A structural model to analyze the educational values in Chinese mathematical Olympiad

Abstract. The purpose of this research was to clarify the educational values of Mathematical Olympiad and avoid the distortion of education attribute of it using a confirmatory factor analysis approach. The literature on the education of Mathematical Olympiad was sorted out, relevant concepts were defined, and the educational values of Mathematical Olympiad were summarized. The educational values structural model of Mathematical Olympiad was established and a second order model is proposed based on the overall framework of the core literacy system of Chinese student's development. A survey was carried out with an effective sample of 427 secondary mathematics teachers from 28 provinces in China. The questionnaire consists mainly of 12 Likert scale questions. IBM SPSS 22.0 and AMOS 22.0 were used to analyze the data and structural models. The results showed that the adaptive degree of the structural model was very high and the adaptive index was good. The model clarifies the educational values of Mathematical Olympiad itself, indicating that education attribute is the essential attribute of Mathematical Olympiad in China. Relevant researchers should better explore new methods, create new ideas and take practical actions to realize the educational values of Mathematical Olympiad, to avoid the alienation of education attribute of it.

1. Introduction

Some research shows that junior high school and high school students are given mathematical Olympiad problems [1], [2]. China has also done the same with giving junior high school and high school students mathematical Olympiad problems to improve their mathematics skills early on [3], [4]. There were arguments about giving students mathematical Olympiad problems very early as there are various factors that should be considered such as the pressure to the students, students' stress level and teachers' and schools' demand . But if we see in other developed countries, junior high school and high school students were given mathematical Olympiad problems as their thinking ability are developing very fast compared to adults [5]–[8]. Every choice will have its good and side effects and in this case by giving students mathematical Olympiad problems, there are students who are success and there are also students who feel stress [9].

Mathematical Olympiad usually focuses on developing students that has a high mathematical ability [10], [11]. In every school, city or province there would be some students that has a high mathematical ability. If it's not utilized properly, the ability will not develop. Giving mathematical Olympiad problems will filter students who are talented to keep going to an international level and be the pride of the country.

Mathematical Olympiad is a high-class competition that are held all around the world. There are 6 aspects that are tested in mathematical Olympiad problems for junior high school students which are numbers, algebraic expression, equation and inequality, functions, geometry and mathematical ability. While the high school Olympiad problems not only it includes all the material in high school, but it also focuses on geometry, algebra, elementary number theory and combinatorial problems. The Olympiad characteristic is always creative, challenging and keep on developing throughout the years.

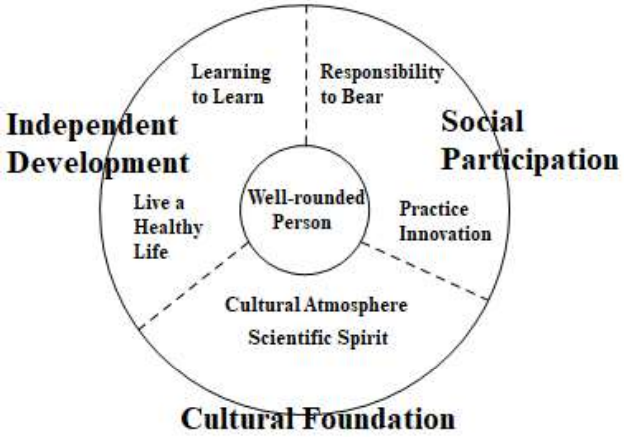

Figure 1. General framework of Chinese students' core literacy development system

Education aims to grow new generations that is suitable and ready to face new problems. Education will also help students in preparing themselves in facing our everyday life. Based on figure 1, we can see that the development of students' quality is surrounded by 3 main factors which are independent development, social participation and cultural foundation. Each of the main factor has 2 aspects of educational values. There are 6 education values in mathematical Olympiad which are cultural awareness, literacy development, interest cultivation, willpower training, extracurricular learning and creativity cultivation. Based on this, researchers did a more detailed research on the teachers' response towards the 6 education values. From the teachers' response we can see if the 6 education values of mathematical Olympiad is beneficial for students.

2. Method

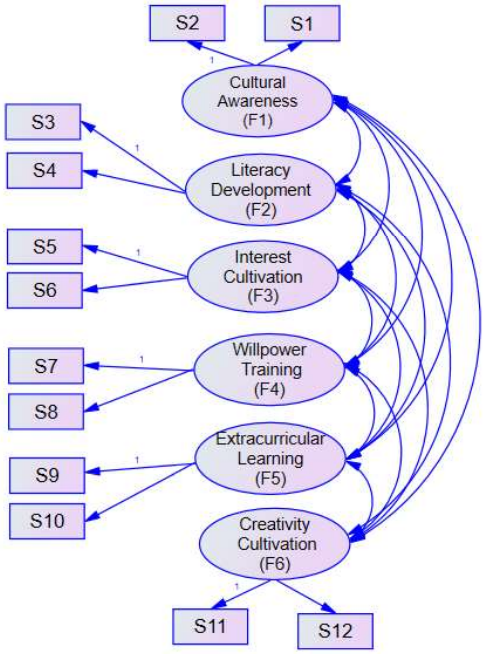

Figure 2. The hypothetical structural model on mathematical Olympiad

Based on the problem shows at introduction parts, researchers analyzed the 6 education values of mathematical Olympiad using a structural model [12], [13]. The model diagram can be seen in figure 2. There are two observational indicators for each education values aspects. The model has 39 free parameters (t) and 78 data points (DP), so the degrees of freedom (DF) in the model is 78-39=39>0. The model is over-identified and further analysis can be carried out.
Researchers gave questionnaires to analyze teachers' attitude towards mathematical Olympiad. This research uses a quantitative and qualitative study. The questionnaire given to teachers consist of 12 questions (table 1). The data is taken using WeChat and the correspondent are 606 teachers in china. The questionnaire result will then be processed using SPSS 22.0 and AMOS 22.0.

Table 1. Questionnaire on teachers' attitude towards mathematical Olympiad in China

Structure	Latent Variables	Observation Indexes
Cultural Foundation	Cultural Awareness (F1)	Learning Mathematical Olympiad help students understand the mathematics concepts better (S1)
		Learning mathematical Olympiad helps students understand the value of mathematics (S2)
	Literacy Development (F2)	Mathematical Olympiad is higher mathematics (S3)
		Learning mathematical Olympiad requires higher mathematical literacy (S4)
Independent Development	Interest Cultivation (F3)	Learning Mathematical Olympiad can cultivate students' learning interest in mathematics (S5)
		Learning mathematical Olympiad can develop students' interest in intellectual thinking (S6)
	Willpower Training (F4)	Learning mathematics Olympiad can shape students' character (S7)
		Learning mathematical Olympiad can cultivate students' willpower (S8)
Social Participation	Extracurricular Learning (F5)	Mathematical Olympiad will be taught in the form of an a-level training class in the school(S9)
		Social training institutions are the main battlefields for students to learn Mathematical Olympiad (S10)
	Creativity Cultivation (F6)	There is often no ready-made solution for solving problems in Mathematical Olympiad (S11)
		Good imagination is needed to learn mathematical Olympiad (S12)

3. Results and Discussion

From 427 questionnaire that are collected, 17.56% of them were filled by junior teachers, 47.31% of them were filled by intermediate teachers, 31.38% were filled by sub-senior

teacher and 3.75% were filled by senior teachers. The teachers who filled these questionnaires are from 28 different provinces in china which includes Shanghai, Beijing, Jiangsu, Zhejiang, Hunan, Hubei, Guangdong, Guangxi and Yunnan.

3.1 Questionnaires' validation and reliability test

The 12 questions in the questionnaire has passed the validation and relatability test to make sure that the questions used by researchers are valid. The Cronbach Alpha coefficient of the questionnaire is 0.777(>0.7), and the reliability of the questionnaire is acceptable. The KMO value of the questionnaire is 0.852(>0.8), and the structural validity of the questionnaire is good

3.2 Structural model

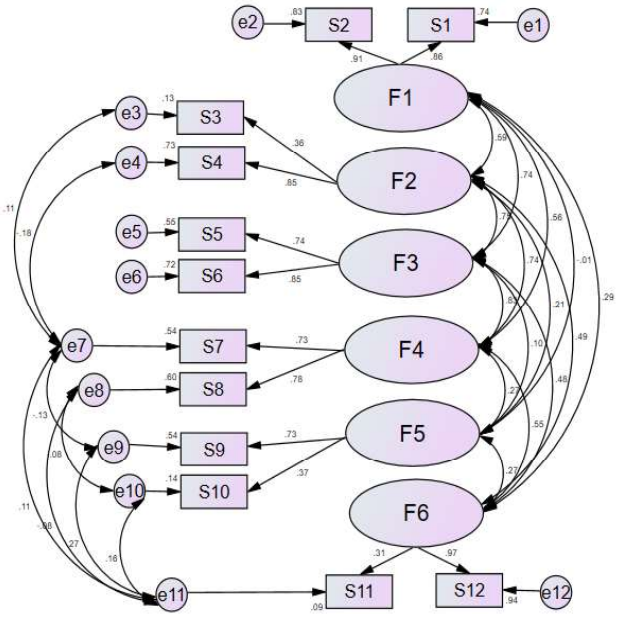

Figure 3. Interview result with the teachers

Chi-squared value is an evaluation index that is very commonly used in structural model. The smaller the chi-squared value, the better the model is. After the model is modified, the chi-squared value of the model is 42.429 and the probability significance is 0.083>0.05. With this, we can assume that the model is compatible with the data that are analyzed. From the adaption index, the AGFI value is 0.960> 0.9, the GFI value is 0.84>0.9, the RMSEA value is 0.029< 0.05 which shows that the model is feasible.

Table 2. Analysis result of the structural model

	Estimate	S.E.	C.R.	P		Estimate	S.E.	C.R.	P
S1<---F1	.946	.050	18.789	***	S10<---F5	.624	.249	2.508	.012
S12<---F6	2.575	.807	3.190	.001	S9<---F5	1.000			
S5<---F3	1.000				S7<---F4	1.000			
S6<---F3	.870	.054	15.974	***	S2<---F1	1.000			
S4<---F2	1.470	.254	5.785	***	S11<---F6	1.000			
S3<---F2	1.000								
S8<---F4	.869	.065	13.283	***					

Table 2 showed the unstandardized regression coefficients estimated with the maximum likelihood method.

Table 3. Standardized Regression Weights

	Estimate		Estimate		Estimate
S1<---F1	.859	S5<---F3	.738	S9<---F5	.734
S2<---F1	.909	S6<---F3	.849	S10<---F5	.370
S3<---F2	.359	S7<---F4	.734	S11<---F6	.307
S4<---F2	.853	S8<---F4	.777	S12<---F6	.968

Standardized regression weights are also known as factor weights or factor loads in confirmatory factor analysis. Standardized regression coefficients represent the impact of common factors on measurement variables. The factor load value is between 0.50 and 0.95, indicating that the basic adaptability of the model is good. The larger the factor load value is, the greater the variation of the indicator variable can be explained by the observed indicator, and the indicator variable can effectively reflect the characteristics of the variable to be measured. Take "S1<-- --F1" as an example, Table 3 shows the factor load value is 0.859. It means that when F1 goes up by 1 standard deviation, S1 goes up by 0.859 standard deviations. From the factor load values shown in table 2, the basic adaptability of the model is acceptable.

Table 4. The covariance between latent variables

	Estimate	S.E.	C.R.	P		Estimate	S.E.	C.R.	P
F1<-->F2	.236	.047	5.014	***	F6<-->F4	.130	.044	2.935	.003
F3<-->F2	.249	.049	5.121	***	F1<-->F4	.386	.049	7.894	***
F3<-->F4	.478	.052	9.188	***	F2<-->F5	.072	.028	2.532	.011
F4<-->F5	.158	.049	3.215	.001	F6<-->F3	.118	.040	2.954	.003
F6<-->F5	.068	.028	2.377	.017	F1<-->F5	-.010	.049	-.200	.841
F1<-->F3	.523	.054	9.666	***	F1<-->F6	.085	.031	2.739	.006
F2<-->F4	.239	.049	4.837	***	F6<-->F2	.067	.025	2.671	.008
F3<-->F5	.062	.044	1.418	.156					

Table 5. Correlation coefficients between latent variables

	Estimate		Estimate		
F1<-->F2	.594	F1<-->F3	.740	F2<-->F5	.211
F3<-->F2	.751	F2<-->F4	.740	F6<-->F3	.483
F3<-->F4	.834	F3<-->F5	.103	F1<-->F5	-.013
F4<-->F5	.268	F6<-->F4	.547	F1<-->F6	.290
F6<-->F5	.269	F1<-->F4	.563	F6<-->F2	.489

Table 4 shows the estimated covariance among the six potential variables. If the covariance test results are is not 0, it means that every variable has a good correlation. When the covariance of two variables reaches the significant level, the correlation coefficient of them reaches the significant level too. Taking "F3<--->F4" as an example in table 4, the covariance of F3 and F4 was 0.478, the standard error of covariance was estimated to be 0.052, and the critical ratio was 9.188, reaching the significance level of 0.05.

Table 6. Squared Multiple Correlations

	Estimate		Estimate		Estimate		Estimate
S11	.094	S9	.539	S6	.720	S3	.129
S2	.826	S8	.604	S5	.545	S12	.938
S10	.137	S7	.538	S4	.728	S1	.738

The data in table 6 are the square of multiple correlations of the observed variables, indicating the amount of variation that the observed variable is explained by its potential variable, and the value of the explained variation is also the reliability coefficient of the corresponding measurement variable.

Among them, except S11, S10 and S3, which are explained by their respective potential variables with the variance less than 0.50, the reliability coefficient of the other observation variables is all above 0.50, indicating that the internal quality test of the model is good.

Overall, based on the model above we can see that mathematical Olympiad has 6 education values that are interrelated and it build the students' character and quality. Based on this research, we can see the benefit for junior high school and high school students to learn mathematical Olympiad problems. This is why until today, international mathematical Olympiad is still held every year and China has always been on the top.

4. Conclusion

Until now, there are still a lot of people who are confused and don't know the benefit of Olympiad for students. Based on this research result it was proved that mathematical Olympiad has 6 educational values the consist of cultural awareness, literacy development, interest cultivation, willpower training, extracurricular learning and creativity cultivation. These 6 factors are interrelated and has a benefit of building students' character and quality.

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