Science Process Skills Based on Genders of High School Students

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Abstract. The 21st-century learning emphasizes the students’ ability to find out for a variety of sources, formulate a problem, think analytically, cooperation and collaborate in solving problems. Science process skills are essential competencies that must be achieved in the 21st century. These skills can also assist students in logical thinking, asking rational questions, and solving problems in their everyday life. The current research aimed to investigate the level of senior high school students’ science process skills. This research was a survey which involved four public senior high schools (SMAN), namely SMAN 4 Malang, SMAN 7 Malang, SMA 8 Malang, and SMAN 1 Turen. The research data were analyzed using an unpaired t-test. The results of the analysis showed that there was a difference between the male students’ science process skills and the female students’ science process skills (p 0.002). It was reported that 23% of the female students had achieved criteria 1 and around 34% had accomplished criteria 2. On the other hand, 26% of the male students had attained criteria 1 and only 17% of them had performed criteria 2. These findings suggest that an innovative learning model needs to be applied to empower the students’ science process skills.

1. Introduction
Education in the 21st century aims to create new learning standards that require a new generation of students to be highly knowledgeable and skillful. The 21st century is known as the century of science, of which emergence was marked by the massive transformation of the agrarian society into the industrial and knowledge societies [1]. To achieve success in the 21st century, students need to master certain skills and acquire abundant knowledge. They have to be prepared to compete in the workplace, become a good citizen, and face various life challenges [2]. The 21st-century learning is thus focused on encouraging learners to master particular skills that can help them to be more responsive to changing social patterns. One of the skills that need to be learned by the students is science process skills.

Science process skills involve cognitive and investigation skills as well as an understanding of methods and procedures to perform a scientific study. These skills should be applied to collect knowledge, conduct an experiment, write field notes, analyze data, and interpret research results [3]. Science process skills are thinking abilities that can be used to obtain information [4]. These skills are
also illustrated as mental and physical abilities used in problem solving and individual and social development [5].

Science process skills are the competencies that need to be mastered and implemented by students through physical and mental activities to generate a more effective science learning [6, 5, 7]. Students need to promote science process skills in order to be able to do a scientific investigation and acquire more meaningful learning experiences [8]. Science process skills can be divided into two types: basic and integrated [5]. The basic science process skills comprise fundamental concepts in science learning which are usually taught to primary school students [9, 10, 5] while the integrated science process skills are commonly used to learn higher levels of science [11, 7]. Both basic and integrated science process skills can be taught to senior high school students [5]. The indicators of the basic process skills include observing, clarifying, measuring, using numbers and space-time relationships, and communicating while the integrated science process skills consist of identifying and controlling variables, interpreting data, formulating hypotheses, defining operationally, and experimenting [8].

Students’ lack of process skills has been a significant problem that requires attention and solutions. Some literature has revealed that students’ process skills in Indonesia, especially in biology learning, have not been well developed [12, 13]. Even, some studies have proven that the majority of senior high school students in this country cannot perform satisfactory process skills. Besides, the educators are also faced with various challenges during practicum, including the inability of the students to follow instructions provided by the instructor and thus misunderstand the objectives of the practicum [14, 15].

There has been a paradigm shift in education that perceives men and women as equal in learning [16]. It is believed that there is no significant difference between male and female in terms of their intelligence in general although, in some aspects, male students are probably more skillful than female students or vice versa [17]. However, a gender stereotype which says that male students can achieve better than female students is still popular among teachers or educators.

Distinguished features of male and female, such as biological structures and life roles developed through a particular culture or a specific environment, are called gender [18]. Gender in education is rarely discussed. In fact, the study of gender may help us to rethink about the division of roles that have been considered as inherent in women and men to build a dynamic and stable picture of gender relations that match with the reality that exists in society [18]. Research has unveiled that there is a correlation between gender and students’ learning achievement and skills [19].

In addition, previous study findings also suggest a connection between gender and science process skills. One of them has shown that there is a difference in science process skills between male and female students [20]. It has been reported that female students could perform better in science process skills compared to male students [21].

The current research aimed to investigate senior high school students’ science process skills based on gender. The levels of the students’ process skills were considered as the criteria to evaluate whether the students’ science process skills had improved significantly or not. The findings, thus, can be referred to as a foundation to prove that an innovative learning process needs to take place in the classroom.

2. Method
The present research was designed as a survey which employed a descriptive qualitative approach. This approach was used to carefully observe particular individuals or groups in a particular situation that has been occurring [22]. The participants of this research came from 23 Public Senior High Schools (SMAN) which are located in Malang, East Java, Indonesia. The research subjects were selected using random sampling method. Consequently, there were 142 eleventh graders (61 males and 81 females) chosen as the representatives of four public senior high schools, namely SMAN 4 Malang, SMAN 7 Malang, SMAN 8 Malang, and SMAN 1 Turen.

An essay test was distributed to the participants to measure their science process skills. The test was developed based on topics related to Fungi. It consisted of eight items modified from [8, 23]. Prior
to the examination, the content validity and construct validity of the instrument was examined. The results of the validity and reliability tests of the instrument were presented in Table 1 and Table 2.

Table 1. The Results of the Instrument Validity Test

| Items | Pearson Correlation | Sig. (2-tailed) | Remarks |
|-------|--------------------|-----------------|---------|
| Number 1a | 0.299 | 0.1587 | Valid |
| Number 1b | 0.400 | 0.1587 | Valid |
| Number 2a | 0.412 | 0.1587 | Valid |
| Number 2b | 0.651 | 0.1587 | Valid |
| Number 3a | 0.628 | 0.1587 | Valid |
| Number 3b | 0.661 | 0.1587 | Valid |
| Number 4a | 0.556 | 0.1587 | Valid |
| Number 4b | 0.619 | 0.1587 | Valid |

Table 2. The Result of the Instrument Reliability Test, showing 0.766 as the alpha value of the instrument’s reliability

| Cronbach’s Alpha | N of items |
|------------------|------------|
| 0.766            | 8          |

Following is an example of the essay test’s item (No. 3):
The *Plutella xylostella* larvae or the cabbage leaf eaters can be destroyed by using the solution extracted from *Beauveria bassiana*, a fungus from *Deuteromycotina* class. Spores sprayed on the cabbage plants will attach to the larvae and within 3–5 days both the adult insects and the larvae are going to lay rigid with the whole body covered in white fungus and die. The fungus intersects with the cuticle skin of the insects, then *Conidia* will enter through the spiracles and holes to their body and thus allows the hyphae of the fungus to grow in it.

a. Based on the text above, explain the role of *Beauveria bassiana*!
b. What do you think is the impact of the pest’s eradication treatment on the environment?

The participants were asked to answer eight questions. Their answers were analyzed using a rubric modified from [8,23]. Not all the indicators of science process skills can be measured by a written test. Therefore, only three indicators were covered in the essay test: classifying, performing procedures, and analyzing data. The scores ranged from 0 to 4. The categories of the scores can be explained as follows: (0) unclear or undeveloped, (1) less developed, (2) start to develop, (3) well developed, and (4) very well developed. To investigate the difference between male and female students’ science process skills, an unpaired t-test was performed.

3. Findings and Discussion

3.1 The Description of the Students’ Science Process Skills Based on the Criteria of the Science Process Skills

Table 3 presented the criteria of the students’ science process skills. Findings of the research indicated that 70 out of 142 students (49%) possessed less developed science process skills and 72 (51%) students belonged to the “start to develop” category. Science process skills are not only useful in science learning, but also in any type of situation that requires critical thinking. These skills help an individual to think logically to find a solution to his/her problems [24].
Table 3. The Results of the Analysis on Students’ Science Process Skills Based on the Science Process Skills Criteria

| Criteria                | Gender | Number of Students | Percentage | Sum of percentage |
|-------------------------|--------|--------------------|------------|-------------------|
|                         | Male   | 0                  | 0          | 0%                |
|                         | Female | 0                  | 0          | 0%                |
| 4 (Very well developed) | Male   | 0                  | 0          | 0%                |
|                         | Female | 0                  | 0          | 0%                |
| 3 (Well developed)      | Male   | 0                  | 0          | 0%                |
|                         | Female | 0                  | 0          | 0%                |
| 2 (Start to develop)    | Male   | 24%                | 17%        | 51%               |
|                         | Female | 48%                | 34%        |                   |
| 1 (Less developed)      | Male   | 37%                | 26%        | 49%               |
|                         | Female | 33%                | 23%        |                   |
| 0 (Unclear or undeveloped) | Male | 0                  | 0          | 0%                |
|                         | Female | 0                  | 0          | 0%                |
| Total                   |        |                    |            | 100%              |

The results of the research suggested that 49% students possessed less developed science process skills indicated by their inability to answer questions related to data analysis. Here are the instances of the students’ responses to question no. 3:

Student AMR: “a) Beauveria bassiana plays a role as a pesticide or an eradicator; b) The soil is not fertile because the earthworms are dead”. Student AKB wrote almost similar answers as follows: “a) Beauveria bassiana is used as a pesticide; b) The soil is not too fertile.

Followings are the examples of the students’ answers that indicated the students’ inability to analyze data. Student SL as follows: “a) The role of Beauveria bassiana in agriculture is to eradicate the cabbage pests; b) The quality of the cabbage may decrease if the plant is sprayed with the Beauveria bassiana solution”.

Around 51% of the students started to develop their science process skills, indicated by their lack of ability in providing reasonable answers. In fact, in order to be able to analyze data, students need to develop skills or abilities to solve problems based on theories and logical thinking [8]. Followings are the examples of the students’ answers that indicated the students’ inability to analyze data. Student IA “a) The role of Beauveria bassiana is to kill Pluttella xylostella larvae, eradicating pests for cabbages; b) Positive because it does not pollute the environment; besides, the use of the fungus will not decrease the quality of the cabbages. Likewise, MYIR answered: “a) [Beauveria bassiana] is the eradicator of the pests, it is a natural pesticide; b) The environment will not be polluted because Beauveria bassiana does not produce harmful chemical waste.

The data indicated that the science process skills of the senior high school students in Malang were still low. This phenomenon could be influenced by many factors, including 1) the teachers’ lack of science process skills; 2) the unavailability of learning materials that can promote students’ science process skills; 3) the unavailability of guidance to assist teachers in developing tools to assess students’ science process skills [25].

Science process skills are important in problem solving [5], critical thinking, decision making, solution finding, and satisfaction seeking [23]. Science process skills help students to be more creative and to develop their scientific attitudes and achieve success in science learning [7]. Therefore, teachers need to promote these skills in students so that they can learn the basic concepts of science thoroughly.

Students’ science process skills can be developed through scientific investigation [7]. Science skills also help students to understand science concepts better by combining knowledge and thinking skills to learn an object [26]. Science process skills facilitate science learning, produce more active learners, developing learners’ thinking skills and communication abilities [27].
3.2 The Description of the Students’ Science Process Skills Based on Gender
The results of the unpaired t-test showed that there was a difference between the male and female students’ science process skills (p 0.002). Table 3 indicated that the average score achieved by the female students was higher than that obtained by the male students.

| Gender | Mean   | Std. Deviation | Std. Error Mean | N    |
|--------|--------|----------------|-----------------|------|
| Male   | 9.9180 | 4.27510        | .54737          | 61   |
| Female | 12.0617| 3.89341        | .43260          | 81   |

Table 3 suggested that female students performed better in science process skills compared to the male students. This finding is in line with the previous related study that successfully proved that the female students’ science process skills were much better than the male students’ science process skills [28]. The female students’ science examination scores improved significantly [29]. A study conducted on the correlation between students’ attitudes towards science and students’ achievement in science revealed that female students showed more positive attitudes towards science, thus achieved higher scores compared to male students [10]. Research has unveiled that female students are more careful and more thorough than male students. Female students have a greater tendency to repeatedly check their work results. They also possess a better ability to debate even though in solving a problem, male and female students will use similar methods [30]. Female students like to ask for the second opinion before coming to a conclusion [31]. They are also more competitive than male students who prioritize dependence on learning [32].

On the other hand, some other research findings suggested that male students possessed better science process skills than female students [33]. The research showed that gender had no effect on mathematics, communication, science, and aggression [34]. There was no significant difference between male and female science process skills [35]. As a matter of fact, male students are more superior in science and mathematics but female students will perform better in a more feminine subject, such as art and music [36]. Male and female students also differ in basic, casual, experimental, and science process skills. Male students are more skillful in basic, casual, and experimental process skills compared to female students [37].

3.3 Promoting Science Process Skills in Students through Learning Models
Science process skills are one of the thinking skills that are often used by an individual in facing challenges in everyday life [38]. Motivation is a factor that may influence students’ achievement in science process skills [39]. Teachers also play a crucial role in determining students’ success in learning at schools [40].

Teachers are responsible for preparing to learn; organizing classroom activities, and interacting with students. Most importantly, the teachers need to maintain a good interaction with students during the learning process [41]. Teachers must possess the knowledge and skills needed to plan and carry out learning experiences [42]. Teachers are required to be able to design and create a biology learning process that is able to develop students’ science process skills.

Innovative learning models are needed to empower students’ science process skills [43]. Science process skills can be developed by involving students in authentic learning activities [44]. The use of inquiry learning models can significantly improve students’ science process skills and attitudes [45]. It was reported that eighth graders were more successful in acquiring science process skills and had more positive attitudes toward science using cooperative learning models than using traditional methods [3].

Inquiry-based learning combined with Student Team Division learning model can improve students’ science process skills [46]. Research has unveiled that activity-based methods have several effects on students’ achievement in science process skills [47]. Process skills need to be developed through direct experiences because through direct experiences allow students to better appreciate the
process or activity being carried out in the classroom [48]. Science process skills are important in problem solving [23], therefore it is also necessary to apply problem-based learning in order to improve students’ science process skills. One of the examples of the problem-based learning models that had been proven feasible by the experts is RICOSRE (Reading, Identifying the Problem, Constructing the Solution, Solving the Problem, Reviewing the Problem Solving, and Extending the Problem Solving) [49].

4. Conclusions
The findings of the study showed that the science process skills of senior high school students in Malang started to develop. There was a difference found between the male and female students’ science process skills. It was reported that female students could achieve significantly higher scores than male students. Even so, the students’ science process skills still need to be improved by implementing an innovative learning model.

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References
[1] Arsad NM, Osman K, Soh TMT 2011 Instrument Development for 21st Century Skills in Biology Procedia Social and Behavioral Science 1470-1474
[2] Zubaidah S Pembelajaran Abad 21 2016 In Seminar Nasional Pendidikan dengan tema “Isu-isu Strategis Pembelajaran MIPA Abad 21 Sintang Kalimantan Barat STKIP Persada Khatulistiwa
[3] Balgin I 2006 The Effects Of Hands-On Activities Incorporating A Cooperative Learning Approach On Eight Grade Students’ Science Process Skills And Attitudes Toward Science Journal of Baltic Science Education 1 27-37
[4] Karamustafaoğlu S 2011 Improving the Science Process Skills Ability of Science Student Teachers Eurasian J. Phys. Chem. Educ. 3 26-38
[5] Akinbobola AO, Afolabi F 2010 Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria Bulgarian Journal of Science and Education Policy (BJSEP) 4 32-47
[6] Semiawan C, Tanyong AF, Belen S, Matahelemudal Y, Suseloardjo W 1992 Pendekatan Keterampilan Proses (Jakarta: Gramedia Wijasaran Indonesia)
[7] Ergul R, Simsekli Y, Calis S, Ozdilek Z, Gocmencelebi S, Sanli M 2011 The Effect Inquiry-Based Science Teaching on Elementary School Students Science Process Skill and Science Attitude Bulgarian Journal Of Science And Education Policy Education 5 48-68
[8] Harlen W, Elstgeest J 1992 Unesco Sourcebook for Science in The Primary School (Paris: UNESCO Publishing)
[9] Chain SE, Evans JM 1990 Sciencing an involvement Approach to Elementary Science Methods (Columbus: Memai Publishing Co)
[10] Warters YB, Soyibo K 2011 An Analysis of High School Students’ Performance on Five Integrated Science Process Skills Journal Research in Science & Technological Education 19 72-83
[11] Brotherton PN, Preece PF 1995 Science Process Skills: Their nature and interrelationships Research in Science & Technological Education 13 5-11
[12] Rokhmatika S, Harlita, Prayotno BA 2012 Pengaruh Model Inkuiri Terbimbing Dipadu Kooperatif Jigsaw terhadap Keterampilan Proses Sains Ditinjau dari Kemampuan Akademik Jurnal Pendidikan Biologi 4 72-83

[13] Naimnule L 2018 Pengaruh Model pembelajaran Inkuiri Dipadu Model Pembelajaran REACT Terhadap Peningkatan Keterampilan Proses sains, Kemampuan Metakognitif dan Berpikir kritis (Pascasarjana Universitas Negeri Malang, Malang)

[14] Maghfiroh N 2006 Pengaruh Project Based Learning Terhadap Keterampilan Proses sains, Motivasi Belajar dan Berpikir Kreatif Siswa (Pascasarjana Universitas Negeri Malang, Malang)

[15] Faridah A 2017 Pengembangan Pembelajaran Biologi Berbasis Inkuiri Dan Fjbl Bersumber Belajar Potensi Lokal Untuk Meningkatkan Pemahaman Konsep, Keterampilan Proses Sains, Dan Sikap Ilmiah Siswa Kelas X SMA Mazraatul Ulum Lamongan (Pascasarjana Universitas Negeri Malang, Malang)

[16] Mutisya S, Rotich S, Rotich P 2013 Conceptual Understanding Of Science Process Skills And Gender Stereotyping: A Critical Component For Inquiry Teaching Of Science In Kenya’s Primary Schools Asian Journal of Social Sciences & Humanities 2 359-369

[17] Mahanal S 2009 Strategi Pembelajaran Biologi, Gender dan Pengaruhnya Terhadap Kemampuan Berpikir Kritis Proceeding of IX Pendidikan Biologi FKIP UNS National Seminar 179-184

[18] Jager PD 2015 The Effects of Gender and Competition on Performance The Huron University College Journal of Learning and Motivation 53 26-34

[19] Niderle M, Vesterlund L 2011 Gender and Competition Annual Review of Economics 3 601-630

[20] Abungu HE, Okere MI, Wachanga SW 2014 The Effect of Science Process Skills Teaching Approach on Secondary School Students’ Achievement in Chemistry in Nyando District, Kenya Journal of Educational and Social Research 4 359–372

[21] Hamdani 2017 Deskripsi Keterampilan Proses Sains Mahasiswa Calon Guru Fisika Jurnal Pendidikan Matematika dan IPA 8 43-51

[22] Singarimbun M 2002 Metode Penelitian Survei (Jakarta: LP3S)

[23] Sheeba MN 2013 An Anatomy Of Science Process Skill In The Light Of The Challenges To Realize Science Instruction Leading To Global Excellence In Education Education Confab. 2 108-123

[24] Vitti D, Torres A 2006 Practicing Science Process Skills at Home (Virginia: VA Pub)

[25] Sukarno, Permanasari A, Hamidah I 2013 The Profile of Science Process Skill (SPS) Student at Secondary High School (Case Study in Jambi) International Journal of Scientific Engineering and Research (IJSER) 1 79-83

[26] Simsek, Kabapinar 2010 The Effects of Inquiry-based Learning on Elementary Students’ Conceptual Understanding of Matter, Scientific Process Skills and Science Attitudes Procedia Social and Behavioral Sciences 2 1190-1194

[27] Simon M, Zimmerman J 2011 Science and Writing Science and Children 3 7-8

[28] Zeidan AH, Jayosi MR 2015 Science Process Skills and Attitudes toward Science among Palestinian Secondary School Students World Journal of Education 19 133-145

[29] Santrock JW 2014 Psikologi Pendidikan (Jakarta: Salemba Humanika)

[30] Rasiman 2015 Leveling OF Students’ Critical Ability In Solving Mathematics Problem Based On Gender Differences International Journal of Education and Research 3 307-318

[31] Wood JT 1994 Gendered lives: Communication, Gender, and Culture (Belmont CA: Wadsworth Pub)

[32] O’Faithaigh M 2000 The social interaction learning styles of Irish adult learners: Some empirical findings. U.S. (United States Of America: ERIC)
[33] Chabalengula VM, Mumba F, Mbewe S 2012 How pre-service teachers’ understand and perform science process skills Eurasia Journal of Mathematics, Science and Technology Education 8 167–176

[34] Hyde JS 2005 The gender similarities hypothesis American Psychologist 60 581–592

[35] Saracoglu S, Boyuk U, Tanik N 2012 Scientific Process of Primary and Secondary School Students Skill Levels Turkish Journal of Science Education 9 83-100

[36] Elliott S, Kratochwill R, Cook JL 2000 Educational psychology: Effective Teaching, Effective Learning, Third Edition (United State of America: McGrawhill Companies, Inc)

[37] Hazir A, Turkmen L 2008 The fifth-grade primary school students’ the levels of science process skills Ahmet Keleşoğlu Eğitim 26 81-96

[38] Aydogdu B, Erkol M, Erten N 2014 The Investigation of Science Process Skills of Elementary School Teacher in Term of Some Variable: Perspectives from Turkey Asia-Pacific Forum on Science Learning and Teaching 15 1-28

[39] Ghassan S 2007 Learning difficulties in Chemistry: An overview Journal of Turkish Science Education 2 2-20

[40] Marzano R, Pickering D, Pollock J 2001 Classroom instruction that works: research-based strategies for increasing student achievement (Alexandria: Association for Supervision and Curriculum Development)

[41] Harlen W 2000 Teaching, learning and assessing science (London: Paul Chapman Publishing)

[42] Zubaidah S, Corebima AD, Mahanal S, Mistianah M 2018 Revealing the Relationship between Reading Interest and Critical Thinking Skills through Remap GI and Remap Jigsaw International Journal of Instruction 11 41–56

[43] Zubaidah S 2017 Pembelajaran Kontekstual Berbasis Pemecahan Masalah Untuk Mengembangkan Kemampuan Berpikir Kritis Makalah disampaikan pada Seminar Nasional dengan tema Inovasi Pembelajaran Berbasis pemecahan Masalah dalam Pembelajaran Biologi di Universitas Muhammadiyah Makasar 1-17

[44] Keys C, Bryan L 2015 Co-constructing Inquiry-based Science with teachers: Essential research for lasting reform Journal of Research in Science 25 6631-6645

[45] Remziye Y, Sevgul Z, Meral 2011 The effects of inquiry-based science teaching on elementary school students’ science process skills and science attitudes Bulgarian Journal of Science and Education Policy (BJSEP) 5 1-10

[46] Prayitno BA, Corebima AD, Susilo H, Zubaidah S, Ramli M 2017 Closing the Science Process Skills Gap Between Students with High and Low-Level Academic Achievement Journal of Baltic Science Education 16 266–277

[47] Turpin T, Cage B 2004 The Effects Of An Integrated, Activity-Based Science Curriculum On Student Achievement, Science Process Skills, And Science Attitudes Electronic Journal of Literacy through Science 312-324

[48] Rustaman NY 2003 Strategi Belajar Mengajar Biologi (Bandung: Jurusan Pendidikan Biologi FMIPA UPI)

[49] Mahanal S, Zubaidah S 2017 Model Pembelajaran Ricosre yang Berpotensi Memberdayakan Keterampilan Berpikir Kreatif Jurnal Pendidikan, Teori, Penelitian, dan Pengembangan 2 676-685