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The statistical thinking skill and adversity quotient of English pre-service teacher

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ABSTRACT

Statistics is a branch of mathematical study in universities. Statistics courses are not too tricky to master for students in Mathematics education. In contrast, non-mathematics students, such as students of English education, own the paradigm that statistics is a complex subject since they have to apply formulas and substitute those formulas with numbers as a basic knowledge of general statistics course. There are a lot of studies on the statistical thinking skills of a pre-service teacher. However, statistical thinking skills influenced by the adversity quotient factor have not been widely studied. This study aimed to identify and examine the statistical thinking skills of pre-service English teachers based on the dimensions of adversity quotient and statistical thinking ability. This is a quantitative study with a sample of 314 students of English pre-service teachers who took statistics courses for language education and were selected by cluster random sampling technique at a university in Cimahi, West Java, Indonesia. The results showed that based on control, origin, ownership, and endurance positively influenced students' thinking abilities. However, there is no positive effect between the latent variable of the reach dimension on the students' statistical thinking ability. The students' thinking skills tend to be classified at the quantitative level.

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1. INTRODUCTION

The ability to think in Statistics is one of the important elements for teachers, especially in English studies [1], [2]. This is because the ability to statistical think skill is one part of systematic, and logical thinking [3], [4]. From the statistical thinking process educators describe quantitative information from learning process [5], [6]. Thus, statistical thinking ability is the ability to understand statistical data comprehensively by interpreting contextual problems so that they can generalize their understanding related to describing data, organizing data, representing data, and analyzing data [7]–[11].

The current conditions of English pre-service teachers in Indonesia tend to elucidate weaknesses in processing, analyzing and interpreting statistical data. This is in line with Nurfaidah, Patih, and Aini [12] that pre-service teachers in Kendari still find it difficult to process statistical information, especially in sampling and interpreting various data. The difficulty in understanding and describing the statistical data is because students' knowledge that is built to improve statistical thinking skills is only supported by content, pedagogy, technology, and assessment [5], [6], [13].

Statistical thinking is an individual's thinking process of contextual problems by testing the assumptions and variations of data starting from identifying, characterizing, measuring, controlling, and analyzing the interpretation and generalization of the data [14]–[17]. The statistical thinking process has four indicators [18]–[23] which is abbreviated as DORA, namely: i) Describing data displays; ii) Organizing and data reduction; iii) Representing data; and iv) Analyzing and interpreting data.

By reviewing the achievements of individuals in statistical thinking skills, there are four levels of ability: idiosyncratic, transitional, quantitative, and analytical [19]–[21], [23]–[25]. The idiosyncratic level is the lowest stage of statistical thinking skills, in this process individuals is not being able to provide assumptions structurally and logically on the results of their thoughts. The transitional level is the transition from the idiosyncratic level to the quantitative stage. The individual's thought process at this stage can convey quantitative thinking ideas. However, they still focus on one aspect of the data and sometimes return to the idiosyncratic thinking stage. Furthermore, individuals at the level of quantitative statistical thinking focus on exploring data to solve the problems from one perspective. The next level in statistical thinking skills is analytical, a higher-order thinking ability from statistical thinking skills. Individuals belonging to this level will be able to provide explanations and compare perceptions from various perspectives based on previously explored data [8], [26].

In the statistics course, students' cognitive and students' affective support students' achievements. Individual attitudes elements which affect learning achievement is adversity quotient (AQ). AQ is an individual's attitude in responding to problems [27], [28]. This responsiveness is defined as individual's endurance to solve the problems at hand [28]–[31].

There have been many studies on the statistical thinking skills of pre-service teacher [5], [6], [8], [9], [12]. However, statistical thinking skills influenced by the AQ factor have not been widely studied, especially in Indonesia. In addition, based on the results of previous studies, statistical thinking skill is only influenced by four factors; content, pedagogy, technology, and assessment [5], [6]. Observing the AQ is also important in order to find how this AQ effecting the statistical thinking skill. Thus, this study aims to identify and examine the statistical thinking skills of English pre-service teachers based on AQ dimension (control, origin, ownership, reach, and endurance (CO2RE)).

2. RESEARCH METHOD

2.1. Description of study

This quantitative study aims to identify and examine the statistical thinking ability of pre-service teachers in English studies based on the AQ dimension. Statistical thinking ability in this study is the ability of pre-service teachers to explain solutions to statistical problems in a structured and logical manner. In addition, the statistical thinking skills of pre-service teachers also provide critical and logical comments from statistical information, as well as conduct structured and logical investigations to obtain conclusions from the context of statistical problems.

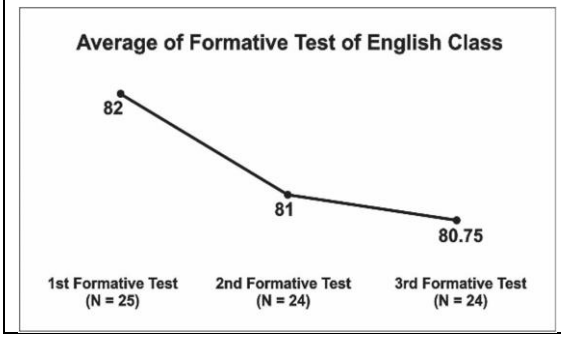
2.2. Participants

The population in this study were all English pre-service teachers at a university in Cimahi, West Java, Indonesia. The sample in this study was an English pre-service teacher who took Statistics course. The sample was selected through a cluster random sampling technique by considering the characteristics of the population. The sample size of this study is 314 students.

2.3. Instruments

The research instrument is used in the form of test and non-test questions. The questions of the test consist of three description items which is made based ono the characteristics of statistical thinking skill indicators. The topic of the test is descriptive statistics and inferential statistics. There are examples of questions on this instrument can be seen in Figure 1. In addition to the test instrument in the form of a description, there is also a non-test instrument that contains the AQ scale. The AQ instrument contains four dimensions called control, origin and ownership, reach, and endurance (CO2RE) [32]–[34]. The dimensions of AQ are described in Table 1.

An English teacher is targeting the average value of the formative test in his class is at least 81. It is known that the formative test scores of the English subject are taken from three examinations of 25 students:



Questions:
a. What can you explain from the phenomena in the graph?
b. There is one student named Robi has not taken the 2nd and 3rd formative tests because he is sick. The teacher allowed Robi to take a follow-up formative test. Can you determine and explain what minimum score Robi must get so that the teacher's target of the minimum class average can be achieved?
c. Is there any increase in the results of the 2nd and 3rd formative tests of students who take the follow-up formative tests?

Figure 1. The example of a student's statistical thinking ability test instrument

Table 1. Dimensions of adversity quotient

Dimensions	Description
Control	Students are able to control an event related to difficulties in learning that can cause future difficulties.
Origin	Students are able to examine the causes of difficulties or failures in learning statistics.
Ownership	Students are able to recognize themselves as the cause of difficulties and feel confident that they can improve the situation.
Reach	Students are able to assess a problem in learning, and not interfere other activities.
Endurance	Students are able to be optimistic in facing various difficulties in learning statistics.

The research instrument containing the dimensions, indicators and statements of the AQ consists of 39 statements as shown in Table 2. Each statement consists of four options; highly agreed, agreed, disagreed, and highly disagreed. The score from the positive statement category is 4=highly agreed, 3=agreed, 2=disagreed, and 1=highly disagreed. On the other hand, the score for the negative statement category is 1=highly agreed, 2=agreed, 3=disagreed, and 4=highly disagreed. In addition, this AQ instrument has been empirically validated by an educational psychologist, Dr Sutirna, M.Pd.

Table 2. Students' adversity quotient scale

Dimensions	Indicators	Statements number	Number of statements		
			Positive	Negative	Total
Control	Students respond positively to a situation	C1, C2, C3, C4, C5	2	3	5
	Students have strong control over the difficulties experienced	C6, C7, C8	2	1	3
Origin	Students assume the sources of difficulty come from other people or from outside and place their roles in reasonable	OR1, OR2, OR3, OR4, OR5, OR6, OR7, OR8, OR9, OR10	3	7	10
Ownership	Students are able to judge what they are doing is right or wrong	OW1, OW2, OW3	1	2	3
	Students are able to learn from mistakes made as a result of the difficulties they face and fix them	OW4, OW5, OW6, OW7	4	0	4
Reach	Students limit the range of their problems to the events they are facing	R1, R2, R3, R4, R5, R6, R7, R8	4	4	8
Endurance	Students view the difficulties and causes of the difficulties they face are temporary	E1, E2, E3, E4, E5, E6	3	3	6

2.4. Research data processing procedures

After obtaining data related to statistical thinking skills and AQ, the data were grouped based on the level of statistical thinking as presented in Table 3. The next stage was processing and analyzing the data using structural equation modeling (SEM) to measure the direct effect of each dimension of AQ on students' statistical thinking skills. Processing and analyzing the SEM data using the LISREL application version 8.80.

Table 3. Student statistical thinking level grouping

Indicator	Statistical thinking level			
	Idiosyncratic	Transitional	Quantitative	Analytical
Explain the solution to solving statistical problems in structured and logical manner	Explaining solutions but not based on structured and logical problem solving	Explaining structured and illogical problem-solving solutions	Presenting problem-solving solutions from a particular perspective in a structured and logical manner	Explaining problem-solving solutions in a structured and logical manner based on various perspectives as a form of justification
Provide critical and logical comments from statistical information	Unable to provide essential words according to statistical information	Provide critical comments that are by statistical information but are not logical	Provide critical and logical comments that are by statistical information but still in a particular perspective	Provide critical and logical comments by statistical information from various perspectives as a form of justification
Conduct structured and logical investigation to obtain conclusions from the context of statistical problems	Unable to conduct a structured and logical investigation to conclude from the context of statistical problems	Conducting structured investigation but not yet logical in obtaining conclusions from the context of statistical problems	Conducting structured and logical investigation in obtaining conclusions from the context of statistical problems but still in one particular perspective	Conducting structured and logical investigation in obtaining conclusions from the context of statistical problems in various perspectives as justification

3. RESULTS AND DISCUSSION

3.1. Results

Structural equation modeling (SEM) in this study is to carry out a model compatibility test which includes the overall model compatibility test (Overall Model Fit), the measurement model fit (Measurement Model Fit), and the structural model fit (Structural Model Fit). Overall Model Fit is used to determine whether all independent variables affect the dependent variable. Measurement Model Fit explains how a research model is measured from indicators and their relationship to variables in a construct whether it can produce well-tested data and can be used as an instrument in testing a research model. Structural Model Fit is the last stage of SEM analysis which describes the relationship between latent variables and is modeled in the form of a path diagram [35]–[37].

3.1.1. Latent variable of dimension control

Based on the SEM test through the LISREL application, the latent variable measurement model for the control dimension is obtained as shown in Figure 2. The model of the control dimension latent variable has a good fit based on goodness of fit index (GOFI) analysis as presented in Figure 2. Based on the latent variable of control dimension model as shown in Table 4, three instruments (C4, C5, and C6) meet the number of control dimension instruments, as many as eight instruments. Meanwhile, the five instruments (C1, C2, C3, C7, and C8) that did not meet the valid and reliable criteria were not used to measure the control dimension on the adversity quotient in this study.

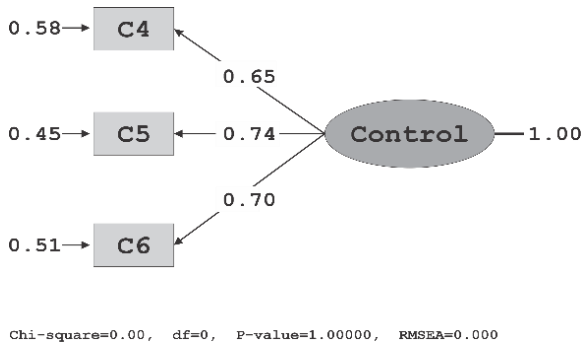


Figure 2. The measurement model for the latent dimension control variable

Table 4. Test the validity and reliability of the control dimension latent variables

Observe variable	Standardized loading factor (SLF)	Error	Construct reliability (CR)	Variance extracted (VE)	Interpretation	
C4	0.65	0.58			Good validity	
C5	0.74	0.45	0.752	0.504	Good validity	Good reliability
C6	0.70	0.51			Good validity	

3.1.2. Latent variable of origin dimension

Based on the SEM test through the LISREL application, the measurement model for the latent variables for the origin dimension is obtained as shown in Figure 3. To see the compatibility of the latent variable model on the origin dimension, the overall model Compatibility test (Overall Model Fit) and the measurement model Compatibility test (Measurement Model Fit) were carried out. Good compatibility was obtained based on GOFI indicator analysis as presented in Table 5.

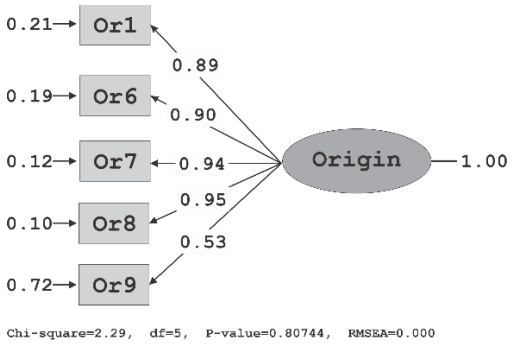


Figure 3. Latent variable measurement model of origin dimension

Table 5. Test of model fit, validity and reliability of latent variables origin dimension

Indicators	Good compatibility	Compatibility test results	Interpretation
Root mean square error of approximation (RMSEA)	≤0.08	0.00	Good compatibility
Normed fit index (NFI)	≥0.90	1.00	Good compatibility
Non normed fit index (NNFI)	≥0.90	1.00	Good compatibility
Comparative fit index (CFI)	≥0.90	1.00	Good compatibility
Incremental fit indices (IFI)	≥0.90	1.00	Good compatibility
Relative fit index (RFI)	≥0.90	1.00	Good compatibility
Standardized root mean square residual (SRMR)	≤0.05	0.012	Good compatibility
Goodness of fit (GFI)	≥0.90	0.99	Good compatibility
Adjusted goodness of fit (AGFI)	≥0.90	0.97	Good compatibility

Based on the compatibility test results for the latent variable model origin dimension as shown in Table 6, five instruments (OR1, OR6, OR7, OR8, and OR9) meet the number of instruments for the origin dimension as many as ten instruments. Meanwhile, for other five instruments (OR2, OR3, OR4, OR5, and OR10) that do not meet the valid and reliable criteria. They are not used to measure the origin dimension of the adversity quotient in this study.

Table 6. Test the validity and reliability of the origin. dimension latent variables

Observe variable	SLF	Error	CR	VE	Interpretation	
OR1	0.89	0.21			Good validation	
OR6	0.90	0.19			Good validation	
OR7	0.94	0.12	0.930	0.732	Good validation	Good reliability
OR8	0.95	0.10			Good validation	
OR9	0.53	0.72			Good validation	

3.1.3. Latent variable of ownership dimension

Based on the SEM test through the LISREL application, the measurement model for the latent variable for the ownership dimension is obtained as shown in Figure 4. To see the compatibility of the latent variable model on ownership dimensions, the overall model Compatibility test (Overall Model Fit) and the measurement model Compatibility test (Measurement Model Fit) were performed. The results obtained a good fit based on GOFI indicator analysis as presented in Table 7. Based on the compatibility test results for the latent variable model originating dimension as shown in Table 8, six instruments (OW1, OW3, OW4, OW5, OW6, and OW7) fulfil the number of instrument ownership dimensions as seven instruments. Meanwhile, one instrument (OW2) that does not meet the valid and reliable criteria is not used to measure this study's ownership dimension in the adversity quotient.

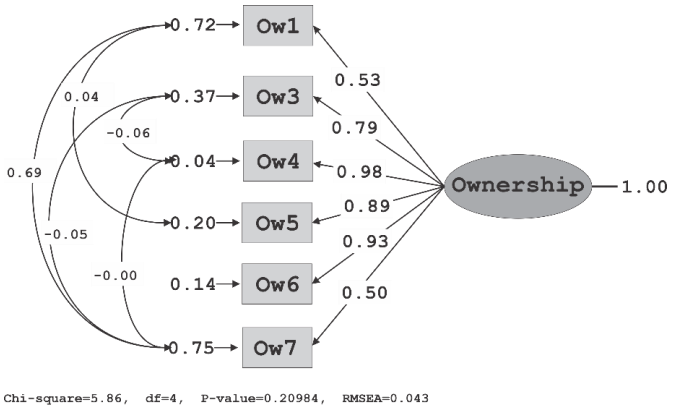


Figure 4. Latent variable measurement model of ownership dimension

Table 7. Test of model fit, validity and reliability of latent variables ownership dimension

Indicator	Good compatibility	Compatibility test	Interpretation
RMSEA	≤0.08	0.043	Good compatibility
NFI	≥0.90	1.00	Good compatibility
NNFI	≥0.90	1.00	Good compatibility
CFI	≥0.90	1.00	Good compatibility
IFI	≥0.90	1.00	Good compatibility
RFI	≥0.90	0.99	Good compatibility
Standardized RMR	≤0.05	0.0085	Good compatibility
GFI	≥0.90	0.98	Good compatibility
AGFI	≥0.90	0.90	Good compatibility

Table 8. Validity and reliability test of the latent variable ownership dimension

Observe variable	SLF	Error	CR	VE	Interpretation	
OW1	0.6	0.65	0.906	0.630	Good validity	Good reliability
OW3	0.74	0.46			Good validity	
OW4	0.98	0.04			Good validity	
OW5	0.87	0.24			Good validity	
OW6	0.95	0.1			Good validity	
OW7	0.51	0.74			Good validity	

3.1.4. Latent variable of reach dimension

Based on the SEM test through the LISREL application, the latent variable measurement model for the reach dimensions is obtained as presented in Figure 5. The model of the reach dimension latent variable has a good fit based on GOFI analysis as shown in Figure 5. Based on the compatibility test results for the latent variable model of reach dimensions as presented in Table 9, three instruments (R3, R4, and R6) meet the number of reach dimension instruments, as many as eight instruments. As for the five instruments (R1, R2, R5, R7, and R8) that do not meet the valid and reliable criteria, they are not used to measure the reach dimensions on the adversity quotient in this study.

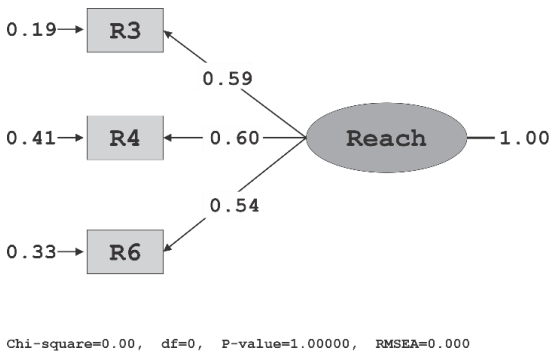


Figure 5. Latent variable measurement model of reach dimension

Table 9. Test the validity and reliability of the latent variable dimensions of reach

Observe variable	SLF	Error	CR	VE	Interpretation	
R3	0.59	0.19			Good validity	
R4	0.6	0.41	0.763	0.518	Good validity	Good reliability
R6	0.54	0.33			Good validity	

3.1.5. Latent variable of endurance dimension

Based on the SEM test through the LISREL application, the latent variable measurement model for the endurance dimension is obtained as presented in Figure 6. To see the compatibility of the latent variable model for the endurance dimension, the overall model compatibility test (Overall Model Fit) and the measurement model Compatibility test (Measurement Model Fit) were carried out. Good fit results were obtained based on GOFI indicator analysis as shown in Table 10.

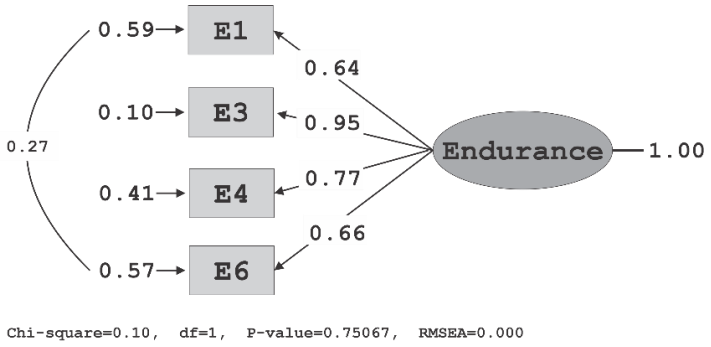


Figure 6. Endurance dimension latent variable measurement model

Table 10. Test of model fit, validity and reliability of latent variables endurance dimension

Indicator	Good compatibility	Compatibility test result	Interpretation
RMSEA	≤0.08	0.00	Good compatibility
NFI	≥0.90	1.00	Good compatibility
NNFI	≥0.90	1.00	Good compatibility
CFI	≥0.90	1.00	Good compatibility
IFI	≥0.90	1.00	Good compatibility
RFI	≥0.90	1.00	Good compatibility
Standardized RMR	≤0.05	0.0027	Good compatibility
GFI	≥0.90	1.00	Good compatibility
AGFI	≥0.90	1.00	Good compatibility

Based on the compatibility test results for the latent variable model of endurance dimensions as presented in Table 11, four instruments (E1, E3, E4, and E6) met the number of instruments for the endurance dimension of six instruments. As for the two instruments (E2 and E5) that do not meet the valid and reliable criteria. Thus, they are not used to measure the endurance dimension on the adversity quotient in this study.

Table 11. Test the validity and reliability of the latent variable of endurance dimension

Observe variable	SLF	Error	CR	VE	Interpretation	
E1	0.64	0.59			Good validity	
E3	0.95	0.1	0.845	0.584	Good validity	Good reliability
E4	0.77	0.41			Good validity	
E6	0.66	0.57			Good validity	

3.1.6. Latent variable of statistical thinking

Based on SEM testing through the LISREL application, the measurement model for latent variables for statistical thinking is obtained as shown in Figure 7. The model of the statistical thinking latent variable has a good fit based on GOFI analysis as shown in Figure 7. Based on the compatibility test results for the latent variable of the statistical thinking model as shown in Table 12, the entire test instrument is declared valid and reliable.

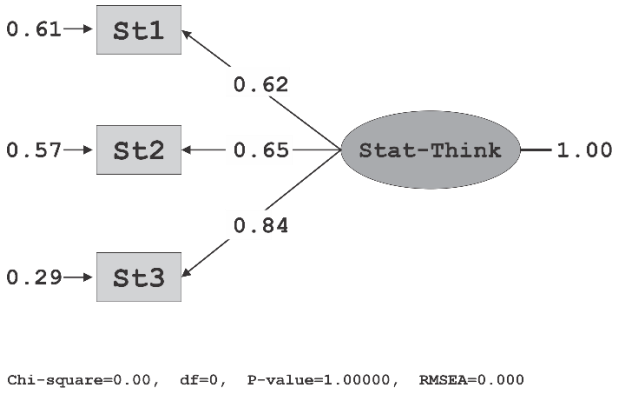


Figure 7. The statistical thinking latent variable measurement model

Table 12. Test the validity and reliability of statistical thinking latent variables

Observe variable	SLF	Error	CR	VE	Interpretation	
ST1	0.62	0.61			Good validity	
ST2	0.65	0.57	0.752	0.507	Good validity	Good reliability
ST3	0.84	0.29			Good validity	

3.1.7. Confirmatory factor analysis (CFA)

Based on the results of the SEM test at LISREL, the confirmatory factor analysis (CFA) latent variable measurement model is obtained as presented in Figure 8. The model of the CFA has a good fit based on GOFI analysis as shown in Figure 8. Based on the compatibility test results for the CFA latent variable model, information was obtained that the CFA model has a good level of validity and reliability as shown in Table 13.

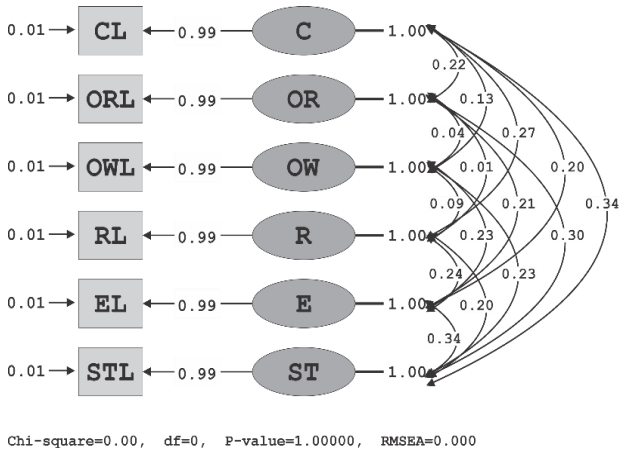


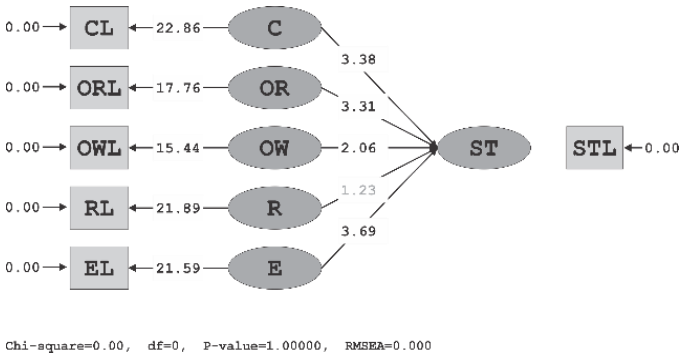
Figure 8. Confirmatory factor analysis test

Table 13. Validity dan reliability of variable latent of CFA

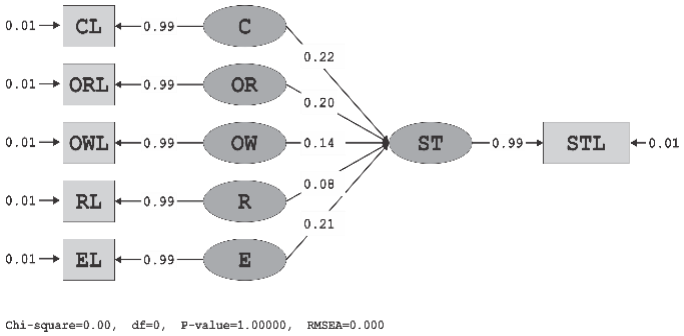
Observe variable	SLF	Error	CR	VE	Interpretation	
CL	0.99	0.01			Good validity	
ORL	0.99	0.01			Good validity	
OWL	0.99	0.01	0.998	0.990	Good validity	Good
RL	0.99	0.01			Good validity	reliability
EL	0.99	0.01			Good validity	
STL	0.99	0.01			Good validity	

3.1.8. Structural model test

The structural model has a good fit based on GOFI analysis as shown in Figure 9. The results are obtained based on the T-value as shown in Figure 9 (a) and its standard coefficient as shown in Figure 9 (b). The recapitulation of the structural model test results is presented in Table 14. It is concluded that there is a significant positive effect between the latent variables of control, origin, ownership, and endurance dimensions on the achievement of students' statistical thinking abilities. Meanwhile, the reach dimension does not significantly affect the achievement of students' statistical thinking abilities.



(a)



(b)

Figure 9. Result of structural model test based on a) T-value and b) coefficient standard

Table 14. Structural model test results

Information	Relationship between variables	T-value	Standard coefficient
Hypothesis 1	There is a positive influence between the latent variables of the control dimension on students' statistical thinking ability	3.38	0.22
Hypothesis 2	There is a positive influence between latent variables of origin dimension on students' statistical thinking ability	3.31	0.20
Hypothesis 3	There is a positive influence between the latent variable of ownership dimension on students' statistical thinking ability	2.06	0.14
Hypothesis 4	There is no positive effect between the latent variable of the reach dimension on the students' statistical thinking ability	1.23	0.08
Hypothesis 5	There is a positive influence between the latent variables of the endurance dimension on students' statistical thinking ability	3.69	0.21

3.2. Discussion

The study results show that students' statistical thinking skills are influenced by the dimensions of AQ control, origin, ownership, and endurance. Meanwhile, the reach dimension does not significantly affect the students' statistical thinking ability. This is because students are considered concerns in answering the questionnaire, so these students limit the range of their problems to the events. This is in line with Hulaikah *et al.* [38], the reach factor will affect difficult to a new problem that interferes other activities. In addition, students also sometimes reduce their free time to think about and solve problems. This shows that the level of the Reach dimension in a person is uncertain [39], [40]. Reach measures how far a difficulty will be achieved in aspects of a person's life [28], [30], [31], [40].

Concerning the achievement of students' statistical thinking skills, the classification of statistical thinking skills is (idiosyncratic, transitional, quantitative, and analytical). The indicators for each ability can be seen in Table 3. The result showed that all students had passed the Idiosyncratic level of thinking, but based on the overall students, it showed that the achievement of students' statistical thinking skills was dominated at the quantitative level as shown in Table 15. This indicates that students can explain and provide critical comments about problem-solving solutions from a certain perspective in a structured and logical manner. However, the justification is still in the perspective of solving routine problems.

The results of this study are in line with the research of Meylasari *et al.* [20], which suggests that students with quantitative statistical thinking skills tend to be more effective and complete in presenting their ideas and using quantitative information in solving statistical problems. In addition, students who have a level of quantitative statistical thinking ability can also provide correct responses and make comparisons from several data in accordance with the data provided. Still, they cannot compare the data as a whole and can only make correct conclusions based on the given problem even though the student has not been able to make overall conclusions [14]–[16], [20], [21], [41]. In addition, individuals at the quantitative statistical thinking level will focus more on exploring data to solve the problems they face but still from one particular perspective [8], [26].

Table 15. The achievement of students' statistical thinking ability

No	Transitional		Quantitative		Analytical	
	Count	%	Count	%	Count	%
1	104	33.12%	169	53.82%	41	13.06%
2	98	31.21%	179	57.01%	37	11.78%
3	167	53.18%	96	30.57%	51	16.24%
Overall	52	16.56%	193	61.46%	69	21.97%

4. CONCLUSION

The results of the study show that the statistical thinking ability of prospective English teacher students was generally at the quantitative level. In addition, it was also found that there was a significant positive effect between the latent variables of control, origin, ownership, and endurance dimensions on the achievement of students' statistical thinking abilities. Meanwhile, the reach dimension does not significantly affect the achievement of students' statistical thinking abilities. The results of this study can also be used as a recommendation, that students' statistical thinking ability can be influenced by adversity quotient which contains four indicator variables, namely control, origin, ownership, and endurance variables.

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