A path analysis model of students’ statistics achievement

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Abstract. Students achievement in statistics course could be influenced by various factors, both cognition and non-cognition factors. This article presents the preliminary study result about the causal relationship of some those factors, namely students’ statistics achievement (Stat_ACH), students’ attitudes toward statistics (ATS), self-regulated learning (SRL), academic achievement (Ac_ACH) and its prediction model about Stat_ACH. The hypothetical model was proposed by determining that ATS and SRL were two correlated exogenous variables and Ac_ACH as an intervening variable in its effect on the endogenous variables of Stat_ACH. A sample of 150 undergraduate active students who have taken a statistics course in their study participated in filling the questionnaire as a research instrument. Validity and reliability test was conducted to the instruments. A path analysis model was used to obtain a prediction model. The results showed that students’ ATS and SRL was moderately correlated; students’ Ac_ACH was influenced by SRL variable; students’ Ac_ACH was more appropriated to be an independent variable rather than as an intervening variable. Students’ statistics achievement could be predicted through their academic achievement. The higher of students’ academic achievement the higher of students’ statistics achievements.

1. Introduction
Statistics, known as one of the branches of mathematics but in its development statistics became a separate from mathematics [1,2] that used mathematics in solving its problems. Statistics was an important topic in the area of education [2] and it was widely used in various disciplines for all levels of education [3], from primary education to higher education [4]. Likewise in Indonesia, one or both of topics namely statistics and mathematics are the compulsory topics that should be available in higher education curriculum for each undergraduate and diploma study programs [5].

The purpose of giving statistics topics in higher education was written by researchers, including [6–8] that was to produce smart graduates in dealing with information or statistical problems and active participants as a member of a statistical society who were able to face the "age of information". In Indonesia, the purpose of giving statistics in higher education is to enhance students ability in understanding and applying the basics of quantitative method according to the needs of their study program [5]. These objectives can be operationally seen in the learning outcomes of the statistics courses that proposed by [9] that was in line with statistical learning focus from several statistics education researchers such as [10,11]. The focus was to achieve and improve statistical literacy, statistical reasoning, and statistical thinking.

One of the factors that can influence the statistics achievement is the difficulty in learning statistics. That can be caused by cognitive and non-cognitive aspects of learning [12]. Non-cognitive aspects
such as learning motivation, learning interest, learning habits, self-concept, and attitude [13] were the aspects of affective domain.

The attitudes, especially the attitudes toward statistics could influence academic achievement [14]. It also can be an important role in determining students learning atmosphere. A negative attitudes toward statistics could affect students learning atmosphere in the class [15] or outside as well. The various researchs on the relationship of attitudes toward statistics and students achievement have been done but the results have not been showed the same conclusion [16]. There were some results showed a significant association between attitudes toward statistics and academic achievement and some results were not. For example, [17] expressed that someone who has positive attitudes toward statistics still indicated a difference in terms of statistical achievement. Based on their studies, [12] stated that there was no significant difference in statistics achievement as the impact of attitudes toward statistics. These two of examples showed that the relationship of attitudes toward statistics and statistics achievement have not been consistent.

Another aspect in affective domain is self-regulated learning. According to [18] said that the ability to self-regulate was one of the important aspect that should belong to students in any level of education more over students in higher education. The importance and the influence of self-regulated learning to academic achievement was delivered by [19–21].

Some researchers who observed the relationship of self-regulated learning and academic achievement variables in various topics were [22–26]. Their results showed that there was a significant association between those two variables on each topic research. Specifically, [23] stated that self-regulated learning positively correlated with attitudes toward statistics in addition to it correlated with academic achievement.

The purpose of this preliminary study was to obtain a path analysis predictive model of students’ statistics achievement based on the causal relationships of attitudes toward statistics, self-regulated learning, and academic achievement.

2. Methods

2.1. Participant
Participants are the active undergraduate students who have taken a statistics introduction course. They filled the online questionnaire of attitudes toward statistics and self-regulated learning. The 150 participants came from various years of entered to higher education, namely years of 2014, 2015, 2016, and 2017. They were 45 of male (30%) and 105 of female (70%). The participants age were about 18 to 25 years old.

2.2. Measurement
Attitudes toward statistics (ATS) and self-regulated learning (SRL) variables were measured by the questionnaire with a 5-points Likert scale. The ATS questionnaire included of 25 items that were chose from the instrument was belong to [27, 28]. The completely ATS instrument from [27, 28] has been adopted by [29]. The SRL questionnaire included of 26-items that was designed based on the three stages of SRL namely forethought and planning, performance and monitoring, self-reflection [30].

Academic achievement (Ac_ACH) was measured by the value of Grade Point Average (GPA) and statistics achievement (Stat_ACH) was measured by the statistics final value at the end of the semester. The hypothetical model of the ATS, SRL, Ac_ACH, and Stat_ACH were pictured in Figure 1.

![Figure 1. Hypothetical Path Analysis Model](image)
Figure 1 show that the ATS and SRL are the exogenous variables. Ac_ACH as one of the endogenous variables was assumed as an intervening variable that influenced to the other endogenous variable namely Stat_ACH.

2.3. Data Collection
Data was collected through an online survey that was conducted from 8th to 11th of August 2018. That time was considered by the fulfillment of sufficient data to be analyzed. The online questionnaire links were given to prospective participants with the permission of their lecturers.

2.4. Validity and Reliability Instruments
The pilot testing of ATS and SRL instruments was carried out on data from 20 participants. The results of the ATS validity test showed that the 7 items were not statistically significant with a reliability Cronbach's alpha coefficient was 0.919. Furthermore, these of 7 items were excluded from the instrument and showed the reliability Cronbach's alpha coefficient was 0.953. The result of the SRL validity test showed that there were 6 items that did not meet the validity. Those of 6 items were excluded from the SRL instrument. The final version of SRL instrument was consisted of 20 valid items which had a reliability coefficient of 0.967

2.5. Statistical Analysis
Data were analyzed statistically using path analysis model. Path analysis techniques can be obtained from [31]–[36]. Briefly, the process of path analysis can be done by some steps, namely 1) describing the hypothetical model path diagram, 2) calculating the correlation matrix $R_{XX}$, 3) identifying the substructure and equation, 4) calculating the inverse of correlation matrix $R_{XX}^{-1}$, 5) calculating path coefficients $\rho_X = R_{XX}^{-1} * R_{XY}$, 6) stating structural equation of all sub-structure, 7) calculating determination coefficient $R^2 = \rho_X * R_{XY}$ and residual coefficient $\epsilon = \sqrt{1 - R^2}$, 8) testing simultaneously and partially all path coefficient, 9) calculating the value of direct and indirect affects, 10) testing goodness of fit model.

3. Result and Discussion

3.1. Participants Descriptive
The simple descriptive of the 150 participants related to scores of the attitudes toward statistics, self-regulated learning, academic achievement, and statistics achievement were presented on Table 1.

| Variables                          | Measured          | Score   |
|-----------------------------------|-------------------|---------|
| Attitude toward statistics (ATS)  | 18 items          | Range 3.95 Mean 0.6 SD 0.06 |
| Self-regulated learning (SRL)     | 20 items          | Range 3.90 Mean 0.06 SD |
| Academic achievement (Ac_ACH)     | GPA               | Range 3.32 Mean 0.03 SD |
| Statistics achievement (Stat_ACH) | StatScore         | Range 80.34 Mean 0.83 SD |

3.2. A Path Analysis Predictive Model of Statistics Achievement
The parameter estimation of the hypothetical model in Figure 1 was processed using AMOS software to result the prediction model of students’ statistics achievement. The results could be showed on Figure 2.
Figure 2 shows the estimation values of model parameter. This structural model was consisted of two sub-structure models that pictured on Figure 3a and Figure 3b. The standard error and p-value of each estimation parameter was presented on the Table 2.

![Figure 3a. Sub-Structure 1](image)

![Figure 3b. Sub-Structure 2](image)

Significant value (p-value) of the model and its path coefficients were showed on Table 2.

| Model       | Correlation | Standardized Regression Weights (SRW) | Standard Error (SE) | p-value | $R^2$ |
|-------------|-------------|----------------------------------------|---------------------|---------|-------|
| **Figure 3a** |             |                                        |                     |         |       |
| ATS ↔ SRL   | 0.603       |                                        |                     |         |       |
| Ac_ACH ↔ ATS | -0.074      | -0.074                                 | 0.055               | 0.466   | 0.019 |
| Ac_ACH ↔ SRL | 0.171       | 0.171                                  | 0.049               | 0.093   |       |
| **Figure 3b** |             |                                        |                     |         |       |
| ATS ↔ SRL   | 0.603       |                                        |                     |         |       |
| Stat_ACH ↔ ATS | 0.135      | 0.135                                  | 1.945               | 0.143   |       |
| Stat_ACH ↔ SRL | 0.076      | 0.076                                  | 1.175               | 0.411   | 0.195 |
| Stat_ACH ↔ Ac_ACH | 0.384  | 0.384                                  | 1.318               | 0.000   |       |

Each of sub-structure could be defined as structural Model (1) and Model (2) as follow.

Model (1). Ac_ACH = - 0.07ATS + 0.17SRL + 0.99ε₁ ($R^2 = 0.02$)
Model (2). Stat_ACH = 0.14ATS + 0.38Ac_ACH + 0.08SRL + 0.90ε₂ ($R^2 = 0.20$)

There were a positive correlation (r = 0.603) between ATS and SRL. This correlation was in line with research conducted by [23] for students participating in statistics and revealed that those two variables were positively correlated.

The ATS variable in the Model (1) showed a negative effect on Ac_ACH but statistically the effect was not significant (p-value > 10%). The SRL variable had a positive influence on Ac_ACH even though it was only about 17% but statistically significant at alpha 10%. This condition indicated that the students academic achievement that was measured by the GPA could be positively influenced by their SRL. The positive effect of SRL on academic achievement was also expressed by [22], [24], [25] who conducted research on SRL and academic achievement in each their learning topic.

The second model (Model 2) had a determination coefficient ($R^2$) about 20%. The model was not high enough to predict the variations in students Stat_ACH based on the variations in ATS, SRL, and Ac_ACH variables. Both of the ATS and SRL variables were not directly effect on Stat_ACH (p-value > 10%). However, students Ac_ACH as measured by the GPA variable had a positive effect (38.4%) on Stat_ACH and statistically significant (very small of p-value). This model indicated that the higher the students academic achievement, the students statistical achievement would increase.

The amount of direct, indirect, and total effect among the variables in the academic achievement and statistical achievement structural models is written in Table 3. The direct effect of self-regulated learning on students academic achievement was 17.1% which was statistically significant.
The direct effect of self-regulated learning variable on the statistics achievement was 0.076 and its indirect effect through the academic achievement was 0.066. This indirect effect was smaller than its direct effect, that mean students’ academic achievement was not an intervening variable for self-regulated learning and statistics achievement relationships. Both of self-regulated learning and students’ academic achievement variables could be viewed as independent variables which influenced students’ statistics achievement. Students’ statistics achievement variable were directly and significantly influenced by students’ academic achievement (38.4%) and indirectly by self-regulated learning through academic achievement (14.2%).

4. Conclusion and Discussion
The analysis results of the causal relationship among variables in the hypotetical model showed that the significant influence factor on students’ academic achievement was self-regulated learning. A significant factor influencing students’ statistics achievement was students’ academic achievement.

Students’ academic achievement was not significantly influenced by students’ attitudes toward statistics, but was influenced by students’ self-regulated learning. Statistically, this could be caused by a positive correlation between those two variables. One of that variables should be removed from the analysis to predict students’ academic achievement.

Students’ academic achievement was not an intervening variable for the relationships between the attitudes toward statistics and self-regulated learning and their effects on students’ statistics achievement. This variable could be viewed more appropriate as an independent variable for students’ statistics achievement.

Students’ statistics achievement was influenced by students’ academic achievement. This means that the higher of students’ academic achievement the higher of students’ statistical achievements. To enhance students’ statistics achievement could be conducted by strengthening students’ positive perception toward statistics and strengthen students be a self-regulated learner beside the effort to increase their academic achievement as well.

The limitation of this preliminary study could be considered. The determination coefficient of the model was not high enough, it was just about 20%. The other factors that could be correlated among the factors in its effects on the statistics achievement should be analyzed more for next research.

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