The relationship among critical thinking skill measured by science virtual test, gender, and motivation in 9th grade students

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Abstract. The purpose of this study was to identify the relationship among critical thinking skill, gender and motivation in 9th grade students of Junior High School in Kuningan. This descriptive study used purposive sampling that comprised 110 ninth grade students taken from three junior high school that has good computer literacy and use 2013 curriculum. The data were obtained through Science Virtual Test on living things and environmental sustainability theme, respondent identity, and science motivation questionnaire (SMQ). Female students scored highest on generating purpose skill (M = 73.81), while male students performed better on generating implication and consequences skill (M = 78.01) where both groups differed significantly (p = 0.011). Students scored highest on generating purpose skill for high and moderate motivation group, while for the lowest score, moderate and low motivation group performed it on making assumption skill. Additionally, some critical thinking elements differed significantly by motivation to learn science. Despite, there was no correlation between students’ critical thinking and motivation (r = 0.155, p > 0.05). The finding indicated that students’ critical thinking is not differed by gender and not affected by motivation to learn science.

1. Introduction
Critical thinking is one of students’ competence that encouraged by government on 2013 national curriculum [1]. As part of 21st century skills, critical thinking is not a new concept or skill, but a worthy challenged skill that students need to reflect and express their thinking to be more relevant [2]. As a process which requires a person to think rationally for answering those question that cannot be easily answered, critical thinking needs judgment. All relevant arguments, facts, and reasons that promote good decision making are the instruments that direct a person to think critically about an issue [3].

Nowadays, most critical thinking assessments are not externally validated against measures that reflect how adults think in real-world situations. Most researchers use academic achievement and aptitude measures (e.g. grades, standardized test scores), or measures of cognitive abilities (e.g. fluid intelligence, tests of reasoning) to establish the validity of their instruments [4]. Meanwhile, measuring critical thinking should use interpretive materials so that students can utilize their higher-level thinking skills [5]. The instrument should contains graphics, scenarios, quotes or videos that can help students to be challenged with high-level tasks and assessments.

The need of interpretive materials can be faced by using computer based test (CBT). CBT can perform some capabilities as present numerous opportunities to improve a test. On computerize test, the
test developer can manipulate the characteristics and the features of the test item presented to students. By using this, the test allows for richer assessment to follow the students’ individual differences include the format of a test (i.e. adaptive), the format of items or tasks (i.e. essay, simulations, etc), media employed by a test (i.e. graphics, sound, etc.), and the construct that the test assesses (i.e. skills, performance abilities) [6]. Some recent studies have been conducted to evaluate the effectiveness of CBT by comparing it with paper–pencil testing [7]. Computer-based testing appear as the current issue to assess students. It emerged as an innovative test which most pursued by many states. CBT show up as the answer to have cheaper and speedier test delivery for state and district-wide assessments [8].

This study introduced the science virtual test as an interactive and attractive computer based test which included video, graphics, comics, etc. to assess critical thinking in such interesting way. Hence the critical thinking through Science Virtual Test is constructed based on Inch critical thinking elements. Some researchers argued that the result of their study indicates that male and female learners did not differ in critical thinking or testing performance [9,10]. Critical Thinking can be learned through gaining life experiences and teaching it to others [11]. Hawthorn et al. concur that motivational prompts were not found to affect students’ critical thinking sub-scores or self-reported effort and importance scores [12]. For the purpose of this study, science virtual test on living things and sustainability theme used to determine the critical thinking difference viewed on gender and students’ motivation including the relationship between students’ critical thinking and motivation.

2. Methods
This study used descriptive method or non-experimental research that allowed researcher to simply describe achievements or other characteristics of the subjects in natural setting and did not involve manipulation of independent variables [13]. The respondents were 110 ninth grade students taken from 3 different school in Kuningan. The sampling technique was purposive sampling that allowed the researcher to select the particular elements from the subjects which can support or be representative of the research interest [13]. Thus, the schools was chosen because of the school have good computer literacy, use 2013 curriculum, and represent the quality of national education standard schools: referral school, model school, and national standard school. A total 110 critical thinking attainments and questionnaires were collected. For the responses rate, 43% were male students and 57% were female students.

In this study, the critical thinking measured by Science Virtual Test (SVT) on living things and sustainability theme which has been developed [13]. This instrument has high reliability (Cronbach alpha 0.71) and moderate difficulty level [14]. The SVT contains 26 multiple choice test items that included eight elements of critical thinking skill: generates purpose, raises question at issue, makes assumption, embodies point of view, uses information, utilize concepts, makes interpretation and inference, and generates implication and consequences [3]. Based on mean and standard deviation of each element and overall critical thinking score, the critical thinking skill attainments categorized into low, moderate, and high [15]. Hence, the students’ critical thinking attainments are categorized on three following levels: low (score \(< 43.33\)), moderate (43.33 \(\leq\) score \(< 69.75\)), and high (score \(\geq 69.75\)).

Science Motivation Questionnaire (SMQ) [16] is 25-item included five-item scales: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. Students respond to each item on a Likert-type rating scale: never (0), rarely (1), sometimes (2), often (3), or always (4). The raw scores should be interpreted carefully, as the scales are ordinal. The Likert-type data is reported using mean and standard deviation [17]. Thus, the motivation are categorized into three levels: low (attainments \(\leq 56.14\)), moderate (56.14 \(\leq\) attainments \(\leq 81.92\)), and high (attainments \(\geq 81.92\)) [15].

Data analysis was conducted using IBM SPSS version 23.0. Descriptive statistics (means and standard deviations) and inferential statistics (t-test, one way ANOVA and partial correlation) were used. Students’ independent t-test was used to determine the difference between critical thinking and gender. Students’ one way ANOVA was used to determine the critical thinking difference among students’ motivation (low, moderate, and high) level groups. Correlation coefficient was used to test the relationship between students’ critical thinking and students’ motivation.
3. Results and Discussion

3.1 Students’ critical thinking based on gender

The first objective was to examine the difference between male and female group. Both descriptive statistics were generated. For the inferential statistics, the data was approximately normal, then independent t-test was conducted. The statistical result was summarized on Table 1.

Table 1. Students’ attainments based on gender

| Critical Thinking Element       | Male (n = 47) | Female (n = 63) | p value |
|--------------------------------|--------------|----------------|---------|
|                                | Mean SD      | Mean SD        |         |
| Purpose                        | 71.28 20.84  | 73.81 23.94    | 0.563   |
| Question at Issue              | 33.51 23.47  | 29.37 25.22    | 0.382   |
| Assumption                     | 31.56 30.14  | 28.84 30.41    | 0.642   |
| Point of View                  | 70.04 26.50  | 63.22 28.23    | 0.202   |
| Information                    | 62.41 24.69  | 54.23 25.13    | 0.092   |
| Concepts                       | 53.90 31.51  | 54.50 29.51    | 0.919   |
| Interpretation and Inference   | 60.99 26.30  | 63.49 22.97    | 0.597   |
| Implication and Consequences   | 78.01 26.26  | 63.49 30.94    | 0.011*  |
| Overall Score                  | 59.00 13.83  | 54.70 12.54    | 0.091   |

The highest score which attained by male group was in generating implication and consequences (78.01) and the lowest was in making assumption (31.56). In other side, generating purpose arose to be the highest score in female group (73.81), while as same as male group, making assumption have the lowest score (28.84). Both male and female students considered to have high level of critical thinking skill on generating purpose while on raising question at issue and making assumption both groups were on low level of critical thinking skill. On embodying point of view and generating implication and consequences, male and female group had different skill level of critical thinking, male was on high level skill and female group was on moderate level skill. On using information, utilizing concepts, and making interpretation and inference, both groups were on moderate level as well as the overall critical thinking skill.

At significant level 0.05, most of elements and overall critical thinking score showed there were no significant differences (p > 0.05). Different with other data, generating implication and consequences skill showed there was significant difference between male and female group (p = 0.011). In general, there was no significant difference between male and female group on critical thinking skill on living things and environmental sustainability theme. However, the data showed while male group had slightly higher overall critical thinking attainments rather than female group. The data showed that both male and female groups had moderate level of critical thinking. Most of elements also presented the fair ability on both group. This condition indicated that the teaching and learning activities in science class were triggering the students to think critically.

The result of this study revealed that there was no significantly difference between male and female students in term of critical thinking. This finding also in line with some empirical studies. The non-significant role of gender also concurred with the findings of some researches. In summary researchers argued that the result of their study indicated that male and female learners did not differ in critical thinking or testing performance [9] [10]. Gender did not play role in enhancing and declining the critical thinking skill which in line with a statement regarding critical thinking whether it can be learned through gaining life experiences and teaching it to others. Thus, it was the evidence that gender was not a matter in critical thinking [11].

Differently generating implication and inference skill showed there was significant difference between male and female group. Male showed up to have high mean score on this critical thinking element. It was reported that the difference between male and female was found on the problem solving. Male had better ability in solving problem than female.
3.2 Students’ critical thinking based on motivation to learn science
The next focus of the study was to examine the difference of critical thinking among students who had high, moderate, and low level of motivation to learn Science. The statistical analysis was conducted which summarized on Table 2.

| Critical Thinking Element | High Motivation (n = 23) | Moderate Motivation (n = 70) | Low Motivation (n = 17) | p value |
|--------------------------|------------------------|----------------------------|------------------------|---------|
|                          | Mean    | SD    | Mean    | SD    | Mean    | SD    |         |
| Purpose                  | 77.17   | 19.81 | 72.50   | 23.37 | 67.65   | 22.99 | 0.419    |
| Question at Issue        | 32.61   | 23.15 | 30.31   | 25.24 | 30.88   | 24.25 | 0.949    |
| Assumption               | 34.05   | 34.98 | 29.52   | 28.54 | 26.47   | 31.21 | 0.721    |
| Point of View            | 75.00   | 23.70 | 67.38   | 28.12 | 49.02   | 23.91 | 0.010*   |
| Information              | 64.13   | 21.09 | 54.64   | 26.49 | 61.76   | 23.58 | 0.227    |
| Concepts                 | 56.52   | 27.40 | 56.19   | 32.37 | 43.14   | 22.86 | 0.260    |
| Interpretation and Inference | 65.22 | 27.48 | 64.76   | 21.89 | 49.02   | 26.66 | 0.046*   |
| Implication and Consequences | 79.71 | 19.43 | 70.00   | 31.16 | 54.90   | 31.05 | 0.032*   |
| Overall Score            | 61.36   | 13.29 | 56.52   | 13.37 | 49.33   | 9.34  | 0.016*   |

For the description of students’ attainments on critical thinking skill, the data showed that students’ attainments on generating purpose on high and moderate motivation group were categorized to have high critical thinking level, meanwhile low motivation group had moderate critical thinking skill level. On raising question at issue and making assumption elements, all group had low critical thinking skill level. On embodying point of view, high motivation group is in high critical thinking skill level. Moderate and low motivation group appeared to have moderate level critical thinking level. On using information, two group had moderate level of critical thinking whether moderate motivation group was categorized to have low critical thinking level. On utilizing concept skill, high and moderate motivation group had moderate level of critical thinking while, low motivation group had low critical thinking level. The rest elements such as interpretation and inference, implication and consequences, and overall critical thinking showed up to have moderate critical thinking level.

One way ANOVA was conducted. At significant level 0.05, five elements showed whether there was no significant difference. In contrast, embodying point of view, making interpretation and inference, generating implication and consequences, as well as overall critical thinking score showed there was significant difference among the groups (p < 0.05). Post hoc analysis was conducted since there were four critical thinking elements which had p value that greater than 0.05. The analysis was conducted for embodying point of view, making interpretation and inference, generating implication and consequences, and overall critical thinking skill to see the comparison between high, moderate, and low motivation group.
Figure 1. Students’ critical thinking attainments viewed on students’ motivation level group on point of view, interpretation and inference, implication and consequences, and overall score

On embodying point of view the significant difference appeared between high and low motivation group and also between moderate and low motivation group ($p < 0.05$). Meanwhile, between high and moderate motivation group there was no significant difference ($p = 0.232$). Similar with this critical thinking element, interpretation and inference as well as overall critical thinking skill present the significant differences which appeared between high and low motivation group and moderate and low motivation group. Moreover, in generating implication and consequences the significant difference only appeared between high and low motivation group. Researchers indicates that motivational condition had significant effect on testing performance [12].

3.3 The correlation between students’ critical thinking skill and students’ motivation

The next focus of this study was to investigate the correlation between students’ critical thinking on science virtual test on living thing and sustainability theme and students’ motivation to learn science. Since the data was ordinal with students’ motivation as independent variable, the Kendall Tau-b test was conducted. The output summarized on Table 3.

![Table 3. Correlation between students’ critical thinking and students’ motivation to learn science](image)

As showed on the Table 3, correlation coefficient between overall critical thinking score and students’ motivation was 0.155. The $p$ value for two-tailed is 0.081 which was greater than significant level 0.05. Hence, there was no correlation between students’ critical thinking and students’ motivation. In other word, students’ motivation level did not influence the students’ critical thinking level or vice versa.

However in the same research, they concurred that motivational prompts were not found to affect students’ critical thinking sub-scores or self-reported effort and importance scores which supported the result of this study [12], after the Kendall-Tau b correlation test was conducted between students’ critical thinking skill and students’ motivation group. At significant level 0.05, this study showed that there was no correlation between students’ critical thinking and students’ motivation ($r = 0.155, p = 0.081$).
meant whether students who have high critical thinking level in science was not influenced by their motivation to learn science in class.

4. Conclusion
In general, there was no significant difference between male and female group on their critical thinking skill. Gender did not play role in enhancing and declining the critical thinking skill. Gender was not a matter in critical thinking. There were significant differences between low and high motivation level group in overall critical thinking skill which can indicate that motivational condition had significant effect on testing performance. Students who have high critical thinking level in science were not influenced by their motivation to learn science in class. No correlation between students’ critical thinking and students’ motivation supported by the finding that motivational prompts were not affect students’ critical thinking sub-scores or self-reported effort and importance scores.

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