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# Exploring the different trajectories of analytical thinking ability factors: An application of the second-order growth curve factor model

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**The purposes of this study were 1) Compare analytical thinking ability by testing the same sets of students 5 times 2) Develop and verify whether analytical thinking ability of students corresponds to second-order growth curve factors model. Samples were 1,093 eighth-grade students. The results revealed that 1) Analytical thinking ability scores of 5 tests are significantly different at .01 level and the means score rises consecutively 2) Second-order growth curve factors model of analytical thinking ability for the analysis of elements and analysis of organizational principles corresponds to piecewise growth model while the analysis of relationship corresponds to linear growth model, and that second-order growth curve factors model of analytical thinking ability is in accord with empirical evidence.**

**Key words:** Second-order growth curve factors, growth curve, MANOVA, longitudinal studies, development, analytical thinking.

## INTRODUCTION

Analytical thinking is an essential skill in developing a country's youths to have a capability and potential to compete internationally. Several researchers have studied and shown that analytical thinking is correlated positively with academic success including Greene et al. (2004), Zhang (2005), Groothohh et al. (2008), Dunn et al. (2009) and Kuhn and Holling (2009). In a study of giftedness (Sternberg, 1997), analytical thinking skill together with synthesis skill and problem solving skill are three essential attributes. Analytical thinking also forms part of a higher-ordered complicated thinking which is essential in an individual's learning and living. If such individual has an analytical mind, he/she can evaluate, plan and decide what is the best option and direction for the future (Munkham, 2008).

Results of national compulsory education assessments

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of Thai students found that students' analytical thinking needed improvement (Office for National Education Standards and Quality Assessment, 2010), which was in line with the result of PISA (Program for International Student Assessment Thailand, 2013) that Thai students were categorized in the low achievement group in mathematics, science and reading when compared with other countries in the OECD (Organization for Economic Co-operation and Development). These results show that Thailand's education management was below standard, which prompt several education researchers to seriously study how to effectively educate students to think analytically.

Perusing educational research publications in developing analytical thinking, the researchers discovered that there were three types: the first type (about 45%) concentrated on developing education innovation or teaching methods (Yen and Chen, 2004; Kongros, 2007), trying to find effective and efficient tools. The second type (about 5%) stressed development of teachers (Drysdale, 2001) while the third type (about 50%) tried to find factors affecting analytical thinking (Athman, 2003; Wu, 2008). All three types (about 95%) studied at a fixed evaluation period, which was contrary to the recommendation of Ma and Ma (2004) who advocated longitudinal study which could provide essential data that indicated more accurate trend than one-time observation. Furthermore, education process must undergo continuous development and that educators must periodically observe changes and adapt to cope if there are problems in hindering students' analytical thinking ability development (Damrongpanit, 2009).

The analytical thinking ability is innate, cannot be directly observed due to its abstract nature. Therefore, to measure analytical thinking ability it must be measured indirectly by observing innate ability that corresponds to observable/measurable behaviors (Kanjanawasee, 2009). Bloom's analytical thinking measurement comprises three aspects 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles (Bloom, 1981). To study the shape and growth rate of analytical thinking ability, it is appropriate to employ the second-order latent growth curve model (Hancock et al., 2001; Day and Lance, 2004; Hong and Ho, 2005; Sayer and Cumsille, 2006; Grimm et al., 2009), which applied second-order factor model and latent growth curve model to explain unusual measurement errors of these indicators whereby measurement variables would be culled at the first level while the growth model was jointly composed by variables at the second level. This helped to identify the studied variables and their growth and can explain measurement errors (Hancock et al., 2001). But the weak point was the failure to identify shape and growth rate of observable factors. Therefore, it was deemed suitable to switch growth model of observable factors to be raised to level 1 while initial and slope of factors to be culled at level 2 (Shelton, 2010). This method was called second-order growth curve factors model, which included examining data distribution of observable factors under the principle that long-term growth score of each individual varied from each other. The present research studied three aspects 1) linear growth model 2) quadratic growth model and 3) piecewise growth model (Akihito, 2012). This method should point out the change shape and growth rate of each observable variable, which would yield relevant specific variables to be used to determine development policy and to deploy education resources effectively.

The researchers, thus, were interested in studying the shape and growth rate of students' analytical thinking ability by analyzing second-order growth curve factors model in order to obtain accurate, relevant, specific facts and information that benefit parties concerned with developing students' analytical thinking ability. This research also aims to expand knowledge in analyzing second-order growth curve factors model.

## Objective

The two research objectives were 1) Compare analytical thinking ability by testing the same sets of students 5 times, and 2) Develop and verify whether analytical thinking ability of students corresponds to second-order growth curve factors model.

## Research hypothesis

Based on the literature review, the analytical thinking ability was innate and could not be directly measured. This study measured analytical thinking ability in line with Bloom's 3 observable aspects 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles. Analysis of elements is the ability to indicate or categorize elements of communication, distinguishing what is essential, necessary or play the largest role. Analysis of relationship is the ability to distinguish in details how communication elements relate, decide relationship and what relationship that affects each other by finding what are related, how are they related and the degree of relationship, corresponding or opposing by linking causes and consequences. Analysis of organizational principles is the ability to realize and see organizational principle behind elements that are combined to communicate the total picture by finding related rules and principles that differentiate situations or prescribed objects. Therefore, it was hypothesized that 1) Analytical thinking ability scores of analysis of elements, analysis of relationship and analysis of organizational principles differ in all 5 tests, 2) Second-order growth curve factors model of analysis of elements, analysis of relationship, and analysis of organizational principles is backed by empirical evidence with difference in shape and growth rate.

## LITERATURE REVIEWS

### Second-order growth curve factors

Second-order growth curve factors model was developed from second-order factors model and latent growth curve model to explain the measurement errors of indicators by filtering variable factors at level 1 while the growth model is determined by elements at level 2, which reflect the growth of studied factors and can explain measurement errors (Hancock et al., 2001). However, the weakness was ignoring the shape and growth rate of observable factors. Therefore, it was deemed necessary to apply second-order growth curve model which had latent variables by switching growth model of observable factors to level 1 while initial and slope of factors were filtered at level 2 (Shelton, 2010). This included examining data distribution of observable variables under the principle that long-term growth scores (at least 5 tests) of individuals varied from each other (Akihito, 2012). Such analysis is called second-order growth curve factors model, which could enhance knowledge on specific factors.

### Growth curve

The early growth measurement was based on traditional prior and after-learning tests to get observed difference score. This method was easy and popular and the obtained scores were unbiased (Raykov, 1993). However, the weakness of this method was the way-ward scores of prior and after tests were not related. Several researchers tried to overcome this weakness by conducting at least 3 tests applying Structural Equation Model (SEM) to measure progress (Hancock et al., 2001; Day and Lance, 2004; Hong and Ho, 2005). The most used and popular model was Latent Growth Curve Model (LGCM) due to its several strong points including the ability to estimate parameter values even with incomplete samples, the ability to obtain progress scores when testing was done at different time or how often, including wayward scores as parameters to obtain progress scores, and there was ample data/information to determine whether the progress was linear or curved (McArdle and Hamagami, 1995). It could be said the more tests were conducted, the more accurate growth score of each student, reflecting overall growth test accuracy (Willett, 1994).

### Analytical thinking

Analytical thinking is the ability to distinguish, categorize elements out of events/things to see what are important, how the elements are related, what is cause/effect, and what is the underlying reason. Analytical thinking is higher-ordered complicated thinking (Munkham, 2008) and constitutes one of the three attributes of giftedness (Sternberg, 1997), comprising analytical thinking skill, synthesis skill, and problem solving skill, which are essential for learning and conducting daily business/life of each individual because if such individual can think analytically, he/she can estimate, plan, decide and forecast what is likely in the future (Charoenwongsak, 2003). Bloom (1981) explained that analytical thinking comprised three aspects 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles.

Analysis of elements is the ability to specify and categorize elements of communication. Illustrative educational objectives as 1) the ability to recognize unstated assumptions, 2) skill in distinguishing facts from hypotheses, 3) the ability to distinguish factual from normative statements, 4) skill in identifying motives and in discriminating between mechanisms of behavior with reference to individuals and groups, and 5) ability to distinguish a conclusion from statements which support it.

Analysis of relationship is the ability to distinguish in details how communication elements relate, decide relationship and what relationship that affects each other by finding what are related, how are they related and the degree of relationship, corresponding or opposing by linking causes and consequences. Illustrative educational objectives as 1) skill in comprehending the interrelationships among the ideas in a passage, 2) ability to recognize what particulars are relevant to the validation of a judgment, 3) ability to recognize which facts or assumptions are essential to a main thesis or to the argument in support of that thesis, 4) ability to check the consistency of hypotheses with given information and assumptions, 5) ability to distinguish cause-and-effect relationships from other sequential relationships, 6) ability to analyze the relations of statements in an argument, to distinguish relevant from irrelevant statements, 7) ability to detect logical fallacies in arguments, and 8) ability to recognize the causal relations and the important and unimportant details in an historical account.

Analysis of organizational principles is the ability to realize and see organizational principles behind elements that are combined to communicate the total picture by finding related rules and principles that differentiate situations or prescribed objects. Illustrative educational objectives as 1) ability to analyze, in a particular work of art, the relation of materials and means of production to the "elements" and to the organization, 2) the ability to recognize form and pattern in literary or artistic works as a means of understanding their meaning, 3) the ability to infer the author's purpose, point of view, or traits of thought and feeling as exhibited in his work, 4) ability to

infer an author's concept of science, philosophy, history, or of his art as exemplified in his practice, 5) ability to see the techniques used in persuasive materials, such as advertising, propaganda, etc, and 6) ability to recognize the point of view or bias of a writer in an historical account.

## METHODOLOGY

### Participants

The data were collected from 1,093 eighth-grade students who enrolled in the academic year of 2013, in the north-east area of Thailand. The subjects were selected by multi-stage random sampling.

### Instruments

The analytical thinking ability test was of multiple choices with 4 alternatives. There were 2 parallel test versions, each with 30 items, designed to measure analytical thinking ability (Bloom, 1981) on 3 aspects 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles, with 10 items for each aspect.

Out of the 150 eighth-grade students who enrolled in the academic year of 2013, in the north east area of Thailand, and the results (No.1, No.2) showed that the difficulty of items (p) and the discrimination (r) were ranged from 0.248-0.762, 0.267-0.772 and 0.783-0.815, 0.760-0.779 respectively, and the reliability (KR-20) was 0.801, 0.775.

### Data collection and analysis

Tests were carried out 5 times from 4 November 2013 to 28 March 2014 so that the obtained model would be flexible and be able to analyze growth with proper data distribution in accord with Tisak and Meredith (1990), McArdle and Hamagami (1995) and Wiratchai (1999). One-hour test followed the previous one after 5 weeks. Tests 1, 3 and 5 were used the first version while tests 2 and 4 were used the second version.

Scores were computed on 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles with 10 maximum scores for each aspect. Missing data comprised 5.78% which were filled with phantom representatives using Mplus program version 6.12 (Muthén and Muthén, 2009).

To test the first hypothesis whether scores of analysis of elements, analysis of relationship, analysis of organizational principles were statistically significant in all 5 tests, repeated measures MANOVA was used. Testing the second hypothesis whether the result corresponded to second-order growth curve factors model of analytical thinking ability, and that analysis of elements, relationship and organizational principle is in accord with empirical evidence with different shape and growth rate. To study the shape, the researchers analyzed variation within group and derived shape from the average scores whether they were in accord or not. If they were, they would be selected to analyze growth. If not, data were subjected to analysis to select the most appropriate to determine shape either by analyzing variation in group or considering average scores. This was done by looking at blending statistics whereby $x^2$/df is less, CFI > 0.90, TLI > 0.90, RMSEA < 0.079, and SRMR < 0.079 (Wiratchai, 1999). Studying growth rate of analytical thinking ability, the researchers employed second-order growth curve factors model using Mplus program version 6.12.

## FINDINGS

The results are as follows:

1) Analytical thinking ability scores of 5 tests using repeated measures MANOVA revealed centroid point of analysis of elements (F = 1568.381, p = 0.000), analysis of relationship (F = 1051.732, p = 0.000), and analysis of organizational principles (F = 2101.229, p = 0.000) are significantly different at .01 level. Measuring using Bonferroni's method revealed that means scores of every pair of analysis of elements, analysis of relationship, and analysis of organizational principles are statistically significant at .01 level in all 5 tests. Means scores of analytical thinking ability scores of 5 tests rose consecutively (Table 1).

2) Testing development and conformance to second-order growth curve factors model of analytical thinking ability from the analysis of variation within group yielded scores of analysis of elements (Linear = 5605.734, Quadratic = 832.430, p = 0.000), analysis of relationship (Linear = 4193.600, Quadratic = 38.968, p = 0.000), and analysis of organizational principles (Linear = 7316.247, Quadratic = 129.280, p = 0.000), showing linear growth. However, when considering shape of average scores of 5 tests, the scores of analysis of relationship ($\bar{x}_1$ = 4.11, $\bar{x}_2$ = 5.26, $\bar{x}_3$ = 6.19, $\bar{x}_4$ = 7.10, $\bar{x}_5$ = 7.86) revealed data distribution as linear growth model in line with analysis of variation within group, while scores of analysis of elements ($\bar{x}_1$ = 4.29, $\bar{x}_2$ = 6.02, $\bar{x}_3$ = 7.38, $\bar{x}_4$ = 8.06, $\bar{x}_5$ = 8.44) and analysis of organizational principles ($\bar{x}_1$ = 4.03, $\bar{x}_2$ = 4.73, $\bar{x}_3$ = 5.12, $\bar{x}_4$ = 6.49, $\bar{x}_5$ = 7.27) showed data distribution as piecewise growth model, which was contrary to analysis of variation within group. To ascertain selecting suitable growth model, the researchers compared the growth model of variation within group and average scores to see which model yielded the most compatible index. It was found that scores of analysis of elements and analysis of organizational principles yielded higher compatible index when used with piecewise growth model than linear growth model (Table 2).

The study found that second-order growth curve factors model of analytical thinking ability was in accord with empirical evidence ($x^2$ = 438.140, df = 59, CFI = 0.978, TLI = 0.961, RMSEA = 0.077, SRMR = 0.055) with all parameters were statistically significant at .01 level. Latent variables of analysis of elements had low initial value (2.754), had high growth rate during Week 1-10 (2.194), but declined during Week 11-20 (0.818). Latent variables of analysis of relationship had low initial value

**Table 1.** Results of repeated measurements of 5 tests of analysis of elements (AOE), analysis of relationship (AOR), and analysis of organizational principles (AOP).

| Multivariate tests | | | | | | |
|---|---|---|---|---|---|---|
| **Effect** | | **Value** | **F** | **Hypothesis df** | **Error df** | **p-value** |
| AOE | Pillai's trace | 0.852 | 1568.381 | 4 | 1089 | 0.000 |
| AOR | Pillai's trace | 0.794 | 1051.732 | 4 | 1089 | 0.000 |
| AOP | Pillai's trace | 0.885 | 2101.229 | 4 | 1089 | 0.000 |

| **(I) time** | **(J) time** | **Mean Difference (I-J)** | | | **Std. Error** | | | **p-value** |
|---|---|---|---|---|---|---|---|---|
| | | **AOE** | **AOR** | **AOP** | **AOE** | **AOR** | **AOP** | |
| 5 | 4 | 0.382 | 0.755 | 0.785 | 0.029 | 0.034 | 0.039 | 0.000 |
| | 3 | 1.061 | 1.673 | 2.158 | 0.042 | 0.049 | 0.035 | 0.000 |
| | 2 | 2.418 | 2.598 | 2.546 | 0.051 | 0.052 | 0.039 | 0.000 |
| | 1 | 4.153 | 3.749 | 3.246 | 0.053 | 0.059 | 0.038 | 0.000 |
| 4 | 3 | 0.679 | 0.919 | 1.373 | 0.035 | 0.036 | 0.041 | 0.000 |
| | 2 | 2.036 | 1.844 | 1.761 | 0.045 | 0.042 | 0.044 | 0.000 |
| | 1 | 3.770 | 2.995 | 2.461 | 0.052 | 0.053 | 0.046 | 0.000 |
| 3 | 2 | 1.357 | 0.925 | 0.388 | 0.037 | 0.036 | 0.033 | 0.000 |
| | 1 | 3.091 | 2.076 | 1.088 | 0.049 | 0.052 | 0.039 | 0.000 |
| 2 | 1 | 1.735 | 1.151 | 0.700 | 0.041 | 0.041 | 0.036 | 0.000 |

Pairwise Comparisons.

**Table 2.** Compatible index values of linear growth model and piecewise growth model.

| **Variable** | **Shape** | $x^2$ | **df** | $x^2$**/df** | **p-value** | **CFI** | **TLI** | **RMSEA** | **SRMR** |
|---|---|---|---|---|---|---|---|---|---|
| AOE | Linear | 1752.240 | 10 | 175.224 | 0.000 | 0.696 | 0.696 | 0.399 | 0.235 |
| | Piecewise | 105.328 | 6 | 17.555 | 0.000 | 0.983 | 0.971 | 0.123 | 0.040 |
| AOP | Linear | 658.509 | 10 | 65.851 | 0.000 | 0.803 | 0.803 | 0.244 | 0.201 |
| | Piecewise | 179.097 | 6 | 29.850 | 0.000 | 0.947 | 0.912 | 0.162 | 0.055 |

(2.582), rose to the highest (2.457), and continued to rise continuously. Latent variables of analysis of organizational principles had high initial value (3.931), had low growth rate during Week 1-10 (1.652), but rose during Week 11-20 (2.483). Measured variables' scores in all 5 tests could explain latent variables very well. (Table 3, Figures 1 and 2).

= 438.140, df = 59, CFI = 0.978, TLI = 0.961, RMSEA = 0.077, SRMR = 0.055

## Conclusion

Scores of analytical thinking ability of analysis of elements, analysis of relationship, and analysis of organizational principles in all 5 tests are statistically significant at .01 level with average scores rising consecutively. This may be due to the fact that students have more time to accumulate knowledge and exercise their brains constantly (Khammanee, 2001). Human brain can be trained and developed. Humans distinguish from other animals with larger brain, usage, and thought-process training (Khammani et al., 2006), which is backed up by studies of brain growth (Compton, 2003), which shows what factors play important role in analytical thinking ability growth.

Second-order growth curve factors model of analytical thinking ability is in accord with empirical evidence ($x^2$ = 438.140, df = 59, CFI = 0.978, TLI = 0.961, RMSEA = 0.077, SRMR = 0.055). Analytical thinking ability of analysis of elements, analysis of relationship, and analysis of organizational principles exhibit different shape and growth rate. Analysis of elements and analysis of organizational principles correspond to piecewise growth model while analysis of relationship corresponds to linear growth model. This may be due to the flexibility of conducting 5 tests, which makes it possible to analyze what is the most appropriate model for the data distribution (Tisak and Meredith, 1990; McArdle and Hamagami, 1995; Wiratchai, 1999), enabling the possibility of more than one growth curve model (Akihito, 2012). Data analysis of analytical thinking ability growth shows that all parameters are statistically significant at 0.1 level. The average latent variables have low initial

value, growth rate rising during Week 1-10, declining during Week 11-20, and measured variables in all 5 tests



**Table 3.** Results of second-order growth curve factors model of analytical thinking ability.

| Latent Variable | $\bar{x}$ | SE | Z-test | Observed Variable | Initial | | Slope1 | | Slope2 | | $r^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | b | $\beta$ | b | $\beta$ | b | $\beta$ | |
| | | | | AOE1 | 1 | 0.950 | 0 | - | 0 | - | 0.902 |
| IAOE | 2.754 | 0.080 | 34.588** | AOE2 | 1 | 0.763 | 1 | 0.351 | 0 | - | 0.769 |
| SAOE1 | 2.194 | 0.090 | 24.506** | AOE3 | 1 | 0.682 | 2 | 0.628 | 0 | - | 0.961 |
| SAOE2 | 0.818 | 0.041 | 20.109** | AOE4 | 1 | 0.725 | 2 | 0.667 | 0.5 | 0.292 | 0.850 |
| | | | | AOE5 | 1 | 0.796 | 2 | 0.733 | 1 | 0.641 | 0.947 |
| | | | | AOR1 | 1 | 0.970 | 0 | - | - | - | 0.940 |
| IAOR | 2.582 | 0.070 | 36.681** | AOR2 | 1 | 0.739 | 1 | 0.173 | - | - | 0.658 |
| SAOR1 | 2.457 | 0.104 | 23.556** | AOR3 | 1 | 0.630 | 2 | 0.295 | - | - | 0.601 |
| | | | | AOR4 | 1 | 0.625 | 3 | 0.440 | - | - | 0.758 |
| | | | | AOR5 | 1 | 0.612 | 4 | 0.572 | - | - | 0.926 |
| | | | | AOP1 | 1 | 0.789 | 0 | - | 0 | - | 0.622 |
| IAOP | 3.931 | 0.128 | 30.675** | AOP2 | 1 | 0.678 | 0.5 | 0.231 | 0 | - | 0.616 |
| SAOP1 | 1.652 | 0.102 | 16.186** | AOP3 | 1 | 0.635 | 1 | 0.434 | 0 | - | 0.774 |
| SAOP2 | 2.483 | 0.122 | 20.311** | AOP4 | 1 | 0.622 | 1 | 0.425 | 1 | 0.252 | 0.523 |
| | | | | AOP5 | 1 | 0.877 | 1 | 0.599 | 2 | 0.711 | 0.854 |

| Endogenous Latent Variable | Exogenous Latent Variable | b | $\beta$ | SE | Z-test | $r^2$ |
|---|---|---|---|---|---|---|
| | IAOE | 1.000 | 0.777 | 0.023 | 33.744** | 0.604 |
| IATA | IAOR | 0.573 | 0.435 | 0.040 | 10.816** | 0.396 |
| | IAOP | 0.713 | 0.836 | 0.020 | 42.450** | 0.698 |
| | SAOE1 | 1.000 | 0.667 | 0.032 | 20.549** | 0.445 |
| SATA1 | SAOR | 0.709 | 0.908 | 0.037 | 24.312** | 0.824 |
| | SAOP1 | 0.728 | 0.493 | 0.053 | 9.353** | 0.244 |
| SATA2 | SAOE2 | 1.000 | 0.402 | 0.038 | 10.471** | 0.162 |
| | SAOP2 | 0.694 | 0.836 | 0.047 | 17.840** | 0.699 |

$x^2$ = 438.140, df = 59, CFI = 0.978, TLI = 0.961, RMSEA = 0.077, SRMR = 0.055. Note: **p-value<0.01.

can explain latent variable very well. This may be due to the fact that all humans have different thinking abilities and attributes that contribute to such difference (Munkham, 2008). Human's analytical thinking ability is innate, abstract and directly unobservable. To measure, it must be done indirectly using hypotheses and measuring theory (Kanjanawasee, 2009). Bloom (1981) proposed measuring analytical thinking ability in 3 aspects 1) analysis of elements, 2) analysis of relationship, and 3) analysis of organizational principles, pointing out that analysis of elements comes first because if one can analyze elements, one can analyze their relationship, which tells what element relating to what, and how they are related. Analysis of organizational principles comes last because it is the ability to realize and see what behind the structural order when elements are combined to form a total picture, trying to find the principle behind the relationship and the difference in the event or prescribed object (Bloom, 1981; Banks, 1985; Michaelis, 1992; Khammani et al., 2006). Therefore, the study of shape and growth rate of analytical thinking ability is well served by second-order growth curve factors model due to its outstanding attributes in showing the shape and growth rate of observable variables (Shelton, 2010).

## RECOMMENDATIONS

Teachers or education administers should organize learning activities during Week 1-10 that emphasize analysis of organizational principles while during Week 11-20 more emphasis should be placed on analysis of elements in order to properly develop students' analytical thinking ability.

Since long-term education learning activities with at least 5 tests show a variety of changes (Akihito, 2012), it is advisable to study nature of growth before undertaking

data analysis so as to obtain appropriate and accurate results.

The researchers observe that in analyzing variation within group, if linear/quadratic < 60, it is advisable to inspect shape of the growth from average value, and then analyze to compare the more compatible index in determining the growth shape from within group variation

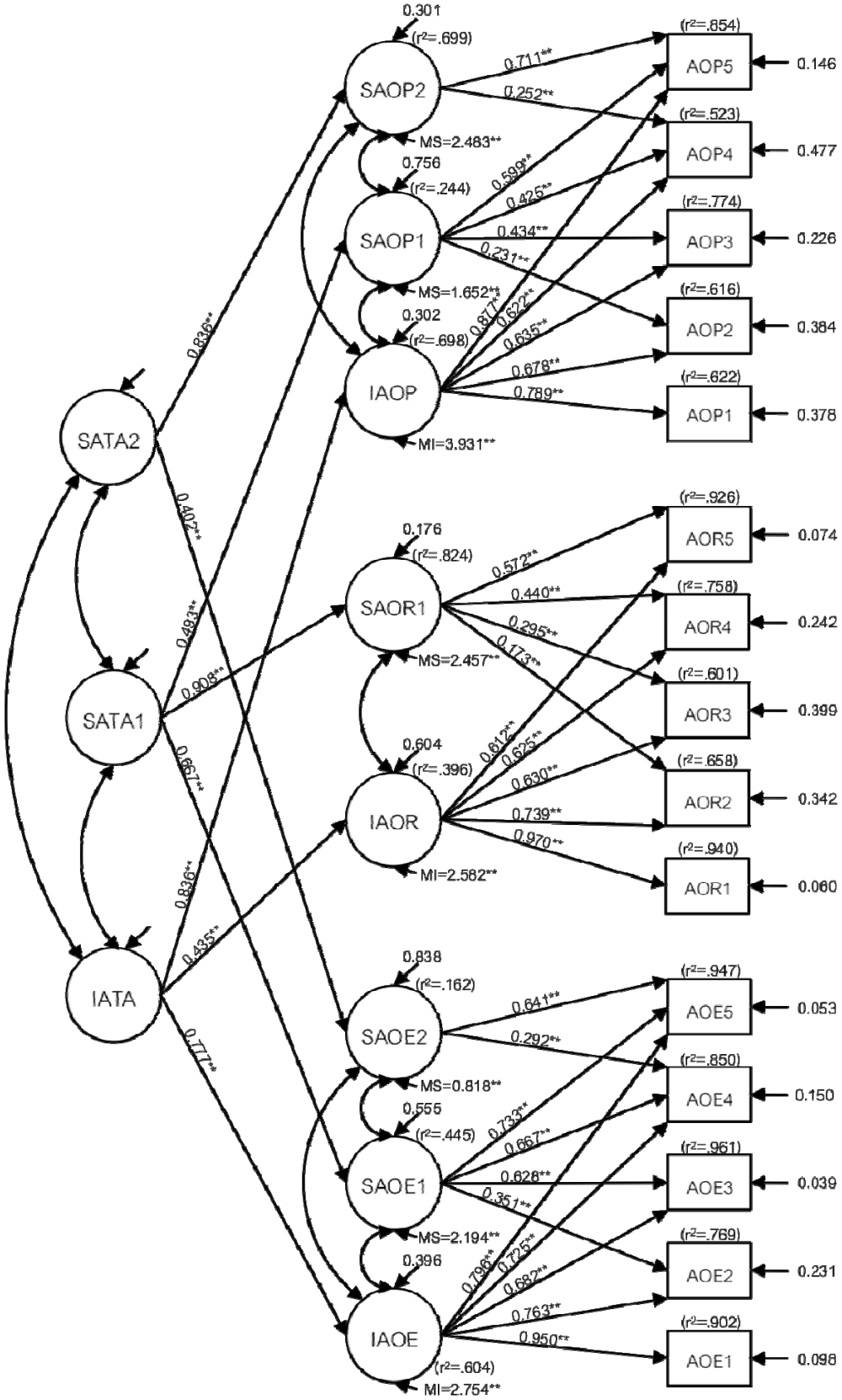


**Figure 1.** Second-order growth curve factors model of analytical thinking ability. Note: 1) **p-value<0.01, 2) Parameters in the model show standard values.

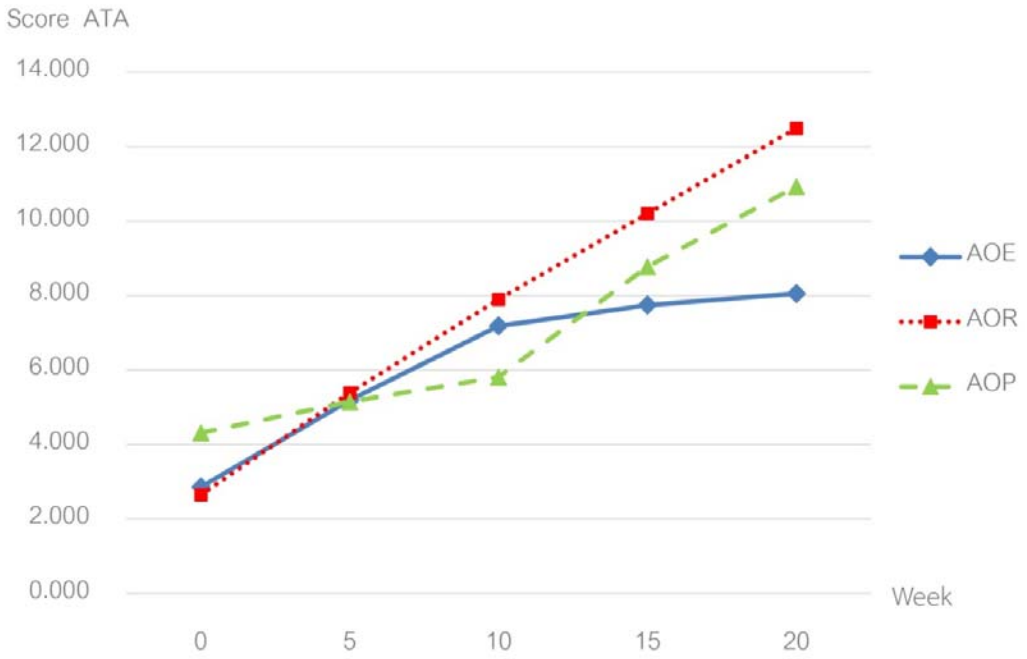


**Figure 2.** Analytical thinking ability growth in analysis of elements, analysis of relationship, and analysis of organizational principles.

analysis or from average value.

This research on second-order growth curve factors model of analytical thinking ability still lacks several variables mentioned in the theory including learning attitude, self-concept, learning styles and motivation. Nor does it include teacher-related variables such as classroom and school climate, teaching and school styles. If future research includes more of such variables, the obtained data will be more robust, relevant and effective.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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