

d) Data Analyzed

Questionnaire data were analyzed descriptively to gage inquiry perception and IA of pre-service teachers. All data of inquiry perception and IA calculated the mean score and SD and specified categories of scores to Campbell et al. (2010) (Table 2). Finally, to examine the question “Do scientific inquiry perception and IA of pre-service teacher have meaningful difference according to gender and university?,” independent t- test with statistical analysis package SPSS 22 (Statistical Package for Social Sciences Program, Version 22) was used.

Table 2. Score category for inquiry ability and PSI-T

Score	Category
1–33	Low
34–65	Middle
66–100	High

FINDINGS AND DISCUSSION

Quantitative Data

1. *Category of Scientific Inquiry Perception (SIP) and Ability of Pre-service Teacher*

The three research questions will be discussed in this article are: What are the category of SIP and IA of pre-service teachers? Three categories have been determined, i.e., high, middle, and low for both inquiry perception and ability.

Table 3. Percentage of scientific inquiry perception of pre-service teachers from two universities

Participants	Low		Middle		High	
	N	%	N	%	N	%
University A	1	2	24	49	24	49
University B	0	0	10	24	31	76
Total	1	1	34	38	55	61

Table 3 shows the percentage and category of SIP of pre-service teachers. The findings show that the SIP of pre-service teacher dominated in the high category (61%), medium category (38%), and only 1% in the low category. University A has the same SIP score with medium and high categories (49%) and 2% of a low category. University B has 76% in the high category, 24% in medium category, and 1 % in the low category.

Table 4. Percentage response of scientific inquiry perception

PSI-T	**Scale**									
	almost never		**seldom**		**sometimes**		**often**		**almost always**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Asking questions (A)	4	4,44	15	16,67	37	41,67	30	33,33	4	4,44
Designing investigations (B)	4	5,00	17	18,33	30	33,61	30	33,06	9	10,00
Conducting investigation (C)	5	5,28	9	10,00	22	24,44	39	43,06	15	17,22
Collecting data (D)	3	3,61	9	10,28	32	36,11	36	39,44	10	10,56
Drawing conclusions (E)	2	2,50	8	9,17	31	34,44	37	41,11	12	12,78

Based on Table 4, there was gradation response in the SIP of pre-service teachers. From Table 4, it can be seen the positive response from SIP of pre-service teachers in each component of principle inquiry (scale often and almost always) is greater than the negative response (scale almost never and seldom). This shows that the prevalence of inquiry learning has been implemented of a pre-service teacher in the classroom.

Tabel 5. Percentage negative response of scientific inquiry perception

Sub of PSI-T	Scale									
	almost never		seldom		sometimes		often		almost always	
	N	%	N	%	N	%	N	%	N	%
B2*	5	5,56	22	24,44	42	46,67	17	18,89	4	4,44
B4*	9	10,00	27	30,00	41	45,56	13	14,44	0	0
C1*	15	16,67	26	28,89	33	36,67	13	14,44	3	3,33

*negative response

However, as shown in Table 5, there are negative responses from sub-principle scientific inquiry, i.e., B2, B4, and C1. The following description indicates the perceived negative response:

(1) B2. Students design their own procedures for investigations;
(2) B4. Students justify the appropriateness of the procedures that are employed when they conduct investigations;
(3) C1.Students conduct their own procedures of investigations.

Table 6. Percentage of inquiry ability of pre-service teachers from two universities

	Low		Middle		High	
Participants	N	%	N	%	N	%
University A	4	8	7	14	38	78
University B	8	20	11	27	22	54
Total	12	13	18	20	60	67

Table 6 shows the percentage of IA of pre-service teacher from two universities. The findings show that the IA of pre-service teachers dominated in the high category (61%), medium category (20%), and 13 % in the low category. University A has 78% of the high category, 14 % in the middle, and 8% in a low category. University B has 54% of the high category, 27% of the medium category, and 8% in a low category. A profile of IA can be seen in Table 7, which can help understand the IA of pre-service teachers better in formulating problems and developing hypotheses.

Table 7. Inquiry ability of pre-service teachers

Inquiry Ability	Mean	SD
A. Formulating Problems		
Identifying variables	55,90	21,54
Formulating problem	85,11	29,19
Developing hypotheses	83,88	28,86
B. Planning Experiment		
Drafting tool materials	54,75	20,26
Developing research procedures	58,10	27,83
Predicting data to be acquired	21,26	23,51

2. Scientific Inquiry Perception and Inquiry Ability of Pre-service Teacher with Gender

The second problem of the study has been determined as "Do SIP and IA of a pre-service teacher show meaningful difference depending on the gender?" There is 11% males compared with 89% female pre-service teacher.

Table 8. Result of t-test score of scientific inquiry perception of pre-service teachers according to gender

Gender	**N**	**X**	**SD**	**Levene`s Test** F	Sig	**t (df)**	**Signf**
Male	10	73	8.11	0.426	0.516	1.697 (88)	0.093
Female	80	67	10.85				

***Significance (p < 0.05)**

As is seen from Table 8, it was found that there was not a significant difference among the SIP of male and female pre-service teachers (t(88) = 1.697; p > 0.05). It can be reported that the mean scores SIP of a male was 73 and female 67.

Table 9. Result of t-test inquiry ability of pre-service teachers according to gender

Gender	N	X	SD	Levene`s Test F	Sig	t (df)	Signf
Male	10	56	18,27	0.033	0.857	−1.296 (88)	0.198
Female	80	65	20.93				

***Significance (p < 0.05)**

As is seen from Table 9, it was found that there was not a significant difference among the score IA of male and female pre-service teachers (t(88) = -1.296; p > 0.05). It can be reported that the mean scores IA of male was 56 and female 65.

3. Scientific Inquiry Perception and Inquiry Ability Pre-service Teacher with university

The third problem of the study has been determined as "Do SIP and IA of a pre-service teacher of a particular gender show meaningful difference depending on different university?"

Table 10. Scientific inquiry perception of pre-service teachers with university

University	N	X	SD	Levene`s Test F	Sig	t (df)	Sign
A	49	65	10.64	0.80	0.779	−3,058 (88)	0.003*
B	41	71	9.75				

***Significance (p < 0.05)**

Table 10 shows that there was a meaningful difference in SIP depending on different universities. The t-test results of the difference university with (t(88) = −3,058; p < 0.05).

Table 11. Independent t-test SIP for gender

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Asking questions	,781	,379	2,234	88	,028*	1,863	,834	,206	3,519
Designing investigations	,009	,927	,877	88	,383	,725	,827	−,919	2,369
Conducting investigation	,001	,971	1,636	88	,105	1,413	,863	−,303	3,128
Collecting data	,576	,450	1,398	88	,166	1,325	,948	−,558	3,208
Drawing conclusions	1,375	,244	,711	88	,479	,713	1,002	−1,278	2,703

***Significance ($p < 0.05$)**

In order to see if pre-service teachers differ in their SIP according to gender, a t-test for independent samples have been used and the results indicated that they differ only in asking questions ($p < 0.05$; Table 11).

Table 12. Inquiry ability of pre-service teacher with university

University	N	X	SD	Levene`s Test		t (df)	Sign
				F	Sig		
A	49	69	17.29	0.80	0.016	−3,058 (88)	0.009*
B	41	58	23.04				

***Significance ($p < 0.05$)**

Table 12 shows that there was a meaningful difference of IA of pre-service teacher depending on the different universities. The t-test results of the difference according to university was found to be ($t(88) = -3,058$; $p < 0.05$).

Table 13. Independent t- test inquiry ability according to gender

IA	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Identifying variables	,700	,405	−,902	88	,369	−6,52500	7,23271	−20,89849	7,84849
Formulating problem	,043	,836	−,815	88	,417	−8,00000	9,81013	−27,49557	11,49557
Developing hypotheses	,034	,854	−,799	88	,426	−7,75000	9,70038	−27,02746	11,52746
Drafting tool materials	2,446	,121	−1,053	88	,295	−7,15000	6,79306	−20,64979	6,34979
Developing research procedures	,000	,997	−1,418	88	,160	−13,16250	9,28471	−31,61391	5,28891
Predicting data to be acquired	,516	,474	−1,636	88	,105	−12,78750	7,81471	−28,31760	2,74260

***Significance ($p < 0.05$)**

In order to see if pre-service teachers differ in their IA according to gender, t-test for independent samples was used and the results indicated that there is no meaningful difference ($p < 0.05$), as seen in Table 13.

DISCUSSION

The results showed that most of the perception of scientific inquiry and IA among pre-service teachers has a high category (61% vs 67%) and there are no significant differences with gender. Instruments of teacher perception provide prevalence information about the teachers' implementation of the inquiry strategy in the classroom. Instrument PSI-T is in line with the instrument RTOP that describes teachers' realization of inquiry strategy in the classroom (Campbell et al., 2010).

Another research finding was that the perception of scientific inquiry and IA among pre-service teachers has significant difference according to university. The results above are consistent with the results of interviews with pre-service teachers focusing on inquiry-based learning in lectures. Pre-service teachers of all categories in two universities have understood the meaning of inquiry as a process of discovery, but the students' IA of high and medium category was better in defining the appropriate inquiry learning understanding as its essence, that one of the keywords of inquiry is evidenced through scientific methods (Bianchini & Solomon, 2002; Ramey-Gassert, Shroyer, & Staver, 1996).

The research result is in line with Alhendal & Dalal (2015), who reported that 496 public elementary school teachers in Kuwait used inquiry significantly in their capacity to inquire in the classroom. Although science teachers in Kuwait showed positive attitudes associated with the implementation of inquiry teaching, there are factors that limit the use of in the classroom.

Judging from the complexity of inquiry learning, there are three levels: structured inquiry, guided inquiry, and free inquiry (NSTA, 2002). In structured/discovery inquiry, students are invited to make discoveries through scientific activities involving the basic ability of scientific work, such as asking, formulating a problem, interpreting, proving evidence, and concluding. While the setting of guided inquiry problem submission is determined by the teacher and the open inquiry is based on the direction of the teacher, students are challenged to formulate their own problems, which can bring up questions on an activity in further learning. This process of inquiry provides students with the opportunity to develop self-reliance, creativity, and innovation.

Interviews showed that all pre-service teachers implement the inquiry learning strategy in biology class by setting discovery/structured inquiry. These results are consistent with the score of inquiry perception that shows the pattern of inquiry levels to be the most dominant in structured/discovery inquiry. This is shown in the data patterns of negative response perceived by pre-service teachers at both universities (as seen in Table 5). There are three negative responses from statements of Principal Scientific Inquiry, such as:

> "*B2. Students design their own procedures for investigations; B4. Students justify the appropriateness of the procedures that are employed when they conduct investigations; C1.Students conduct their own procedures of investigations"*

Campbell et al. (2010) state that category *(formulating problem, designing experiments, and conducting investigations*) as the main guarantor of inquiry experience has been used in the classroom. It gives a real impact if teachers change from traditional teaching patterns into inquiry strategies that allow students to engage actively in investigating and drawing conclusions (*collect data and conclude*). Based on the result of perception on scientific inquiry, it can be noted that pre-service teachers have made some progress in implementing the inquiry strategy in their class.

It provides information that pre-service teachers are able to develop *a scientific research planning*. However, it is important to get attention primarily on the ability to identify the variables. Pre-service teachers are able to identify independent and dependent variables as supported by the good scores in developing hypothesis ability and formulating the problem. However, the inability of pre-service teachers to determine control variables is still found, and

gives them low score in identifying variables. The same pattern was reported by Hofstein, Navon, Kipnis & Mamlok-Naaman (1987), who applied the inquiry approach that helps students ask questions better than traditional approaches. Students have a substantial issue in the inquiry process, such as the difficulties in expressing tested hypotheses and selecting the right variables (Madden, Baxter, Beauchamp, Bouchard, Huff, Ladd, Pearon, & Plague, 2013; Soprano & Yang, 2013).

Table 14. Quantitative and qualitative findings

Quantitative Findings	Qualitative Findings
Inquiry perception and inquiry ability of both universities most have the high category with tendencies of structure inquiry learning strategy patterns.	It was found from the interviews that pre-service teachers at both universities found that it is difficult to *design experiments*, specifically because of the following: (1) Confusion about what kind of data that can be obtained because it is possible to identify several of the variables [it shows that pre-service teachers already have predictive ability, but not sure how to answer]; (2) They do not understand the concept [lack preliminary knowledge]; (3) They are lack of reading references [low literacy]; (4) Has never been experienced laboratory theme in case of Biotechnology [need models/examples of relevant learning experiences]. The pre-service teacher has taught structure inquiry learning strategy.

The quantitative and qualitative findings are shown in Table 14. The interviews show the difficulties of pre-service teachers at both universities related to *designing an experiment.* The three components of that inquiry are part of *designing an experiment*. These preliminary results are in line with Anggraini (2006), who stated before intervention with inquiry-based Biology Course Program (BUBI) that biology pre-service teachers have a low ability to *design experiments*. Implementation of the BUBI course has proven its effectiveness to equip IA for pre-service biology teachers. The inquiry abilities (formulating hypotheses, planning experiments, observing, analyzing data) showed highly significant differences compared to the control class. Through inquiry-based course debriefing from the beginning, the students become experienced to inquire and have an idea of how inquiry-based learning is carried out. It builds their confidence and motivation to apply inquiry-based learning later in their career.

IA or scientific work ability is the integration of knowledge and skills that demonstrate learning outcomes in the long term (Haladyna, 1997). This IA performance is in line with the research results of Zulfiani (2006), who stated that inquiry development program on biotechnology can improve the IA performance of pre-service teachers, despite the lower performance in planning the experiment's ability (structured inquiry and free inquiry).

The results of the study suggest that the integration is considered important to Teacher Education Program, as institutions which produce teachers are increasingly being challenged by the rapid development of science and technology. It is expected that the IA given will become a "tool" for students/ pre-service teachers to maintain the existence of "life and

living." The IA is supposed to be "familiar with" the students/pre-service teachers because it indirectly gives concrete examples of instilling an inquiry learning culture (*knowing the investigation process*). The sustainability of this implementation is that the lecturer can develop a learning program that integrates the IA in the course (Bryce, Wilmes & Bellino, 2016), developing knowledge and skill on inquiry learning as meaningful learning (Ohn, 2013). Integration was developed at the level of the study program curriculum, syllabus, and lecture plan that integrates IA into biological knowledge. A lecturer in the field of study should be able to provide experience to students that science is not merely a *product*, but as the *process and attitude* (Biggers & Forbes, 2012). To achieve this, the lecturer should provide guidance and examples to students so that the character of inquiry is strongly embedded.

Çalik, Ebenezer, Özsevgeç, Küçük, & Artun (2015) reported that a Model Technology Embedded Scientific Inquiry (TESI) is a form of integration of technology and IA which have an important role in shaping and strengthening the Professional Teachers Program, which can improve technology fluency and eliminate the barrier between teachers and pre-service teachers and technology literacy. This model is recommended in Teacher Education Programs as a catalysis in the reform of teacher education to connect disciplines and constraints in the classroom. If pre-service teachers integrate technology into teaching, it will be useful to professionalism in the future.

The IA on NSES is gradual and continuous, and this ability is integrated into every subject, from primary education to higher education (Zion, Cohen & Amir, 2007; Tseng, Tuan & Chin, 2013). The IA requires each student to support their life (Plevyak, 2007). Pre-service teachers in teacher education have the mission of implementing IA in school. Pre-service teachers, without exception, have the duty to internalize IA from the beginning of their teacher education program, because, as Anggraini (2006) asserts, the earlier the ability is introduced to student teacher, the easier it will be to understand the urgency of their IA. This is consistent with Barrow (2006) in (Varma & Hanuscin, 2009), who stressed the need for standards of inquiry in the higher level that can guide students to achieve their IA.

Furthermore, Amprasto (2016) asserts that pre-service teachers need concrete examples like field trip design experience that can be implemented in their future teaching at a school. Inquiry-based field trip design program has proven to improve scientific work and problem-solving. The integration of IA in the course is the main thing to be urgently addressed (Varelas, Pappas, Kane & Arsenault, 2008; Minner, Levy & Century, 2010). Particularly, the courses in the teacher education program involve more than just transferring knowledge to students (Nowicki, Sullivan-watts, Shim, Young & Pockalny, 2013).

CONCLUSION

Perception of scientific inquiry and IA among pre-service teachers have mostly a high category and used to structure inquiry learning strategy in the classroom. Pre-service teachers need to improve the inquiry strategy quality in the classroom to the next levels, i.e., guided inquiry and open inquiry, which provide positive implications for students to be more independent and creative.

There is no significant difference between SIP and IA of pre-service teacher with gender, but have significant difference according to university. The low IA of pre-service teachers, such as identifying variables, drafting tool materials, developing research procedures, and predicting data to be acquired indicates that the integration of scientific inquiry skill with the course content is required. This is especially urgent when a learning institution aims to redesign its biology content for pre-service teachers.

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REFERENCES

Aktamiş, H., Hiğde, E. & Özden, B. (2016). Effects of the inquiry- based learning method on students' achievement, science process skills and attitudes towards science : a meta-analysis science. *Journal of Turkish Science Education, 13* (4), 248–261. https://doi.org/10.12973/tused.10183a.

Alhendal, D., Marshman, M. & Grootenboer, P. (2016). Kuwaiti science teachers' beliefs and intentions regarding the use of inquiry-based instruction. *International Journal of Science and Mathematics Education*. *14*, 1455. https://doi:10.1007/s10763-015-9671-0.

American Association for the Advancement of Science Project 2061. (1993). *Benchmark for science literacy*. Washington: Oxford University Pres.

Amprasto, A. (2016). Pengembangan program field trip berbasis inkuiri untuk meningkatkan kemampuan bekerja ilmiah dan memecahkan masalah calon guru biologi. Bandung: UPI. Disertasi.

Anggraini, S. (2006). Pengembangan program perkuliahan biologi umum berbasis inkuiri bagi calon guru biologi. Bandung: UPI. Disertasi. http://digilib.upi.edu/digitalview.php?digital_id=1180.

Balım, A. G. (2009). The effects of discovery learning on students' success and inquiry learning skills. *Eurasian Journal of Educational Research, 35*(35), 1–20.

Bianchini, J. A. & Solomon, E. M. (2003). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research Science Education Technology*, *40*, 53–76. https://doi:10.1002/tea.10060.

Biggers, M. & Forbes, C. T. (2012). Balancing teacher and student roles in elementary classrooms: preservice elementary teachers' learning about the inquiry continuum. *International Journal of Science Education, 34* (14), 2205-2229.

Bryce, N., Wilmes, E. D. Sara. & Bellino, M. (2016). Inquiry identity and science teacher professional development. *Cultural Studies of Science Education 11* (2), 235–251 http://doi:10.1007/s11422-015-9725-1.

Bulunuz, M. (2011). Evaluation of pre-service elementary science teachers' experiences with science projects. *Journal of Turkish Science Education 8*, (4), 74-85.

Çalik, M., Ebenezer, J., Özsevgeç, T., Küçük, Z. & Artun, H. (2015). Improving science student teachers' self-perceptions of fluency with innovative technologies and scientific inquiry abilities**.** *Journal of Science Education Technology*, *24* (448). http://doi:10.1007/s10956-014-9529-1

Campbell, T., Abd-Hamid, N. H. & Chapman, H. (2010). Development of instruments to assess teacher and student perceptions of inquiry experiences in science classrooms. *Journal of Science Teacher Education, 21*, 13-30. http://doi:10.1007/s10972-009-9151-x.

Chen, C. & She, H. (2015). The effectiveness of scientific inquiry with/without integration of scientific reasoning. *International Journal of Science and Mathematics Education, 13* (1). http://doi:10.1007/s10763-013-9508-7.

Çimer, A. (2007). Effective teaching in science: a review of literature. *Journal of Turkish Science Education 4* (1), 20-44.

Creswell, J. W. & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: Sage.

Haladyna. (1997). *Writing test items to evaluate higher order thinking*. Arizona: State University West.

Hofstein, A., Navon, O., Kipnis, M. & Mamlok-Naaman, R. (2005). Developing students' ability to ask more and better questions resulting from inquiry-type chemistry laboratories. *Journal of Research Science Technology, 42* (7), 791–806. http://doi:10.1002/tea.20072.

Nuako, J.O., Shore, M. Bruce., Saunders-Stewart, S. Katie., Gyles, D. Petra. (2015). Using brief teacher interviews to assess the extent of inquiry in classroom. *Journal of Advanced Academics, 26* (3) 197-226.

Kemdikbud, Indonesia Ministry of National Education (2013). Pengembangan Kurikulum 2013. [Powerpoint slides]. Retrieved from https://kemdikbud.go.id/kemdikbud/dokumen/Paparan/Paparan%20Wamendik.pdf

Llewellyn, D. (2002). *Inquire within: implementing inquiry-based science standards.* Thousand Oaks, CA: Corwin Press.

Madden, M. E., Baxter, M., Beauchamp, H., Bouchard, K., Huff, M., Ladd, B., Pearon, J., Plague, G. (2013). Rethinking stem education : an interdisciplinary steam curriculum. *Procedia-Procedia Computer Science, 20,* 541–546. http://doi:10.1016/j.procs.2013.09.316.

Minner, D. D., Levy, A. J. & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? results from a research synthesis years 1984–2002. *Journal of Research in Science Teaching, 47* (4), 474–496.

Muukkonen, H. Lakkala, M. & Hakkarainen, K. (2005). Technology mediation and tutoring: How do they shape progressive inquiry discourse. *Journal of the Learning Sciences, 14* (4), 527-565.

National Research Council. (2001). *Adding it up: Helping children learn mathematics*. Washington DC: National Academies Press.

National Research Council. (2002). *Inquiry and the national science education standard: A guide for teaching and learning.* Washington DC: National Academy Press.

National Science Teacher Association. (2002). *Teaching teachers: bringing first-rate science to the elementary classroom*. Arlington, Virginia: NSTA Press.

Nowicki, B. L., Sullivan-watts, B., Shim, M. K., Young, B. & Pockalny, R. (2013). Factors influencing science content accuracy in elementary inquiry science lessons. *Research in Science Education, 43,* 1135–1154. https://doi.org/10.1007/s11165-012-9303-4.

Ohn, J. D. (2013). Constructing the past: assessment of elementary pre-service teachers' perception about history. *The Social Studies, 104* (1), 15–22. https://doi.org/10.1080/00377996.2011.644641.

Organization for Economic Cooperation and Development. (2006). *Assessing scientific reading and mathematical literacy: A Framework for PISA*. Paris: Author.

Parmin, Sajidan, Ashadi, Sutikno, Maretta, Y. (2016). Preparing prospective teachers in integrating science and local w through practicing open inquiry. *Journal of Turkish Science Education 13* (2), 3-14. https://doi.org/10.12973/tused.10163a.

Plevyak, L. H. (2007). What do pre-service teachers learn in an inquiry-based science methods course ?. *Journal Elementary Science Education 19* (1), 1-13. http://doi:10.1007/BF03173650.

Ramey-Gassert, L., Shroyer, G. & Staver, J. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80* (3), 283-315.

Reaume, R. (2011). Pre-service teacher perceptions of and experiences with implementation of inquiry based science teaching. *Electronic Theses and Dissertations*. http://scholar.uwindsor.ca/etd/109.