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The Role of Inventive Thinking in Winning Science Project Competition in Indonesia

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ABSTRACT

The report on PISA from 2000 to 2015 showed that Indonesia was below the average of the international PISA scores in science literacy. The 2013 national curriculum has incorporated research and the 21st century skills but it was corrected in 2016 due to the lack of readiness of the teachers and the students in adopting the 21st century skills. Several studies have reported the lack of science skills of Indonesian students has detrimental effect on Indoensia's ranking in PISA and TIMSS. Hence, science and higher-order thinking skills are important to be taught in schools. Higher-order thinking is a precursor to inventive thinking. The theoretical framework in this study was based on a model of enGauge 21st century skills by Burkhardt et al. They proposed six elements of inventive thinking: adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking. The purpose of this study was to identify the inventive thinking of the Indonesian students in the context of science project competition. This study was a quantitative research using a survey method to collect the empirical data. The population in this study was 700 secondary school students who were the 2017 participants of science project competitions in Indonesia. Based on Kriejie and Morgan's sample size table, a sample of 250 students was selected by using stratified random sampling. The main instrument used in this study was a set of questionnaires that possessed an overall reliability of 0.97 using Cronbach Alpha index. The key finding of the study showed that the students believed that they possess inventive thinking (M = 4.13; SD = 0.34) in the context of science project competition. The data from the questionnaires also revealed that inventive thinking is reflected by curiosity, adaptability, risk-taking, creativity, and higher-order thinking. The open-ended items illustrated that in order to win a science competition, these aspects are required: novelty, creativity, adequate science and research facilities, and the end result of the project must have impact on the society. Finally, this study contributed to the new framework of inventive thinking in the context of winning a science project competition.

Keywords: Inventive thinking, enGauge 21st century skills, science project competition, PISA, Indonesia

INTRODUCTION

In 2013, the Indonesian government took an audacious move to alter the national curricula at the primary and secondary levels to adopt a student-centered learning paradigm. The transformation was in line with the concept of becoming a golden generation by 2045 (Rokhman et al., 2014). The vision has incorporated the renowned enGauge 21st century skills model that comprised four key components in learning: digital literacy, inventive thinking, effective communication, and high productivity (Burkhardt et al., 2003). In particular, inventive thinking is considered important in conducting research or science project. From that point of view, it is critical to determine the inventive thinking of the students in the context of science project competition. Indonesia has the potential to become the seventh largest economy in the world if it could foster the inventive thinking of its students − who could be the future inventors.

According to Henderson (2002), the achievement of the professional inventors is influenced by their inventing behaviors while Weiner (2000) asserted that thinking, together with emotion, could change individual's behaviors. In this study, based on the enGauge 21st century skills' model, the inventive thinking comprises six elements − adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking (Burkhardt et al., 2003). Also, Abdullah and Osman (2010) mentioned the importance of setting the environment of thinking and problem-solving in the classroom in order to nurture inventive thinking of the learners, which could be in the form of a science project. The PISA assessment revealed that Indonesian students, in general, have scored lower in the three aspects: identifying scientific issues, scientifically describing phenomena, and utilizing scientific evidence (Poluakan, 2012). A small number of schools in Indonesia have included research in their curriculum, which are mostly international schools. Students in the international schools are taught with the "inquiry learning" method, which leads them smoothly to the concept of the scientific inquiry. Students are required to complete their projects at the end of each year as part of the final examination. A different scenario, however, will be found in public or government schools, where students are taught by using conventional curriculum and an "old school" style of teaching which is mostly teacher-centered (Bahri, 2013). In the public schools, students who have a keen interest in doing research are expected to join out of the school activities or choose science club as an extra-curriculum activity.

According to Czerniak (1996), little is known about the factors that influence the success in a science competition. However, several reviews have discussed about the predictors of success in science fairs. Czerniak (1996) examined from both students' and parents' perspectives, such as parental influence, self-concept, motivation, and anxiety, as the predictors of success in a district science fair covering six counties in Northwest Ohio. Dionne et al. (2012) explored the students' motivation toward their achievement in the Canada-Wide Science Fairs in 2008. They found critical factors to explain students' motivation in participating in a science competition: keen interest in science, possess high motivation and have a strong self-efficacy. Moreover, the students valued appreciation to their project and used certain strategies to win the competition.

Supports for students in completing their academic tasks could be in varied forms. The learning environment, for instance, including parents at home and teachers at school, has its role in students' achievement in academic success (Henderson, 2002). In general, the main problem faced by young participants in science competition is the lack of creativity (Bahri, 2013). A study on problem-based learning conducted by Suparman and Husen (2016) confirmed that the low creativity of Indonesian students. Moreover, several studies reported lack of creativity of the Indonesian students in science projects (Noer, 2011; Sugiyanto & Masykuri, 2016). Another study found that lack of creativity in a science project is due to the lack of science skills (Subali, 2011). Creativity is also related to inventive thinking. However, in reviewing related literature about inventive thinking, there is a paucity in the research regarding the role of inventive thinking in winning a science competition in Indonesia. Thus, it is critical to conduct this study to determine the role of inventive thinking toward Indonesian students' achievement in science competition.

PROBLEM STATEMENT

The Indonesian secondary education is divided into two different levels: junior and senior high schools. In junior high school, learners are expected to have skills in reasoning, analyzing, and presenting. At the senior high school, the learners are expected to be creative, productive, critical, self-directed, collaborative, good communicator and problem-solver. These skills could be acquired and integrated in a science research project. However, Permanasari (2010) reported that a science project in the form of research is not a common practice in public secondary schools in Indonesia; it may be practiced separately as laboratory activities. Hence, in general, the Indonesian secondary school students lack of research skills, creativity and innovation (Triyono & Insih, 2015).

Moreover, based on the PISA report from 2000 to 2015, Indonesian students have had low scores in science literacy as compared to the average international score (Poluakan, 2012). The low scores indicated that Indonesian students were still lagging behind the other advanced countries such as OECD countries in terms of science and mathematics achievement. In 2013, national curriculum in Indonesia was reformed to integrate the 21st century skills. Critical elements in science literacy and inventive thinking such as higher-order thinking, creativity, self-direction, and risk-taking were derived from enGauge model of 21st century skills. They were embedded in the curriculum but the teachers' readiness to implement the curriculum was questionable. Most teachers were not equipped and trained to teach students using the new paradigm of scientific inquiry. Krisdiana et al. (2014) conducted an empirical research on the implementation of the new national curiculum in five provinces in Indonesia. The study reported that both the teachers and the learners faced difficulty in the new curriculum. There was inadequate time for the learners to observe and conduct experiments, whereas the teaching became challenging to the teachers because they were not ready to teach in a new way.

Another indicator of poor science literacy among Indonesia students was unimpressive performance of Indonesian students in international science project competitions. At international science competitions and olympiads, in general, Indonesian students seldom gain the top places. Scientific and higher-order thinking may be lacking in secondary school students. Based on the relevant literature, higher-order thinking plays a vital role in linking the scientific literacy to inventive thinking (Burkhardt et al., 2003). Therefore, it is critical to determine the role of inventive thinking in winning a science project competition among Indonesian students.

THE CONCEPTUAL FRAMEWORK

A conceptual framework shows the relationship between the relevant variables. In this study, the independent variable was the inventive thinking and the dependent variable was the students' achievement in science project competition. The moderator variables were gender and level of schooling. Based on the enGauge 21st century skills model (Burkhardt et al., 2003), the main construct was inventive thinking that comprised six sub-constructs − adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking (Burkhardt, 2003). Figure 1 showed the conceptual framework for this study.

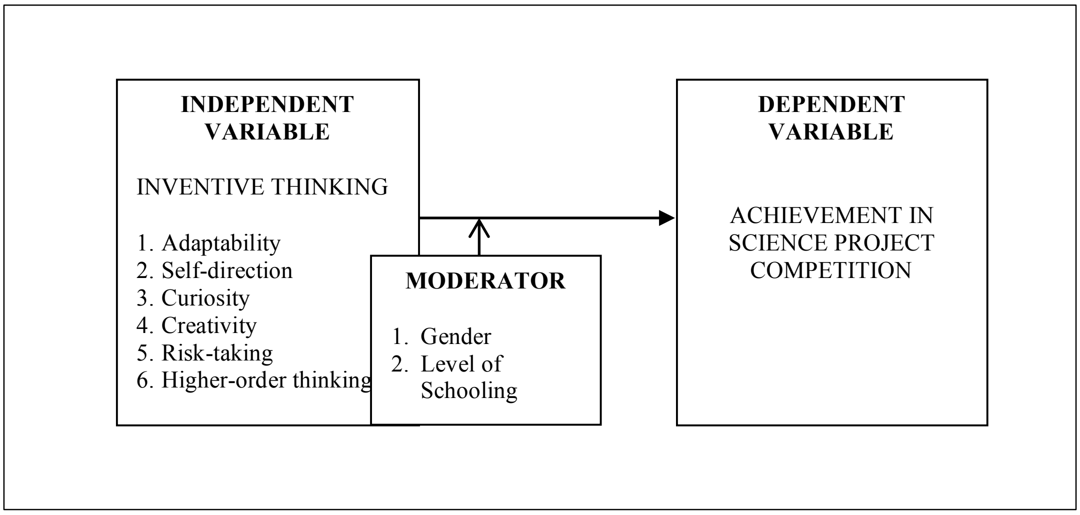

Figure 1: The conceptual framework

THE PURPOSE AND OBJECTIVES OF THE STUDY

The purpose of the study was to identify the role of inventive thinking of Indonesian secondary school students in winning science project competition in Indonesia. Specifically, the objectives of this study were as follows:

1. To identify the inventive thinking of the students based on their demographic factors.
2. To determine the relationships between inventive thinking and its elements.

The Research Questions of the Study

Based on the objectives of the study, two research questions were constructed as follows:

1. What is the inventive thinking of the students based on the demographic factors?
2. What are the relationships between inventive thinking and its elements in the context of science project competition?

The Null Hypotheses

The researcher has developed fourteen null hypotheses to test the construct (inventive thinking) based on the demographic factors, as stipulated in the Research Question 1, as follows:

H_{01} : There is no significant difference in adaptability between male and female students.
H_{02} : There is no significant difference in adaptability between junior and senior high school students.
H_{03} : There is no significant difference in self-direction between male and female students.
H_{04} : There is no significant difference in self-direction between junior and senior high school students.
H_{05} : There is no significant difference in curiosity between male and female students.
H_{06} : There is no significant difference in curiosity between junior and senior high school students.
H_{07} : There is no significant difference in creativity between male and female students.
H_{08} : There is no significant difference in creativity between junior and senior high school students.
H_{09} : There is no significant difference in risk-taking between male and female students.
H_{010} : There is no significant difference in risk-taking between junior and senior high school students.

H_{011} : There is no significant difference in higher-order thinking between male and female students.
H_{012} : There is no significant difference in higher-order thinking between junior and senior high school students.
H_{013} : There is no significant difference in inventive thinking between male and female students.
H_{014} : There is no significant difference in inventive thinking between junior and senior high school students.

To answer Research Question 2, the researcher developed six null hypotheses to test the correlation between the inventive thinking and its elements as follows:

H_{015} : There is no significant correlation between inventive thinking and adaptability.
H_{016} : There is no significant correlation between inventive thinking and self-direction.
H_{017} : There is no significant correlation between inventive thinking and curiosity.
H_{018} : There is no significant correlation between inventive thinking and creativity.
H_{019} : There is no significant correlation between inventive thinking and risk-taking.
H_{020} : There is no significant correlation between inventive thinking and higher-order thinking.

METHODOLOGY

This study was a quantitative research using a survey method to collect the empirical data. The population in this study was 700 secondary school students who were the participants of science project competitions in Indonesia in 2017. Based on Kriejie and Morgan's sample size table, a sample of 250 students was selected by using stratified random sampling. The stratification was designed based on zones (provinces) in Indonesia. The respondents were selected from ten zones (provinces) in Indonesia: Sumatera Utara, Sumatera Selatan, Jawa Barat, DKI Jakarta, Jawa Tengah, Jawa Timur, Kota Surabaya, DI Yogyakarta, Bali, Kalimantan Tengah. The sample comprised 44% male and 56% female students. They were studying in junior high schools (47%) and senior high schools (53%). The main instrument used in this study was a set of questionnaires that possessed an overall reliability of $\alpha = 0.97$ using Cronbach Alpha index.

The questionnaire consisted of three parts. Part A of the questionnaire was the demographic information of the students such as gender and school level. Part B of the questionnaire consisted of items about the elements of inventive thinking: adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking. Lastly, Part C of the questionnaire consisted of two open-ended items on inventive thinking regarding the supportive and suppressive factors of students' participation in science project competitions. In Part B of the questionnaire, the five-point Likert scale was used. The options ranged from strongly agree (5), agree (4), uncertain (3), disagree (2), to strongly disagree (1).

Three experts evaluated the questionnaire to validate the items and 30 students were involved in a pilot study. The experts agreed the items of the questionnaire were suitable to measure the constructs and the sub-constructs and the items were easily understood. In the pilot study, in general, the sample also concurred that the items were valid except some items that have to be reworded to enhance the clarity of the items. In terms of the reliability of the questionnaire, the internal consistency of the items was measured. The result of the reliability test showed that the Cronbach Alpha coefficient was relatively high ($\alpha = 0.97$). Quantitative data were analyzed using descriptive and inferential statistics and the qualitative data were thematized using qualitative analysis put forward by Miles and Huberman (1994).

RESULTS

The findings of this study were arranged based on the research questions. The first research question asked about the respondents' perceptions regarding inventive thinking in the context of science project competition. The second research question was about the relationship of inventive thinking and its elements. In this study, the empirical data from the questionnaire regarding the six elements of inventive thinking were presented by their mean and standard deviation. The demographic factors consisted of gender and school level. Based on the enGauge 21st century skills model (Burkhardt et al., 2003), the six elements of inventive thinking in this study were adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking.

Table 1 showed the mean and standard deviation of inventive thinking in the context of adaptability as perceived by the students. Items S1 to S8 posed to the students to identify their adaptability trait in the context of science project competition. In general, the students believed (M = 4.31; SD = 0.42) that they possessed adaptability trait in the context of science project competition. The students concurred (M = 4.42; SD = 0.71) that they would modify their science project if there were compelling evidence against their earlier idea (item S1). In terms of willingness to accept suggestions, the majority of the respondents strongly agreed (M = 4.54; SD = 0.08) that they were willing to revise their science project based on their mentor's suggestions (item S2). However, the students slightly agreed (M = 4.18; SD = 0.76) that they modified their science project based on the trial/pilot test or experimental results (item S3).

On item S4, the respondents strongly agreed (M = 4.54; SD = 0.63) that they revised their science project after getting new input from the experts. Regarding item S5, the students admitted (M = 4.20; SD = 0.83) that they were willing to change the materials of their science project if they found more suitable replacement/substitution. The respondents concurred (M = 4.29; SD = 0.72) that they adapted their school schedule to allocate time to conduct the science project (item S6). Nevertheless, the students were uncertain (M = 3.39; SD = 0.82) whether they possessed the competence to handle multiple tasks to complete the science project when the time was constrained (item S7). Finally, the respondents were resilient (M = 4.33; SD = 0.66) to change their research method when the old way did not produce intended outcome (item S8).

Table 1: The mean and standard deviation of inventive thinking in the context of adaptability as perceived by the students

	Items	M	SD	Interpretation
S1	I am willing to modify my science project if there is compelling evidence against my earlier idea.	4.42	0.71	Strongly Agree
S2	I am willing to revise my science project based on my mentor's suggestions.	4.54	0.08	Strongly Agree
S3	I modify my science project based on trial/ pilot test (experiment) results.	4.18	0.76	Agree
S4	I revise my science project when getting new input from the experts (scientists, other researchers, etc).	4.54	0.63	Strongly Agree
S5	I am willing to change the materials of the science project if I find a more suitable replacement/substitution.	4.20	0.83	Agree
S6	I adapt my school schedule to allocate time to conduct the science project.	4.29	0.72	Strongly Agree
S7	I have the competence to handle multiple tasks to complete the science project when the time is constrained.	3.39	0.82	Uncertain
S8	I try a new experiment method when the old way does not produce expected results.	4.33	0.66	Strongly Agree
	Total average	4.31	0.42	Strongly Agree

The first null hypothesis H_{01} stated that there was no significant difference regarding adaptability between male and female students. The result of the independent t-test was presented in Table 2. It showed that there was no significant difference in adaptability trait between the male and female students [t (248) = -1.84, p = 0.07] with the p-value was larger than 0.05. Hence, H_{01} was accepted. The result showed that the mean of adaptability of the male students was 4.26 (SD = 0.43) and the mean of adaptability of female students was 4.36 (SD = 0.41). However, the difference between the two groups was not significant at the 0.05 α-level.

Table 2: Independent t-test for adaptability based on gender

Gender	n	Mean	SD
Male	126	4.26	0.43
Female	124	4.36	0.41

	Levene test		t-test for equality of means 95% CI						
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.14	0.71	-1.84	248.00	0.07	-0.10	0.05	-0.20	0.01
Unequal			-1.84	247.53	0.07	-0.10	0.05	-0.20	0.01

$p>0.05$

To examine the difference in terms of school level, the null hypothesis H_{02} was tested. The outcome was presented in Table 3 and it revealed that there was no significant difference ($p > 0.05$) in adaptability trait between the students in junior and senior high schools [t (248) = -0.111, p = 0.27]. Hence, H_{02} was failed to be rejected. The mean of adaptability of the junior high school students was 4.26 (SD = 0.44) and the mean for senior high school students was 4.33 (SD = 0.42). The t-test showed that the difference between the means was not significant at the 0.05 α-level. Thus, it could be concluded that adaptability trait of the students is almost the same despite their level of schooling.

Table 3: Independent t-test for adaptability based on level of schooling

Level of schooling	n	Mean	SD
Junior high school	71	4.26	0.44
Senior high school	179	4.33	0.42

	Levene test		t-test for equality of means 95% CI						
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.82	0.37	-0.111	248.00	0.27	-0.07	0.06	-0.18	0.05
Unequal			-0.109	122.77	0.28	-0.07	0.06	-0.19	0.05

$p>0.05$

Next, items S9 to S14 were constructed to assess the respondents' inventive thinking in terms of self-direction. Table 4 posited the mean and standard deviation of self-direction from the students' perspective. In general, the students slightly agreed (M = 4.04; SD = 0.52) that they possessed self-directed ability in the context of science project competition. Moreover, the respondents believed (M = 4.38; SD = 0.65) that they have a clear goal of what they wanted to achieve (item S9). However, the students just slightly agreed (M = 3.91; SD = 0.81) that they have tried their own idea to solve the problem in the science project, rather than waiting for the help from their mentor (item S10). In terms of choosing a research topic, the respondents barely agreed (M = 3.86; SD = 0.95) that they chose their own science project's topic, which was attractive to them rather than asking their mentor to suggest a topic (item S11).

Regarding item S12, the students were unanimous (M = 4.19; SD = 0.81) that, although there was no science project course in the school, they learned about conducting proper scientific project by themselves. However, the respondents were ambivalent (M = 3.94; SD = 1.08) whether they used their own money to fund their science project when there was no other source of funding (item S13). The standard deviation for item 13 was relatively high (SD = 1.08) that it could be due to the polarization of the responses. Finally, the students agreed (M = 3.93; SD = 0.83) that they analyzed the science project data without any help from others (item S14).

Table 4: The mean and standard deviation of inventive thinking in the context of self-direction as perceived by the students

	Items	M	SD	Interpretation
S9	I have clear goal of what I want to achieve.	4.38	0.65	Strongly Agree
S10	I try my idea to solve the problem in my science project rather than waiting for help from my mentor.	3.91	0.81	Agree
S11	I choose my own science project's topic, which is interesting to me instead that ask my mentor to suggest a topic.	3.86	0.95	Agree
S12	Although there is no science project course in the school, I learn about conducting a proper scientific project by myself.	4.19	0.81	Agree
S13	I use my own money to fund my science project when there is no other source of funding.	3.94	1.08	Agree
S14	I analyze my science project data.	3.93	0.83	Agree
	Total average	4.04	0.52	Agree

Next, the difference in self-directed ability of the male and female students was examined through null hypothesis 3. H_{03} stated that there was no significant difference in self-direction between male and female students. Table 5 presented the result of the independent t-test and it showed that there was no significant difference in self-direction between male and female students [t(248) = 0.13, p = 0.90]. The outcome showed that H_{03} was accepted which meant that there was no significant difference in terms of gender regarding the perceived self-directed ability of the students.

Table 5: Independent t-test for self-direction based on gender

Gender	n	Mean	SD
Male	126	4.04	0.43
Female	124	4.03	0.41

Variance	Levene test F	Sig.	t-value	df	Sig. (2-tailed)	t-test for equality of means 95% CI Mean diff.	SE diff.	Lower	Upper
Equal	0.63	0.43	0.13	248.00	0.90	0.01	0.07	-0.12	0.14
Unequal			0.13	245.33	0.90	0.01	0.07	-0.12	0.14

p>0.05

In terms of level of schooling, H_{04} was tested. The result of the t-test (see Table 6) illustrated that no was significant difference in the perceived self-directed ability of the junior and senior high school students [t (248) = 0.00, p = 1.00]. The p-value was larger than 0.05 hence the null hypothesis H_{04} was accepted.

Table 6: Independent t-test for self-direction based on level of schooling

Level of schooling	n	Mean	SD
Junior high school	71	4.04	0.51
Senior high school	179	4.04	0.53

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.98	0.32	0.00	248.00	1.00	0.00	0.07	-0.14	0.14
Unequal			0.00	132.00	1.00	0.00	0.07	-0.14	0.14

p>0.05

The third sub-construct of inventive thinking is curiosity. The respondents were asked to rate their curiosity level to reflect their inventive thinking in winning a science competition. In general, the students believed (M = 4.38; SD = 0.41) that they possessed curiosity (Table 7). On item S15, the students strongly agreed (M = 4.57; SD = 0.60) that they were curious about what happened surround them. Even though the majority of the respondents convinced (M = 4.48; SD = 0.62) that they were observant (item S16) but they only slightly agreed (M = 4.10; SD = 0.75) that they asked critical questions regarding the problems surround them (item S17). For item S18, the students admitted (M = 4.34; SD = 0.67) that their high curiosity could spark a new idea for their science project. In addition, the respondents were confident (M = 4.25; SD = 0.63) that they thought of alternative solutions to their science project (item S19). On item S20, the students believed (M = 4.21; SD = 0.61) that they were curious to try out different strategies to solve their science project problem. Regarding item S21, the respondents strongly agreed (M = 4.56; SD = 0.58) that when they were not sure, they would ask their teacher to clarify the concept because they were curious to know. Finally, the students were very curious (M = 4.56; SD = 0.57) to invent something new that they believed that it could benefit society (item S22).

Table 7: The mean and standard deviation of inventive thinking in the context of curiosity as perceived by the students

	Items	M	SD	Interpretation
S15	I am curious about what happens in my surroundings.	4.57	0.60	Strongly Agree
S16	I am very observant.	4.48	0.62	Strongly Agree
S17	I ask critical questions regarding the problems surround me.	4.10	0.75	Agree
S18	I have a high curiosity that sparks a new idea for my science project.	4.34	0.67	Strongly Agree
S19	I think of alternative solutions to my science project.	4.25	0.63	Strongly Agree
S20	I am curious to try out different strategies to solve my science project problem.	4.21	0.61	Strongly Agree
S21	When uncertain, I ask my teacher to clarify the concept because I am curious to know.	4.56	0.58	Strongly Agree
S22	I am curious to invent something new that I believe that it could benefit society.	4.56	0.57	Strongly Agree
	Total average	4.38	0.41	Strongly Agree

Null hypothesis H_{05} was developed to test the difference of curiosity between male and female students in the context of science project competition. The result of the independent t-test showed that there was no significant difference in curiosity between male and female students [t (248) = -1.05, p = 0.29] with the p-value bigger than 0.05 (see Table 8). In Table 8, the mean of curiosity of the male students was 4.36 (SD = 0.42), and the mean of curiosity of the female students was 4.41 (SD = 0.39). Based on the t-test, the difference between the two groups was not significant at the 0.05 α-level.

Table 8: Independent t-test for the curiosity based on gender

Curiosity	n	Mean	SD
Male	126	4.36	0.42
Female	124	4.41	0.39

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.92	0.34	-1.05	248.00	0.29	-0.05	0.05	-0.16	0.05
Unequal			-1.05	246.68	0.29	-0.05	0.05	-0.16	0.05

$p>0.05$

In this study, the difference in curiosity between the students in junior and senior high schools was tested via H_{06}. The result of the independent sample t-test showed that there was no significant difference in curiosity between the two groups [t (248) = -1.78, p = 0.08] as shown in Table 9. The test showed that null hypothesis 6 was accepted. The empirical data in Table 9 showed that the mean of curiosity for high school students (M = 4.41, SD = 0.41) was slightly higher than the mean for junior high school students (M =4.31, SD = 0.40). However, the mean difference between the two groups was not significant at the 0.05 α-level.

Table 9: Independent t-test for the curiosity of the students based on level of schooling

Curiosity	n	Mean	SD
Junior high school	71	4.31	0.40
Senior high school	179	4.41	0.41

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.23	0.63	-1.78	248.00	0.08	-0.10	0.06	-0.21	0.01
Unequal			-1.80	131.65	0.07	-0.10	0.06	-0.21	0.01

$p>0.05$

Five items posed to the respondents (S23 to S27) regarding creativity as perceived by the students, and the mean and standard deviation were tabulated in Table 10. In general, the respondents agreed (M = 4.14; SD = 0.48) that they were creative. Regarding item S23, the students slightly agreed that they created a new science project idea by modifying the existing idea (M = 3.82; SD = 1.04). On item S24, the students strongly agreed (M = 4.43; SD = 0.73) that they read widely to come up with a new idea for their science project. For item 25, the respondents only agreed (M = 4.06; SD = 0.77) that they have creative idea. The students also convinced (M= 4.16; SD = 0.70) that they have an original idea (item S26). Finally, the respondents strongly believed (M = 4.24; SD = 0.75) that they have "out-of-the-box" idea (item S27). However, item S23 showed a relatively high standard deviation (SD = 1.04) that it could indicate divergent responses.

Table 10: The mean and standard deviation of inventive thinking in the context of creativity as perceived by the students

	Items	M	SD	Interpretation
S23	I create a new science project idea by modifying the existing one.	3.82	1.04	Agree
S24	I read widely to come up with a new idea for my science project.	4.43	.073	Strongly Agree
S25	I have an original idea.	4.06	0.77	Agree
S26	I have a creative idea.	4.16	0.70	Agree
S27	I believe that I have "out-of-the-box" idea.	4.24	0.75	Strongly Agree
	Total average	4.14	0.48	Agree

The null hypothesis H_{07} was formed to test the difference in creativity in the context of science project competition between male and female students. The result of the test showed that there was no significant difference in creativity between male and female students [t(248) = -1.65, p = 0.10]. Table 11 showed that the p-value was bigger than 0.05; hence, H_{07} was accepted. The mean of creativity for the male students was 4.09 (SD = 0.47), while the mean for female students were 4.19 (SD = 0.48). Nevertheless, the difference in the means of creativity between the male and female students was not significant at the 0.05 α-level.

Table 11: Independent t-test for the creativity based on gender

Creativity	n	Mean	SD
Male	126	4.09	0.47
Female	124	4.19	0.48

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.02	0.90	-1.65	248.00	0.10	-0.10	0.06	-0.22	0.02
Unequal			-1.65	247.47	0.10	-0.10	0.06	-0.22	0.02

p>0.05

With regards to H_{08} which tested the creativity between the students in junior and senior high schools, the outcome of the t-test indicated that there was no significant mean difference in creativity between the junior and senior high school students [t(248) = -0.86, p = 0.51]. Table 12 showed the mean and standard deviation of creativity of the students in junior (M = 4.11, SD = 0.49) and senior high schools (M = 4.15, SD = 0.48). It could be concluded that level of schooling did not affect the respondents' perception on their creativity in the science project.

Table 12: Independent t-test for the creativity of the students based on level of schooling

Creativity	n	Mean	SD
Junior high school	71	4.11	0.49
Senior high school	179	4.15	0.48

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.84	0.36	-0.86	248.00	0.51	-0.04	0.07	-0.18	0.09
Unequal				124.98	0.52	-0.04	0.07	-0.18	0.09

p>0.05

In the context of risk-taking, the items S28 through S33 were formulated to determine the risk-taking behaviors of the students involved in the science project competition. The result showed that in general, the students strongly agreed (M = 4.24; SD = 0.63) that learn fast from their mistakes that they made. The respondents admitted that they were confident (M = 4.25; SD = 0.60) that they tried different ways to obtain the optimum results (item S29). However, the students only slightly agreed (M = 4.04; SD = 0.76) that they went beyond their traditional discipline by venturing into multi-disciplinary research areas (item S30). Concerning criticism, the respondents concurred (M = 4.50; SD = 0.63) that they were open to criticisms on their science project and that they would accept the criticisms with an open heart (item S31). On item S32, the students were willing to stay after school to complete their science project (M = 4.43; SD = 0.71). Finally, the respondents were determined (M = 4.31; SD = 0.78) to go to other research institutions to use their labs for testing/analyzing their data (item S33).

Table 13: The mean and standard deviation of inventive thinking in the context of risk-taking as perceived by the students

	Items	M	SD	Interpretation
S28	I learn fast from the mistakes I made.	4.24	0.63	Strongly Agree
S29	I try different ways to obtain optimum results.	4.25	0.60	Strongly Agree
S30	I go beyond my traditional discipline by venturing into multi-disciplinary research areas.	4.04	0.76	Agree
S31	I am open to criticisms on my science project and accept the criticisms with an open heart.	4.50	0.63	Strongly Agree
S32	I am willing to stay after school to complete my science project.	4.43	0.71	Strongly Agree
S33	I am eager to go to other research institutions to use its lab for testing/analyzing my data.	4.31	0.78	Strongly Agree
	Total average	4.29	0.42	Strongly Agree

Next, H_{09} was tested to determine the difference in risk-taking behaviors between the male and female students. H_{09} stated that there was no significant difference of the respondents' risk-taking behaviors based on gender. Based on the t-test, the H_{09} was accepted which meant that there was no significant difference in risk-taking behaviors between the male and female students [t(248) = -0.35, p = 0.73]. As shown in Table 14, the mean of risk-taking of the male students was 4.29 (SD = 0.43) and the mean of risk-taking of the female students was 4.30 (SD = 0.40). However, the difference between the two groups was not significant at the 0.05 α-level.

Table 14: Independent t-test for risk-taking based on gender

Risk-taking	n	Mean	SD
Male	126	4.29	0.43
Female	124	4.30	0.40

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	1.66	0.20	-0.35	248.00	0.73	-0.02	0.05	-0.12	0.09
Unequal			-0.35	246.57	0.73	-0.02	0.05	-0.12	0.09

p>0.05

In the context of the schooling, H_{010} was formulated and analyzed. As usual, t-test was used to test the difference between the two independent groups. The outcome of the t-test showed that there was no significant difference with regard to risk-taking trait of the respondents based on the level of schooling [t(248) = -1.11, p = 0.27]. Table 15 illustrated that the mean of risk-taking of the junior high school students' was 4.25 (SD = 0.41) while the mean for the high school students was 4.31 (SD = 0.42) but the difference between the two groups was not significant at the 0.05 α-level.

Table 15: Independent t-test for risk-taking of the students based on level of schooling

Risk-taking	n	Mean	SD
Junior high school	71	4.25	0.41
Senior high school	179	4.31	0.42

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.01	0.94	-1.11	248.00	0.27	-0.06	0.06	-0.18	0.05
Unequal			-1.11	12.82	0.27	-0.06	0.06	-0.18	0.05

p>0.05

Regarding the higher-order thinking in the context of science project competition, items S34 through S42 posed to the respondents (see Table 16). In general, the students agreed (M = 4.11; SD = 0.42) that they possessed higher-order thinking. The respondents slightly agreed (M = 4.07; SD = 0.68) that they could explain the scientific concept underlying their science project accurately (S34). The students were also concurred (M = 4.10; SD = 0.59) that they built research hypotheses to be tested (item S35). Concerning support on research justification, the respondents admitted (M = 4.18; SD = 0.63) that they adopted relevant theories to support their research justification (item S36). Moreover, the students agreed (M = 4.10; SD = 0.63) that they compared different theories/models to explain their science project (item S37).

The students slightly agreed (M = 4.09; SD = 0.63) that they provided correct interpretation of their research results (item S38), and they provided (M = 4.13; SD = 0.63) alternative explanation of the results of their research (item S39). Regarding synthesizing the result, the respondents barely agreed (M = 4.07; SD = 0.72) that they synthesized the results of their research into a new framework or model or product (item S40). On item S41, the students concurred (M = 4.21; SD = 0.59) that they made a proper conclusion about their research based on the empirical data that they have collected. Finally, the respondents barely agreed (M = 4.05; SD = 0.79) that they have successfully solved the problem that they hypothesized in the beginning (item S42).

Table 16: The mean and standard deviation of inventive thinking in the context of higher-order thinking as perceived by the students

	Items	M	SD	Interpretation
S34	I can explain the scientific concept underlying my science project accurately.	4.07	0.68	Agree
S35	I build research hypotheses to be tested.	4.10	0.59	Agree
S36	I adopt appropriate theories to support my research justification.	4.18	0.63	Agree
S37	I compare different theories/models that explain my science project.	4.10	0.63	Agree
S38	I provide a correct interpretation of my research results.	4.09	0.63	Agree
S39	I offer alternative explanations of the results of my research.	4.13	0.63	Agree
S40	I synthesize the results of my research into a new framework or model or product.	4.07	0.72	Agree
S41	I make a proper conclusion about my research based on the empirical data that I have collected.	4.21	0.59	Strongly Agree
S42	I have successfully solved the problem that I hypothesized in the beginning.	4.05	0.73	Agree
	Total average	4.11	0.42	Agree

Next, to test the difference with respect to higher-order thinking between the male and female students (H_{011}), an independent t-test was conducted (see Table 17). The result of the t-test indicated that there was no significant difference in the respondents' higher-order thinking based on gender [t(248) = -0.33, p = 0.74]. The p-value was bigger than 0.05, hence H_{011} was accepted. The mean of higher-order thinking of the female students (M = 4.12, SD = 0.42) was slightly higher than the male students' (M = 4.10, SD = 0.42) but the difference was not significant at the 0.05 α-level.

Table 17: Independent t-test for higher-order thinking based on gender

Higher-order thinking	n	Mean	SD
Male	126	4.10	0.42
Female	124	4.12	0.42

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.16	0.69	-0.33	248.00	0.74	-0.02	0.05	-0.12	0.09
Unequal			-0.33	247.93	0.74	-0.02	0.05	-0.12	0.09

p>0.05

In terms of the level of schooling, null hypothesis 12 (H_{012}) tested the higher-order thinking (HOT) between the students in junior and senior high schools. Table 18 posited the outcome of the t-test. There was no significant difference in higher-order thinking between the students in junior and senior high schools [t(248) = -1.18, p = 0.24]. This result indicated that the H_{012} was accepted. The mean of HOT of the senior high school students was 4.13 (SD = 0.41) and the mean of HOT of the junior students was 4.06 (SD = 0.45).

Table 18: Independent t-test for higher-order thinking of the students based on level of schooling

Higher-order thinking	n	Mean	SD
Junior high school	71	4.06	0.45
Senior high school	179	4.13	0.41

	Levene test					t-test for equality of means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.00	0.95	-1.18	248.00	0.24	-0.07	0.06	-0.19	0.05
Unequal			-1.13	118.67	0.26	-0.07	0.06	-0.19	0.05

p>0.05

Table 19 illustrated the means and standard deviations of inventive thinking from the students' perspective. According to Bukhardt et al. (2003), the elements of inventive thinking comprised adaptability, self-direction, curiosity, creativity, risk-taking, and higher-order thinking. In general, the students (M = 4.13, SD = 0.34) believed that they possessed inventive thinking in the context of science project competition. From the students' perspective, the highest mean of the elements of inventive thinking was curiosity (M = 4.38, SD = 0.41), followed by adaptability (M = 4.31, SD = 0.42), risk-taking (M = 4.29, SD = 0.42), creativity (M = 4.14, SD = 0.48), and higher-order thnking (M = 4.11, SD = 0.42). The lowest mean was self-direction (M = 4.04, SD = 0.52).

Table 19: The means and standard deviations of the elements of inventive thinking as perceived by the students

Elements of Inventive Thinking	M	SD
1. Curiosity	4.38	0.41
2. Adaptability	4.31	0.42
3. Risk-taking	4.29	0.42
4. Creativity	4.14	0.48
5. Higher-order thinking	4.11	0.42
6. Self-direction	4.04	0.52
Average	4.13	0.34

To test whether there was a difference in inventive thinking based on gender, the null hypothesis 13 was formulated. The result of the independent t-test [t(248) = -1.09, p = 0.28] as shown in Table 20 illustrated that there was no significant difference in inventive thinking between male and female students, with the p-value bigger than 0.05. The mean of inventive thinking of male students was 4.19 (SD = 0.35) while the mean of inventive thinking of female students was 4.24 (SD = 0.32) but the difference was not significant at 0.05 α level.

Table 20: Independent t-test for inventive thinking of the students based on gender

Inventive thinking	n	Mean	SD
Male	126	4.19	0.35
Female	124	4.24	0.32

	Levene test		t-test for equality of means 95% CI						
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	3.03	0.83	-1.09	248.00	0.28	-0.46	0.43	-1.31	0.04
Unequal			-1.09	246.30	0.28	-0.46	0.43	-1.30	0.04

p>0.05

The null hypothesis H_{14} was formulated to determine the difference in inventive thinking between students in junior and senior high schools. As seen in Table 21, the independent sample t-test result for inventive thinking of students in junior and senior high school illustrated that, there was no significant difference in inventive thinking of the students in junior and senior high school [t (248) = -1.22, p = 0.23]. The mean of inventive thinking of junior high school students was 4.17 (SD = 0.34) while the mean of senior high-school students was 4.23 (SD = 0.34). However, the difference was not significant at 0.05 α-level.

Table 21: Independent t-test for inventive thinking of the students based on level of schooling

Inventive thinking	n	Mean	SD
Junior high school	71	4.17	0.34
Senior high school	179	4.23	0.34

	Levene test		t-test for equality of means 95% CI						
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean diff.	SE diff.	Lower	Upper
Equal	0.99	0.76	-1.22	248.00	0.23	-0.06	0.05	-0.15	0.04
Unequal			-1.21	127.74	0.23	-0.06	0.05	-0.15	0.04

p>0.05

To test hypotheses H_{015}, H_{016}, H_{017}, H_{018}, H_{019} dan H_{020}, Pearson correlations were conducted to determine the relationship between inventive thinking and its elements. The result of the test was posited in Table 22 indicated that there were significant positive and strong correlations between inventive thinking and higher-order thinking [$r(248) = 0.817$; $p < 0.001$], curiosity [$r(248) = 0.764$; $p < 0.001$], adaptability [$r(248) = 0.733$; $p < 0.001$], risk-taking [$r(248) = 0.720$; $p < 0.001$], self-direction [$r(248) = 0.710$; $p < 0.001$], and creativity [$r(248) = 0.654$; $p < 0.001$]. The result showed that the top three strong correlation coefficients toward inventive thinking were higher-order thinking, curiosity, and adaptability. But the moderate correlation was creativity.

Table 22: Pearson correlation coefficients between inventive thinking and its elements

Elements	Pearson	Sig (2-tailed)
Higher-order thinking	.817**	.000
Curiosity	.764**	.000
Adaptability	.733**	.000
Risk-taking	.720**	.000
Self-direction	.710**	.000
Creativity	.654**	.000

** Correlation is significant at the 0.01 level (2-tailed)

Table 23 presented a model summary of the influence of inventive thinking on the students science project achievement. After the regression analysis, only two elements of inventive thinking that are significant in affecting the respondents' achievement in science competition − curiosity and risk-taking. The model suggested a weak influence ($R^2 = 0.036$) of curiosity and risk-taking toward the achievement in science project competition and only 3.6% of the variance in achievement in science project competition can be explained by curiosity and risk-taking.

Table 23: The model summary of the influence of inventive thinking toward the achievement in science project competition

Model	R	R^2	Adjusted R^2	Standard error of the estimate
1	.190[a]	.036	.023	.810

aPredictors: (Constant), Curiosity, Risk-Taking

The result of the regression analysis was presented in Table 24, which indicated that curiosity and risk-taking were the only significant predictors of achievement in the context of science project competition. It could be summarized that the dominant elements in inventive thinking, which influenced the success in a science project competition, were curiosity and risk-taking. The coefficient of regression (β) for curiosity was 0.403 and for risk-taking was -0.402, while the constant was 3.964. Hence. the formula of the regression result could be written as follows:

$$Y = 3.694 + 0.403 X_1 -0.402 X_2$$

Y was achievement in science project competition, X_1 was curiosity, and X_2 was risk-taking

Table 24: The coefficients of regression for inventive thinking

Factors	Unstandardized coefficients		Standardized coefficients		
	β	Std. Error	Beta	t	Sig
(Constant)	3.964	.759		5.223	.000
Curiosity	.403	.186	.219	2.173	.031
Risk-taking	-.402	.201	.202	-2.000	.047

aDependent Variable: Achievement

Next, the students were asked to answer the open-ended item regarding Research Question 1. The first open-ended item asked about how the students obtained new ideas for their science projects. Table 25 illustrated the emerging themes of the students' answers based on the thematic analysis. In this study, qualitative data collected from the open-ended was analyzed thematically using Miles and Huberman (1994) approach.

The first ranked theme to the question about the source of idea in the science project was observing the surrounding. By observation, the respondents could identify the problems around them and tried to find the potential solution. For instance, the students observed dumped wastes in their environment such as food or plastic wastes. This gave the students some ideas on how to solve the problem. The second emerging theme for the first open-ended item was reading. The students believed that they could find new ideas for their science project by reading books, newspapers and scientific journals. The students made use of the internet and printed materials such as books and journals to find information in the scientific articles. Googling on the internet and reading Wikipedia were also included in how the students obtained their new ideas for science projects. Finally, the third emerging theme was expert consultation. The students agreed that consultation with experts in the field would triggered new ideas for their scientific project. Experts included university lecturers and engineers in industry.

Table 25: The sources of a new idea for science project from the students' perspective

Rank	Themes	Frequency (f)
1	Observation	126
2	Reading	92
3	Expert Consultation	20

The second open-ended item was formulated to obtain the students' input on the criteria of a good science project. Table 26 illustrated the emerging themes from the qualitative data. Based on the students' opinions and experience participating in the science project competition, the first emerging theme was beneficial to society. The respondents mentioned that a good science project should provide a solution to a critical problem faced by a community, which eventually solve the societal problem. The second emerging theme was easy-to-use solution. The solution to the problem must be user-friendly and if possible cost-effective. And the final theme emerged from the qualitative data was novelty. Respondents suggested that a good science project that has a significant potential to win a science competition must be new or novel. Novelty would contribute or add to existing corpus of scientific knowledge.

Table 26: Characteristics of a good science project

Rank	Themes	Frequency (f)
1	Beneficial to the society	104
2	Easy-to-use solution	75
3	Novelty	52

The third open-ended items asked about challenges that the students faced in completing their science project competition. Table 27 showed the emerging themes from the qualitative data. The top barrier was time factor. Since science project was not part of the school curriculum, the students who were going to compete in science competition have to find "other times" outside of the regular school schedule to complete their project. The second emerging theme was inadequate science and lab equipment and facilities at their schools. And also the difficulty to obtain permission and access to the nearby university's facilities. Lack of mutual cooperation between the school and the university or research institution was also a significant challenge. The final theme emerged from the data was lack of creativity. The respondents admitted that they were not creative enough to find a novel project topic and thus, it may affect their chance of winning a medal in the science competition.

Table 27: Challenges in winning a science project competition

Rank	Themes	Frequency (f)
1	Time constrain	81
2	Inadequate science facility	38
3	Lack of creativity	32

DISCUSSION OF RESULTS

The purpose of this study was to identify the role of inventive thinking of the Indonesian students in winning science project competition. Based on the empirical data gathered, the discussion in this section would be focused on answering the two main research questions: (a) to identify the inventive thinking of the students based on their demographic factors, and (b) to determine the relationship between inventive thinking and its elements. The survey data from the Likert scale questionnaire found that, in general, the respondents agreed that they possessed several traits of inventive thinking especially − curiosity, adaptability, risk-taking, creativity, and higher-order thinking. But they rated not very highly on self-directed learning. In the context demographic factors, however, there were no significant differences regarding the inventive thinking variables based on gender and the level of schooling.

In elaboration, the key findings of the Likert-based questionnaire showed that curiosity was perceived as an important trait by the students in order to find a good science project topic. This result seemed to be in line with Pathack et al. (2017)'s study who reported that curiosity is needed to explore the environment and to find critical problems to be solved. Moreover, correlational data showed that curiosity is strongly linked to inventive thinking. Another pertinent element of inventive thinking was adaptability. Data from the questionnaires revealed that the students were willing to adapt their research method and materials if they found better ways as advised by their mentor. However, the students were uncertain whether that they were capable of handling multiple tasks when the time was constrained.

Risk-taking was perceived as another critical trait in science project. The students were willing to make mistakes and to revise their project. They were also open to criticism on their project and they were willing to stay after school to work on their project. The results of correlational test between inventive thinking and its factors revealed that inventive thinking has the strongest relationship with higher-order thinking, followed by curiosity, and adaptability. The weakest relationship was between inventive thinking and creativity. Moreover, the regression test showed that the most dominant elements of inventive thinking in the context of science project competition were curiosity and risk-taking.

Next, the respondents believed that they were creative. By reading, they came up with a new idea for their science project. The students also convinced that they have an original and "out-of-the-box" idea. In terms of higher-order thinking, in general, the students believed that they possessed higher-order thinking. They could explain the scientific concept underlying their science project accurately and they built research hypotheses to be tested. Concerning support on research justification, the respondents admitted that they adopted relevant theories to support their research justification. However, the students barely agreed that they compared different theories/models to explain their science project.

In the context of the qualitative data, the main themes emerged from the open-ended items related to selecting project topic were observation, literature review and expert consultation. The first ranked theme deciphered from the qualitative data regarding the source of idea in the science project was observing the surrounding. By observation, the respondents could identify the problems around them and tried to find the potential solution. For example, by observing the polluted environment surrounding their schools, the students obtained a critical idea on how to solve the problem. The second emerging theme was reading. The students believed that they could find new ideas for their science project by reading books, newspapers and scientific journals. The students made use of the internet and printed materials such as books and journals to find information in the scientific articles. Googling on the internet and reading Wikipedia were also included in how the students obtain their new ideas for science projects. Finally, the third emerging theme was expert consultation. The students agreed that consultation with experts in the field would triggered new ideas for their scientific project. Experts were included university lecturers and engineers in industry.

Next, the characteristics of a good project were asked in the open-ended items. The pertinent theme emerged from the open-ended data was that a good science project should be beneficial to society. This finding supports the study by McLaughlin (2013), which stated that the solutions proposed by the students to solve the problems they identified in their daily life, were expected to help other people. Besides the altruistic value, the project should provide easy-to-use or user-friendly tool. Finally, novelty was perceived as important part of the project.

With regard to hurdles or barriers in conducting science project, the major theme derived from the open-ended data was time constraint. The respondents complained about the limited time they had to complete the project due to out of school arrangement must be made to complete the project. The research component would consume significant amount of time spent on the project. The second main hurdle was the lab equipment and facilities. The poor condition of school science lab with old equipment was not viable to conduct proper experiment. Some participants were reported to have used university or research institute facilities to conduct their experiment and to analyze their data. The third challenge in winning a science project competiton was creativity. The respondents lamented that their project was not very creative. This is in line with Triyono and Insih (2015) statement that Indonesian secondary school students lack of research skills, creativity and innovation. Moreover, several studies reported lack of creativity of the Indonesian students in science projects (Noer, 2011; Sugiyanto & Masykuri, 2016). Another study found that lack of creativity in a science project is due to the lack of science skills (Subali, 2011).

Next, looking at the relationships between inventive thinking and its elements provided the evidence of a strong correlation between inventive thinking and higher-order thinking followed by curiosity and adaptability. Moreover, the result from the regression analysis showed that curiosity was one of the dominant factors that affect the achivement in science fair. Similarly, the correlation between inventive thinking and risk-taking was also strong. And the result from the regression showed that risk-taking was one of the dominant factors the influence the winning in science project competition. In general, these findings supported the conceptual framework of the study, which illustrated that curiosity and risk-taking were critical elements of inventive thinking in the context of science project competition. However, the moderator variables – gender and level of schooling were not significant influence on the achievement in science project competition.

NEW FRAMEWORK

Based on the empirical data in this study, a new framework (see Figure 2) was developed to serve as a model for future students who are interested to participate in science project competition or science fair. The critical elements in the new framework were derived from the findings of the study. For example, the quantitative data showed that the important traits that the students must possess to win science project competition included curiosity, adaptability, risk-taking, creativity, and higher-order thinking (HOT). The questionnaire data showed that curiosity was perceived as important trait by the students in order to find a good science project topic. This result seemed to be in line with Pathack et al. (2017)'s study who reported that curiosity is needed to explore the environment and to find crtitical problem to be solved.

Another pertinent element of inventive thinking was adaptability. The data from the questionnaires revealed that the students were willing to adapt their research method and materials if they found better ways as advised by their mentor. Risk-taking was perceived as another critical trait in science project. The students were willing to make mistakes and to revise their project. They were also opened to criticism on their project and they were willing to stay after school to work on their project. Next, the data from the questionnaire showed that creativity was pertinent in inventive thinking. The students also convinced that they have an original idea and that they have "out-of-the-box" idea. Finally, the Likert-based questionnaire data posited the importance of high-order thinking (HOT) in making a good science project. The respondents used HOT to make proper conclusion based on the empirical data. Based on the students' experience in participating a science project competition, they admitted the importance of having sufficient knowledge to win the competition. In addition, the quantitative data from the questionnaire illustrated that inventive thinking was strongly related to higher-order thinking, curiosity, adaptability, and risk-taking. The regression analysis showed that the most dominant elements of inventive thinking which influence the achievement in science project competition were curiosity and risk-taking.

Furthermore, the qualitative data analyzed thematically from the open-ended items revealed several approaches have been used by the respondents to find appropriate topic for their science project including observation, literature review and consultation with experts. In terms of defining what is a good science project, the students indicated three characteristics: clear benefits to society, user-friendly, and novelty. In addition, the open-ended items revealed that there several hurdles in completing science project such as time constraint, lack of facilities and lack of creativity. The students mentioned in the open-ended items that they lacked of creativity, which they admitted as the one of the challenges in science project competition. In the nutshell, based the empirical data, a new framework comprised curiosity, adaptability, risk-taking, higher-order thinking, creativity, benefits to society, facility, and novelty is proposed. Figure 2 shows the new framework contained eight critical factors for projecting a dynamic science project.

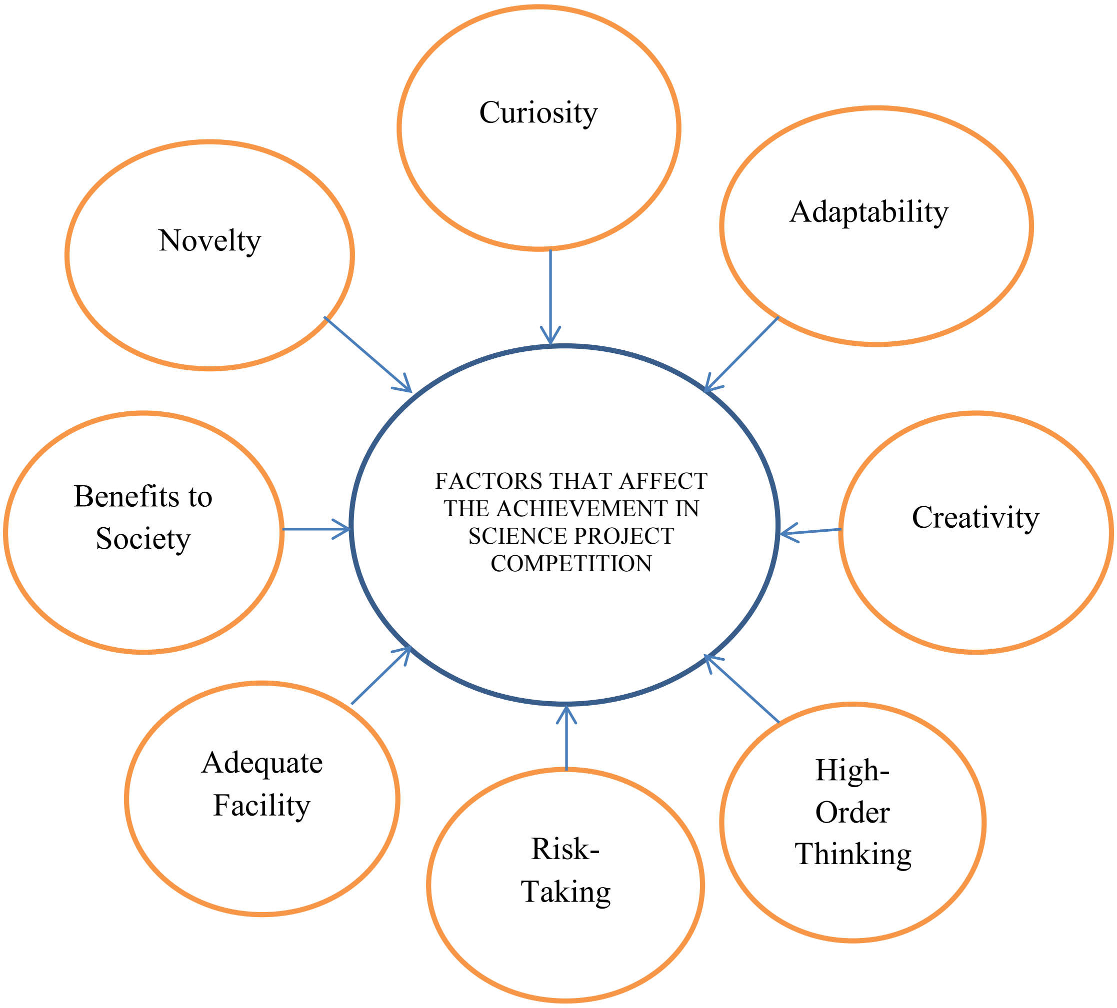

Figure 2: New framework for winning science project competition

CONCLUSION

Based on the empirical data, several conclusions can be derived. In the context of science project competition in Indonesia, the quantitative data showed that inventive thinking could be represented by these traits − curiosity, adaptability, risk-taking, creativity, and higher-order thinking (HOT). However, demographic factors such as gender and level of schooling have no effect on respondents' perception on their inventive thinking. Curiosity could be seen from the ability of the students to observe the surroundings to obtain a new idea with novel solution for their science project. Another pertinent element of inventive thinking was adaptability. Data from the questionnaires revealed that the students were willing to adapt their research method and materials if they found better ways as advised by their mentor. Risk-taking was perceived as another critical trait in science project. The students were willing to make mistakes and to revise their project. Risk-taking in the context of science project competition was associated with the openness of the students in accepting criticism and suggestions. Next, the respondents believed that they were creative. By reading, they came up with a new idea for their science project. The students also convinced that they have an original idea and that they have "out-of-the-box" idea. In terms of higher-order thinking, in general, the students believed that they possessed critical thinking. They could explain the scientific concept underlying their science project accurately and they built research hypotheses to be tested. In terms of the correlational analysis between inventive thinking and its elements, the evidence showed a strong correlation between inventive thinking and HOT followed by curiosity, adaptability, and risk-taking. Moreover, the result from the regression analysis showed that curiosity and risk-taking as the dominant factors that affect the achievement in science competition.

Qualitative data from the open-ended items illustrated that idea-finding was conducted by the students through observation, literature review and expert consultation. The first theme emerged from the qualitative data regarding the source of idea in the science project was observing the surrounding. By observation, the respondents could identify the problems around them and tried to find the potential solutions. The second emerging theme was reading. The students believed that they could find new ideas for their science project by reading books, newspapers and scientific journals. The third emerging theme was expert consultation. The students agreed that consultation with experts in the field would triggered new ideas for their scientific project. Next, the characteristics of a good project were asked in the open-ended items. The pertinent theme emerged from the open-ended data was that a good science project should be beneficial to society. Besides the altruistic value, the project should provide easy-to-use or user-friendly tool. In addition, novelty was perceived as important part of the project. Nonetheless, there were also challenges in conducting scientific work, such as time constraints and inadequate science facility at school. The study also revealed that lack of novelty, low creativity and inadequate facility could adversely affect the robustness of the students' science project. Overall, the empirical data have been used to develop a new framework of the study. The new framework could be used to guide future participants of science fair or science project competition to win medals in science competition. The eight critical elements in the new framework include: curiosity, adaptability, risk-taking, creativity, higher-order thinking (HOT), benefits to society, adequate facility, and novelty.

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