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ANALYSIS OF MATHEMATICAL LEARNING FOR PRE-UNIVERSITY STUDENTS IN LOCAL UNIVERSITY

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Abstract

By the collected questionnaires on mathematical concepts, propositions and logical reasoning and the scores in the final examination, this paper investigates the mathematical learning of pre-university students in Hunan University of Technology. The results showed that female students performed better on mathematical concepts and propositions, while the comprehensive logical reasoning ability of male students was statistically better than female students, although there was no significant difference in mathematics learning ability between different genders. Besides, the level of basic mathematics experience accumulated by the pre-university students in the basic education stage has a significant impact on their mathematics learning in university stage. Some discussions and suggestions are also provided for cultivating the mathematics learning ability of pre-university students.

Keywords: *Pre-university students, learning ability, local university*

Introduction

The Pre-university education is an important part of higher education in China. It is a basic implementation of national policies in the field of education for effectively cultivating talents to develop regional economies in under-developed areas and ethnic minority areas. Pre-university education is not only different from the basic education at the middle school level, but also from the professional education of undergraduates. As a special education level, it is the preparatory or transitional stage before entering undergraduate education. Pre-university students participate in the National College Entrance Examination (NCEE) with a moderately lowered score admission and accept the university-based, but incomplete undergraduate education before they formally enter university.

This educational mode is regarded as an effective supplement for pre-university students, helping them lay a solid foundation for higher education (Hazel 2006, Zhang 2004). However, instructors in the traditional university are required to change the educational concept and explore proper training models for preparatory education (Song 2006). Pre-university education in China is borrowed from western countries (George et.al. 1998), incorporating its own experiences due to the wideness of geographic area and diversity of multi-culture. To bridge the educational gap between the developed and the underdeveloped areas, the pre-university education policy, on one hand, should be adhered to and even strengthened. On the other hand, a new stage is supposed to be created to cater to the changes of times. Pre-university education has various modes around the world (Sezer 2002, Hanna et.al. 1992, Abdullah 2013). Nevertheless, it now conducts in a way of centralized training in China. One type of training base is the national-level preparatory college and the teaching mode has been studied by (Yang 2004). The other type is provincial-level preparatory in terms of the practical condition of the respective province, for example, Hebei, Heilongjiang, Guangxi, and Inner Mongolia (Wang B. 2017, He L, 2011, Cui & Wu 2012, Guan & Buhegeerdun 2016). No matter

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what type of the base is, many difficulties occur in the pre-university education including the outdated educational management concepts, unenlightened curriculum structure system, and the relatively low quality of the faculty. Some valuable suggestions, such as the exploration of new management and examination modes have been proposed by various scholars and conducted in different universities, receiving some positive effects (Zhang & Ouyang 2009). In terms of courses in the pre-university education, mathematics is the main one, undertaking the dual tasks of strengthening elementary mathematics and preparatory advanced mathematics. Nevertheless, the mathematics of the pre-university level has its special characteristics and teaching requirements. In view of this, instructors should fully understand the mathematical abilities of pre-university students before the start of teaching activities. In mathematical learning, memorizing, understanding, and logical reasoning are indispensable for students. Especially, the logical reasoning emphasizes the thinking activity, after the process of analysis, synthesis, induction, analogy, abstraction, generalization and conjecture, to prove the connection between mathematical objects according to some rules, and the ability to express the thinking activity in mathematical language (Yu 2012). As the current mathematical knowledge goes into a stage of explosive growth, the pre-university education should not concentrate on the transmission of knowledge merely, but more prefer to cultivate mathematical thinking ability, which reversely helps to improve students' self-learning ability and mathematical literacy. However, domestic research on pre-university education now is mainly on the reform of teaching methods, teaching content, and teaching management (Li 2008, He 2011), few on the questionnaire survey of the pre-university students' mathematical reasoning ability. Moreover, the research on the particularity of the source of students in central and western provinces of China is still insufficient. This paper takes the Hunan University of Technology, a local university in the Chinese central region, as an example to investigate the mathematical learning ability of pre-university students. The main topics includes: (1) Does the gender of the pre-university students has a significant difference in mathematics learning? (2) Does the level of basic mathematics experience accumulated by the preparatory students in the basic education stage have an impact on the mathematics learning?

Research Methodology

Research objects

In this research, the object is 119 students of School of Science (3 classes enrolled in 2019) of the Hunan University of Technology. A total of 119 questionnaires were distributed, and 111 valid questionnaires were retrieved.

This survey employs an unstructured questionnaire, which is consisted of three parts mathematical concepts, mathematical proposition, and logical reasoning. There are 10 questions with each 10 points and total of 100 points. The distribution of test questions is shown in Table 1. For example, Question 1 comes from some noun concepts, definitions, theorems, etc. in middle school textbooks, which are converted into mathematical symbolic language through text language and associated with memory and understanding ability; Question 5 starts from the perspective of the quantitative relationship among the number of faces, vertices, and edges of the polyhedra, examining students' mathematical induction ability; Question 6 is a statistical problem, from the perspective of frequency, examining students' memory and mathematical understanding ability; Question 10 is a combination of the set and mathematical function from a perspective of classification and discussion, examining students' logical reasoning ability and mathematical expression ability.

The evaluation criteria for the students' response concentrating on (1) whether the students having a deep and overall understanding of the mathematical concepts; (2) whether the students apply the mathematical propositions correctly and flexibly; (3) whether the students' logic reasoning is correct

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and rigorous.

Table 1

Descriptive statistics in test

Content	Question number distribution
Concepts	1 4 8
Propositions	2 5 6 9
Logical easoning	7 10

Characteristics of samples

The 119 pre-university students enrolled by Hunan University of Technology in 2019 are mainly from underdeveloped areas with low GDP or ethnic minority settlements, which mostly lie in the central or the west area of China. These students come from a total of 8 different nationalities and there are 56 male students and 55 female students.

ANALYSIS AND FINDINGS

Overall descriptive statistics

The descriptive statistics of the points obtained by the students in each part of the test are shown in Table 2, where Min., Max., and Ave. stand for the minimal, the maximal and the average points.

Table 2

Descriptive statistics in test

	Points	Min.	Max.	Ave.
Total	100	25	95	58.1
Concepts	30	9	30	28.4
Propositions	40	4	38	22.4
Logical easoning	30	2	28	7.3

Several aspects could be seen from Table 2.

● The full score of the test is 100 points. The highest and the lowest are 95 and 27, respectively, showing an extremely large gap. The overall average score of the students is only 58.1, indicating that the overall performance of the mathematics ability of students still needs to be improved. Especially, the difference in the logical reasoning ability of different students is relatively large.

● The questions of math concepts in the test have 30 points totally. The highest and the lowest score are 30 and 9 points, respectively. The average score is 28.4, showing students have a good memory of mathematical concepts. Specifically, the first question of the test examines the students' direct understanding of the two mathematical concepts of "sufficient conditions" and "necessary conditions". The overall average score of the students is as high as 8.56. The fourth question of the test requires students to apply the two mathematical concepts of "sufficient condition" and

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"necessary condition" to solve the problem and the overall average score is 7.85. Therefore, pre-university students in this test are more optimistic about the application of direct retelling of mathematical concepts.

● The full score of the second part associated with the mathematical proposition in the test is 40 points. The highest score and the lowest are 38 and 4 points, respectively. The average score is 22.4, indicating that students' ability to apply mathematical propositions (formulas, theorems, rules, properties, etc.) requires to be improved. For example, the second question examines the application of the algorithm structure, and requires students to calculate the output results according to the block diagram.

● The logical reasoning part of the test is totally 30 points. The highest and the lowest score are 28 and 2 points, respectively. The average score of the overall student however is only 7.3, meaning the logical reasoning ability of pre-university students is relatively weak. For example, Question 10 is respect to the nature of functions and the application of derivatives. Since this question is more complicated in classification, reasoning, synthesis, deduction and argumentation, the average score is only 3.78, showing that the students' overall ability to solve the more complex problem still needs to be improved and more attention should be paid to the training of logical reasoning ability.

To highlight the performances of pre-university students of different genders, we make a comparison and list related results in Table 3.

Table 3.

Comparison of average scores of students of different genders

	Average	Concepts	Propositions	Logic reasoning
Female	59.6	29.6	23.5	6.5
Male	56.7	27.2	21.4	8.2

It is seen from Table 3 that the average scores of female and male students are respectively 59.6 and 56.7, showing female students might get higher mathematical scores than male students. However, their scores, either male students or female students, are not evenly distributed in the practical tests, and the phenomenon of polarization is serious. Moreover, the performance differentiation of male students is worse than that of male students.

In terms of questions of concepts, the average score of female students is 29.6 points, higher than that of the male students, 27.2 points, showing female students are better at memorizing and direct repetition of the mathematical concepts. Similar performance of the mathematical proposition part can be seen from Table 3 that female students' average score 23.5 is higher than the male students' average score, 21.4, mostly implying more insufficient memory of the formula and the lower accuracy of the calculation of male students than those of female students. However, the average scores on logical reasoning for female and male students are 6.5 and 8.2, respectively. That is, male students performed better than female students did in terms of logic reasoning, although the gap is not very significant, i.e. 1.7 points. In fact, statistical results reveal that, for example the

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question 10, the percentage of the excellent score for male students is about 15.1%, over that for female students, about 8.8%. This shows that male students might be superior to female students in logical reasoning ability in the derivation of more comprehensive and difficult problems.

Testing difference of mathematical learning ability for male and female students

It is obvious that male and female pre-university students have different scores in this test. According to our past experiences, there also exists difference in learning ability for two genders. By exploiting the statistical software SPSS 22.0, we will test whether this difference is statistically significant.The obtained results are given in Table 4.

Table 4.

The difference of mathematical learning ability for different genders

t-test (two-tail)		
t	df	Sig.
0.602	109	0.512

Note: **p<0.01, *p<0.05

It is seen that the Sig. value of the two-sided test is 0.512, greater than 0.05, indicating that the difference in mathematical learning ability for female and male students is not significant in the statistical sense. On the other hand, it is seen, from descriptive statistics in the last subsection, that female students beat male students in questions of concepts and propositions, while male students have better performance in questions of logic reasoning. Here we further test whether these differences are statistically significant. Similarly, the software SPSS 22.0 is used, and the obtained results are listed in Table 5.

Table 5.

The difference of different abilities for different genders

	Levene test		t-test (two-tail)		
	F	Sig.	t	df	Sig.
Concepts	0.106	0.702	-0.994	109	0.201
Propositions	0.036	0.805	0.661	109	0.283
Logical reasoning	0.281	0.572	1.768	109	0.018*

Note: **p<0.01, *p<0.05

It can be seen from Table 5 that Sig. of the two-tail T-test takes various values for students of different genders when testing the abilities of mathematical concepts, propositions, and logical reasoning. Specifically, Sig. value is not statistically significant for testing questions of concepts (0.201) and proposition (0.283), but significant for testing questions of logical reasoning, (0.018, less than 0.05), indicating that the male students do perform better than the female in terms of the

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logic reasoning in the statistical sense.

Impact of basic mathematics experience on the mathematics learning.

To see the impact of experiences accumulated by the preparatory students in the basic education stage on the mathematics learning, we collected all scores of the final exam of 119 pre-university students and employed a regression analysis in this subsection to make a statistical interpretation. That is, a regression analysis is conducted on the final scores of pre-university students at the end of the semester (standing for the students' gain after one semester's learning) and their questionnaire test scores at the start of the semester (representing the students' basic level of mathematics activity experience). The regression results are shown in Table 6, where "Se" is the score of the final exam and "Ss" is the questionnaire score at the start of the semester.

Table 6.

Regression of the scores at the end and the start of the semester

	Num. of Students	Ss	Constant	R-squared
Se	111	0.501	47.75*	0.071

Note: **p<0.01, *p<0.05

It is seen from Table 6 that the questionnaire test score, under a significance level of 0.05, has a positive effect on the final score. The derived regression equation is Se = 0.549 × Ss + 47.75, implying that the final score, on average, will increase 0.501 point correspondingly when the questionnaire test score enhances by 1 point. In other words, the richer mathematical experiences of pre-university students have in the basic education stage, the better performance they attain at the final exam. Furthermore, the regression between the final score and three classified parts in the questionnaire test (concepts, propositions, logical reasoning) also made to interpret the statistical relation. The obtained results are given in Table 7, where "C", "P" and "R" respectively represent the score of the concept, proposition and logic reasoning.

Table 7.

Regression of the scores at the end and the start of the semester

	Num. of Students	C	P	R	Constant	R-squared
Se	111	0.747*	0.304	0.149	64.47*	0.213

Note: **p<0.01, *p<0.05

It is seen that the regression equation is Se= 0.747×C + 0.304×P + 0149×R + 64.47 and the coefficient of C is significant while those of P and R are not significant under the significance level of 0.05. This explains that only the coefficient of the score of concept topics is significant. On average, for enhancement of 1 point in concept, the score of the final exam is higher by 0.747 points. Combining with the analysis of the final exam and the interview of pre-university students, we

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found that the questions of concepts in the final exam are more related to the weekday homework and the difficulty is not high, which also confirms the rationality of the regression results.

Conclusion and suggestion

According to the above results and analysis, several aspects of instructing mathematical concepts, propositions and logical reasoning can be concluded to help pre-university students develop mathematical learning ability.

1. Whether understanding mathematical concepts correctly is a prerequisite for cultivating pre-university students' mathematical ability. The degree of understanding related concepts directly affects their application of mathematical concepts and their interest in mathematics. Also, the instruction of mathematics concepts is an important part of the mathematical teaching activity. Instructors are supposed to make an interesting design of concepts in class according to students' cognitive level and strive to help students experience the process of concept formation, generation, and development. Specifically, (1) The incorporating materials of the new class should be close to the students' life and the instruction to the students is supposed to be in an intuitive way to stimulate the students' interest, which is conducive to their active thinking activities; (2) Deepen students' understanding of the essence of concepts via listing some comparison of positive and negative examples or concluding their similarities. (3) Guide students to abstract, generalize, analyze and summarize the learning materials, so that they can have a deeper understanding of the formation, generation, and development of concepts.

2. Proper proof of mathematical propositions is indespensable for cultivating students' ability of deduction. In the pre-university stage, as pre-university students have known some mathematics propositions with omitted proof in high school textbooks, so that the students only memorize these propositions mechanically, without an in-depth understanding of the logical relationship between conditions and conclusions in mathematical propositions. Therefore, instructors can properly present the process of the deduction of propositions, promoting students to understand propositions correctly. Another approach to strengthen students' application of mathematical propositions is deviding the proof into several parts from easy to hard. Instructors may distribute assignments after class at different levels to enable students to recognize the applicable conditions of propositions and the slight difference from other similar propositions, so that students can apply propositions and their reverse version flexibly.

3. In the derivation of mathematical proof, instructors may focus on training students' mathematical logic reasoning ability. The way of logic reasoning could be design to permeate the teaching activities, and it could be refined by students after solving a series of mathematical problems. Students often make use of analogy, induction, analysis, synthesis, and other derivation methods in the process of solving problems. Therefore, a good design of proof problems according to students' level is an effective way to cultivate students' logical reasoning ability. Besides, mathematical language is a more rigorous than common language. Although many students know how to deduce conclusions, they cannot express their own reasoning activity process in

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standardized mathematical language, which directly affects the development of students' logical reasoning ability. Therefore, instructors could be rigorous to students' customs of using mathematics language, so that they can express their views freely in mathematics language.

4. Although there exists no statistical difference in the mathematical learning ability of different genders, it can be seen from the previous that female students can perform better at mathematical concepts and mathematical propositions via using mechanical memory, and male students are better at abstract logical reasoning. Therefore, the male and the female can be paired together for learning in the form of group cooperation. By the cooperative process between male and female students, the male can learn from the female how to memorize mathematical concepts and propositions with their better logical reasoning ability, and the female can learn from the male how to perform mathematical logical reasoning proofs effectively. Besides, group learning can also be conducted in the dormitory by providing different learning materials for male students and female students. Materials for female students may incoporate the deduction of theory while those for male students may enhance the proportion of mathematical concepts and propositions.

5. The regression analysis in the previous section shows that the final scores of the pre-university students are closely related to their level of experience in basic mathematics activities. Further research reveals that this close connection mainly comes from the score of concept questions, which may be somewhat related to the ones of the final test questions and the usual homework. Since the pre-university students come from different places, the teaching level and teaching methods of mathematics instructors vary distinctly, and the mathematics learning habits of students during middle school are different. Consequently, the pre-university students showed different learning effects when they first contacted the university mathematics courses, even if the mathematics scores of the college entrance examination did not differ much at the time of admission. The instructors can employ various methods to improve the subjective initiative of some students via some methods, such as "small class discussion", "cooperative learning between students". Also, the teacher may set students with strong mathematics learning ability as an example to drive ones with poor mathematics learning ability, then the whole class could be promoted and pushed forward together.

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