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Influence of the Reform of College Entrance Examination on High School Physics Curriculum in Shanghai

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Abstract: A new round of the reform of college entrance examination is in progress in China, which would inevitably influence high school curriculum, especially physics. According to our statistics, the proportion of students choosing physics as a selective subject decreased significantly after the reform of college entrance examination was carried out. We conducted a study in Shanghai, one of the pilot areas of the reform, to investigate the impact of the new reform policy of college entrance examination on high school physics curriculum with interviews and FCI tests, thus to provide references for the future reform. We found that compared with the conditions before the reform, the high school students from Shanghai learned less about physics and physics teachers has less time to teach and communicate with students. What is more, college freshmen from Shanghai fell behind those who came from other areas in FCI performance before and even after a term of formal instruction.

Keywords: the reform of college entrance examination; physics curriculum; high school

1. Introduction

As one of the most important methods of selecting talents for higher education in China, the college entrance examination has undergone constant reform since it was resumed in 1977. After more than 30 years of reform and opening-up, China's examination and enrollment system has been continuously improved, and a relatively complete system of examination and enrollment has been formed, which has made a historic contribution to students' growth and fair selection of talents for the country (State Council, 2014).

In 2014, to promote fairness and develop students' personal interests at the same time, the State Council of China issued The Implementation Suggestions of the State Council on Deepening the Reform of Examination and Enrollment System. According to the document, Shanghai is one of the pilot areas where the new reform of college entrance examination was carried out. Before the new policy was issued, besides the three compulsory subjects -- Chinese, math and English, high school students in Shanghai were asked to choose another selective subject out of physics, chemistry, biology, politics, history and geography for the college entrance examination, which was also known as the "3+1" policy (3 compulsory + 1 selective) (Ni & Zhu, 2019). After issuing the new policy for the reform of examination and enrollment system, students who were enrolled into high school after 2014 would be supposed to choose three selective subjects out of physics, chemistry, biology, politics, history and geography while

Chinese, math and English remained to be the compulsory subjects for college entrance examination, which is also called as the "3+3" policy (3 compulsory + 3 selective) (Zhou, Feng, & He, 2016).

In terms of the three compulsory subjects, whose full mark is respectively 150, Chinese and math require students to participate in the unified college entrance examination at the end of the senior year, while English test provides two opportunities for students in January and June. For students who choose physics as one of their selective subjects, they are supposed to pass the **qualification test** first, and then take the **ranking test** in the senior year. As long as students pass the qualification test, they will get 40 basic points no matter what the specific mark is. The final mark of physics which will be counted into the college entrance examination scores, depends on their ranking test performance. The grading system is showed in TABLE 1. Thus, the final mark ranges from 40 to 70 with the score gap of 3 points for each grade. As for those who do not choose physics as a selective subject, they only have to pass the qualification test before the college entrance examination (Shanghai Municipal Education Commission, 2018).

TABLE 1. The grading system of selective subjects for college entrance examination in Shanghai

Grade	A+	A	B+	B	B-	C+	C	C-	D+	D	E
Rank	5%	10%	10%	10%	10%	10%	10%	10%	10%	10%	5%
Mark	70	67	64	61	58	55	52	49	46	43	40

After the first group of students graduated from high school in 2017 under the new "3+3" policy, some problems were exposed with respect to physics. The number of students who choose physics as a selective subject showed a sharp decline, causing the imbalance of physics (Zhu, 2017). In order to demonstrate the influence of the reform of college entrance examination on high school physics curriculum in recent years, we interview high school students and physics teachers about their reactions to the new reform of college entrance examination in Shanghai. Furthermore, we measure the college students' physics performance after they entered the university through the new college entrance examination, thus to further study the impact of the new policy of examination and enrollment on students' physics learning.

2. Changes of high school physics curriculum

2.1. High school students' attitudes to learning physics

Based on the "3+3" policy in Shanghai, there are 20 kinds of combinations for students to choose as the 3 selective subjects. The original intention of the new policy is to provide more opportunities for students to choose what to learn according to their own interests and strengths. However, due to the grading system and the difficulties of learning different subjects, most students tend to choose selective subjects based on the purpose of getting higher scores. Thus, the number of students who choose physics as a selective subject drops significantly, which results in the imbalance in physics as a discipline.

In 2017, the first year when the college entrance examination was carried out based on the "3+3" policy, among all the 50 thousand candidates in Shanghai, only 37.68% of them chose physics as a selective subject, which ranked last but one on the list of 6 selective subjects (See TABLE 2) (Peng, 2018; Tong, Zhou, & Xing, 2018). We collected the statistics of 59 high schools in Shanghai from different levels in terms of the proportion of students choosing physics as a selective subject (See TABLE 3). It can be seen that schools of higher levels have more students choosing physics as a selective subject in the college

entrance examination. As for the reasons, on the one hand, compared with other subjects, physics is more difficult to learn and have a good command of; on the other hand, according to the grading system, students' grades depend on their relative rankings, and students from better schools who perform well are more likely to choose physics as a selective subject, for which those who are in the middle level lose their strengths to get higher scores. What is more, the proportion of students choosing physics as a selective subject decreased year by year with a little rise in the graduates of 2020.

TABLE 2. Students' choices of different selective subjects in Shanghai in 2017.

Subject	Number of candidates	Proportion in total candidates	Rank
Geography	29628	58.09%	1
Biology	24157	47.36%	2
Chemistry	22314	43.75%	3
History	20151	39.51%	4
Physics	19218	37.68%	5
Politics	14834	29.08%	6

TABLE 3. The proportion of graduates from different levels of high schools choosing physics as a selective subject.

Schools (quantity)	Graduates of 2017	Graduates of 2019	Graduates of 2020
Level 1(8)	67.5%	55.4%	57.9%
Level 2(10)	44.2%	26.7%	28.2%
Level 3(41)	21.6%	9.3%	9.6%

According to the new reform policy of the college entrance examination in Shanghai, students who do not choose physics as a selective subject only have to pass the qualification test which would be conducted in grade 10 and grade 11. And the qualification test generally covers some relatively simple and basic knowledge of high school physics, for which most students find no difficulties passing it without much extra efforts. As a result, 2/3 of them tend to study other subjects in the physics class instead of listening to the physics teacher attentively, which has become a common phenomenon among those who do not choose physics as a selective subject, causing lack of knowledge in terms of physics. As for those who choose physics as a selective subject, the requirement of the ranking test is less demanding than the college entrance examination of physics before the reform, covering less knowledge points. Thus, to make the best of time to gain higher scores, students would rather spend more time on other compulsory and selective subjects than learn physics.

2.2. High school teachers' teaching

For physics teachers in high school, they generally recognize the new reform of college entrance examination with the intention to increase students' diversification in the basic education. However, the

new policy has changed how they teach physics. We interviewed 8 physics teachers in high schools ranging from level 1 to level 3 about their opinions towards the new reform of college entrance examinations. According to the interviewees' responses, there are some common existing issues in high schools in Shanghai under the influence of the reform.

Firstly, the class period of physics per week is lessened by about one class after the "3+3" policy was carried out, for which teachers narrowly manage to finish the course content but they could hardly spend time on explaining the related exercise. In a school of level 1, the class period of physics before the reform was 4 classes per week for those who chose physics as a selective subject; after the reform, they have 3 physics classes every week. According to the new "3+3" policy, there are various exams for different subjects throughout the three years in high school (See TABLE 4) (Peng, 2018). Therefore, more class time is arranged for compulsory subjects (Chinese, math and English) as well as the selective subjects whose ranking test is scheduled earlier (geography and biology).

TABLE 4. Schedule for academic level examinations in Shanghai

Grade	Subject	Exam type	Exam time
Grade 10	Information technology Geography, biology (choose at least one)	Qualification test	At the end of June
Grade 11	Geography, biology (besides those who have passed the qualification test in senior 1) Politics, history, physics, chemistry	Qualification test	At the end of June
	Geography, biology (optional for those who have passed the qualification test in senior 1)	Ranking test	Middle and late May
Grade 12	Chinese, math, English	Qualification test	January
	Politics, history, physics, chemistry, geography, biology (for those who have not passed the qualification test yet)	Qualification test	Middle and late April
	Politics, history, physics, chemistry, geography, biology (besides the subjects that have been passed in senior 2)	Ranking test	Middle and late May

Secondly, to adjust to the new policy, high schools rearranged their classrooms to fit students' different selection of curriculum. Previously, students in the same class (say, Class B in grade 11) had a fixed classroom (say, Classroom 11-B) and all their courses were taught there. Hence if a teacher needs to communicate with some students, the teacher can find them easily in their classroom. After the reform, students have to move to different classrooms for different courses. Thus, in the break time between two classes, students have to leave the classroom for another one, leaving little time for communications between teachers and students. Additionally, a teacher mentioned that if she went to explain some

exercise for those who chose physics as a selective subject in self-study class, the students would feel disturbed.

Thirdly, due to the decrease of the number of students who choose physics as a selective subject, the demand for physics teachers also drops accordingly. On the one hand, physics teachers' teaching load is relatively lighter than before; on the other hand, the work of head teachers becomes more complicated which mainly includes student management and mobilization for exams. According to the schedule for academic level examinations in Shanghai as shown in Table 4, students are supposed to take various exams for different selective and compulsory subjects from the end of grade 10. After finishing the academic level examinations, they would take the final college entrance examination for compulsory subjects. Therefore, for those schools hosting the standard exams, teachers are bound to organize many formal tests and help adjust students' mentality. Generally speaking, most schools hosting the formal exams are those of level 1 and level 2, where the teachers' workload becomes larger.

Last but not least, from the interviews with high school physics teachers, we found that students learning habits had been affected by the new reform of college entrance examinations. Previously, students would make long-term learning plans based on their own strengths or weakness as well as teachers' suggestions. For example, those who found physics more difficult to learn would spend more time on it. However, after the reform, due to a large number of periodic exams, students' learning becomes a repeated and short-term sprint. From February to April in grade 11, students mainly focus on learning geography and biology to prepare for the ranking tests in May. Thus, in the process of learning new knowledge of physics, students do not have much time to reflect and solve their learning problems and difficulties on time. When they prepare for the physics ranking test, it is harder for them to solve the problems effectively.

3. College students' performance

To further study the impact of the new policy of examination and enrollment on students' physics learning, we look into college students' performance in learning college physics. According to Ni and Zhu's investigation (Ni & Zhu, 2019), among the first group of students who experienced the new college entrance examination based on the "3+3" policy in Shanghai in 2017, their FCI performance was poorer than those who came from other provinces where the reform of college entrance examination had not started, reflecting that students from Shanghai had poorer performance in learning physics (See TABLE 5). Specifically, there was significant difference between the performance of students from Shanghai and those from other provinces in the pretest of FCI but not for the posttest ($p_{pre}=0.027$, $p_{post}=0.344$), which means that students from Shanghai lagged behind those who came from other provinces to some extent at the beginning of learning college physics.

In 2018, we conducted FCI test on 100 freshmen in the department of chemistry in East China Normal University before and after they took the college physics course. They were from different areas of China, including 16 from Shanghai and 84 from other provinces and areas. Among those who were from Shanghai, only 2 students chose physics as one of their selective subjects and took physics ranking test.

The original FCI consists of 30 questions to measure students' understanding about some basic force concepts. However, the full-length FCI is too long for students to finish at once in class because the normal class is already in a tight time schedule. Thus, we split the FCI into two pieces of half-length FCI based on Han and Bao's study (Han, Bao, & Chen, 2015) for pretest and posttest, and translated them into Chinese through a rigorous process. In this way, we can achieve the same measuring purpose with shorter tests and less test-retest effects in the pre-post testing. Each half-length FCI includes 14 items and

requires students to finish within 20 minutes. The pretest was carried out in the first lesson of the introductory physics course for the freshmen. Hence the FCI pretest score reflected the students' mastery of high school physics contents. The posttest was carried out at the end of the first term when the introductory physics course was about to be finished.

The result shows that students from Shanghai are far below those from other areas in both FCI pretest and posttest. Even after a semester of taking college physics course, students from Shanghai still got rather poor performance (the accuracy is 70.98%), considering the terms of FCI only cover some basic force concept (See TABLE 6). In this case, it can be reflected that under the new "3+3" policy, students from Shanghai have relatively poorer learning foundation in terms of physics. What is more, after entering college and taking a term of formal instruction, their understanding about basic physics is still not good enough. In Ni and Zhu's study, they also used half-length FCI tests for pretest and posttest before and after a term of college physics course learning. Compared with their study, we found that the gap of physics performance between students from Shanghai and those from other areas was growing after the new "3+3" policy was carried out. And this phenomenon further reveals the impact of the reform of college entrance examination on students' physics learning.

In Shanghai, for students who do not choose physics as a selective subject, the qualification test is based on the basic curriculum requirements in the high school curriculum standards; for those who choose physics as a selective subject, the content of ranking test is based on the basic and extended curriculum requirements in the high school curriculum standards (Ni & Zhu, 2019). To meet the level of test difficulty, high school physics courses skip many important concepts such as horizontal projectile motion, celestial motion, and momentum and so on. As a result, most high school graduates from Shanghai do not have a complete physics knowledge system, for which they find it harder to perform well in learning college physics.

TABLE 5. College students' accuracy of FCI pretest and posttest in 2017 (Ni & Zhu, 2019)

	FCI pretest	FCI posttest
Students from Shanghai	75.6%	91.5%
Students from other areas	87.6%	94.2%
Sig.	0.027<0.05	0.344

TABLE6. College students' accuracy of FCI pretest and posttest in 2018

	FCI pretest	FCI posttest
Students from Shanghai	57.52%	70.98%
Students from other areas	88.73%	95.04%
Sig.	<<0.05	<<0.05

4. Summary and prospective

As an important method of selecting talents, college entrance examination is experiencing a new round of reform in Shanghai, which has significant impact on high school physics curriculum. To study the impact, by interviewing students and physics teachers in high schools, we found that the number of students who chose physics as a selective subject dropped and students' learning attitudes to physics

became less positive. What is more, the teaching pace and working pattern of physics teachers were altered accordingly. Additionally, we conducted FCI tests on 100 freshmen in a university before and after they took the college physics course and found that the performance of students from Shanghai was poorer than those from other areas where the reform of college entrance examination has not started then. Compared to the previous related research, the gap is growing wider and wider in terms of 2017 and 2018.

Behind these changes, the grading system is one of the biggest reasons. According to the system, students' final grades basically depend on their rivals who choose the same selective subjects, for which they tend to adopt tactics to avoid more powerful rivals instead of choosing according to their own interests and strengths. As a result, less and less students choose physics for it is more difficult for them to achieve good grades in the competition. What is more, both the ranking test and qualification test of physics do not require students to master much comprehensive knowledge. Gradually, for both of those who choose and who do not choose physics as a selective subject, they spend more time on compulsory subjects and the selective subjects whose tests are scheduled earlier, leading to incomplete and inconsistent physics knowledge reserves, for which they lag behind in college physics learning. Accordingly, physics teachers in high schools have to spend more time on class management instead of teaching physics.

To deal with the existing problems of physics under the influence of the reform of college entrance examination, on the one hand, high schools are supposed to attach more significance to physics and help students to better understand the fundamentality and importance of physics thus to improve their learning attitudes; on the other hand, universities should not only require physics as a selective subject for enrollment in some related majors but also provide some optional courses for those who lack enough physics knowledge in previous learning in order to help them adapt to college physics learning.

After the reform of college entrance examination was first put into practice in Shanghai and Zhejiang, we can see that there are existing problems concerning certain subject such as physics. At present, other areas in China also start the reform policy of college entrance examination gradually in 2019 with some adjustments according to previous experience in the pilot areas. For example, in Guangdong, one of the biggest provinces in China, the new policy requires students to choose between physics and history with the purpose to ensure the number of students choosing physics as a selective subject. In the future, the impact of the improved version of the reform policy of college entrance examination on local physics education is to be continued.

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