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The performance of solving interdisciplinary problems for higher vocational college students

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Abstract: Interdisciplinary teaching has been widely used in vocational education, which constructs the relationship among different disciplines and improves the ability of students to analyze and solve practical problems, while the examinations to assess the performance of students in soling interdisciplinary problems are limited. In this study, we investigated the performance of 164 students from Jiangsu Higher Vocational and Technical College in China in solving interdisciplinary problems, and analyzed the differences in students' aspects in solving these problems such as gender, majors, ages, self-efficacy and attitudes. After analyzing their scores using t test or ANOVA test, we found the female students had a better performance than male students (2.96 vs 2.28, p=0.001). Besides, the mean scores between students in majors was statistically different where students in major 1 (Big data and Accounting) had a significantly higher score (3.03 vs 2.44 and 2.23, p=0.001). Meanwhile, we found that students with a positive self-efficacy performed better than those students with the negative self-efficacy (3.07 vs 2.72, p=0.023). Hence, we believe that the differences are objectively existed in different students to solve interdisciplinary problems, and the personalized teaching methods should be carried out in the daily interdisciplinary teaching processes.

1. Introduction

Nowadays, interdisciplinary teaching has been a hot topic for teachers and educators as this method can improve the overall problem-solving skills of students. Compared with traditional departmental teaching, which leads to the isolation, separation and lack of coordination and horizontal connection among disciplines, interdisciplinary teaching improves the ability of students to solve practical problems using multi-disciplinary knowledge [1]. Besides, it is possible for students to solve the contradiction between school curriculum and disciplinary development, and increase their adaptability to society in the future after having a good command knowledge of interdisciplinary subjects [2].

As an important part of interdisciplinary teaching, STEM education (Science, Technology, Engineering and Mathematics) has developed in the US for over 30 years [3]. STEM education is not a simple superposition of science, technology, engineering and mathematics education, but a

combination of four subjects to form an entirety, in order to cultivate the innovation and practical ability of students [4]. According to study of V M Bazurin et.al, it was found that the system of interdisciplinary practice-oriented problems of mathematical content was more effective than that of problems given in school textbooks [5]. Besides, other educators have studied the application of interdisciplinary teaching in the junior and senior high school [6]. However, there was a limited number of studies investigating the performance of higher vocational college students after accepting interdisciplinary teaching.

In this study, we investigated the performance of 164 students from Jiangsu Higher Vocational and Technical College in China in solving interdisciplinary problems, and then analyzed the differences in students' aspects in solving these problems such as gender, majors, ages, self-efficacy and attitudes.

2. Materials and Methods

2.1 Participants

There were totally 164 students from commercial department of Jiangsu Vocational and Technical College participating in this study. Their basic information, self-efficacy, self-cognition and scores solving after interdisciplinary problems were collected and analyzed. These interdisciplinary problems derived from economical mathematics, which examined the ability of students to solve practical economic problems using theoretical mathematical knowledge during the spring semester of the academic year of 2022-2023.

2.2 Procedures

This report mainly focuses on three tasks below: (1) Investigate the performance of vocational students in dealing with interdisciplinary problems, mainly focused on academic, self-efficient and attitude. (2) Analyze vocational students' performance and define responding reasons. (3) Propose practical suggestions for pedagogical methods.

According to six requirements for Interdisciplinary problems with mathematical content offered by V M Bazurin and the curriculum arrangement of higher mathematics in the college form From February to April. We designed 3 interdisciplinary problems with mathematical and economic content to investigate students' performance in dealing with interdisciplinary problems, and these questions mentioned are selected from *Applied Mathematics* and *Economic Mathematics*.

After completing three interdisciplinary problems mentioned above, subjects were required to fill out questionnaire 1 with 15 questions to survey their age, gender, majors, self-efficacy and self-attitude towards the interdisciplinary teaching and interdisciplinary questions.

This study contained three stages in total: preparatory phase (about 4 weeks), implementation phase (about 2 weeks) and analysis phase (about 4 weeks).

2.3 Statistical analysis

Continuous variables are presented as the mean and standard deviation (SD). Comparisons between groups were made using Student's t test or one way ANOVA. The weighted mean was calculated by multiplying the variable's relative proportion or percentage by its value in sequence and adding those sums together.

3. Results and Data analysis

3.1 Academic Performance of Three Interdisciplinary Problems

To assess the performance, 3 interdisciplinary questions about economic mathematics were designed. 164 students from commercial department of Jiangsu Vocational and Technical College have completed those questions. These 3 interdisciplinary problems corresponded to three topics in mathematics. Question 1, 2 and 3 respectively focused on Definite integrals and their applications, Differential equation and Multivariable differential calculus.

As shown in table 1, there was a significant difference in 3 questions scores ($p<0.05$), where students performed better in Question 3 than Question 1 and 2 with the level of 3.52 mean score. It indicated that vocational students mastered Multivariable differential calculus better than other two topics. It was supposed to be reasoning to 60 class hours are scheduled for this topic according to teaching plan, which is more than other topics.

Table 1: ANOVA results in regard to the problem-solving scores based on different interdisciplinary questions

Dependent variables	**Interdisciplinary questions**	**N**	**Mean**	**SD**	**F**	**P**
Scores	1	164	2.69	1.56	35.49	0.001
	2	164	2.26	1.34		
	3	164	3.52	1.23		

3.2 Academic Performance of Male and Female students in disciplinary problems

As shown in table 2, there was a significant difference of mean scores in male and female vocational students ($p<0.05$). The mean score of female student academic performance was 2.96, which was statistically higher than that of male students. It might implicated that female vocational students had better academic performance than male.

Table 2: t-test results in regard to the problem-solving scores based on the gender

Dependent variables	**Gender**	**N**	**Mean**	**SD**	**t**	**P**
Scores	Male	33	2.28	0.88	-4.02	0.001
	Female	131	2.96	0.86		

3.3 Academic Performance of different Majors in disciplinary problems

Table 3: ANOVA results in regard to the problem-solving scores based on different majors

Dependent variables	**Major**	**N**	**Mean**	**SD**	**F**	**P**
Scores	1	109	3.03	0.86	6.51	0.001
	2	18	2.44	0.86		
	3	16	2.23	0.90		
	4	21	2.54	0.83		

The 164 students participated in this study were from 3 different majors. Among these students, 109 students were from Big data and Accounting (major 1), 18 were from International Economics and Trade (major 2), 16 were from Engineering Cost (major 3), 21 were from Electronic Commerce (major 4). The difference between different majors was significant, which was shown in table 3. After analysis, we found that students from major 1 achieved better scores in interdisciplinary

problems than others (3.03 vs 2.44, 2.23 and 2.54, p=0.001).

3.4 Academic Performance of different Ages in disciplinary problems

Among 164 students, 126 students completed the survey about their personal information, such as age, self-efficacy and self-attitude towards disciplinary problems. As shown in table 4, it was obvious that the age was not significantly correlated with academic performance of solving interdisciplinary problems at the level of P>0.05.

Table 4: ANOVA results in regard to the problem-solving scores based on different ages

Dependent variables	**Age**	**N**	**Mean**	**SD**	**F**	**P**
Scores	18	40	3.11	0.79	1.71	0.186
	19	58	2.76	0.92		
	20	38	2.84	0.70		

3.5 Academic Performance of the Self-efficacy in disciplinary problems

In this study, we designed 5 question concerning about the self-efficacy of students towards disciplinary problems. The detailed information of these questions was presented in the table 5, and the weighted mean (WM) of students' answer was also given in the table. In general, the students had a moderately positive self-efficacy in solving interdisciplinary problems with a weighted mean of 3.07.

Table 5: Level of self-efficient of the students in solving interdisciplinary problems

Number	**Indicators**	**WM**	**Description**
1	I believe I have lots of strengths in required mathematics knowledge	3.02	Moderately Positive
2	I believe I have lots of strengths in required economics knowledge	2.90	Moderately Positive
3	I feel sure about myself in solving interdisciplinary questions	3.71	Positive
4	I am confident about my ability in solving interdisciplinary questions	3.30	Moderately Positive
5	I have lots of advantages in solving interdisciplinary questions compared with other students	3.08	Moderately Positive
	Aggregate WM	**3.20**	**Moderately Positive**

Legend: 4.21 - 5.00 Very Positive, 3.41 - 4.20 Positive, 2.61 - 3.40 Moderately Positive 1.81 - 2.60 Less Positive, 1.00 - 1.80 Negative. WM: weighted mean

After that, we divided students into 2 groups (Positive or negative self-efficacy) according to the aggregate WM in the table 5. As indicated in the table 6, participants who hold the positive self-efficacy achieved a higher score than those who had the negative self-efficacy (3.07 vs 2.72, p=0.023).

Table 6: t-test results in regard to the problem-solving scores based on the cognition levels

Dependent variables	**Cognition level**	**N**	**Mean**	**SD**	**t**	**P**
Scores	Positive	67	3.07	0.77	2.30	0.023
	Negative	69	2.72	0.99		

Positive: Very positive or positive or moderately positive. Negative: Less positive or negative

3.6 Academic Performance of the Self-attitude in disciplinary problems

As shown in the table 7, 5 questions about the self-attitude towards disciplinary problems of 126 students were presented. After aggregation, these students hold a moderately positive self-attitude towards interdisciplinary problems with a weighted mean of 3.03.

Table 7: Attitudes towards interdisciplinary questions

Number	Indicators	WM	Description
1	I am interested in mathematics	2.62	Moderately Positive
2	I can easily solve interdisciplinary questions by myself	2.86	Moderately Positive
3	I feel more interested in solving interdisciplinary questions than normal mathematics questions	3.10	Moderately Positive
4	I enjoy the struggle to solve interdisciplinary questions	3.08	Moderately Positive
5	I believe that solving interdisciplinary questions is helpful to the future job	3.48	Positive
	Aggregate WM	**3.03**	**Moderately Positive**

Legend: 4.21 - 5.00 Very Positive, 3.41 - 4.20 Positive, 2.61 - 3.40 Moderately Positive 1.81 - 2.60 Less Positive, 1.00 - 1.80 Negative. WM: weighted mean

Afterwards, students were divided into 2 groups (Positive or negative self-attitudes) according to the aggregate WM in the table 7. However, we found that students with the positive self-attitude did not achieved a higher score than those with the negative self-attitude (2.84 vs 2.96, p=0.453) (table 8).

Table 8: t-test results in regard to the problem-solving scores based on the attitude levels

Dependent variables	Attitude level	N	Mean	SD	t	P
Scores	Positive	78	2.84	0.92	-0.75	0.453
	Negative	58	2.96	0.88		

Positive: Very positive or positive or moderately positive. Negative: Less positive or negative

4. Discussion

According to Nace Job Outlook, problem-solving skill (70.2%) is one of significant attributes that employers seek on the candidate's resume [7]. In 2019, China Ministry of Education (CME) proposed Implementation Plan for National Vocational Education Reform which requires adopting a new vision for development, serving the needs of building a modernized economy and achieving higher quality and fuller employment. Government will encourage and support all sectors of society to actively support vocational education, and focus on training high-quality workers and skilled technical personnel who own high quality problem-solving skills [8]. To improve the problem-solving skills of students, interdisciplinary teaching has been widely used in vocational college. Interdisciplinary teaching is a kind of interdisciplinary education approach that is driven by real problems, based on the learning process, and integrated with multiple technologies. The fundamental goal of this teaching method is cultivating students with comprehensive scientific literacy and innovative practical ability [9].

Responding to these requirements, talent training program of Jiangsu Higher Vocational and Technical College claims that students should improve their mathematical quality which benefits their competition during seeking-job period, especially in interdisciplinary problem-solving. To

assess the performance of students in solving those interdisciplinary problems, we designed 3 interdisciplinary questions for students from commercial department of Jiangsu Vocational and Technical College after accepting semester interdisciplinary education of economic mathematics. After examination, we found that students in different majors achieved statistically discrepant scores. Also, the performance of female students was significantly better than male students, which might suggest us to pay more attention to those male vocational students during interdisciplinary lessons. Besides, assigning gradient tasks to the entire students, which would be beneficial to those male students. These results might provide a reasonable suggestion to the teachers or educators that they needed to carry out some personalized teaching methods to help those students master interdisciplinary knowledge.

In this study, we found that students with high self-efficacy achieved higher academic scores than those with low self-efficacy in solving mathematical interdisciplinary questions. Students with high-efficacy might be motivated to spend relatively more time studying mathematic and economic, both in-class and after-class [10, 11]. However, we also found that students felt more confident in sole mathematics or economic knowledge than interdisciplinary knowledge. This might be caused by their relatively less acceptance of interdisciplinary education as they just graduated from high school. Besides, for self-attitudes, students with high or low self-attitudes did not show significant difference in the performance of solving disciplinary questions. This might be due to the relatively small amounts of questions designed for self-attitudes or the students' unreasonable cognition of their attitudes towards interdisciplinary problems.

As a sample survey, this study had some apparent limitations. First, the distribution of male and female students was unbalanced as the number of male students in economic department was relatively small. This might also lead to the bias of the study result. Second, the different admission grades of these students from different majors might have an influence on the performance of solving interdisciplinary problems. Third, the questions designed for investigating self-efficacy and self-attitudes were inadequate, which might result in the deviation of the eventual evaluation.

In conclusion, we found the differences in students' aspects in solving interdisciplinary problems such as gender, majors, ages, self-efficacy and attitudes, and we thought that personalized teaching methods might be needed to help students understand the interdisciplinary knowledge.

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