Student’s achievement in Lawson’s classroom scientific reasoning (LCTSR): the effect of gender and age on scientific reasoning ability

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Abstract. Scientific reasoning is currently considered the central goal for development of 21st century people. Scientific reasoning is important factor in science learning. This study aims to examine the effect of gender and age influenced student’s scientific reasoning ability. This research was a descriptive quantitative. The samples of the result were 200 students (female=100, male=100) on first year physics education class of Tadulako University in Palu, Indonesia with the age range was 18-20 years old. The data on student’s scientific reasoning ability were taken from a multiple choice test on scientific reasoning ability using Lawson Classroom Test of Scientific Reasoning (LCTSR). Lawson was administered to investigate students’ scientific reasoning ability in six constructs namely (1) Conservation of Mass and Volume, (2) Proportional Thinking, (3) Control of Variables, (4) Probabilistic Thinking, (5) Correlational Thinking, and (6) Hypothetical-deductive Reasoning. The results showed that no statistical difference between male and female scientific reasoning mean’s scores were observed. The gender and age do not significantly impact on students’ scientific reasoning ability for each construct. In addition, the lowest mean score for the students’ reasoning ability for both genders was control of variable.

1. Introduction

Students of twenty first century learning need integrated understanding of science learning great idea such as scientific reasoning ability. Scientific reasoning is examined in terms of a set of basic reasoning skills that are commonly needed for students to successfully in science learning. Scientific reasoning which includes exploring a problem, formulating and testing hypotheses, manipulating and isolating variables, and observing and evaluating the consequences [1]. The scientific reasoning skills is assessed by Lawson’s Test of Scientific Reasoning (LTSR). LCTSR provides a solid starting point [2]. The test is a small set of dimensions, namely (1) conservation of matter and volume, (2) proportional reasoning, (3) control of variables, (4) probability reasoning, (5) correlation reasoning, and (6) hypothetico-deductive reasoning [3]. These skills are important concrete components of the broadly defined scientific reasoning ability [4]. Several studies in the field of science education about
relationship between reasoning ability and learning achievement indicating that people's reasoning abilities can be used to solve and pinpoint problems appropriately.

Scientific reasoning with the logical thinking and correlated strongly and contribute significantly to the learning values and can be assessed by gender and age. Some factors that influence students in learning are gender, the effective characteristics of the students. Many research on the effect of gender on scientific reasoning ability that identifies differences in reasoning abilities in female and male. The effect of gender and grade levels on students' reasoning abilities indicates that male score higher than female in proportional, probabilistic and combinational reasoning, while female have higher scores on control and correlation variables [5]. In addition there are statistically significant gender differences in support of male for proportional reasoning [5]. Another study showed that some male students at the Logical Thinking Test (TOLT) were significantly higher than female students [6] Research that investigates the reasoning ability of Cypriot's 12th grade students in relation to gender shows that male perform far better than female on probabilistic reasoning items and female have a higher achievement than male, regarding student's achievement [7]).

Aspects that influence students' understanding of the concept of science and attitudes toward science such as reasoning ability and gender are of particular interest to many studies [6, 8–10]. Furthermore, other studies reported that male and female reached the same level on this standard size until high school years, when male began to have a lasting advantage until [11]. On the other hand, there are significant gender differences regarding the achievement of science [12]. Other studies have revealed significant gender differences in biological achievements that support [12] Female have significantly higher scientific reasoning abilities in completing tasks where content is taken from biological sciences and the task is a written assignment that assesses the science skills of [13] Male, however, were found to have greater success in physics. Female have a much higher achievement than male, regarding student achievement [7][14].

Gender differences in significant scientific reasoning [12, 14]. [15] reveals that male and female exhibit different scientific reasoning profiles [16]. In the gender context the resulting scientific reason shows that the problem solving done by male is better than the female. [12] reported that male can find, build and use theory on aspects of scientific reasoning better than women. Similarly, males perform far better than female in probabilistic reasoning [7] [14]. Gender-related studies have different results. In contrast to some of the above studies, the results of this study show that there is no significant difference in punishment between male and female. [14], [16], [17] found that there was no significant difference to gender-based scientific ability at Lawson's Law of Reasoning Test. substantial deficiencies in students' abilities associated with proportional reasoning items[7]. The results found no significant differences found.

Scientific reasoning is the ability to define science questions, plan ways to answer questions, analyze data, and interpret results [18]. Women perform better than men in scientific reasoning with topics related to biology [5] [19] [20] but the case turns on topics related to scientific reasoning on the topic of physics [8], [9]. As a result, Lawson's general conclusion about reasoning abilities is that the patterns of reasoning (undetermined real nature) do develop in adolescence, at least in some students, and play an important role in the ability to reason in science and to build the concept of science[10], [21]. scientific reasoning is the ability to define science questions, plan ways to answer questions, analyze data, and interpret results [18]. Female perform better than male in scientific reasoning with topics related to biology [5] [19] [20] but the case turns on topics related to scientific reasoning on the topic of physics [8] [9].

As a result, Lawson's general conclusion about reasoning abilities is that the patterns of reasoning (undetermined real nature) do develop in adolescence, at least in some students, and play an important role in the ability to reason in science and to build the concept of science [2] [22]. The adolescent age mentioned in Lawson's study of scientific reasoning can be further analyzed by connecting scientific reasoning and age. Some previous research such as a classical study in the field of scientific reasoning is done by [23]. He tested a sample of 13 years with a verbal, spatial and inductive test. At the age of 18, some parts of the sample took part in tests with the same composition.
In the analysis, test results for different educational purposes. This study shows that students who have higher education levels than students with the least academic education. Several similar studies have been conducted on Swedish data [24]. There are also several other, Scandinavian [25] All of these studies have shown strong influence, about 2.0-2.5 points IQ per school year the school is represented by an outline discontinuity for two adjacent spaces. Functions, differences between students and effects in each class. The difference between the youngest at the grade level and the lower level gives the value of a school year.

Research with this design, and calculated a greater outcome of cost. This suggests that different ages with different brain growth affect the level of reasoning ability possessed [25]. To study the theory of brain growth, intellectual development, and these concepts combine 14 lessons relating to eight different student groups, ranging in age from 13 to 17 years. Understanding conceptual understanding (the concept of air derived from kinetic-molecular theory) is given before and after. Can not be effective among younger students, but should be more effective among children 15, 16, and 17 years. On the other hand, if the increase in prefrontal activity of the brain is related to age and reasoning ability is highly environmental dependent (eg, Increasing declarative knowledge with school only), which must be discovered and traversed should be more effective in linear fashion [25]. The new electroencephalographic data allows for a connection between Piaget's development in terms of scientific reasoning and brain growth. Interestingly, five growths were not 4 growths, occurring around the age of 18 [25] [26].

Assuming a time of about 12-14 years and a time of 14-16 years can be discussed with such activities as reasoning and theoretically analyzed. Several previous studies have suggested such a relationship. For example, [7] [19] found no difference between sixth graders (mean 12.9 years average) and eighth grade students (mean 14.3 years) in using proportional and probabilistic reasoning. However, they found considerable progress in the use of proportional and probabilistic reasoning from 8 to 10 students (mean age 16.1 years). Also, in a sample of 6130 Korean students, [26] found common scientific reasoning on proportional, combinational, probabilistic, and correlational measurements between the ages of 12, 13 and 14 years, on average only 3, 8% experienced an increase in the number of successful responses across this age range. However, they found an increase in scholarly reasoning in 15-year-olds (ie, an average increase of 15.2% in the number of successful responses). Several studies have established a clear relationship between scientific reasoning and science concepts [22] [27] [28]. Despite our analysis of data from Heaton et al. and this science education study shows that the growth and growth of early adolescent brain (age influence) can affect some scientific reasoning skills, to date no study attempting to test this theory is associated with involving additional variables of systemic gender influence, the main purpose of this study is to do so.

2. Method
This study was conducted to explore the influence of gender and age on students' scientific reasoning abilities by using quantitative descriptive research. The sample in this research is 200 students in first year physics education class on Tadulako University. This research was conducted in the first semester of physics education 2017/2018. 200 students were selected by generalizing the number of male and female students, 100 male and 100 female. The instrument used was The Lawson Classroom Test of Scientific Reasoning (LCTSR) (Lawson, 2000) which was first developed in 1978 and revised in 2000. LCTSR consists of 12 two level questions and thus 24 items. Each question has a second level of questions designed to measure students' deep scientific understanding of the process. Concepts measured by (items 1, 2, 3 and 4), Proportional Thinking (PPT), the instruments are: Mass Conservation and Volume (items 5, 6, 7 and 8), Variable Controls (item 9) (Items 15, 16, 17 and 18), Correlational Thinking (CT) (item 19, 20), and Hypothetical-deductive Reasoning (HDR) (item 21, 22, 23, and 24). The instrument has been assigned validity and reliability.

Jing [3] show cronbach’s α 0.71 for pretest, 0.61 for post-test, and 0.76 for retention tests. Test reliability was found to be 0.71 by calculating internal consistency using Cronbach alpha which is considered normal for use in this study. The correct response is given one point which is the correct
answer. Pattern of scientific reasoning ability (i) Mass Conservation and (V) Correlational Thinking (CT), and (vi) Hypothetical-deductive Reasoning HDR). In this section, you are asked to describe method, model, design, subject and location of your research. To determine the effect of gender and age on scientific reasoning ability, LCTSR is given to students in physics class. To measure reasoning ability is used mean, standard deviation, and paired t test to choose between gender score as well as age. Please put the procedure of your research clearly so that it is easy to read. Make sure that you employ appropriate research method in line with research problem and the purpose of your research.

3. Result and Discussion

3.1 Is there any gender differences in scientific reasoning?

To test the first research question, analyses t-test was performed for, scientific reasoning and age understanding separately. In these analyses, gender and age was the independent variable. According to the result t-test, scientific reasoning between females and males not different significantly.

Table 1. T-test result for difference on LCTSR based on gender

<table>
<thead>
<tr>
<th>Scientific Reasoning Aspect</th>
<th>Gender</th>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>T test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation of Mass and Volume (CMV)</td>
<td>Males 18-20</td>
<td>100</td>
<td>36</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>31</td>
<td>19.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportional Thinking(PPT)</td>
<td>Males 18-20</td>
<td>100</td>
<td>22</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>19</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of Variables(CV)</td>
<td>Males 18-20</td>
<td>100</td>
<td>21</td>
<td>13</td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>17.5</td>
<td>8.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probabilistic Thinking (PBT)</td>
<td>Males 18-20</td>
<td>100</td>
<td>27</td>
<td>9.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>21</td>
<td>8.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlational thinking (CT)</td>
<td>Males 18-20</td>
<td>100</td>
<td>44</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>41</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothetical-deductive Reasoning (HDR)</td>
<td>Males 18-20</td>
<td>100</td>
<td>32</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Females 18-20</td>
<td>100</td>
<td>33.5</td>
<td>18.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows that there were no differences between genders. The evidence is consistent with research finding of [7], [17] that no differences were found among alges and females in the scientific reasoning ability. However, descriptive scores for specific scientific reasoning patterns were generated as assessed by the LCTSR. Students within the observed population demonstrated significant difficulties with PPT, CV, PBT and HDR. Our result confirm the findings of [29] that students had significant difficulties with CV, and HDR. Interestingly, scientific methods were necessary to develop both CV and HDR. The students in this study showed low performance on CV which could attributeto poor. It is because could be attributed to the fact that the teaching intervention were lacked of emphasis on laboratory.

3.2 Is there age effect in scientific reasoning?

This study this was conducted on the first year physics students aged 18-20 years. Based on the results of data analysis in Table 1 can be seen that is gender does not has effect for students who made the sample of this research. This is as a result of exposure to equivalent brain growth. This is in line with Cahan and Cohen’s research that mentions can not be effective among younger students, but should be more effective among children 15, 16, and 17 years. On the other hand, if the increase in prefrontal activity of the brain is related to age and reasoning ability is highly environmental dependent (eg, Increasing declarative knowledge with school only) which must be discovered and traversed should be more effective in linear knowledge.
4. Conclusion
No differences were found among males and females in the scientific reasoning ability. The results also revealed that there is no interaction between gender and ability to reason scientifically, that is, the scientific reasoning ability effect does not depend on gender and age. This finding highlights the importance of the need for instructional design that is focused on supporting content knowledge might not suffice to promote scientific reasoning ability among students. Therefore, devising curricula that focus on promoting students’ scientific reasoning, especially PPT, CV and HDR patterns. Moreover, it is suggested that science instruction should be taught by inquiry-based methods[2], [30], computer-based laboratories [31] which foster students’ scientific reasoning ability as the core of scientific literacy.

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References


