Examining the relationship between students’ motivation and critical thinking skills in learning torque and static equilibrium.

R Andriani¹, A Hidayat*¹, E Supriana¹, R Anantanukulwong²

¹Universitas Negeri Malang, Malang, Indonesia
²Yala Rajabhat University, Thailand

*Corresponding author : arif.hidayat.fmipa@um.ac.id

Abstract. This study designed to determine the motivation components that most motivated students in learning torque and static equilibrium and the relationship of the motivation with students’ critical thinking skills on Torque and Static Equilibrium subject. The research was conduct in Senior High Scholl Laboratory State University of Malang. This study used correlational research design and using the Physics Motivation Questionnaire II (PMQ II) and Torque and Static Equilibrium Critical Thinking test as Instrument. The analysis showed that students have a weak motivation level in learning torque and statistic equilibrium. Grade motivation found to be the most motivating for students. The least motivated for students is Career Motivation. Researcher found that critical thinking skills correlate significantly with intrinsic motivation, grade motivation, and self-efficacy, but the relationship between critical thinking skills with self-determination and career motivation were not significant. However, the overall motivation has a significant correlation with students’ critical thinking skills.

1. Introduction

Critical Thinking one of the important skill for student to adapt in 21st century [1-5]. Thinking critically about information in increasingly complex and technical world is needed [6]. Individual need to sort of important and trustworthy information from the information that available extensively and rapidly, so that critical thinking skill is very important to developed and considered as a very important learning outcome [7].

Based on study by Reid [8], statistically, students’ can be taught and learned critical thinking skills, and transferred it across domains. Empirical efforts to improve critical thinking skills have shifted from teaching critical thinking skills separately from the learning material domain to teaching critical thinking skills by embedding critical thinking skills into teaching material. The success of teaching critical thinking skills in an integrated manner with teaching material content is expected to develop students’ critical thinking skills so that students can use critical thinking skills to solve everyday problems [7]. A well-designed learning that embedded Critical Thinking Skill into teaching material proves influential in improving students' critical thinking skills [7,9-10].

In science learning, motivation to learn is an important factor [11]. Motivation is one of factor that can make learning more effective [12-14] and has a significant impact on learning success [15]. Motivation is processing that goal-directing activity stimulated and maintained, so that student will find academic activity meaningful and valuable [13-14].
Critical thinking as one of learning outcome could be influenced by motivation. Based on social cognitive theory, student’s ability to understand, monitor, and control their behavior and motivation, can lead to the expected learning outcome [16]. Study by Castillo-Merino & Serradell-López [17] found that one of factors that can enable students to obtain a better grade is higher motivation.

There are many studies that seeking correlation with critical thinking. A study indicated that critical thinking had a positive and significant relationship with creativity and its components i.e., flexibility, fluency and elaboration (except for originality) as well as academic self-efficacy [18].

Theorists have hypothesized that critical thinking with consistent internal motivation is correlated positively [19]. Meyers [20] study used motivated strategies for learning questionnaires (MSLQ) to collages student in biology, English, and social department, support the positive relationship between motivation, deep strategy used, and critical thinking. Semerci[5] study, student that attending the faculties of education in Turkey found that domain general critical thinking has a positive relationship with achievement focused motivation.

These studies investigate the relationship of general critical thinking skill and motivation factor in learning. Study to explore the students’ motivation relationship with critical thinking on solving physics problem is still lacking. In this study, authors aim to determine the motivation components that most motivated students and the relationship between students’ motivation and students’ critical thinking skill in solving problem on Torque and Static Equilibrium subject. So that it can provide insight into students’ motivational levels and determined which motivation component that might have relationship with critical thinking skill in resolve Torque and Static Equilibrium problems, so that enable us to intervene and improve learning.

2. Methods

This study employee quantitative correlational design to measure the relationship degree between variables in this study Creswell [21], in this study the variable is Motivation components and Critical thinking skills. There were 31 participants in this study. The participant was students in class XI IPA who learn physics subject about torque and static equilibrium (part of their official curriculum).

Student motivation evaluated with The Physics Motivation Questionnaire II (PMQ II). One of extended discipline specific version of Science Motivation Questionnaire II (SMQ II) designed by Glynn et al. [16]. The questionnaires consist of 25 items that used to assess five motivation components. PMQ II used Likert type scale, that is always (4), often (3), sometimes (2), rarely (1), and never (0). The questionnaire proven valid, reliable, and efficient [16].

The critical thinking skills test consist of eight constructed-response items that is developed based on critical thinking sub-skill that targeted in CTEM [7]. Before using the instrument of critical thinking skill in solving torque and static equilibrium, the instrument was validated by two physics and physics education lecturer in university of Malang. The result of the validity of the content of the instrument of critical thinking skill in solving torque and static equilibrium was the instrument valid. Then the instrument empirically validated to 98 senior high school students. The result of the trial test indicated that the critical thinking skills in solving torque and static equilibrium items are valid and showed high reliability category (Cronbach’s Alpha = 0.717) so that it is feasible using this instrument to measure critical thinking skill in solving torque and static equilibrium problems.

Critical thinking test paper and Physics Motivation Questioner II have given to student at the end of physics class in torque and static equilibrium subject. The results of critical thinking tests and motivation scores were examined based on rubric, then described using descriptive analysis. Student answers are classified based on motivation scores then compared to see differences in critical thinking skills of students with the highest motivation scores with students who have the lowest motivation score.

Before analyzing critical thinking skill correlation with motivation in learning torque and static equilibrium, a prerequisite test for data was carried out. Test of normality using Kolmogorov-Smirnov test indicated that motivation data and critical thinking data were normally distribute (Sig. of motivation data is 0.60 > 0.05 and Sig. of critical thinking data is 0.200 > 0.05). Then, based on test
of Homogenity using Lavene Statistic test, both of data set varied homogenously (Sig. of motivation data is $0.565 > 0.05$ and Sig. of critical thinking data is $0.567 > 0.05$). Meanwhile, motivation and critical thinking skill data were linier based on linearity test (Sig. of Deviation from linearity between critical thinking skill and motivation is $0.598 > 0.05$). Therefore, parametric statistic using Pearson Correlation ware used to examine the relationship between variable. Pearson Correlation Coefficient was interpreted based on Table 1 to find out the level of correlation.

### Table 1. Correlation Coefficient Interpretation

| $r$ | Interpretation |
|-----|----------------|
| $r \geq 0.91$ | Very Strong |
| $0.71 \leq r < 0.90$ | Strong |
| $0.51 \leq r < 0.70$ | Moderate |
| $0.31 \leq r < 0.50$ | Weak |
| $r \leq 0.30$ | Very Weak |

$|r| = $absolute value r (Correlation Coefficient)$[22]

### 3. Results and Discussion

The result about Students’ motivation and critical thinking skill is describe at the Table 2. Motivation result divided to its components. That is Intrinsic Motivation, Self-Efficacy, Self-Determination, Grade Motivation, and Career Motivation.

Based on Table 2, the higher score is Grade Motivation with score means, 2.83 (1.18). It is shows that student always motivated to get the high score in physics. Intrinsic Motivation Category is high with means 2.52 (1.15) that shows that students’ inclination to learning is high. Then students’ self-efficacy score is2.50 (0.99) that classified as a high self-efficacy. But student Self-Determination and Career Motivation were classified as Weak with meant score 2.20 (1.05) and 2.19 (1.11). Overall student motivation was classified as low and Students Critical Thinking Skill to solve Torque and Static Equilibrium problems is Low.

The example of critical thinking skill problems and students answer based on motivation score shown in Figure 1.

### Table 2. Motivation, motivation component, and Critical Thinking score description.

|                      | Mean (SD)       | Category   |
|----------------------|-----------------|------------|
| Critical Thinking    | 40.45 (14.72)   | Deficient  |
| Motivation           | 2.40 (1.09)     | Low        |
| Intrinsic Motivation | 2.52 (1.15)     | High       |
| Self-Efficacy        | 2.50 (0.99)     | High       |
| Self-Determination   | 2.20 (1.05)     | Low        |
| Grade Motivation     | 2.83 (1.18)     | High       |
| Career Motivation    | 2.19 (1.11)     | Low        |

Question shown in Figure 2 measure sub-skill of critical thinking: predict the probability of the event and identify the best among several alternatives in solving problems. To answer the question, students must have sub-skills thinking skills in solving problems and decision-making. Students must be able to choose the right strategy and choose the best problem-solving strategy so students can predict the probability of door rotation direction based on the results of solving the torque problem they have done.

Students with highest motivation score have shown sub-skills to think critically in solving problems. Students have been able to propose problem-solving strategies and predicting probability of door rotating directions based on the results they obtained in applying problem solving sub-skills.
the contrary, students with the lowest motivation score proposed the answer directly without problem solving evidence.

**Sample of Critical Thinking test for torque and equilibrium:**
Several objects with different shapes are shown in the following figure. Point G shows the location of the object’s center of gravity.

![Critical Thinking figure](image)

Based on the figures above, can you conclude that “the location of the center of gravity is always in the center of the object”? What is your explanation?

**Comparison of student's answer based on motivation score**

Student's with the highest motivation score: *(Full Score: 2)*

No, because there are still many objects in nature that are not symmetrical or abstract, so that not all the center of gravity of the object is in the center of the object.

Student's with the lowest motivation score: *(Score: 1)*

Not always, because if an object experiences a change in mass, the location of the center of gravity will change. As long as the object doesn't change, the location of the center of gravity is always in the middle.

**Figure 1.** Sample of Critical Thinking test for Torque and Static Equilibrium and Students responses based on motivation score in center of gravity topic

To make the comparison of students answer based on motivation further, the second question and students answer displayed in Figure 2.

Based on the two question and comparison test answer discussed in Figure 1 and Figure 2, students with the highest motivation score obtain higher critical thinking score than students with low motivation score. To further examined the relationship between critical thinking skill and motivation in learning torque and static equilibrium, parametric statistic, Pearson Correlation was used. The results are shown in the Table 2.

Based on this study, motivation and three of its components (Intrinsic motivation, Self-efficacy, and Grade motivation) have weak positive correlation with critical thinking and two of motivation component (Self-determination and Career Motivation) have a negligible (very weak) correlation with student critical thinking skills.

Intrinsic motivation refers to student’s satisfaction in learning, because they find it enjoyable [23]. Critical Thinking skill correlation with Intrinsic motivation is statistically significant *(Sig. 0.048 < 0.05)*, thus proved the hypothesized that critical thinking with internal motivation is correlated positively [19].
Sample of Critical Thinking test for torque and equilibrium:
Question source: Serway, R. A., & Vuille, C. (2015). College physics (Tenth edition). Stamford, CT: Cengage Learning. (modification on individual name on question)

Two students, Ana and Andi use a revolving door, as illustrated in the following figure. Ana on the left side pushes with force ($F_1$) 625 N perpendicular to the door at a distance ($r_1$) 1.20 m from the center, while Andi pushes with force ($F_2$) equal to 850 N perpendicular to the door ($r_2$) 0.8 m from the turn center. Where will the door turn? Write down the problem solving strategies that you use!

\[ r_1 = F_1 \cdot r_1 \]
\[ r_1 = 625 \text{ N} \cdot 1.20 \text{ m} \]
\[ r_1 = 750 \text{ N} \cdot m \]
\[ r_2 = F_2 \cdot r_2 \]
\[ r_2 = 850 \text{ N} \cdot 0.8 \text{ m} \]
\[ r_2 = 680 \text{ N} \cdot m \]

2. Determine the direction of torque rotation of each students
Ana : clockwise so that the torque is negative
Andi : counterclockwise so that the torque is positive

3. Calculate total torque
\[ \tau_t = \tau_1 + \tau_2 \]
\[ \tau_t = -750 \text{ N} \cdot m + 680 \text{ N} \cdot m \]
\[ \tau_t = -70 \text{ N} \cdot m \]

4. Determine the rotating direction of the revolving door
The resulting torque is negative, so the door rotates clockwise

Student's with the lowest motivation score: (Score: 1)
Moves to Andy, because the torque of the Andi is smaller than the torque produced by Ana.

**Figure 2.** Sample of Critical Thinking test for Torque and Static Equilibrium and Students responses based on motivation score in torque by multiple forces topic

Based on social learning theorist the perception of self-efficacy is confidence in carrying out certain tasks [24] and belief to success in assessment [14]. Self-efficacy of students can have implications in improving the learning environment and consequently on student learning outcomes [24]. The result shows that Self-Efficacy have a significant relationship with students critical thinking skill in solving torque and static equilibrium problem, ($\text{Sig. 0.019 < 0.05}$). The found support the study of Shaabani et al[18] that between academic self-efficacy with critical thinking have positive and significant relationship.
Grade motivation have a significant correlation statistically with critical thinking skill. ($Sig. 0.022 < 0.05$), this means that students' interest in learning physics in the material of torque and static equilibrium is related to their eagerness to achieve high scores. This is in line with the research of Stoyanova et al[15] who found that students' interest in learning was only related to the acceptance of high scores on mathematics subjects.

Table 3. Critical thinking, motivation, and motivation component correlation.

| Motivation          | Critical Thinking | Category  |
|---------------------|-------------------|-----------|
| Career Motivation   | Pearson Correlation | $0.227$  | Very Weak |
|                     | Sig. (2-tailed)   | $0.219$  |           |
| Self Efficacy       | Pearson Correlation | $0.378$  | Weak     |
|                     | Sig. (2-tailed)   | $0.036$  |           |
| Self Determination  | Pearson Correlation | $0.255$  | Very Weak |
|                     | Sig. (2-tailed)   | $0.166$  |           |
| Intrinsic Motivation| Pearson Correlation | $0.410$  | Weak     |
|                     | Sig. (2-tailed)   | $0.022$  |           |
| Motivation          | Pearson Correlation | $0.358$  | Weak     |
|                     | Sig. (2-tailed)   | $0.048$  |           |

Career motivation considered to affect students’ achievement. Career motivation students’ conviction that learning science beneficial to their career, conviction can has a big influence on their achievement [25]. Self-Determination also estimated to influence learning outcomes [26]. Self-determination is students’ desire to engage in learning voluntarily [27]. It is students’ belief that they can control their own learning [25]. However, based on the analysis, both of Self Determination and Career Motivation have a negligible (very weak) correlation with critical thinking skill based on this study with significance statistically $0.166 > 0.05$ for self-determination and $0.219 > 0.05$ for Career Motivation.

Overall, the correlation between Critical Thinking Skill with Motivation is significant statistically ($Sig. 0.048 < 0.05$) but categorized as Weak positive Correlation. Its support the hypothesis that Critical thinking skill correlated with motivation. This study supports that motivation have a positive relationship with critical thinking skill [28].

4. Conclusion
Students have a weak motivation level in learning torque and statistic equilibrium. It was found that the most motivation component that motivated students were Grade motivation. The least motivated for students is Career Motivation. Researcher found that there was a significant correlation between students’ critical thinking skills with intrinsic motivation, self-efficacy, grade motivation, but there were no significant relationship between self-determination and career motivation with students’ critical thinking skills. However, the overall motivation has a significant correlation with students’ critical thinking skills. This study support that critical thinking has a positive Correlation/ Relationship with motivation.

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