Gender Differences in Students’ Science Literacy towards Learning on Integrated Science Subject

M L Kristyasari¹*, S Yamtinah¹, S B Utomo¹, Ashadi¹, and N Y Indriyanti¹
¹Master program of Science Education, Universitas Sebelas Maret, Indonesia

*Email: christmarli417@gmail.com

Abstract. In the 21st century, science literacy is very important and must be owned by students in all level of education. This study aims to analyse gender differences in the mastery of students science literacy on Integrated Science learning and variations in each science literacy indicators in junior high school. 166 female students and 117 male students 283 from three schools with different school rank in academic achievement participated in the study. The participants were tested for scientific literacy skills using Computerized Two-Tier Multiple Choice (CTTMC) instrument. CTTMC instrument used consists of 20 questions and have been validated. In addition, CTTMC instrument contains five indicators of science literacy: recognizing the scientific question, identifying the evidence, drawing a conclusion, communicating the conclusion, and demonstrating the understanding of these scientific concepts. Overall, the percentage of mastery of science literacy for female students is better than male students. Of the five predefined science literacy indicators, female students have a dominant value on four indicators except drawing a conclusion. While the male students had more dominance in the third indicator, that is the drawing of a conclusion. The results show that students’ literacy skills are influenced by gender differences.

1. Introduction
Gender differences in achievement have been widely reported. Gender is one of the personal variables related to differences found in motivational functioning and in self-regulated learning. Independent learning is a learning environment with the school environment has adequate facilities and infrastructure such as classrooms, laboratory space, and computer lab space. So, that it can support learning activities in schools, especially science learning goes smoothly, and gives a significant impact on improving student learning outcomes, student curiosity, students learning interests, students discipline and gender differences in student attitudes. The study of gender differences in science learning has differentiated between female students and male students in their learning outcomes, their behaviours, and activity in the classroom, the teacher’s exposure to theoretical and practical and teacher leadership in teaching [1, 4]. In addition, other studies have suggested that the school environment may influence teachers’ and students’ perceptions of motivation, attitudes, and aspirations in science learning outcomes [2, 4]. Over the years, much of the literature has supported the difference in attitudes in science learning that are influenced by school level and gender levels, where high-categorical schools show better attitudes than low-categorical schools level [3, 4]. In scientific studies, during the last decade, in math and science lessons gender differences decreased [5]. Male students still have good attitude skills than female students. Male students in high schools take training in math and science lessons aimed at exploring their abilities. The American Association of University has conducted a survey aimed at encouraging female students to become more active in order to compete with male students in math and science lessons [6]. Other literature suggests that it is difficult to separate innate from student behavior or understand the extent to which stereotypes affect individual perceptions and behavioural or cognitive differences [7].

In addition, there are other studies that also address the major differences between the number of boys and girls who pursue their careers in science, math, and engineering [8]. Some argue that gender
differences in career achievement are related to findings that girls have lower visuospatial abilities than boys [9]. Meanwhile, it has also been widely argued that in addition to the boy’s visuospatial abilities, life experiences and response strategies have also been a point that influences cognitive capacity in achieving [10, 11]. So far in the physical sciences, requires students to be able to understand about spatial phenomena [12]. So it is this that causes girls less successful in the field of physics because their ability of visuospatial is very low. There is other evidence that shows consistently higher boys’ performance and interest than girls in physics and in terms of sharing tasks about the components of visuospatial ability [13]. While some argue that this is trivial and produces only very small statistical effects, it is important to realize that what is considered trivial in one’s core capabilities, especially, can turn into a big impact not only in the interest of learning, but also the speed of knowledge accumulated in one’s mind [14].

Now, research that has been done will focus on the mastery of science literacy students, both female students, and male students. Science literacy is a tool used by students in building the concept of science to connect science learning Integrated with the surrounding environment. Science literacy is a tool used by students in building the concept of science and applying theories to real life that we often encounter. Therefore, it is very important for teachers to have a good understanding and mastery of science literacy. However, to define science literacy is not as simple as its meaning. All related to science literacy should be used in several contexts. Science literacy can be expressed scientifically when applied in the context of science, if not applied in the context of science then this skill is only literary. Science literacy is not only used in science content, but also about the process of science and the context of its science applications [15]. In addition, one form of scientific literacy in individuals is sensitive to the progress of science and technology, can identify the impact of actions taken [16], and support the achievement of learning outcomes and learning activities of students in the classroom. A science literate is a person who uses the concept of science, process skills, and values in making day-to-day decisions that relate to others and the environment and understand the interrelation between science, technology, and society including in terms of social and economic development.

In general, science literacy has several components, these components are: able to distinguish which is included in the context of science and which is not a scientific context; understand the parts of science and have a general understanding of the application of science; have the ability to apply science knowledge in problem solving; understand the characteristics of science itself and understand the relation of science to culture; know the benefits and negative impacts caused by science [17]. However, in the 19th century, the literacy component of science changed and became the ability to understand, identify, interpret, create and communicate knowledge by using written materials adapted to varied situations [18]. Thus, it is hoped that science learning should provide knowledge and understanding of science to make students able to understand the reading of science. Mistakes in understanding science readings will lead to errors in understanding science as well. The development of science literacy skills has also been conducted in the United States through research, whose results are used to establish the standard science education that is there. This standard was created with the aim of realizing concrete scientific literacy in American education which in the long run is towards the heyday of science and technology in future [19]. The PISA study, coordinated with the OECD [20], aims to measure achievement of reading literacy, mathematical literacy, and student science literacy.

Characteristics of questions in the PISA test are: does not contain the concept of any curriculum, but is further expanded; the matter of PISA presents some information or data in various forms; learners are asked to process the relationship of information in the matter; the statements that accompany the questions need to be analysed and reasoned; the problem is made in the form of multiple choice, short stuff, and essay; PISA issues include rich application contexts such as personal, community, global, environment and technology [15]. In addition, according to Wenning [21] in his research, the ability of science literacy can be known by measuring the ability of student inquiry. Inquiry means the ability to investigate. Scientific investigation includes several competencies that must be possessed by learners, namely: have a strong curiosity about the problem to be investigated; able to identify the problem to be investigated; using the inductive mindset, so that learners are able to
develop hypotheses; using the inductive mindset, so learners can formulate what possibilities will occur based on the hypothesis that has been prepared; able to design experiments and make observations to test hypotheses; collect data, organize data, and analyze data accurately; able to apply statistical calculations in data processing to make decisions; can logically explain the experimental results if the desired data is not obtained; using technology to communicate its findings. The required scientific literacy measurements are measurements that use standardized test preparation rules. Based on some of the above statements then, in this study using measurement of science literacy assessment according to Holbrook and Rannikmae [17] which consists of five components: recognizing the scientific question, identifying the evidence, drawing conclusion, communicating the conclusion, and demonstrating the understanding of these scientific concepts, where these five components are selected as an indicator of students' science literacy assessment.

Teerada [22] stated that students' science literacy assessment can be done using multiple choice tests, but this test still has limited reliability because it can still produce students who guess answers randomly to get the correct answer and choose a neutral response on a scale rather than an extreme. So that a two-tier diagnostic test instrument was chosen to test the mastery of science literacy. This two-tier diagnostic test instrument is almost similar to the instrument used in this study. The difference lies only in the base used. In the two-tier diagnostic test instrument used by Teerada [22] is still based on paper and pencil while on CTTMC instrument using computerized base. In addition, according to Kanli [23], multi-tier tests can also be used for conceptual understanding and student achievement. From the various thoughts of previous researches stating that measurement of scientific literacy can use two-tier diagnostics test, constructed concepts test, as well as multi-test which are all still done with paper and pencil. Therefore, the researchers currently choose to combine these tests with a computer so that the CTTMC instrument is developed which aims to measure students' scientific literacy and to distinguish between scientific-literacy mastery of female and male students.

2. Method
This study aims to analyze gender differences in the mastery of students science literacy on Integrated Science learning and variations in each science literacy indicators in junior high school. 166 female students and 117 male students 283 from three schools with different school rank in academic achievement participated in the study. The participants were tested for scientific literacy skills using Computerized Two-Tier Multiple Choice (CTTMC) instrument. Computerized Two-Tier Multiple Choice (CTTMC) instrument used consists of 20 questions and have been validated. In addition, Computerized Two-Tier Multiple Choice (CTTMC) instrument contains five indicators of science literacy: recognizing the scientific question, identifying the evidence, drawing a conclusion, communicating the conclusion, and demonstrating the understanding of these scientific concepts.

| No | Science Literacy Indicators | Question | Total Item |
|----|----------------------------|----------|------------|
| 1  | Recognizing the scientific question | 5,10, 15,20 | 4          |
| 2  | Identifying the evidence | 1,2,8,17 | 4          |
| 3  | Drawing conclusion | 3,9,14,18 | 4          |
| 4  | Communicating the conclusion | 7,11,16,19 | 4          |
| 5  | Demonstrating the understanding of these scientific | 4,6,12,13 | 4          |

3. Result and Discussion

3.1. Mastery of Students in Indicators of Science Literacy
An analysis of the mastery of student science literacy based on any predetermined indicator. The result of mastery of science literacy students presented in table 2.

| Indicators | Percentage of Students’ Mastery of Science Literacy in Science-Literacy Indicators |
|------------|-----------------------------------|
|            | High-categorical | Moderate- | Low-categorical |

3
Recognizing the scientific question
Identifying the evidence
Drawing conclusion
Communicating the conclusion
Demonstrating the understanding of these scientific concepts

Table 2 shows the differences in the mastery of science literacy among female students and male students at different school levels. Students in high-categorical schools levels, male students outperform female schools. While in schools with moderate and low categories, the result are inversely related to high-categorical schools level, where female students have a better mastery of science literacy than male students.

Meanwhile, the total percentage mastery of students’ science literacy in each indicator is shown in Table 3.

Table 3. Total Percentage of Students’ Mastery of Science Literacy

| Indicators                                      | Female | Male |
|------------------------------------------------|--------|------|
| Recognizing the scientific question            | 66.83  | 63.32|
| Identifying the evidence                        | 65.78  | 63.63|
| Drawing conclusion                              | 59.95  | 60.69|
| Communicating the conclusion                    | 65.26  | 61.84|
| Demonstrating the understanding of these scientific concepts | 58.56  | 56.98|

Figure 1. Total Percentage of Students' Mastery of Science Literacy Indicators

The results of the science literacy master test consisting of 283 students, 166 female students, and 117 male students showed a clearer difference in each science literacy indicator in three different schools. Female students have better mastery in some indicators such recognizing the scientific question, identifying the evidence, communicating the conclusion, and demonstrating the understanding of these scientific concepts. Meanwhile, male students are better at drawing conclusions. This is because of the high interest of female students. The superiority of female students in the mastery of science literacy also applies across different countries, age groups, survey periods, and study programs on a consistent basis [6]. Fond of reading is one that makes gender differences between female and male students more prominent [7]. The fourth year in the 8th grade of SMP, in
mathematics learning, male and female students have the same result [6, 8, 9]. Achievement of gender differences in science learning is the smallest thing [8]. While performing equally well with male students in most countries, female students tend to have weaker self-concept in science than male students [6, 9]. On average, female students have lower levels of confidence in the mastery of science skills than male students. However, both male and female students, they are equally interested in science learning and there is no overall difference between female students and male students [7].

Nevertheless, reading is still considered important by female students rather than male students in all European countries. Male students in Europe are students who have a very low interest in reading. In addition to the high reading interest factor in female students, there are other factors that influence the result of mastery of science literacy is high spirits, owned by female students in science learning, have a good time management attitude, internal locus for control and wider self-control strategy. Thus, some of these factors make mastery of science literacy for female students better than male students [24, 26]. However, in mathematics and science learning, in most countries, there is no gender difference among achieving students. While in mathematics learning, female students are at a lower level about one-third according to the education system in Europe [7]. Male students are always better at learning mathematics because male students have a high logic power but it also has a high imagination. It is proven, in this study, mastery of science literacy of male students better in drawing a conclusion than female students. The success of male students in drawing a conclusion in science literacy shows that it is true that male students have high imagination and logic [25, 26]. Meanwhile, the overall student literacy mastery results in this study are consistent with data from the Program for International Students Assessment (PISA) which states that mastery of science literacy of female students outperforms male students [27].

3.2. Categories of Students in the Mastery of Science Literacy
In this study, the mastery of student science literacy is divided into the three groups, namely high, medium and low. The result of mastery of science literacy among female students and male students is comparatively shown in table 4.

| Category | Percentage of Students’ Mastery of Science Literacy |
|----------|------------------------------------------------------|
|          | High-categorical School | Moderate-categorical School | Low-categorical School |
|          | Female     | Male     | Female     | Male     | Female     | Male     |
| High     | 62,54      | 68,10    | 32,11      | 36,00    | 16,32      | 24,35    |
| Medium   | 36,77      | 31,43    | 56,32      | 54,33    | 52,11      | 53,91    |
| Low      | 0,69       | 0,48     | 11,58      | 9,67     | 31,58      | 21,74    |
The result in Figure 2, show that mastery of science literacy of male students in high-categorical school is better than female students. This is seen from the percentage of mastery of science literacy obtained is 0.48% mastery of low category science literacy, and 68.10% mastery of high category science literacy while female students have 0.69% mastery of low category science literacy and 62.54% mastery of high category science literacy. Meanwhile, for mastery of medium category science literacy, male students only 31.34% while female students have 36.77%. In medium-category schools, female students have a better mastery of science literacy than male students. Female students have 36.00% mastery of high category literacy and 9.67% mastery of low category science literacy while male students only have 32.11% and 11.58% mastery of low category science literacy. Meanwhile, for the mastery of medium category science literacy, male students have 56.32% while female students have 54.33%. In low-category schools, female students also have a better mastery of science literacy than male students. Female students have 24.35% mastery of high science literacy, 53.91% mastery of medium category science literacy and 21.74% mastery of low category science literacy, whereas male students only have 16.32% mastery of high category science literacy, 52.11% mastery of medium category science literacy and 31.58% mastery of low category science literacy.

Based on observations, these three categories of schools have used a scientific approach. The approach is something that cannot be separated from the learning activities. The purpose of this approach is to encourage students to be more active in science learning in the three representative schools, different results are obtained. In high-categorized school, male students tend to be more active than female students and male students’ achievement is also higher than for female students. Whereas in middle and low categorized schools, female students have higher and more active achievement than male students.

This condition is also in line with the result of mastery of students’ science literacy shown in Figure 2, where female students in medium and low categorized schools have a better mastery of science literacy than female students in high-categorized school. This can happen because medium and low-grade schools provide more opportunities for female students to be more activities, especially in Integrated Science Learning. In addition to the approach, learning activities cannot be separated from the assessment process. The assessment process is the final stage that has a great influence on learning activities, can be used to motivate students and facilitate them in improving understanding and skills.
The study of differences in learning outcomes between female students and male students can use different instruments, namely constructed respond, multiple choice and multi-tier test [23, 28].

The result of research using constructed respond and multiple choice instrument shows that constructed responded instrument is better than multiple choice. This can be seen from the results of student achievement. Results of student achievement with constructed respondents higher, while with multiple choice of student achievement becomes low. This is because the student when answering the problem with multiple choice types is mostly by guessing [23] while using multi-tier tests indicates that student achievement increases. The results of these three categories of schools are 52.9% from high-category school, 75.2% of schools are in medium-category and 71.9% from low-category school [22]. The condition is in accordance with the result of this study, where female students in high-categorized schools have a lower percentage of mastery of science literacy using CTTMC instruments than female students in moderate and low categorized schools. From the results of this study, both the percentage mastery of science literacy of female students and male students in general and the percentage of female students and male students based on the category of schools can be concluded that the use of appropriate and innovative strategies in making the instrument and its content can minimize the existence of gender differences in science literacy.

4. Conclusion
Based on the results of research, it can be concluded that there are differences in the mastery of science literacy among female students and male students. Overall, the mastery of science literacy of female students outperformed male students. This is evident from the five indicators of science literacy used, female students are able to master the four indicators that are recognizing the scientific question, identifying the evidence, communicating the conclusion, and demonstrating the understanding of these scientific concepts. The male students are only able to master one indicator that is drawing a conclusion. In high-categorized schools, the percentage of female students is lower than male students while for the middle and lower category, the percentage of female students is higher than the male students. Besides that, mastery of science literacy of female students in low-category school and medium-category school is better than high-category school. The CTTMC instrument can be used as an alternative to gender-based instruments, scientific literacy and able to minimize differences in learning achievement.

5. Acknowledgments
The authors would like to thanks Institute of Research and Community Service (LPPM), Universitas Sebelas Maret, Surakarta, Indonesia for providing grant funding for the research through The Research Group 2018.

6. References
[1] Y. Doppelt, Learning Environments Research, 7, 271-293, 2004.
[2] S.L. Huang, and B.J. Fraser, Journal of Research in Science Teaching, 46, 404-420, 2009.
[3] N. Mattern, and C. Schau, Journal of Research in Science Teaching, 39, 324-340, 2002.
[4] S. Yamtinah, M. Masykuri, Ashadi, and A.S. Shidiq, American Institute of Physics Conference Proceedings, 1868, 030003, 2017.
[5] I.V.S. Mullis, and S.E. Stemler, In. D.F. Robitaille & A.E. Beaton (Eds.), Secondary Analysis of the TIMSS data, pp. 277-290, 2002.
[6] S.M. Reis, and S. Park, Journal for the Education of the Gifted, 25(1), 52-73, 2001.
[7] A. Vassiliou, Gender Differences in Educational Outcome: Study on the Measures Taken and the Current Situation in Europe, Eurydice, pp. 15-32, 2010.
[8] C.P. Benbow, D. Lubinski, D.L. Shea, and H. Eftekhari-Sanjani, Psychological Science, 11(6), 474-480, 2000.
[9] D.F. Halpern, C.P. Benbow, D.C. Geary, R.C. Gur, J.S. Hyde, and M.A. Gernbacher,
Psycological Science in the Public Interest, 8(1), 1-51, 2007.

[10] D.T. Burkham, V.E. Lee, and B.A. Smerdon, American Educational Research Journal, 34(2), 297-331, 1997.

[11] M. Hirnstein, U. Bayer, and M. Hausmann, Learning and Individual Differences, 19(2), 225-228, 2009.

[12] C.S. Carter, M.A. LaRusso, and G.M. Bodner, Journal of Research in Science Teaching, 24, 645-657, 1987.

[13] P.L. Ackerman, Journal of Applied Psychology, 77(5), 598-614, 1992.

[14] J.S. Hyde. And M.C. Linn, Science, 314, 599-600, 2006.

[15] OECD, Knowledge, and skills for life: First result from PISA 2000. Paris, OECD, 2001.

[16] J.D. Miller, In Science and the Educated American: A core component of liberal education, John G. Hildebrand and Jerrold Meinwald (Eds.), Cambridge, MA: American Academy of Arts and Sciences, pp. 241-255, 2010a.

[17] J. Holbrook, and M. Rannikmae, International Journal of Environmental and Science Education, 4(3), 275-288, 2009.

[18] A. Schleicher, Securing quality and equity in education: Lessons from PISA.UNESCO IBE, 2010.)

[19] J.D. Miller, In Science, Technology, and Society: A Sourcebook on Research and Practice, David D. Kumar and Daryl E. Chubin (Eds.). New York: Plenum Press, 21-47, 2000.

[20] Program for International Students Assessment (PISA), OECD Publications, 2015.

[21] Wenning, Journal of Physics Teacher Education Online, 4(2), 21-24, 2007.

[22] T. Longsiri, S. Vanitchung, M. Boonprakob, and C. Dahsah, International Conference New Perspectives in Science Education, pp. 111-114

[23] U. Kanli, Science Education International, 26(2), 148-165, 2015.

[24] C.A. Sanchez, and J. Wiley, Learning and Individual Differences, 20, 271-275, 2010.

[25] G.M. Faitar, and S.L. Faitar, Procedia-Social and Behavioral Sciences, 106, 1265-1270, 2013.

[26] S.D. Ghazvini, and M. Khajehpour, Procedia-Social and Behavioral Sciences, 15, 1040-1045, 2011.

[27] OECD, Reading for change: Performance and engagement across countries: result from PISA 2000. Paris OECD, 2002.

[28] A.J. Weaver, and H. Raptis, Journal of Science Education and Technology, 10, 115-126, 2001.