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COMMENTARY

Developing Pre-Service Science Teachers' Entrepreneurship Mindsets

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"Only the paranoid survive."

–Andy Grove

Abstract: *The demand for knowledge in science, technology, engineering, and mathematics (STEM) is expanding as the twenty-first century progresses. Growing K-12 STEM education has risen to the top of the priority list in many countries' educational reform efforts. Typical contexts for giving scientific instructions should be designed around engineering design-based thematic activities rather than the other way around. Teachers' responsibilities as designers of design-based thematic activities would also present them with numerous chances for professional development and advancement. It is claimed that introducing entrepreneurship ideas into the engineering curriculum results in improved student satisfaction, longer professional careers, and a shift in attitudes toward engineering difficulties. It allows students to enjoy themselves more and draws their attention to the possibility of self-employment.*

Keywords: *STEM, Thematic Education, Entrepreneurial Activities, Student Improvement*

THE 21st century is witnessing an increasing demand for expertise in science, technology, engineering, and math and improving K-12 STEM education has become a top priority in many countries' educational reform. It is essential to develop and sustain quality programs that focus on systematic and effective STEM education for educators (Guzey, 2016). Currently, the need for explicit integration of science with engineering demands teachers to express intersecting notions and core disciplines using scientific and engineering practices, which would permanently make contributions to students' prospects through guiding them to discover various connections between and among different STEM subjects and thus help them to increase the motivation to learn science, as well as reinforce conceptual comprehension of science (Marulcu & Barnett, 2016).

To promote the integration of disciplines and improve teachers' professional competence, the teaching concept of engineering design-based thematic activities has been highly recommended. It is estimated that about 90% of human being's learning process is composed of indirect experiences, which explains students' devotion to standardized assessments and examinations. To transform the conventional practice, numerous educational experts have suggested that engineering design-based activities should be adopted as a typical context for delivering scientific instructions to arouse the sense of engagement among students. Engineering design-based thematic activities both emphasizes student's perception of engineering process and supports their understanding of scientific contents (Joseph, 2004). It is firmly based on prior research carried out in educational settings, seeks to trace the evolution of learning, and examines relevant theoretical results in order to construct instructional tools that survive the challenges of everyday practice. What is more, previous literature implies that the role of teachers as the designers of such activities would also provide them with rich opportunities for professional growth, fabricating a relaxed environment for teachers and learners to dynamically interact with each other. The experience of developing design-based thematic activities offers teachers a variety of chances to analyze their teaching, reflect on their practices and reorganize their previous instructions from students' viewpoints.

In addition, some scholars argue that incorporating entrepreneurship mindsets into engineering curriculum not only associates theoretical training with practical experience, but also leads to higher student satisfaction, longer professional careers, changing attitude toward engineering challenges, teamwork skills, thus triggering their autonomous entrepreneurial interest. Andalibi (2019) discovers that students would be more interested in learning about entrepreneurship and using technical skills learned in class in solving several real-world problems with potential business opportunities. As expected, students under entrepreneurial engineering education tend to raise interesting topics that have commercial meanings and present an essential need of the campus or the society. It allows students to enjoy more and attracts students' attention to self-employment, which cultivates talents with the willingness to start their own businesses for the society.

Engineering Design-Based Thematic Activities: An Investigation of Pre-Service Science Teachers' Entrepreneurship Mindsets in this issue of the journal discusses the pre-service teachers' use of Entrepreneurship Mindsets (EM) in solving real-life problems during engineering design-based activities and collects research data via the engineering design challenge worksheet and PSA. The undergraduates' EM is evaluated in six sub-dimensions: curiosity connections, creating value, communication, character, and collaboration (Kiyici et al., 2022). While providing evidence that pre-service science teachers need more training in entrepreneurship, this paper draws our attention to the importance of science teachers' level of knowledge about entrepreneurship and their tendency to develop their students' entrepreneurship skills.

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COMMENTARY

A Meaningful Experiment in Industry-School Partnership in Vocational Education

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> *"From a young age I had a real sense of the world of work. This is what vocational education gives you."*
>
> *–Steph McGovern*

Abstract*: Worldwide, vocational education with an emphasis on industry has gained popularity. China's rapid industrial change creates a demand for individuals with a breadth of skills rather than a tight focus on a single expertise. Vocational education equips students with practical knowledge, skills, and abilities, which helps business gain from timely collaboration between industry and academia.*

Keywords*: Vocational Education, Skill Training, Education, Business*

INDUSTRY-school collaboration has become a critical component of China's vocational education reform in light of the shift in socioeconomic development mode and the transformation of industrial structure. Foster (1992) argues that vocational educators' primary focus should be the job opportunities and development prospects of trainees in the labor market, and that the development of vocational and technical education should be based on genuine labor market needs. This concept has developed into a consensus among researchers regarding the role of vocational education and has been widely cited by them. The importance of enterprise-school collaboration is well reflected in several countries' vocational education reform programs, such as Germany's Dual System of Vocational Training, Canada's Cooperative Education method, and Korea's Contractual System (Chen, 2014).

Vocational education focused on industry has become popular throughout the world. Due to the influence of subject-based general education, most vocational colleges and schools used to place an emphasis on the uniqueness and completeness of each specialty when developing school curricula, ignoring the connections between different specialties. This resulted in excessive segmentation of student learning and a lack of alignment between school specialty planning and industrial demands for human resources. However, China's ongoing industrial transformation and upgrading creates a demand for multi-skilled people rather than those with a narrow focus on a particular technique. The schools that are best able to adapt their vocational education to industrial development and have a flexible and open framework for specialty planning will attract additional resources to sustain their continued development. Similarly, businesses that engage in timely industry-school collaboration have an advantage in hiring high-quality skilled individuals. The increased efficiency and technological innovation brought about by the latter will enable businesses to maximize their revenues. Thus, by integrating specialist construction and regional industry development, vocational colleges and schools may better serve the community by providing skilled human resources and assisting in the optimization of the local industrial structure.

The purpose of vocational education is to equip students with application-oriented knowledge, skills, and talents. The primary focus of vocational education is on practical training, with the goal of supplying the workforce with highly trained and well-rounded workers. Enterprise-school cooperation maximizes the strengths of both firms and schools in developing instructional strategies and materials, thereby facilitating the relationship between industry and vocational education. Longgang No.2 Vocational and Technical School of Shenzhen have extensive experience collaborating with businesses. The school arranges off-campus training for students at local ICT companies, and the companies also send professional training teams to the school to develop appropriate training plans based on current industry demand. The Coordinated Development of Secondary Vocational School Specialty Clusters and Industry Clusters: A Case Study of Longgang No.2 Vocational and Technical School of Shenzhen in this issue examines the mechanism for coordinating the construction of specialty clusters and the development of industry clusters, drawing on the school's experience in configuring specialty clusters to meet the needs of industrial chains, with the goal of providing useful guidelines for school-enterprise collaboration in specialty planning (Wang & Huang, 2022).

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ORIGINAL ARTICLE

Engineering Design-Based Thematic Activities: An Investigation of Pre-Service Science Teachers' Entrepreneurship Mindsets

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***Abstract**: The purpose of this study is to examine changes in pre-service science teachers' entrepreneurship mindsets during engineering design-based activities. A holistic single-case study was used in the study. Twenty-eight pre-service teachers carried out engineering design-based activities (five weeks, 20 hours) in the science teaching laboratory practices course. The pre-service teachers' use of Entrepreneurship Mindsets (EM) in solving the water pollution problem during engineering design-based activities was examined in this study. Data were collected via engineering design challenge worksheets and public service announcements. The data were analyzed with the Extended KEEN Student Outcomes (eKSOs) rubric. Frequency tables were created in line with the sub-dimensions of EM (curiosity, connections, creating value, communication, character, and collaboration). As a result of the research, it was found that the pre-service teachers mostly used curiosity, connections, and creating value during the water treatment and wastewater assessment plant design process. Engineering is an important context for the development of EM as it creates various contexts that contribute to the development of these mindsets in pre-service science teacher education.*

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***Keywords**: Pre-service Science Teacher, Engineering Design-Based Thematic Activities, Entrepreneurship Mindsets (EM)*

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***Conflict of Interests**: None.*

Introduction

DUE to global problems such as population growth and climate change, individuals frequently encounter complex problems in their daily lives. To solve these problems, there is a need to use interdisciplinary approaches that remove the traditional barriers between disciplines instead of focusing on knowledge about a single discipline (Wei & Chen, 2020). Curricula in the fields of physics, chemistry, biology, and engineering are based on an interdisciplinary process that covers scientific knowledge and ways to develop scientific knowledge (Nesmith & Cooper, 2019). In Science, Technology, Engineering, and Mathematics (STEM) education, real-life problems such as social, cultural, political, economic, and environmental issues are solved with the transdisciplinary integration of disciplines (Hoffmann-Riem et al., 2008). Engineering plays an important role in the transformation of knowledge into a product, skill, or innovative invention in STEM education. The role of engineering in STEM education is emphasized in the framework of K-12 education published by the American National Research Council (National Research Council [NRC], 2013). According to the report entitled "Engineering in K-12 Education: Understanding its Status and Improving its Prospects", engineering should be taught to K-12 students. Students need to understand what engineers do at school and they need to learn about engineering as a career. Engineering education in schools increases students' (i) understanding of science and mathematics, (ii) awareness of engineering, (iii) understanding of engineering by engaging in the engineering design process, (iv) willingness to pursue engineering as a career, and (v) technological literacy (Katehi et al., 2009).

Engineering design-based activities in STEM education are carried out in real-world contexts (Moore et al., 2014). These activities enable students to approach problems from a transdisciplinary perspective (Hoffmann-Riem et al., 2008; Takeuchi et al., 2020). In the USA, Next Generation Science Standards emphasise that students gain a better understanding of the nature of science and engineering within the scope of science and engineering practices, and the standards emphasise the importance of the integration of engineering design processes into science education at the K-12 level (Next Generation Science Standards [NGSS], the Lead States, 2013). In Turkey, science, engineering, and entrepreneurship practices were included in the middle school science curriculum in 2018 (Ministry of National Education [MoNE], 2018). The science, engineering and entrepreneurship practices aim to develop students' entrepreneurial, science and engineering skills.

Entrepreneurship Mindsets (EM) and Engineering Design-based Activities

Entrepreneurship is the process of starting a business, taking risks, or taking action to develop, regulate and manage a business in an evolving competitive global market. An entrepreneur is a pioneer, innovator, and a leader. Entrepreneurship is not only an economic value, but also a social and cultural phenomenon, and entrepreneurial individuals are the initiators of an innovative process (Aytaç & İlhan, 2007). An entrepreneurial individual is responsible for making decisions in any field. In other words, an entrepreneur is an individual who analyses the situation, predicts opportunities and problems, and makes rational decisions about the future. As shown in "An Entrepreneur's Guide to the Big Issues" in **Figure 1**, entrepreneurial individuals follow the stages of "defining goals, developing the right strategies, and implementing the strategies".

Entrepreneurial individuals move to the next stage of the entrepreneurial process if they are sure that their business can tolerate risk, that they have fulfilled their personal aspirations in the defining-targets step (**Figure 1**), and that they have determined their business sustainability and size. In the second step, the question "Do I have the right strategy?" helps to clarify definitions and helps to evaluate profitability and the potential for growth, durability, and the route to growth. If the answer is positive, the entrepreneur moves to the last stage: "Can I execute the strategy?" At this stage, to seek the answer to this question, the entrepreneur evaluates resources, organisational infrastructure, and the founder's role.

Universities are effective in developing entrepreneurial characteristics. Entrepreneurship education enables students to develop entrepreneurship capabilities, understanding, attitudes, and motivation (Handayati et al., 2020). Students can be directed to new initiatives through their courses (Rasmussen & Sørheim, 2006). Entrepreneurship education is included in undergraduate programmes, especially in engineering, economics, and business departments. However, apart from these departments, the importance of interdisciplinary entrepreneurship education is emphasised to develop students' entrepreneurial mindset (EM) (Jamira et al., 2021; Stenard, 2021). It is necessary to draw attention to the importance of entrepreneurship, which is thought to be related to commercial affairs in modern life, especially for teachers who are social engineers. However, the entrepreneurial skills of pre-service teachers are significantly lower than those of students of medicine, economics and administrative sciences, and engineering. One of the fields where entrepreneurship can be supported is science education (Bolaji, 2012). However, the science teachers' level of knowledge about the concept of entrepreneurship and their tendency to develop their students' entrepreneurship skills are limited (Deveci, 2016, 2018). Considering the science, engineering, and entrepreneurship practices in the science curriculum in Turkey, both science teachers and pre-service science teachers must have entrepreneurial skills (Aslan, 2021). The Kern Entrepreneurial Engineering Network (KEEN), which was created in 2005 to support the development of entrepreneurship skills of engineering students, sees entrepreneurship as a fundamental element of engineering education. KEEN states that in engineering education, students should develop as individuals who recognise opportunities, evaluate markets and learn from their mistakes (KEEN, 2021). Students' EM are seen as an important component for the development of these skills (Liguori et al., 2018). The EM is a set of attitudes and skills that facilitates an engineer's ability to innovate and create in a way that adds value to society (Riley et al., 2021). EM is framed by curiosity, connections, creating value, communication, collaboration, and character (Hylton et al., 2020).

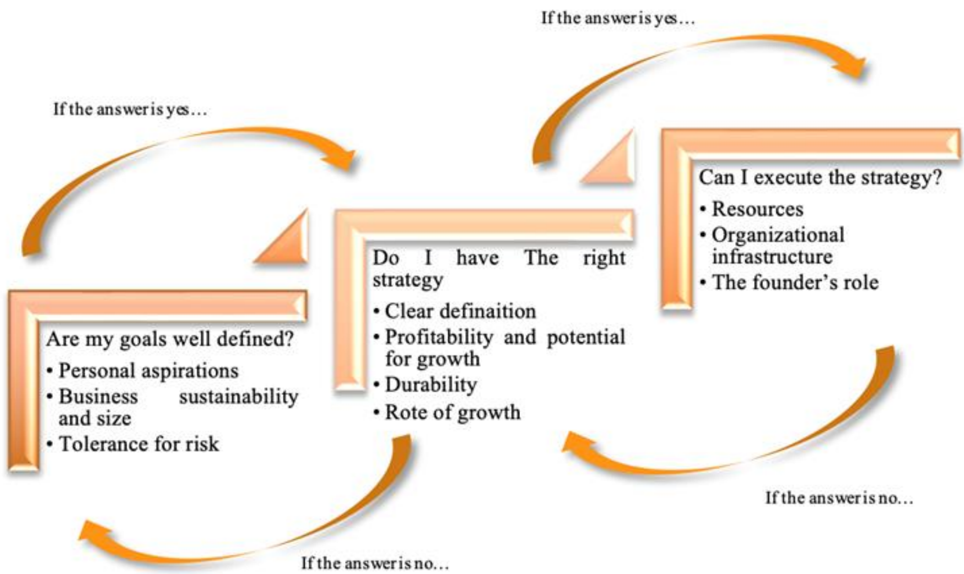

Figure 1. An Entrepreneur's Guide to Big Issues (Bhide 1996).

In science education, prompts to improve students' entrepreneurship mindsets are used during the presentation of the product developed for real-world problems in engineering design-based activities. In this research, the need for clean water and the evaluation of wastewater are discussed as real-life problems. The engineering discipline provides an important context for the development of entrepreneurial mindsets. However, individuals with entrepreneurial mindsets are needed to predict possible problems that may arise and to generate innovative solutions to these problems within the scope of the engineering design process.

To this end, it is important to create environments that will enable pre-service teachers to explore engineering design-based activities in their education. In this study, the science teaching laboratory practices course was restructured since there were no specific courses on engineering education and entrepreneurship in the undergraduate science education curriculum. Within the scope of the course, pre-service science teachers designed a water treatment system (WTS) and a wastewater assessment system (WwAS) by following the steps of the engineering design process, so that the entrepreneurship mindsets (curiosity, connections, creating value, communication, and collaboration, character) in solving the water pollution problem could be developed.

Method

Research Design and Participants

Table 1. Overview of the Research.

Week	Content
1	What is Engineering? Engineering design process Science and engineering integration 21st-century skills: Entrepreneurship
2	Pilot activity: Design Gloves
3	Pilot activity: Light Sensor Curtain
4	Water Treatment System (WTS)
5	Wastewater Assessment System (WwAS)

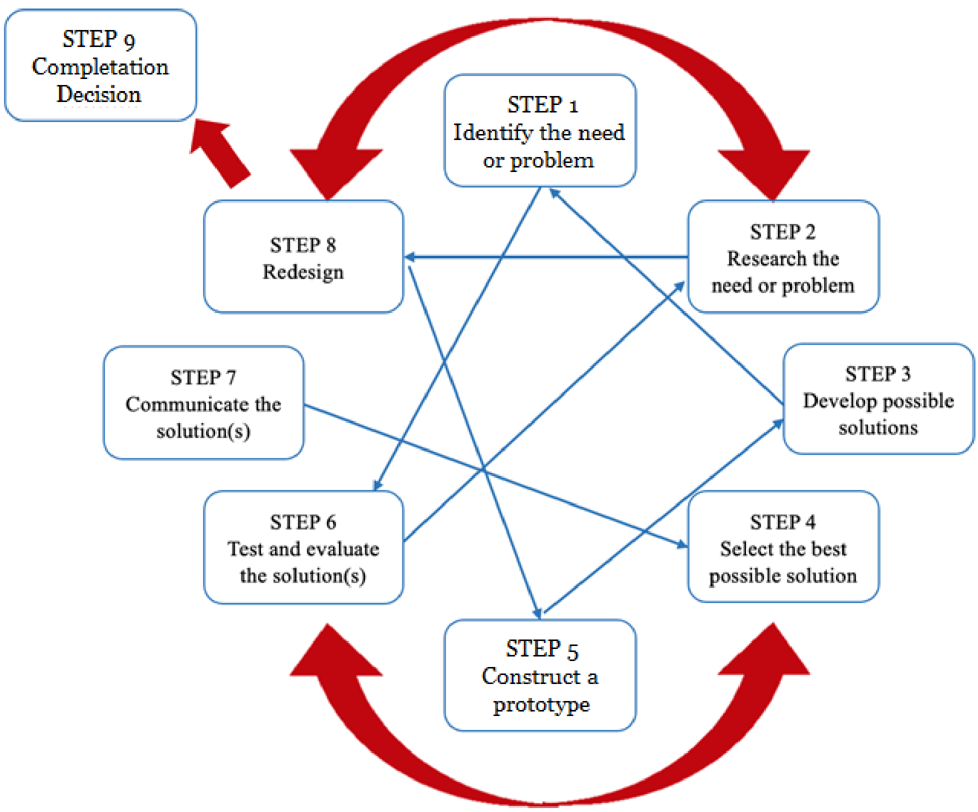

Figure 2. Engineering Design Process (Hynes et al., 2011, p.9).

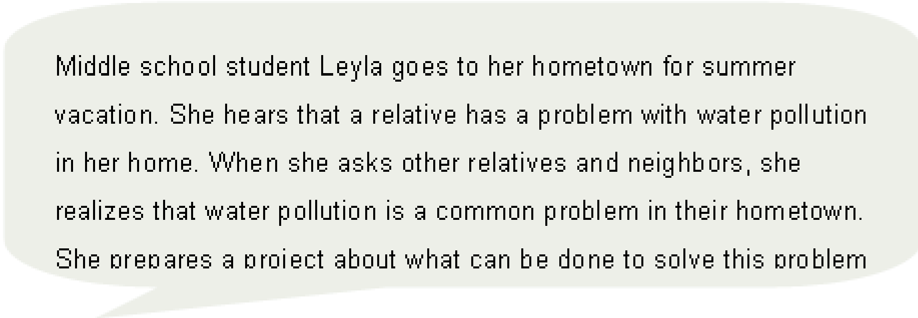

Figure 3. Real-World Problem Used in the "Water Treatment System" Activity.

This holistic single-case study was carried out over five weeks (20 hours) in the science teaching laboratory practice course, with 28 pre-service teachers (23 female, five male) in the third year of the four-year science teaching undergraduate programme.

Context of the Study

The science teaching programme of education faculties in Turkey is a four-year undergraduate programme. In the undergraduate science teacher education curriculum, there is a science teaching laboratory applications course in the third year. This course is the last laboratory course in the pre-service teachers' programme. Before this course, students will have completed courses that cover the subject matter of physics, chemistry, and biology. The research was carried out within the scope of the laboratory course for five weeks (20 hours), as shown in **Table 1**.

The pre-service science teachers had not taken any courses in engineering and entrepreneurship education before the laboratory course. For this reason, as shown in **Table 1**, in the first week of the study, one of the researchers, who is also the course supervisor, gave information to the pre-service teachers about entrepreneurship and the engineering design process. The engineering design process steps (Hynes et al., 2011) indicated in **Figure 2** was explained to the pre-service teachers. In addition, the importance of engineering design-based activities and entrepreneurship skills for science education was discussed. The use of worksheets during the course was explained, particularly their focus on the engineering design process.

In the second week of the research, the "Design Gloves" activity, which is one of the pilot activities, was carried out to gain knowledge and experience about the engineering design process. In this activity, a grandmother with joint pain was asked to design a glove that would contribute to reducing her pain. While trying to solve this problem, pre-service teachers were asked to consider the concepts of heat, temperature, heat conduction, and insulation. In the third week of the research, the other pilot activity, "Light Sensor Curtain", was carried out. Pre-service teachers gained experience in designing curtains using motion and light sensors in this activity. In the pilot applications, pre-service teachers discussed the promotion and marketing of their designs. These activities aimed to contribute to the formation of EM.

In the fourth week of the research, the water treatment system activity was carried out. In this activity, pre-service teachers were asked to create solution proposals by taking into account the requirements of entrepreneurship skills through the engineering design process, based on the real- world problem (**Figure 3**).

The pre-service teachers were given time to create their solution proposals to the given problem. Then, they were asked to evaluate their possible solutions in terms of the criteria and limitations they had determined to choose the best possible solution. They made this evaluation by using a decision matrix in line with the criteria of "active carbon, sponge, electrolysis, boiling" solution proposals, and in line with the criteria of "cost, aesthetics, ease of production". Then, the pre-service teachers were expected to prepare, test, and evaluate a prototype in line with their decision matrices. In the first prototype, they were asked to explain the decision to complete their project if there were no problems, and if a problem was detected, they were to return to the design process and re-evaluate their solution proposals to create the most accurate water treatment system. The prototype samples prepared by the pre-service teachers in the WTS activity are presented in **Figure 4**.

In the fifth week of the research, a wastewater treatment system was designed to proactivity water waste and draw attention to the global problem of water scarcity (**Figure 5**). In this activity, the pre-service teachers were requested to evaluate wastewater, especially in domestic use, by taking into account biological and chemical pollution.

The pre-service teachers were asked to plan an advertising slogan, advertising strategy, and sales strategy at the stage of presenting their products. They prepared these presentations in the form of public service announcements (PSA). The benefits to the target audience, the cost of the design, and its superior aspects were included in the PSA videos. The activities were concluded with students watching their PSAs and giving feedback on the redesign process.

Data Collection Tools

Research data were collected using the pre-service science teachers' engineering design challenge worksheets and PSA.

Engineering Design Challenge Worksheets

Worksheets prepared with the engineering design process steps in mind (Hynes et al., 2011) were used in the research. Firstly, the pre-service teachers were provided with a scenario containing a problem typical of daily life. They were asked to identify the problem based on the presented scenario, to summarise the information obtained by

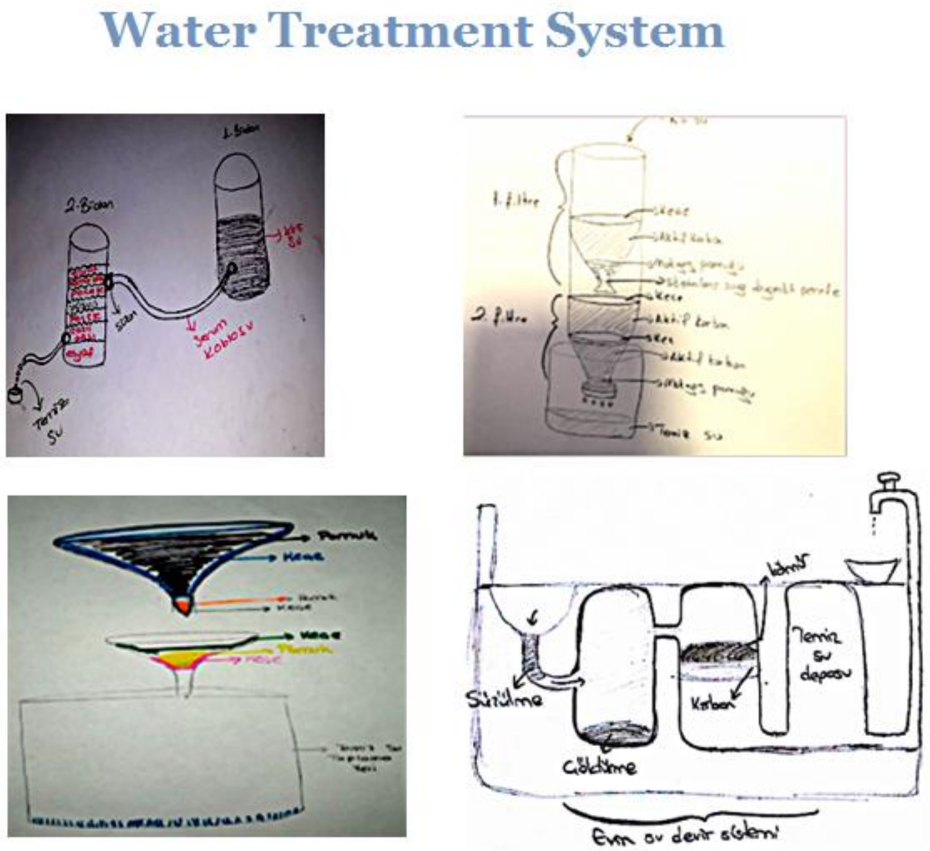

Figure 4. Example Prototypes of Water Treatment System.

doing the research necessary for the solution, to explain the key science concepts to be used in the solution, to determine the criteria and limitations for the solutions to the problem, and to propose a solution. Then, they were asked to draw the design and to explain which materials were used in the drawing and why. After creating a prototype, the pre-service teachers tested it and presented the results with visual tools such as tables and graphics, which constitute an important part of the worksheets. In the last part of the worksheet, the pre-service teachers were asked to create a PSA storyboard for the promotion and marketing of their product to determine their entrepreneurship mindset. In the storyboard, they were asked to include the following elements: finding a source of financial support, planning a sales strategy for the product, identifying the problems and solution suggestions that they may encounter while selling the product, determining the target audience of the product (gender, purchasing power, geographical location, and marital status), and promotion.

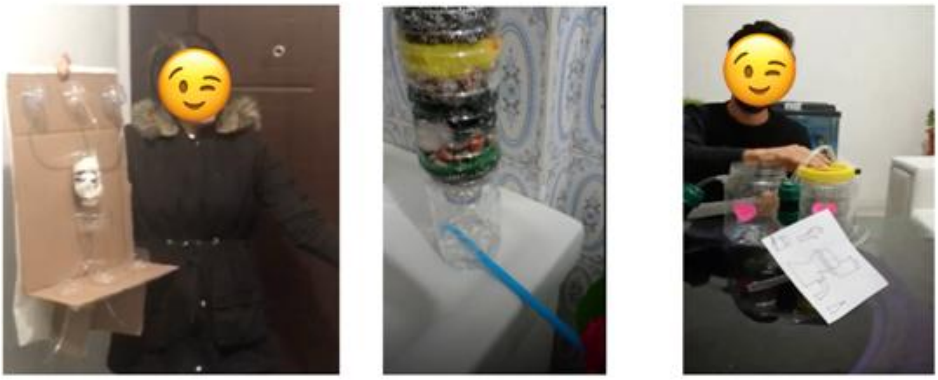

Figure 5. Examples of Student Products.

Public Service Announcement (PSA)

PSAs designed by the pre-service teachers using media design processes constitute the other data collection tool of the research. Media design processes enable students to learn by designing media products with technological tools (Liu, 2003). PSAs are an example of the integration of media design processes into education and are used to make students aware of social and environmental issues (Karahan et al., 2015; Lester et al., 2006). PSAs developed for science subjects enable students to learn science subjects (Newstetter, 2000) and develop life skills such as creative thinking, reflective thinking, and decision making (Hacıoglu et al., 2020). In this research, the pre-service science teachers developed 40 PSAs (20 groups, two each) related to the promotion, sales, and marketing of the products that emerged in the WTS and WwAS process. Each PSA was designed to last approximately 120-240 seconds.

Data Analysis

Extended KEEN Student Outcomes (eKSOs) rubric was used in the analysis of the data obtained from the worksheets and PSAs revealed by the pre-service teachers in the WTS and WwAS activities. The eKSOs were developed by Hylton et al. (2020) to evaluate the EM. The KEEN framework defines the EM in the context of engineering as the combination of curiosity, connections, and creating value, coupled with engineering thought and action, expressed through collaboration and communication, and founded on character. The eKSOs rubric is structured by considering six sub-dimensions of EM (curiosity, connections, creating value, communication, collaboration, character), and 53 mindset outcomes.

Table 2. Findings Related to Curiosity.

eKSOs	f (WTS)	f (WwAS)
Develops a propensity to ask MORE questions	17	9
Be able to formulate SALIENT questions	0	9
Questions information that is given without sufficient justification	6	17
Collects feedback and data from many customers and customer segments	4	7
Recognizes and explores knowledge gaps	24	22
Critically observes surroundings to recognize the opportunity	22	25
Views problems with an open mindset and explore opportunities with passion	16	23
Be able to self-reflect and evaluate preconceived ideas, thoughts, and accepted solutions	7	16
Explores multiple solution paths	26	23
Gathers data to support and refute ideas	22	20
Suspends initial judgment on new ideas	8	11
Takes ownership, and expresses interest in topic/expertise/project. Observes trends about the changing world with a future-focused orientation/perspective	1	7

The worksheets and PSAs of the pre-service teachers were scored separately by two researchers using eKSOs. By evaluating the consensus and differences of opinion among the researchers (Miles and Huberman, 1994), the interrater reliability between the raters was calculated as 80%.

Findings

Curiosity

As seen in **Table 2**, the most frequently observed eKSOs related to the curiosity of the pre-service science teachers in engineering design-based activities, and, in the WTS activity, the most frequently observed eKSO was “explores multiple solution paths (f = 26)”. In the WTS activity, no outcome was determined on whether the participants were “able to formulate SALIENT questions”. In the WaAS activity, the eKSO “critically observes surroundings to recognise opportunity (f = 25)” was observed the most. “Collects feedback and data from many customers (f = 7)” and “takes ownership of, and expresses interest in the topic/expertise/project. Observes trends about the changing world with a future-focused orientation/perspective (f = 7)” was observed the least.

As seen in **Table 2**, students formed more entrepreneurial mindsets related to curiosity in the second WwAS activity. An increase was observed in entrepreneurial mindsets regarding “be able to formulate SALIENT questions” and “question information that is given without sufficient justification”, especially with engineering design-based activities. While pre-service teachers developed a propensity to ask more questions in the first activity, WTS, there was a decrease in this propensity in the second activity.

Table 3. Findings Related to Connections.

eKSOs	f (WTS)	f (WwAS)
Understands the ramifications (technical and non-technical) of design decisions	13	15
Identifies and evaluate sources of information	22	18
Connects life experiences with class content	2	4
Connects content from multiple courses to solve a problem	1	9
Integrates/synthesizes different kinds of knowledge	4	12
Considers a problem from multiple viewpoints	24	23
Persuades why a discovery adds value from multiple perspectives (technological, societal, financial, environmental, etc.)	14	21
Articulates the idea to diverse audiences	8	18
Understands how elements of an ecosystem are connected	17	21
Identifies and works with individuals with complementary skill sets, expertise, and so on	0	1
Develops a professional network	1	5

Connections

"Consider a problem from multiple viewpoints (f = 24)" was the most frequently observed eKSO related to connections in the engineering design-based WTS activity of pre-service science teachers. "Identifies and works with individuals with complementary mindsets, expertise, and so on (f = 0)" was never observed. The most frequently observed eKSO in WwAS activity was "considers a problem from multiple viewpoints (f = 23)", and the least observed was "identifies and works with individuals with complementary skill sets, expertise, and so on (f = 1)", which was not observed at all in the WTS activity.

As can be seen in **Table 3**, the frequency of the recurrence in entrepreneurial mindsets regarding connections increased in the WwAS activity. In particular, the entrepreneurial mindsets of "articulates the idea to diverse audiences", "connects content from multiple courses to solve a problem", and "connects content from multiple courses to solve a problem" increased with engineering design-based activities.

Creating Value

The most frequently observed eKSO related to creating value in both WTS and WwAS activities based on the engineering design of pre-service science teachers was "integrate nonmonetary and monetary factors into a triple bottom line assessment (fWTS = 24, fWwAS = 26)". The least observed eKSO was "describes how a discovery could be scaled and/or sustained, using elements such as revenue streams, key partners, costs,

Table 4. Findings Related to Creating Value.

eKSOs	f (WTS)	f (WwAS)
Identifies the needs and motivations of various stakeholders	13	23
Expresses empathy in identifying problems and exploring solutions.	18	18
Creates solutions that meet customer needs	11	20
Defines market and market opportunities	14	23
Crafts a compelling value proposition tailored to specific stakeholders	11	13
Integrates nonmonetary and monetary factors into a triple bottom line assessment	24	26
Applies technical skills/knowledge to the development of a technology/ product	13	18
Modifies an idea/product based on feedback	2	5
Focuses on understanding the value proposition of a discovery	7	16
Describes how the discovery could be scaled and/or sustained, using elements such as revenue streams, key partners, costs, and key resources	3	8
Engages in actions with the understanding that they have the potential to lead to both gains and losses	7	10

Table 5. Findings Related to Communication.

Items	f (WTS)	f (WwAS)
Presents technical information effectively (graphs, tables, equations)	18	20
Identifies and organize information in a format suited to the audience	16	18
Provides and accept constructive criticism, including self-evaluation	6	13
Produces effective written reports	13	8
Produces effective verbal presentations	0	10
Manages informal communications (meetings, networking, etc.)	5	11

and key resources (f = 3)" in the WTS activity. The least observed eKSO in the WwAS activity was "modifies an idea/product based on feedback (f = 5)".

As can be seen in **Table 4**, an increase in the frequency of the repetition of all eKSOs related to creating value was detected in the WwAS activity. In particular, the entrepreneurial mindsets of pre-service teachers regarding "identify the needs and motivations of various stakeholders" improved with engineering design-based activities.

Communication

The most frequently observed eKSO in the WTS activity in the communication dimension was "presents technical information effectively (graphs, tables, equations) (f = 18)",

Table 6. Findings Related to Collaboration.

Items	f (WTS)	f (WwAS)
Recognize their strengths, skills, and weaknesses, as well as those of others	12	21
Be able to lead, delegate, and follow	7	5
Be aware of and able to work through interpersonal conflict	0	2
Be able to teach and learn from peers	0	5
Be able to network and see the value of others	9	17

Table 7. Findings Related to Character.

Items	f (WTS)	F (WwAS)
Demonstrate an ability to set, evaluate, and achieve personal and professional goals	17	13
Meet commitments	3	2
Recognize and evaluate potential impacts while making informed ethical and professional decisions	18	20
Accept responsibility for their actions, and credit the actions of others	6	4
Develop an appreciation of hard work and recognize the benefits of the focused and fervent effort	1	4
Work toward the betterment of society	22	21

and the least observed eKSO was "manages informal communications (meetings, networking, etc.) (f = 6)". "Produces effective verbal presentations" was never observed. The most frequently observed eKSO in the WwAS activity was "presents technical information effectively (graphs, tables, equations) (f = 20)" and the least observed eKSO was "produces effective written reports (f = 8)".

According to **Table 5**, an improvement in eKSOs was observed in the communication dimension of the entrepreneurial mindset, including "provides and accepts constructive criticism, including self-evaluation", "produces effective verbal presentations", and "manages informal communications (meetings, networking, etc.)".

Collaboration

In the collaboration stage, the most frequently observed eKSO in both activities was "recognise their strengths, skills, and weaknesses, as well as those of others (fWwAS = 21, fWTS = 12)", while the least observed eKSO in the WTS activity was "be able to network and see the value of others (f = 7)" and the least observed eKSO in the WwAS activity was "be aware of and be able to work through interpersonal conflict (f = 2)". The eKSOs "be aware of and able to work through interpersonal conflict" and "be able to teach and learn from peers" were not observed in the WTS activity (**Table 6**).

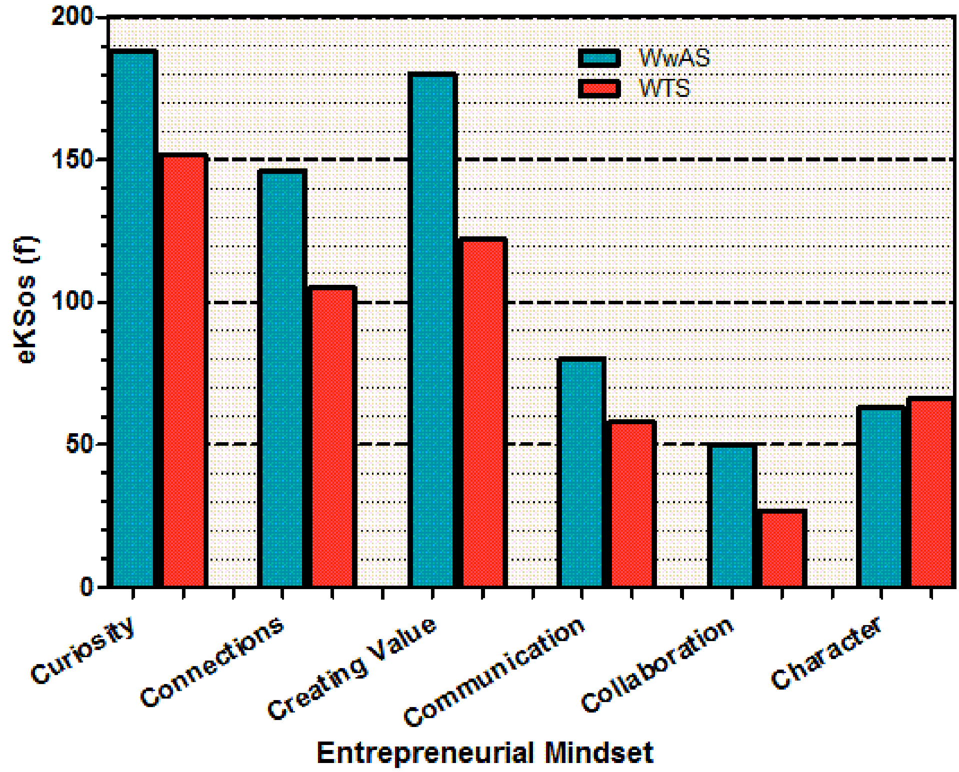

Figure 6. Overall Evaluation of Pre-service Science Teachers' Entrepreneurial Mindsets.

In the collaboration dimension of the entrepreneurial mindset, the incidence of the eKSOs "recognise their strengths, skills, and weaknesses, as well as those of others" and "be able to network and see the value of others" increased in the WwAS activity. "Be aware of and able to work through interpersonal conflict" and "be able to teach and learn from peers" were never observed in the WTS activity, but were detected in the WwAS activity.

Character

Character was also the most frequently observed eKSO partner in the "WwAS" and "WTS" activities. The most frequently observed behaviour was "work toward the betterment of society" (fWwAS = 21, fWTS = 22); the least observed was "develop an appreciation of hard work and recognise the benefits of focused and fervent effort (f =

1)” in the WTS activity and “meet commitments (f = 2)” in the WwAS activity (**Table 7**).

In this sub-dimension, frequencies of items such as “demonstrate an ability to set, evaluate, and achieve personal and professional goals”, “accept responsibility for their actions and credit the actions of others”, “work toward the betterment of society”, and “meet commitments” at the WTS activity was high. In the WwAS activity, the frequencies of the items “recognise and evaluate potential impacts while making informed ethical and professional decisions”, and “develop an appreciation of hard work and recognise the benefits of focused and fervent effort” were found to be high.

When the entrepreneurial mindsets of pre-service science teachers were evaluated overall within the scope of the “curiosity, connections, creating value, communication, collaboration and character” sub-dimensions, the eKSOs related to curiosity, connections, and creating value were observed the most. eKSOs related to communication, character, and collaboration were repeated less frequently compared to curiosity, creating value and connections (**Figure 6**).

As shown in **Figure 6**, the pre-service teachers’ entrepreneurial mindsets (except for the character sub-dimension) improved in WwAS effectiveness. In particular, the frequency of abandonment of eKSOs related to creating value increased. A lesser increase was observed in the communication and collaboration sub-dimensions compared to the other sub-dimensions. There was a decrease in the number of eKSOs for character.

Discussion and Conclusion

In this study, which examined the entrepreneurial mindsets of pre-service science teachers in engineering design-based thematic activities, the entrepreneurial mindset outcomes of the curiosity, creating value, and connections sub-dimensions were observed the most in the activities. Riley et al. (2021) stated that even the activities carried out in a single semester have a great impact on the development of university students’ entrepreneurial mindsets regarding curiosity, creating value, and connections sub-dimensions. Researchers recommend early intervention in the EM development process by providing students with unique, exploratory, and hands-on experiences.

Within the scope of other entrepreneurial mindsets, the outcomes related to collaboration were observed the least. Although the pre-service teachers were in the same class as their peers for three years, they found it difficult to collaborate at the beginning of this study and after the activities. Experience is important for pre-service teachers to cooperate and learn the importance of cooperation (Kropp et al., 2016). In a study in which collaborative project-based learning was applied, while task-related conflict contributed to cooperation, process and relationship conflicts harmed and prevented learning (Lee et al., 2015). The necessity of team harmony consisting of teamwork, interpersonal interactions, and mutual trust and cooperation among team members should also be taken into account (Kao, 2019).

The development of the pre-service teachers' mindsets regarding communication, character, and collaboration in the engineering design-based activities was limited. It is important to include activities that will enable the development of these mindsets before students enter tertiary education. In this respect, it is significant to include science, engineering and entrepreneurship applications in secondary school science courses in Turkey (MoNE, 2018). However, the limitations of pre-service teachers' EM may affect the development of students' EM in their classrooms in the future. In line with this result, instructors in the college of education should structure their lessons in a way that develops the mindsets of future science teachers.

A limitation of this study is that although pre-service teachers were informed about the engineering design process, no entrepreneurship training was given. According to Handayati et al. (2020) entrepreneurship education positively leads to students' entrepreneurship intention and an entrepreneurial mindset. The development of these mindsets can be supported by implementing curricular and extracurricular engineering design-based activities for pre-service teachers. Overall, our results provide evidence that pre-service science teachers need more training in entrepreneurship. Entrepreneurship education provides students with a deep understanding of entrepreneurship and encourages students to gain the experience needed to become entrepreneurs (Fayolle & Gailly, 2015).

In this research, engineering design-based activities were carried out under the theme of water pollution. The entrepreneurial mindsets of pre-service teachers showed a tendency to improve in the second activity, the WwAS activity. More time can be allocated to activities that will enable pre-service teachers to develop their entrepreneurial mindsets, and activities can be implemented according to different themes. In this way, pre-service teachers can be supported to gain experience in engineering design-based activities.

For the development of entrepreneurial mindsets, different pedagogical methods can be used, not only at the presentation stage of the design process but also at all stages. Activities that will support the entrepreneurial mindset of pre-service science teachers can be included in courses other than laboratory courses. The design of these activities can focus on communication, character, and collaboration, which are less of a focus in this research.

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ORIGINAL ARTICLE

The Impact of Extracurricular Tutoring Time Investment on Academic Performance of Secondary School Students: An Empirical Analysis Based on PISA2015 Data of Four Provincial Administrative Regions in China

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***Abstract**: We use the Hierarchical Linear Model to analyze the current state of extracurricular tutoring time for secondary school students and its impact on academic performance using PISA2015 data from four provincial administrative regions in China. The study discovered that the effect of extracurricular tutoring time on academic performance is a non-linear relationship that initially declines and then increases, indicating that subject-specific tutoring have a threshold effect. When tutoring time exceeds a certain threshold, academic performance improves qualitatively. However, when mathematics tutoring time exceeds a certain threshold, the gap in mathematics scores between students from different family backgrounds widens, resulting in educational inequality. The effect of school curriculum time on student achievement is a non-linear relationship that begins with an increase and then declines. When compared to off-campus tutoring time, in-school curriculum time can more effectively improve student academic performance.*

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Introduction

EXTRACURRICULAR tutoring, dubbed "shadow education" in international academic circles (Bray, 1999), has grown rapidly in China's urban and rural areas over the last two decades, with approximately 200,000 extracurricular tutoring institutions, 137 million students enrolled in tutoring, and 7-8.5 million teachers employed by tutoring institutions (Yang, 2018). With the implementation of the balanced compulsory education policy and the burden reduction policy, the time spent in school by primary and secondary school students has been reduced significantly, while after-school homework has been significantly reduced, and after-school time has been significantly increased. This incentivizes an increasing number of compulsory education students to engage in extracurricular tutoring after school and during the holidays in order to enhance their academic performance or develop their talents in order to gain an advantage in future competition for higher education or employment, thereby expanding the on-campus competition to off-campus tutoring institutions (Xue & Li, 2016).

Learning time is critical in educational activities, and extracurricular tutoring time is becoming an increasingly significant part of students' learning time. However, nothing is known about the effect of students' extracurricular tutoring time on their academic achievement. Therefore, who devotes the most time to after-school tutoring? How does extracurricular tutoring time affect kids' academic performance? Is spending more time on extracurricular tutoring beneficial? Does the discrepancy in the amount of time spent on extracurricular tutoring by secondary school students exacerbate the inequality in educational outcomes? To address the above questions, we use the results of the 2015 Program for International Student Assessment (PISA) in Beijing, Shanghai, Jiangsu, and Guangdong to examine the current state of secondary school students' tutoring time and the impact of tutoring time investment on academic achievement using statistical descriptions and a hierarchical linear model. We then make recommendations based on the findings of the study.

A Literature Review

Studies conducted in China and other countries have primarily focused on the influence of extracurricular tutoring on academic attainment, with varying conclusions (Byun, 2014; Lee, 2013; Zhang et al., 2015; Hu et al., 2015; Xue, 2016). Fewer studies have been undertaken on the time commitment of students to extracurricular tutoring and its effect on academic progress. Although some experts have researched the association between extracurricular tutoring time and student progress, their conclusions are inconsistent (Song & Xue, 2017). Several studies have discovered a positive effect on academic attainment of students' extracurricular tutoring time commitment. Liu (2012) discovered that tutoring has a considerable favorable influence on students' reasoning and deductive abilities and mathematics achievement, but that this benefit diminishes with increasing tutoring duration. Fang et al. (2018) discovered a statistically significant favorable effect of tutoring time spent on primary school students' achievement. Moreover, several studies have discovered that extracurricular tutoring time commitment has a detrimental influence on academic attainment. Shen (2014) discovers a negative link between students' extracurricular tutoring time and their mathematical performance. Additionally, Hao (2016) observed a negative association between tutoring duration and math achievement.

Other studies have discovered a nonlinear link between the time spent on extracurricular tutoring and academic attainment. Li et al. (2016) observed a non-linear association between extracurricular tutoring time and academic achievement, with an initial increase and later a decrease. Specifically, students who receive 0-3 hours and 3-6 hours of tutoring per week demonstrate a significant upward trend in academic achievement when compared to students who do not receive extracurricular tutoring, while students who receive 6-8 hours of tutoring per week demonstrate a slight decline in academic performance, and students who receive more than 8 hours of tutoring per week demonstrate a significant decline in academic achievement. Ma and Zheng (2017) discovered that extracurricular tutoring time has a considerable effect on students' academic development, but only when a particular threshold level is exceeded can a qualitative gain in academic achievement occur. According to Hu et al. (2017), mathematics tutoring time has a significant favorable influence on the academic accomplishment of Korean secondary school students in mathematics, but has a significant detrimental effect on the mathematics literacy scores of Hong Kong secondary school students. Additionally, mathematics tutoring time has a considerable positive influence on the mathematical literacy scores of Japanese secondary school pupils, indicating a non-linear relationship.

The majority of recent studies focus on the overall status of extracurricular tutoring and its relationship to academic accomplishment, and the conclusions are inconsistent. There are few studies that focus exclusively on extracurricular tutoring time. Simultaneously, few researchers have investigated the topic of how discrepancies in extracurricular tutoring time amongst students from diverse family origins result in differences in academic achievement, which leads to educational inequality and even educational equity (Xue & Song, 2018). To address this gap, this study undertakes pertinent research on extracurricular tutoring time and systematic investigations into the disparities in students' extracurricular tutoring time investments in various subjects and their impacts on academic achievement, followed by a detailed analysis. Additionally, the impact of extracurricular tutoring time on educational equity is discussed in order to broaden the scope of extracurricular tutoring studies.

Methodology

Variable and Data Source Description

The data for this study came from the Organization for Economic Cooperation and Development's (OECD) 2015 PISA results. PISA is a triennial assessment that aims to enhance educational policies and the quality of education in a country through world-

Table 1. Variable Description.

Variable Type	Variable (Abbr.)	Description
Dependent Variable	Science Literacy Scores (SCILS)	Continuous Variable, Means of the Plausible value (1-10) in Science, Mathematics, or Reading
	Mathematics Literacy Scores (MATLS)	
	Reading Literacy Scores (REALS)	
Independent Variable	**Student Level**	
	Science Extracurricular Tutoring Time (SCIETT)	Continuous Variable, Hours per Week
	Mathematics Extracurricular Tutoring Time (MATETT)	
	Chinese Extracurricular Tutoring Time (CHIETT)	
	Gender (GE)	0=Female, 1=Male
	Schooling Stage (SS)	0=Middle School; 1=High School
	Self-Educational Expectations (SEE)	Classified by ISCED standard education level
	Index of Economic, Social and Cultural Status (ESCS)	Continuous Variable
	School Level	
	Science Curriculum Time (SCICT)	Continuous Variable, Hours per Week
	Mathematics Curriculum Time (MATCT)	
	Chinese Curriculum Time (CHICT)	
	School Location (SL)	0= Rural Area; 1=County/town Area; 2=Urban Area
	School Ownership (SO)	0=Private; 1=Public
	Class Size (CS)	Continuous Variable
	Student-Teacher Ratio (STR)	Continuous Variable
	Shortage of Educational Material (SEM)	Continuous Variable
	Index Proportion of all Teachers Fully Certified (PTFC)	Continuous Variable

wide comparisons. PISA 2015 examined a total of 9,841 schoolchildren from 268 schools in Beijing, Shanghai, Jiangsu, and Guangdong. Science was the primary subject, while reading and mathematics were secondary. This study uses data from the PISA2015 student and school questionnaires. **Table 1** lists the variables used in this investigation.

Research Methods

The academic performance of students is influenced by a variety of factors, including school, classroom, individual, and family. Due to the layered nature of the PISA data, this study employs a hierarchical linear model to examine the effect of secondary school students' extracurricular tutoring time investment on academic achievement. The Hierarchical Linear Model is capable of examining random mistakes across variables from various schools while also conceiving the cross-level data structure, showing the true intrinsic link between the variables.

Zero Model

The zero model has no explanatory variables at the student or school level. It focuses on the individual and contextual differences within the sample under investigation. The zero model is used to calculate the academic performance of each subject for a student i-th attending school j-th (Zhou & Wu, 2008). :

$$\text{Student level: } Y_{ij}=\beta_{0j}+ e_{ij},\ e_{ij}\sim N\ (0,\delta^2) \quad (1)$$

$$\text{School level: } \beta_{0j}=\gamma_{00}+ u_{0j},\ u_{0j}\sim N\ (0,\tau_{00}) \quad (2)$$

j denotes a school, i denotes a secondary school student, Y_{ij} denotes the academic performance of secondary student i-th in school j-th, B_{0j} denotes the average academic performance of secondary students in school j, and e_{ij} denotes the student-level random error, defined as the difference between the academic performance of secondary student i-th in school j-th and the school's average performance. γ_{00} denotes the average academic performance of secondary students in each subject across all schools, and U_{0j} denotes the random error at the school level (Xue et al., 2011).

Full Model

A full hierarchical linear model is one in which explanatory or predictive factors are incorporated at the student and school levels of the linear model of student academic performance. This study employs a two-tiered model:

$$\text{Student level: } Y_{ij} = \beta_{0j} + \beta_{1j}\ GE+ \beta_{2j}\ SS +\beta_{3j}\ SEE+\beta_{4j}\ ESCS+\beta_{5j}\ ETT+ \beta_{6j}\ ETT^2+\beta_{7j}(ETT*ESCS) + e_{ij},\ e_{ij}\sim N\ (0,\ \delta^2) \quad (3)$$

$$\text{School level: } \beta_{0j}=\gamma_{00} +\gamma_{01}CT+\gamma_{02}CT^2+\gamma_{03}SL+\gamma_{04}SO+\gamma_{05}CS+\gamma_{06}CS^2+\gamma_{07}STR+ \gamma_{08}SEM+ \gamma_{09}PTFC+ u_{0j},\ u_{0j}\sim N\ (0,\ \tau_{00}) \quad (4)$$

Results

The Group Differences in Extracurricular Tutoring Time Investment among Secondary School Students

In China, the average weekly extracurricular tutoring time for secondary school students studying science is 2.24 hours, less than the OECD average (2.53 hours). Chinese students spend 3.56 hours per week tutoring in mathematics and 3.14 hours per week

Table 2. Analysis of the Differences in Extracurricular Tutoring Time Investment among Different Groups of Secondary School Students.

Variable Name		SCIETT		MATETT		CHIETT	
		Mean	T-test	Mean	T-test	Mean	T-test
GE	Female	2.22	-4.710***	3.38	-3.808***	2.92	-4.357***
	Male	2.60		3.73		3.34	
SS	Middle School	2.77	10.486***	3.96	9.835***	3.69	13.754***
	High School	1.94		3.02		2.38	
ESCS	Low SES[1]	2.38	-1.339	3.02	-5.048**	3.12	-3.140
	High SES	2.46		3.87		3.15	
SO	Private	2.49	0.703	3.74	1.397	3.28	1.180
	Public	2.40		3.52		3.10	

Note: 1., **, *** indicate significant at the level of 10%, 5%, and 1%, respectively*

tutoring in the Chinese language, both of which are much more than the OECD average (3.03 hours and 2.61 hours). **Table 2** illustrates the group disparities in the amount of time spent on extracurricular tutoring by secondary school students. Girls spend 2.22, 3.38, and 2.92 hours per week on extracurricular tutoring in science, mathematics, and Chinese, respectively, significantly less than boys do (2.6, 3.73, and 3.34 hours); junior secondary school students spend 2.77, 3.96, and 3.69 hours per week on extracurricular tutoring in science, mathematics, and Chinese, respectively, significantly more than senior secondary school students do (1.94, 3.02, and 2.38 hours); students whose family socioeconomic status is lower than the average (referred to as "low SES" students)[1] spend 3.02 hours per week on mathematics extracurricular tutoring, which is significantly less than that of students (3.87 hours) with above-average family socioeconomic status (referred to as "high SES" students). High SES students receive 2.46 and 3.15 hours of extracurricular tutoring in science and Chinese language per week, respectively, which is comparable to the 2.38 and 3.12 hours received by low SES students. Students in private schools receive 2.49, 3.74, and 3.28 hours of extracurricular tutoring in science, mathematics, and Chinese language per week, respectively, while students in public schools receive 2.4, 3.52, and 3.10 hours of extracurricular tutoring per week, respectively, but none of the differences are statistically significant.

Regression Analysis

According to established guidelines for empirical judgment, an intraclass correlation coefficient (ICC) greater than 0.059 indicates significant inter-school variation, necessitating consideration of the between-group effect during statistical modeling treatment. The ICCs are all greater than 0.059 in the zero model of secondary school pupils' academic achievement in science, mathematics, and reading. As a result, it is important to

Table 3. Hierarchical Linear Model Analysis of the Effect of Science Extracurricular Tutoring Time Investment on the Science Literacy Score of Secondary School Students.

Variable	Model 1	Model 2	Model 3
Student Level			
SCIETT	-2.747*** (0.194)	-4.414*** (0.437)	-4.351*** (0.469)
$SCIETT^2$		0.187*** (0.030)	0.186*** (0.030)
SCIETT*ESCS			0.065 (0.174)
Female (Male as a Reference)	-16.292*** (1.320)	-16.221*** (1.319)	-16.209*** (1.320)
Middle school (High School as a Reference)	-25.124** (2.625)	-25.022*** (2.621)	-25.036*** (2.621)
SEE	17.876*** (0.493)	17.863*** (0.492)	17.863*** (0.492)
ESCS	1.812** (0.817)	1.841** (0.816)	1.689* (0.913)
School Level			
SCICT	7.466*** (0.479)	7.535*** (0.479)	7.529*** (0.479)
$SCICT^2$	-0.281*** (0.024)	-0.285*** (0.024)	-0.284*** (0.024)
SL	1.743 (1.904)	1.695 (1.894)	1.694 (1.894)
Private School (Public School as a Reference)	1.958 (7.154)	2.094 (7.118)	2.114 (7.118)
CS	5.015** (1.752)	4.965** (1.744)	4.963** (1.744)
CS^2	-0.058** (0.022)	-0.058** (0.022)	-0.058** (0.022)
STR	-0.096 (0.282)	-0.092 (0.281)	-0.092 (0.281)
SEM	-4.833** (1.618)	-4.830** (1.609)	-4.834** (1.609)
PTFC	69.264** (29.263)	68.914** (29.121)	68.915** (29.119)
Intercept	369.855*** (34.019)	371.952*** (33.855)	371.808*** (33.855)
Model Significance	0.000	0.000	0.000
Observed Value	7663	7663	7663

Note: 1., **, *** indicate significant at the level of 10%, 5%, and 1%, respectively. 2. Standard errors are in parentheses.*

analyze the nested data using the Hierarchical Linear Model in order to precisely explore the correlations between variables (Zhou & Wu, 2008).

The Effect of Extracurricular Tutoring Time Investment on the Academic Performance of Secondary School Students

The effect of science extracurricular tutoring time[2] investment on secondary school students' science literacy scores is seen in **Table 3**. After controlling for other variables, Model 1 indicates that extracurricular tutoring time has a significant negative influence on students' science literacy scores; for every additional hour of science extracurricular tutoring time, students' science scores decline by around 2.7 points. Further analysis of

Table 4. Hierarchical Linear Model Analysis of the Effect of Mathematics Extracurricular Tutoring Time Investment on the Mathematics Literacy Score of Secondary School Students.

Variable	Model 4	Model 5	Model 6
Student Level			
MATETT	-2.408*** (0.154)	-5.355*** (0.401)	-5.650*** (0.427)
$MATETT^2$		0.192*** (0.024)	0.194*** (0.024)
MATETT*ESCS			0.280** (0.139)
Female (Male as a Reference)	-15.272*** (1.285)	-15.159*** (1.281)	-15.174*** (1.280)
Middle school (High School as a Reference)	-25.300*** (2.616)	-24.565*** (2.609)	-24.494*** (2.608)
SEE	19.288*** (0.476)	19.292*** (0.474)	19.290*** (0.474)
ESCS	2.576** (0.793)	2.733** (0.790)	3.736*** (0.933)
School Level			
MATCT	5.429*** (0.860)	5.457*** (0.856)	5.475*** (0.856)
$MATCT^2$	-0.304*** (0.046)	-0.316*** (0.046)	-0.316*** (0.046)
SL	-0.830 (2.129)	-0.960 (2.123)	-0.964 (2.123)
Private School (Public School as a Reference)	-2.320 (8.006)	-2.314 (7.984)	-2.379 (7.985)
CS	5.740** (1.958)	5.686** (1.952)	5.672** (1.951)
CS^2	-0.065** (0.025)	-0.064** (0.025)	-0.064** (0.025)
STR	-0.297 (0.309)	-0.296 (0.308)	-0.296 (0.308)
SEM	-4.201** (1.809)	-4.228** (1.804)	-4.201** (1.804)
PTFC	62.242*** (32.505)	61.430*** (32.418)	61.176*** (32.418)
Intercept	374.087*** (37.968)	379.613*** (37.873)	380.586*** (37.877)
Model Significance	0.000	0.000	0.000
Observed Value	8178	8178	8178

Note: 1., **, *** indicate significant at the level of 10%, 5%, and 1%, respectively. 2. Standard errors are in parentheses.*

Model 2 (obtained by incorporating the quadratic term of science extracurricular tutoring time into Model 1) reveals that science extracurricular tutoring time has a significant nonlinear effect on students' science scores in the form of a U-shaped curve—in other words, science extracurricular tutoring has a negative effect on students' science scores when science tutoring time is less than 12 hours per week, but a positive effect when science tutoring time exceeds 12 hours per week. This implies that scientific extracurricular tutoring has a clear threshold impact, and it is difficult for science tutoring to have a clear influence on academic performance improvement in science without a significant time investment. This suggests that students must receive more than 12 hours of scientific tutoring per week (an average of more than 1.71 hours of science tutoring per day) in order to see a significant increase in their science performance.

Table 5. Hierarchical Linear Model Analysis of the Effect of Chinese Extracurricular Tutoring Time Investment on the Reading Literacy Score of Secondary School Students.

Variable	Model 7	Model 8	Model 9
Student Level			
CHIETT	-3.542*** (0.163)	-7.763*** (0.407)	-7.899*** (0.433)
$CHIETT^2$		0.288*** (0.026)	0.289*** (0.026)
CHIETT*ESCS			0.132 (0.145)
Female (Male as a Reference)	8.760*** (1.319)	8.497*** (1.309)	8.463*** (1.309)
Middle school (High School as a Reference)	-24.833*** (2.686)	-23.863*** (2.665)	-23.828*** (2.666)
SEE	17.195*** (0.485)	17.112*** (0.481)	17.116*** (0.481)
ESCS	4.741*** (0.813)	4.686*** (0.807)	5.098*** (0.924)
School Level			
CHICT	6.887*** (0.959)	6.788*** (0.952)	6.816*** (0.952)
$CHICT^2$	-0.374*** (0.054)	-0.384*** (0.054)	-0.386*** (0.054)
SL	1.412 (2.066)	1.193 (2.048)	1.186 (2.048)
Private School (Public School as a Reference)	1.468 (7.762)	1.001 (7.694)	0.946 (7.696)
CS	5.571** (1.904)	5.474** (1.887)	5.463** (1.887)
CS^2	-0.063** (0.024)	-0.062** (0.024)	-0.062** (0.024)
STR	-0.270 (0.302)	-0.269 (0.299)	-0.269 (0.300)
SEM	-4.763** (1.754)	-4.763** (1.739)	-4.755** (1.739)
PTFC	68.176*** (31.523)	64.521*** (31.249)	64.275*** (31.259)
Intercept	324.625*** (36.828)	335.837*** (36.519)	336.350*** (36.533)
Model Significance	0.000	0.000	0.000
Observed Value	7830	7830	7830

Note: 1., **, *** indicate significant at the level of 10%, 5%, and 1%, respectively. 2. Standard errors are in parentheses.*

Table 4 illustrates the influence of mathematics extracurricular tutoring time invested on secondary school students' mathematical literacy results. After controlling for other variables, mathematics extracurricular tutoring time has a significant negative influence on mathematics scores; with each additional hour of mathematics tutoring time, students' mathematics scores decline by around 2.4 points. Further analysis of model 5 (by including the quadratic term for mathematics extracurricular tutoring time in model 4) reveals that mathematics tutoring time has a significant nonlinear effect on mathematics scores, exhibiting a U-shaped curve, when weekly mathematics tutoring time is less than 14 hours, tutoring has a negative effect on mathematics scores; however, when weekly mathematics tutoring time is greater than 14 hours, tutoring significantly improves mathematics scores. This demonstrates that mathematics extracurricular tutoring has a clear threshold effect, and it is difficult to get a meaningful positive effect with insufficient time of mathematics tutoring. Students require more than 14 hours of mathematics coaching each week (on average, more than 2 hours per day) to significantly enhance their mathematics performance.

Table 5 shows the effect of extracurricular Chinese language tutoring on the reading literacy scores of secondary school pupils. After controlling for other variables, Model 7 demonstrates that, after controlling for other variables, Chinese extracurricular tutoring time has a significant negative influence on students' reading scores; for each additional hour of Chinese extracurricular tutoring time, students' reading scores decline by around 2.8 points. Further analysis of model 8 (which is obtained by adding the quadratic term for Chinese extracurricular tutoring time) reveals that Chinese tutoring time has a significant non-linear effect on students' reading scores, exhibiting a U-shaped curve; that is, when weekly Chinese tutoring time is less than 13 hours, there is no significant effect on students' reading scores; however, when weekly tutoring time exceeds 13 hours, there is a significant effect on students' reading scores. To enhance their reading scores, students must receive at least 13 hours of Chinese language instruction each week (or an average of more than 1.86 hours of tutoring per day).

To further examine the heterogeneity of the effect of extracurricular tutoring time investment on secondary school students' test results, the interaction variables of extracurricular tutoring time and ESCS (economic, social, and cultural status) are added to obtain Models 3, 6, and 9. After controlling for other variables, the results show that family ESCS contributes positively to the effect of mathematics tutoring time on mathematics scores and passes the significance test; students' family ESCS contributes significantly to the effect of science tutoring time on science literacy scores, but does not pass the significance test; and family ESCS significantly contributes to the effect of Chinese tutoring time on student reading results, but does not pass the significance test.

Meanwhile, Tables 3, 4, and 5 demonstrate that school curriculum time has a considerable beneficial influence on students' scores and that the effect is non-linear, following an inverted U-shaped curve that ascends first and then declines. The most significant improvement in pupils' science literacy scores occurs when the school science curriculum is approximately 13 hours per week. Approximately 9 hours of school mathematics curriculum time each week greatly boost pupils' academic achievement in mathematics. The most substantial improvement in students' reading performance occurs when the weekly school curriculum time for Chinese is approximately 9 hours.

Conclusions and Discussion

This study examined the effects of extracurricular tutoring time investment on secondary school students' academic performance and came to the following conclusions:

First, there is a significant nonlinear relationship between extracurricular tutoring time and the academic performance of secondary school students in the form of a U-shaped curve, indicating that extracurricular tutoring has a significant threshold effect and that it is difficult to achieve a significant positive effect on student academic performance with too little tutoring time. Only when a certain threshold is exceeded can a qualitative improvement in academic performance occur, i.e., when students attend more than 12 hours, 14 hours, or 13 hours of weekly tutoring in science, mathematics, or Chinese, respectively (i.e., more than 1.71 hours, 2 hours, or 1.86 hours of tutoring for the three subjects per day).

Time is a critical input in the educational process (Ma & Zheng, 2017). The majority of kids devote significant time after school to extracurricular tutoring in order to improve their exam scores. Extracurricular tutoring, being a supplement to school education, presumably has a similar substance to the school curriculum. As a result, the content of extracurricular tutoring courses during the early stages is repetitious and unfocused, which may contribute to students' aversion and resistance to learning. Thus, coaching may appear to be unsuccessful after a brief duration. However, as the semester progresses, the extracurricular tutoring becomes more targeted, the cumulative effect of learning increases, and students attain improved academic performance. Likewise, the quality of extracurricular tutoring institutions varies throughout China, and the majority of students (75%) receive extracurricular tutoring from private tutors[3]. As a result, the tutors' quality and the tutoring sites' circumstances cannot be guaranteed. Tutoring's effect is further limited by the fragmentation of tutoring time and the decentralization of tutoring venues. At the same time, learning is a cumulative process, and tutoring's effects cannot be felt immediately. The influence of tutoring on academic performance improvement may not become apparent until the student's tutoring time hits a certain threshold.

Second, the influence of extracurricular mathematics tutoring time on mathematics achievement varies dramatically among secondary school students with varying household ESCS. Students with a higher family ESCS devote more time to mathematics tutoring. Thus, mathematics extracurricular tutoring time contributes to the widening of the achievement gap between students from diverse family situations, resulting in inequitable educational outcomes.

The conclusion is adequately described by the Maximally Maintained Inequality (MMI) theory (Raftery & Hout, 1993) and the Effectively Maintained Inequality (EMI) theory (Lucas, 2001). According to the MMI hypothesis, when a certain stage of education is not universally available, educational rivalry is oriented toward acquiring an edge in accessing that stage, hence maximizing the maintenance of educational disparity. According to the EMI theory, once a particular stage of education becomes universally accessible, the focus of educational rivalry switches to the quality of education at that stage in order to effectively preserve educational inequality. With the promotion of balanced compulsory education in China and the implementation of numerous aid programs for underprivileged schools in recent years, the connection between family background and access to a high-quality education has decreased. The disparity in educational quality achieved on the "initial battlefield" (i.e., the classroom) of educational rivalry between children from diverse familial origins is steadily closing. As a result, in order to preserve their competitiveness in obtaining a high-quality education, advantaged families turn to the "second battlefield" of educational rivalry, namely extracurricular tutoring. In today's commercialized market for extracurricular tutoring, financially advantaged families are better equipped to pay for their children's costly extracurricular tutoring. Thus, the disparity in extracurricular tutoring among students with disparate family ESCS exacerbates the disparity in educational acquisition, and it has developed into an alternative mode of intergenerational transmission of family capital, which serves as a social reproduction mechanism for education and also has an effect on the equity of compulsory education.

Third, the effect of school curriculum time on student academic performance follows an inverted U-shaped curve, with the positive effect on student academic achievement improvement peaking at 13, 9, and 9 hours per week for science, mathematics, and Chinese, respectively. In comparison to extracurricular tutoring, curriculum time during the school day may be more helpful in improving student academic achievement.

This demonstrates the vital importance of school curriculum time in ensuring student achievement progress. Because the school serves as the primary location for student learning, where students' schedules are consistent and predictable, and the quality of school teachers is more reliable. Additionally, schoolteachers are typically more familiar with their students' educational circumstances and may provide more relevant tutoring. Additionally, the school's learning environment and atmosphere are more conducive to student learning, resulting in more productive in-school learning time. However, China has been implementing a "burden reduction" program in recent years, decreasing students' in-school and homework time to guarantee that kids have adequate time for sleep and hobbies. While students' in-class learning time is reduced, the majority of students and parents devote additional time to after-school tutoring. As a result, the "burden reduction" policy is ineffective. Therefore, we should approach policy intelligently, particularly when it comes to minimizing students' in-school burden. Returning student learning to campus and optimizing the function of school education can significantly boost student academic achievement.

Limitations

The data in this study was processed using the Hierarchical Linear Model. It is capable of precisely calculating the coefficients of the two levels of variables' effects on academic performance. However, because the PISA data is cross-sectional, it is not possible to determine students' academic levels prior to their participation in extracurricular tutoring. Thus, even while we control for students' personal and familial traits, the exclusion of certain factors may result in biased statistical findings. Additionally, the method through which tutoring time affects student academic achievement is regulated by a number of variables. For example, student factors such as motivation and attitude toward extracurricular tutoring, as well as academic foundation, interest, and effort in learning, all have a significant impact on academic achievement; tutor factors such as tutor quality, competence, patience, and responsibility all have a significant impact on student achievement. A mixed-methods study with high-quality qualitative interviews and quantitative analysis will enable us to gain a better understanding of the process and logic underlying the influence of extracurricular tutoring on student academic progress. It is a subject worthy of further investigation.

Notes

1. *SES is a discrete variable derived from the ESCS variable, with 1 indicating a level of social and economic status above the mean for students in the participating countries and defined as "High SES"; 0 indicating a level of social and economic status below the mean for students in the participating countries and defined as Low SES.*
2. *In this study, the term "science extracurricular tutoring time" refers to the total amount of time spent instructing students in science courses (including physics, chemistry, biology, and earth science).*
3. *According to the 2017 China Financial Household Survey conducted by Peking University's China Institute of Educational Finance Research, less than 20% of students participate exclusively in extracurricular tutoring provided by commercial institutions, while more than 75% participate exclusively in extracurricular tutoring provided* by individuals.

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Original Article

The Coordinated Development of Secondary Vocational School Specialty Clusters and Industry Clusters: Citing Longgang No.2 Vocational and Technical School of Shenzhen as a Case Study

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Abstract: *With the implementation of the state's Plan of Constructing High-Level Vocational Schools and Specialties with Chinese Characteristics, the construction of specialty clusters has become a hot topic. They are critical tools for improving the educational quality of vocational schools by promoting vocational education transformation, upgrading, and innovation. To maximize the effectiveness of specialty cluster development in secondary vocational school curriculum reform, we must first identify the rationale for multi-agency involvement in the development of specialty clusters and then formulate action plans. This article examines the definitions and connotations of specialty clusters and discusses the contexts in which specialty clusters emerged. It examines strategies for developing specialty clusters using Shenzhen's Longgang No. 2 Vocational and Technical School as an example.*

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SECONDARY vocational education's specialty clusters are a response to the growing demand for well-rounded technical and skilled workers in the current development of industry clusters and job clusters. Specialty cluster education is a method of skill development based on an in-depth examination of technical and skilled occupations within regional industry clusters. The strength of a specialty cluster is in its ability to integrate pertinent specialties and then maximize their effectiveness as a "cluster." To advance the quality of vocational education and the development of high-level specialty clusters, secondary vocational schools' original curriculum components, such as curriculum objectives, teaching teams, and practical training, must be transformed. Using policies issued by the Ministry of Education as a guide, this paper seeks to define the mechanism of coordination between the construction of specialty clusters and the development of industry clusters, as well as the implications of this mechanism. We examine the practice of developing specialty clusters using Longgang No.2 Vocational and Technical School in Shenzhen (hereinafter referred to as Longgang No.2 Vocational School) as a case study, attempting to provide useful guidelines for the scientific and efficient construction of high-level specialty clusters for other secondary vocational schools.

Definitions of "Industry Cluster" and "Specialty Cluster"

The term "industry cluster" derives from Michael Porter's industry cluster theory, a Harvard Business School professor who specializes in competitive strategy and international competition. It is a phenomenon in which a group of competitive enterprises in a particular industry, along with their partners, specialized suppliers, service providers, and related institutions, consolidate in a particular area (Zhao, 2011), with the goal of increasing their market competitiveness through production factor optimization, resource sharing, and cost reduction. At a vocational college or school, a specialty cluster is a collection of specialties comprised of one or more core specialties associated with employment advantages and other related specialties that share a common professional and technical background. Specialty clusters are classified into two types: (i) One is defined from the school's perspective. It integrates and shares teaching resources and basic tangible facilities by combining a specialty of abundant resources with other related specialties. (ii) The other is classified according to industry. It is a collection of specialized skills required by a particular industry. The classification's guiding principle is to maximize support for the target industry's overall development. Various vocational colleges and schools use this guideline to classify the specialties required by industrial chains or industry clusters as specialty clusters (Mi & Guo, 2019). Both types share a common objective: to contribute to societal and industrial development.

The Background of the Popularity of Specialty Clusters

A New Phase of High-Quality Development in Vocational Education in China

With the development of China's educational system, public demand for elementary education has evolved into a demand for higher education. Currently, the educational levels of various vocational schools vary considerably, and there is still considerable room for improvement. The purpose of vocational education is to improve the quality of skilled labor, which necessitates the deliberate development of specialties. Secondary vocational education in China began with the development of a market economy, but the emphasis on "planning" and "supply" in the planned economy model has had such a profound effect on vocational education that vocational education in China has for decades followed traditional ideas of specialty design and accumulated numerous problems. For example, secondary vocational colleges and schools' segmentation of specialties limits their service capacities, making it difficult to obtain effective industry support for specialty design. The rate at which new specialties are added, on the other hand, will never keep up with changing market demand. On the other hand, the constant addition of new specialties has resulted in the unnecessary consumption of secondary vocational school educational resources and has even undermined the culture that developing a specialty requires long-term commitments and efforts (Shen & Shi, 2011). These issues become more pressing as China's economic development model shifts, industrial transformation and upgrading accelerates, and a market-oriented employment mechanism is established. In this context, the establishment of specialty clusters becomes even more critical in the reform of vocational education.

At present, China's economy is transitioning from rapid growth to quality growth, and the positive effects of industry clusters are becoming increasingly apparent, resulting in a pressing need for high-quality technical and skilled labor. Not only has internet technology been fully implemented in the service sector, but it is also permeating primary and secondary industries. The integration of traditional industries with new intelligent technologies such as cloud computing, big data, and the internet of things continuously generate new industrial growth points, new trades, and new types of jobs, while also imposing new requirements on workers, such as the ability to handle increased complexity. In comparison to individual specialties, specialty clusters are more adaptable to market demand changes. As a result, secondary vocational schools should prioritize collaboration between specialty clusters and industry clusters in order to increase the adaptability and relevance of training and education (Yuan, 2007).

The Supporting Role of Shenzhen's Information Technology Industry in the Creation of Specialty Clusters in the ICT Industry

The municipal government of Shenzhen has set the goal of developing a world-class new-generation information technology industry base for the city's industrial development. Furthermore, it launched implementation strategies for capitalizing on artificial intelligence and fifth-generation mobile communication (5G) advancements, as well as adhering to the new internet of everything trend. The information and communications technology (ICT) industry in Shenzhen's Longgang District is one of the largest in Asia. Longgang District has been a global leader in research and development of 5G technology, ranking first among China's top 100 industrial districts. The Banxuegang Science and Technology Center in Longgang (also known as the ICT industry center in the Asia-Pacific region) is particularly noteworthy for its ideal and powerful industrial chains.

To ensure the continued development and talent supply of Longgang District, the Ministry of Education and the provincial government of Guangdong encourage vocational education colleges and schools to establish first-class specialty clusters aligned with regional high-end industries and to connect their specialty planning to emerging strategic industries and industry clusters worth 100 billion or more yuan. Longgang No.2 Vocational School, located on Yuanshan Street in Longgang District, has naturally become a target school for establishing high-quality specialty clusters. In September 2021, the Longgang District Local Government officially launched a plan to construct high-level secondary vocational schools, which included Longgang No. 2 Vocational School. Since then, by concentrating on cutting-edge technologies and the critical needs of industrial chains, the school has garnered significant government support for the development of ICT specialty clusters.

Criteria and connotations

Connotations of Specialty Clusters

(i) Market-driven: As industrialization progresses, businesses are increasingly interested in recruiting multi-skilled workers, as those with a single specialty are unable to meet market demand.

(ii) Vocational education remains a vital component of education. The specialty cluster is not arbitrary; it is determined based on the requirements of each vocational position (Li, 2020).

(iii) Coordinative: A cluster's specialties have a coordinated relationship. While each specialty is self-contained, they function in concert with other specialties.

(iv) Systematic: A specialty cluster can be thought of as an organized system. It must not only produce qualified, skilled workers for the world outside the system, but also gather information from outside the cluster in order to optimize internal cluster elements such as relationships between specialties, curriculum, training conditions, and teaching team.

(v) Innovative: The transformation of traditional industries and the rapid growth of emerging industries have resulted in the creation of new types of jobs; digitalization has increased the requirements for a variety of occupations. As a result, secondary vocational schools must constantly innovate and adapt their specialty clusters to changing industrial and environmental conditions. (Wu, 2019).

Criteria for Developing Specialty Clusters

(i) An outstanding teaching team. It is comprised of teaching research groups, top researchers in each specialty, and qualified part-time faculty.
(ii) A state-of-the-art practice and training facility. The base's facilities should be sufficiently advanced to accommodate the training and teaching of the specialties.
(iii) Constant curriculum updates. Curriculum development for specialty clusters requires enterprise involvement in order to reflect emerging technologies, techniques, and industry standards.
(iv) Admissions criteria are in place for qualified students.
(v) Post-graduation survey to determine students' employment status, employers' evaluations of students, and students' job satisfaction.
(vi) Extensive collaboration between schools and businesses. Collaboration between schools, businesses, and industries results in significant collaboration projects and patents (2019, Ren).

Strategies for the Development of Specialty Clusters

To Connect Specialty Cluster Construction with Socio-economic Development

Prior to developing specialty clusters, it is critical to ascertain the relationship between vocational education and regional industrial development. Shenzhen is currently accelerating the development of strategic emerging industries with the goal of establishing a world-class industrial base for next-generation information technology. Longgang District is expected to develop a trillion-yuan ICT industry. Industrialization on a massive scale generates enormous demand. According to the China Software Industry Association's Research on the Demand for Talents in China's ICT Industry, released on August 21, 2018, the industry requires an additional 7.65 million practitioners and the demand is still growing. Shenzhen's advantages in terms of land use, capital, and talent ensure the region's rapid development in the ICT industry. Vocational colleges and schools should seize this opportunity and invest heavily in the development of specialty clusters.

To Focus on the Needs of the Industrial Chain in Designing Specialty Clusters

The industrial chain is a term from industrial economics that refers to a chain relationship that forms spontaneously between various industrial segments as a result of certain technical and economic associations as well as spatial-temporal relationships. Companies in the industrial chain exist in response to market conditions of supply and demand, perform a variety of tasks, and have varying demands for skilled labor. Secondary vocational schools should determine the role of each specialty and the distinct skill requirements of different enterprises along the industrial chain when designing specialty clusters. They should also analyze the trainees' unique learning situations and recommend appropriate specialties and curricula based on their future employers' recruitment plans (Xu & Zhu, 2022).

Along with providing students with fundamental vocational knowledge, Longgang No.2 Vocational School frequently arranges for students to receive off-campus training at Shenzhen Toulang E-Commerce Co., Ltd. Through highly intensive practical training, students will gain a true sense of the corporate atmosphere within the industrial chain, an understanding of how e-commerce related tasks are performed, and a mastery of the various skills required in the e-commerce industry. Students gain an understanding of their potential job positions in the job market, the requirements for multi-skill application-oriented jobs, and the ability to make autonomous decisions about their future development as a result of their practical operation experience (Zheng, 2020).

To be Forward-Looking and Flexible in Developing Specialty Clusters

Apart from meeting the immediate needs of regional core industries, vocational schools should anticipate future specialty cluster development. This means that specialty clusters should focus on emerging industries that are still in their infancy but have the potential to last at least two decades, if not longer. After twenty to thirty years of development, an industry may experience a period of industrial recession or transformation. As a result, the planner must account for the possibility that specialty clusters will need to transform at some point in the future if the industry underlying the specialty clusters experiences a recession. When this occurs, teaching teams responsible for declining specialty clusters should be able to restructure their curricula. The cluster's combination of specialties should be adaptable to changes in demand as industrial development progresses. As long as it retains this adaptability, when an industry's recession renders a specialty cluster obsolete, the vocational school's intellectual resources can rapidly transform and generate a new specialty cluster (Zhou, 2001).

Experts from colleges and universities, as well as industry leaders, have aided in the specialization planning of Longgang No. 2 Vocational School, ensuring that it is aligned with the needs of modern enterprises in Shenzhen. At the school's inception, nine popular specialties were offered: computer network technology, exhibition service and management, animation and game production, e-commerce, accounting, financial services, community affairs administration, high-star hotel management, and optometry and eyeglasses. In 2020, internet of things application technology was added to the specialty range (Zheng, 2020). Longgang No. 2 Vocational School demonstrates foresight and adaptability in specialty settings, ensuring students' employment success.

To Develop High-level Human Resources and Recruit Teachers with Outstanding Professional Background

Secondary vocational schools should recruit teachers with extensive professional knowledge, innovative teaching strategies, and extensive scientific research experience to serve as leaders in developing specialty clusters. Moreover, to better serve regional economic development, vocational schools should recruit senior executives with extensive management experience and a strong sense of reform and innovation from influential leading enterprises in the information and communications technology industry; they can integrate their expertise in the high-end industry into the school's curriculum development and guide the future development of specialty clusters (Wu, 2019).

Shenzhen Toulang E-commerce Co., Ltd. serves as the Longgang No. 2 Vocational School's off-campus training base. It has sent a professional training team to the school to implement a pertinent training plan based on current e-commerce industry demand (Zheng, 2020).

To Upgrade Basic Training Equipment and Facilities for Specialty Clusters

To connect specialties with industry and supply the industry with skilled labor, vocational schools should have training devices that function similarly to the industry's actual production equipment. Due to the constant updating of technologies and equipment in national or local strategic industries, the school should invest sufficient funds in teaching equipment renewal to keep up with the rate of technological advancement. If current training is conducted using obsolete equipment, the school will be unable to produce qualified skilled workers for future industrial development.

Longgang No. 2 Vocational School's newly constructed training building contains 57 classrooms. Additionally, the hotel's training room was converted from the former canteen. Each specialty is assigned four to eleven training classrooms. Besides, the school has constructed an art design training room, a 3D printing training room, and a design display training room; virtual reality technology is being implemented in the specialty of community affairs administration. The comprehensive training facilities each have their own distinct characteristics and functions, laying the groundwork for the development of high-quality specialty clusters.

To Develop Unique Specialty Clusters Different from those of other Schools

Since the country began promoting the development of vocational colleges and schools in 2019, high-level schools and clusters of high-level specialization have sprouted up throughout the country. In Shenzhen City alone, there are two vocational colleges with four specialty clusters and eight secondary vocational schools with 12 specialty clusters; the numbers continue to grow. To avoid oversupply and waste of educational resources in a particular specialty cluster, vocational schools should first investigate established specialty clusters at other schools before embarking on developing their own differentiated ones. The differentiation may be reflected in the various industries they serve or in the various links in the industrial chain through which they operate.

Problems with the Current Coordination between Specialty Clusters and Industry Clusters

Almost all vocational colleges and schools have some form of school-business partnership. While some schools have achieved the desired results, the majority have failed to establish a long-term mechanism for close collaboration with businesses. The primary reason for this is the latter's reluctance to participate fully in the partnership. In a market-oriented economy, enterprises are profit-driven entities; the majority of them view involvement in vocational education as a source of direct or indirect financial loss. (i) School-enterprise collaboration increases their operational costs, as they must cover all living expenses for students trained in their companies, and students are typically inefficient workers who waste raw materials when operational errors occur. (ii) School-enterprise collaboration introduces significant risks. In the event of an accident caused by a student's error, the enterprise is liable for the resulting costs, including medical expenses and compensation, and its goodwill may be harmed. Additionally, without policy incentives, businesses are disincentivized from directly engaging in vocational education. They have not integrated school-business collaboration into their value chain. As a result, the current model of school-business collaboration has not yet been fully integrated into the development of businesses. Promoting school-business collaboration is primarily a temporary and ad hoc endeavor on the part of schools and departments of education. There is no coordinated bilateral action plan in place (Zhang, 2012). To accomplish the goal of deep school-enterprise collaboration, we propose that joint-stock partnerships be encouraged to align both parties' interests. A board of directors shall be established in proportion to the assets invested by schools and enterprises in order to manage and operate the schools cooperatively. Local educational authorities must develop regulations governing school-business collaboration, defining the parties' rights and obligations and prescribing evaluation and incentive mechanisms (Hong, 2010).

Conclusions

Among the ten specialties offered by Longgang No.2 Vocational School, finance and trade can be classified as e-commerce, accounting, and financial services. The three-specialty cluster has already been recognized by Shenzhen educational authorities as a high-level specialty cluster. Its target industry is Shenzhen's modern service sector. Moreover, the school intends to establish an electronic-information cluster based on the two established specialties of computer network technology and internet of things application technology for the following reasons: (i) At present, ICT is a growing industry that encompasses the hardware, software, and equipment associated with IT and telecommunications. It has a long industrial chain, involves numerous enterprises and job clusters, and can generate a large number of technical positions suitable for secondary vocational students. (ii) The Longgang District is the center of the ICT industry, providing a unique opportunity to engage enterprises in the development of specialty clusters. And (iii) the school's existing equipment and teaching resources provide adequate support for the development of a cluster of this type.

It is necessary to emphasize the importance of closely coordinating the development of secondary vocational school specialty clusters with the development of industry clusters. Secondary vocational schools can truly achieve high-quality education and contribute to regional economic and social development by establishing high-level specialty clusters with strong industrial support and following the industrial chain's development trend.

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REVIEW

A Review of Shadow Education

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***Abstract**: At the moment, shadow education is undergoing a rapid global expansion and has garnered widespread attention from a variety of sectors of society. After reviewing a substantial body of literature on after-school tutoring, this paper will attempt to summarize the findings of existing research on the evolution, current landscape, operating patterns, causes, impacts, and regulation of shadow education, with the goal of providing an overview of the subject for academia and sparking future research.*

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SHADOW education, also known as private tutoring or supplemental education, is a collection of after-school educational activities designed to help students improve their academic performance (Bray, 2002). Stevenson and Becker (1992) coined the term "shadow education" in 1992. Later, Bray (2012) elaborated on shadow education in a relatively systematic manner, arguing that the metaphor of "shadow" stems from the fact that shadow education exists only because mainstream education exists and changes in response to the latter's changes, and that its overall picture is not as distinct as the latter's. Despite the global debate over how to conceptualize and characterize shadow education, scholars agree on the following: (i) Shadow education is a supplement to mainstream education; (ii) It requires tuition, which is determined by the profit-making nature of the service providers, whether institutional or individual; and (iii) The teaching content of shadow education is highly consistent with that of formal schooling, and its primary objective is the same.

We searched the Chinese academic database CNKI (China National Knowledge Infrastructure) for the terms "shadow education" and "after-school tutoring" and found 1,204 articles published between January 2000 and February 2022. The top 20 most frequently cited documents indicate that existing research on shadow education focuses primarily on its causes, development trends, effects, existing problems, and governance measures; educational inequality in relation to shadow education is another hot topic of discussion in this field. The results of a Google Scholar search for "shadow education" indicate that, from a global perspective, the discussion of shadow education is also focused on its causes, influences, problems, and other issues. In response to primary concerns expressed by scholars in China and other countries regarding this issue, the paper summarizes the major contents and findings of existing authoritative studies on shadow education in order to present a multi-dimensional picture of shadow education research and to provide useful guidelines for future explorations.

The Evolution of Shadow Education

Each country's history of shadow education is unique due to its socioeconomic development and cultural background.

Shadow education is a relatively new phenomenon in China, having emerged as a result of the country's reforms and opening up in the 1980s. During the early stages of reform, the government gradually relaxed restrictions on private education, recognizing that the public education supported by state revenue could no longer meet the growing demand for education. Private capital and the establishment of private schools have become critical solutions to the educational supply shortage problem. Private education, including tutoring, has begun to grow in popularity. Restricted by market size, social concepts, and educational policies, shadow education during this era consists primarily of in-school supplementary lessons and private tutoring via home visits (Pan & Wang, 2020). However, the State Council's Decision on Deepening *Educational Reform and Comprehensively Promoting Quality Education*, as well as subsequent policies issued in 1999, completely prohibited in-school supplementary lessons, particularly those paid for remedial programs, dealing a fatal blow to the nascent shadow education. The year 2003 marks a watershed moment in China's history of shadow education. The People's Republic of China's Private Education Promotion Law legalized profit-making private schools and tutoring institutions. In the years that followed, shadow education at the compulsory education level exploded in China, albeit in a disorderly and unregulated manner to some extent. In July 2021, the State Council's General Office issued *Opinions on Further Reducing the Burden of Homework and Off-Campus Training for Compulsory Education Students* (also known as the Double Reduction policy), with the goal of reducing student school workloads and off-campus tutoring burdens. As a result of the Double Reduction policy, the scale and scope of shadow education were significantly reduced. This means that numerous subject-specific off-campus training institutions will either close or restructure their operations. Even off-campus training behemoths like New Orient and Xueda Education are struggling to stay afloat. Despite the fact that some off-campus tutoring institutions have remained "underground" and continue to operate in the training market, the entire shadow education industry has taken a severe hit (Zhou, 2021).

The majority of Korean scholars agree that the establishment and growth of shadow education in South Korea are inextricably linked to high-stakes admission examinations. Thus, the development of shadow education in South Korea paralleled the dramatic changes in the country's high-stakes admission examinations and can be classified into three stages: the sprouting period, the period of complete prohibition, and the period of legalization. Between 1960 and 1980, South Korea rapidly expanded the size of colleges and universities under the influence of Western higher education systems, resulting in severe shortages of professors, infrastructure, and funding, which the Korean government was unable to resolve in a timely manner. It was forced to reduce the size of universities and limit enrollments. To compete for limited admissions, students must engage in private supplemental tutoring to bolster their competitiveness, accelerating the growth of shadow education (Bray & Lykins, 2012). In 1980, in order to alleviate the ever-increasing competition among candidates, the Korean Ministry of Education implemented a reform in which students' in-school test scores and practical performance served as admission credentials in place of the college entrance examination, and shadow education was completely prohibited. Despite the Ministry of Education's prohibition, the number of private tutoring institutes in South Korea increased from 381 in 1980 to 14,013 in 2000, demonstrating that there was a sizable market for shadow education and that governmental regulation was ineffective. In this context, South Korea's Ministry of Education issued the *Program for Preventing Overheated Shadow Education and Improving the Quality of Formal Education* in June 2000, signaling a shift away from outright prohibition toward legalization of shadow education. The program formally recognizes shadow education as a legal supplement to formal education and requires educational authorities to assess the impact of shadow education on educational equity across socioeconomic classes and to take necessary measures to coordinate the relationship between formal and shadow education (Byun, 2014).

Scholars discover that the history of shadow education in Japan is inextricably linked to the country's diploma-valued tradition, which places a premium on academic credentials, and to the deficiency created by the "Relaxing Education" reform. It has progressed through four stages: laissez-faire, oversight, cooperation, and consolidation. Prior to 1976, Japan allowed unrestricted development of shadow education, which was typically used by parents to assist their children in winning academic competitions and achieving higher levels of education (Yamato & Zhang, 2017). At this early stage, the Japanese government acknowledged the existence of shadow education but made no specific regulations or laws to govern it. In the early 1980s, as Japan's public schools became increasingly problematic, middle-class parents sought out private education for their children, believing that it would help them develop ideal learning habits and achieve greater academic success. Since then, the Japanese government has increased its focus on shadow education; in 1988, shadow education was classified as an education service industry, subject to regulation by the Ministry of Economy, Trade, and Industry (METI) and oversight by the Ministry of Education. In the 1990s, as the Relaxing Education reform gained momentum, weekly class hours and instructional content were reduced to allow for increased study time for the development of comprehensive competencies, which included students' autonomous learning abilities, independent thinking abilities, and living skills. At this point, a partnership between shadow education and classroom instruction was established, with the former serving as a vital platform for students to conduct after-school extracurricular activities. Japan began measuring student academic achievement in 2000 with the PISA tests, and average PISA scores in 2003 and 2006 decreased in comparison to 2000. In response to media scrutiny and criticism, public schools began amending their curricula and increasing instructional content. As a result, teachers were overworked. To alleviate teachers' workloads, the collaboration between shadow education institutions and public schools has been strengthened: teachers from shadow education institutions teach in public schools, primarily offering students services such as career planning and study counseling; shadow education supports rural education by providing off-campus supplemental tutoring (Bartlett et al., 2012). At present, shadow education in Japan has developed sustainably and has become an integral part of national education.

The Status Quo of Shadow Education

The extent to which shadow education exists in various countries has long been a subject of academic inquiry throughout the world. Data from the existing literature indicates that the growth of shadow education is generally upward-trending and has the potential to create a sizable industry if left unchecked by government policies.

Since the reform and opening up, China's shadow education sector has grown rapidly from a minuscule existence to a massive industry. The target group continues to grow, as does the age range of students participating in after-school tutoring. Chinese scholars have examined the extent to which off-campus supplementary tutoring exists from a variety of perspectives.

Zhao et al. (2021) report that the cumulative number of students enrolled in off-campus tutoring in China has reached 137 million, with 8.5 million teachers employed by approximately 200,000 private tutoring institutions. The 2020H1 Report of China Online Education Survey Data and Case Studies of Representative Enterprises indicates that the total market size of China's online education has increased from 221.8 billion CNY in 2016 to 414 billion CNY in 2017.

Dai (2012) calculated the percentages of students participating in shadow education at various education levels using data from the 2004 Survey of Education and Employment of Urban Residents in China: among all urban students surveyed, the participation rates for primary school, general junior secondary school, and general senior secondary school students were 73.8%, 65.6%, and 53.5%, respectively.

Xue (2015) represented the status quo of shadow education in China by examining students' average time spent in cram schools. Their daily average time commitment to after-school supplementary tutoring is 0.8 hours on working days (Monday to Friday) and 2.1 hours on weekends (Saturdays and Sundays).

However, with the implementation of the Double Reduction policy, limiting the development of shadow education has become a critical measure for relieving students' academic burden. This is a severe crackdown on the shadow education industry, which has resulted in the industry's demise. The rigorous implementation of the Double Reduction policy implies that no new institutions of compulsory education will be approved. Yang and Li (2022) discover that the number of shadow education institutions in Yunnan Province has decreased following the implementation of the Double Reduction policy. The total growth rate of shadow education institutions is approximately -33%, while subject-based shadow education institutions grow at a rate of -37%; the share of subject-based shadow education institutions in the total sector declines from 94% to 88%; and the cancellation rate exceeds 17%.

By contrast, data from Japanese and Korean scholars demonstrates that shadow education has achieved unprecedented popularity in Japan and South Korea at the moment. In recent years, as a result of the economic downturn, admission to prestigious schools and universities has become more critical to students' future job market competitiveness, resulting in a greater reliance on shadow education by Japanese and Korean students. Japan currently has approximately 55,000 private tutoring establishments, and approximately 33.7% of primary school students, 51.9% of junior secondary school students, and 29.3% of senior secondary school students attend after-school remedial classes. In 2020, the Japanese shadow education industry's total revenue will reach 470.29 billion yen. In comparison, South Korea's prevalence of "shadow education" is even more astounding. According to the New York Times, 75% of South Korean students are enrolled in 100,000 cram schools throughout the country. These large-scale cram schools serve as the backbone of the South Korean educational system, and the supplementary tutoring economy generates approximately 2.0997 trillion KRW each year. According to a Hyundai Research Institute (a South Korean think tank) report, the average Korean family spends nearly 20% of their income on extracurricular tutoring for their children (Kim, 2016). As a result, it is common for students throughout the

East Asian region to engage in extracurricular tutoring as a result of the region's intense competition. Shadow education in East Asia is currently characterized by high participation, widespread coverage, profitability, and rapid expansion.

Furthermore, the United Kingdom and Canada, which previously frowned on after-school tutoring, are beginning to recognize the importance of examinations, and shadow education now has a greater influence on their educational systems than ever before. It is rapidly expanding, despite its relatively small size for the time being. Ireson and Rushforth (2005) reported in their study that 18% of 11th grade students in the United Kingdom received remedial tutoring in mathematics in 2005.

Types and Forms of Shadow Education

According to the collected literature, research on shadow education's operational forms focuses on the operating agents, organizational forms, instructional modes, and tutoring content.

As per Ru and Yang (2018), the operating agents of shadow education fall into two categories: institutional and individual. Among Chinese students, the most popular shadow education institutions include New Oriental Education Group, Xueda Education, and TAL Education.

Shadow education can be classified into three types based on class size: class tutoring, group tutoring, and individual (one-to-one) tutoring; and based on instructional space, it can be classified as in-person or online instruction (Huang, 2020).

There are differences in the content of instruction between shadow education programs in different countries. Nonetheless, supplementary tutoring in languages (particularly native language and English), mathematics, and science is common around the world because these three subjects are core components of selective examinations, have the greatest impact on student academic performance, and are required for students interested in science and engineering (Peng, 2007).Approximately one-third of Chinese students currently participate in after-school supplementary tutoring. According to the results of the China Compulsory Education Quality Survey (2018), 43.8% and 23.4% of Chinese fourth- and eighth-grade students, respectively, participate in after-school mathematics tutoring. Additionally, shadow education provides tutoring for compulsory subjects such as Chinese, mathematics, and foreign languages, as well as training in arts and sports such as painting, dancing, and musical instrument playing. While Bray (2012) defines shadow education as subject-based after-school supplementary educational activities, China's unique entrance examination policy, which allows for additional scores for artistic and athletic ability, makes subjects such as painting, dancing, musical instrument playing, and sports examination-oriented for some students and classified as academic subjects in off-campus training schools.

Reasons for Participating in Shadow Education

The high rate of student participation in shadow education in East Asia is not only explained by the historical culture of "He who excels in learning will be chosen as an official," but also by the importance parents place on investing in their children's education. The continuous advancement of modern parents' educational attainment results in an increased awareness of the critical role of knowledge in their children's development. The parental belief that a high investment in child education results in a high return is at the root of shadow education's explosive growth.

According to some scholars, the Confucianist tradition of highly valuing education may explain the growth of shadow education in East Asia. Education, as a critical component of social mobility, has enabled many people to advance socially. Although public school education has long since supplanted the imperial examination system (Ling, 2007), the concept of "scholarship is superior to anything else" remains deeply ingrained in the minds of East Asians, influencing their educational decision-making. As a result, studying diligently has become a widely accepted value in East Asian communities, particularly in highly selective societies such as China, Japan, and Korea, where modern education has inherited the imperial examination system's qualities of high competitiveness and stakes. To differentiate themselves in various selections and examinations, students have no choice but to expand their knowledge through after-school shadow education (Chen & Wei, 2019).

Researchers argue that while grades and academic credentials remain critical criteria for distinguishing individuals, the importance of cram schools is undeniable. Despite urgent calls for academic burden reduction and comprehensive competence education, examinations remain the primary method of selecting talented individuals in East Asian countries (Gao, 2020). In an examination-oriented educational climate, students and parents place a premium on examination results. Those preparing for high school and college entrance examinations are particularly anxious. Regular mock exams and rankings will only instill fear in them, driving them to seek out ways to improve their competitiveness in the battles for school progression. When shadow education institutions exploit their irrational psychology by promising them an immediate and significant improvement in academic performance, they will naturally seek assistance (Yu & Jia, 2020).Moreover, the prevalence of shadow education is inextricably linked to our society's "diploma fever." Employers frequently view a high level of education as a sign of exceptional talent. The social emphasis on educational backgrounds exacerbates students' sense of crisis and increases their willingness to engage in shadow education in order to ensure their success on entrance examinations.

Numerous studies focus their discussion on the influence of the middle class's education anxiety on shadow education when they examine the reasons for participating in private supplementary tutoring. The excessive reliance on and pursuit of educational attainment on the part of the urban middle class stems largely from their anxiety about their children's ability to maintain or even advance family social status. As a result, they exaggerate the impact of education on their children's futures, believing that educational success can stave off the decline of their social status and are thus willing to stake nearly everything on their children's education (Tan, 2010). There is, however, a significant disparity between the quality of public education and the educational expectations of urban middle-class parents. They can hardly accept advocates for "happy education" and "academic burden reduction" in an examination-oriented educational system. Utilizing parents' mistrust of public education, shadow education institutions entice middle-class families to join supplementary tutoring through exaggerated advertisements such as "guaranteed admission to expected universities."

According to some scholars, the inadequacy of home tutoring allows shadow education to thrive. Parents generally feel less capable of providing effective academic tutoring as their children grow older. Given the perceived inferiority of home tutoring to professional shadow education institutions, most parents simply delegate the responsibility of supervising their children's after-school learning to off-campus tutoring institutions (Hu, Fan, & Ding, 2015). Additionally, with a fast-paced urban lifestyle and heavy workloads, parents often lack the time necessary to accompany their children. Enrolling their children in multiple tutoring classes is thus a viable option because it can provide a safe haven for them to stay as well as appropriate supervision over their after-school studies (Zhang & Bray, 2020).

Besides that, Xue (2015) notes that while parents may make decisions regarding after-school tutoring; students are the true participants in shadow education. The majority of students participates voluntarily, out of a desire for self-improvement or peer pressure. Top students are even more motivated to pursue supplemental tutoring than students with medium or low academic levels, as they face greater pressures and must work harder to maintain their current rankings. Pan and Wang (2020) observe that, as shadow education has become ubiquitous, participation in it has developed into a shared identity for students. Non-participants become the minority. In public schools' class-based teaching system, learning content and levels of difficulty are typically standardized for the entire class. Students who do not participate in shadow education, a small minority, are likely to fall behind in their academic progress. Teachers may even suggest that they enroll in after-school remedial tutoring to help them catch up with their classmates.

The Impact of Shadow Education

Existing research on the impact of shadow education considers both its benefits and drawbacks. On the one hand, it supplements traditional education by meeting students' unique needs. On the other hand, the profit-driven nature of off-campus training institutions frequently results in exaggerated advertisements that prey on parents' vulnerable psychology and coerce them into blindly participating in shadow education. Excessive after-school tutoring and parental intervention are detrimental to students' physical and mental health. Furthermore, whether market-oriented and commercialized operations of shadow education exacerbate educational inequality has sparked global debates in academia.

Thus, according to research on the effect of shadow education on student development, shadow education can have a detrimental effect on students' health and motivation to learn. In a survey of junior secondary school students in Beijing, Zhao et al. (2021) discover that subject-based off-campus tutoring significantly reduces students' sleep time. Shadow education, in addition to intensive school learning, consumes additional time and energy from students, undoubtedly increasing their academic burden and robbing them of their learning autonomy. Moreover, excessive after-school tutoring dampens students' enthusiasm for self-directed learning (Zhao et al., 2021). Over time, students may develop academic fatigue and become inefficient learners (Bray, 2012). Likewise, the primary appeal of shadow education is its ability to improve student test scores. Through excessive exam skill training, students are led to place an emphasis on exam results rather than the process of knowledge acquisition, which is detrimental to the development of students' creativity and critical thinking. Correspondingly, shadow education introduces social competition into children's lives at an early age and encourages them to view the world through a utilitarian lens, which runs counter to the principle of healthy child development (Peng, 2007). Peng (2018) believes that excessive extracurricular tutoring burdens students academically and can even make them obsessive about examinations but apathetic about life. According to some researchers, excessive shadow education is detrimental to students' social development, resulting in their estrangement from family members. If children are forced to spend excessive time on after-school tutoring and are unable to communicate with their parents, the love generated by their natural bonds will deteriorate, preventing students from developing a sound personality (Mustary, 2019).

In terms of shadow education's influence on school instruction, some researchers argue that advanced learning conducted in private tutoring institutions impedes the progress of regular school instruction. Students' reliance on after-school tutoring may result in a variety of negative behaviors, including a lack of respect for mainstream school teachers, an inability to concentrate in class, and a preference for ready answers rather than independent thinking (Zhou, 2008).

Through visits and interviews, some scholars have conducted in-depth investigations into the operation mechanisms of shadow education and discovered problems with tutoring institutions such as unregulated operation models, ambiguous objectives, and disorganized management. The quality of tutoring varies between institutions; some training institutions exaggerate the benefits of supplemental tutoring (Xue, 2015). Liu (2020) expresses concern about the tutors' teaching credentials in these institutions. The majority of tutoring institution teachers is college students or recent graduates who lack formal professional training and classroom experience. This may result in inconsistency between their tutoring and the state's official curriculum standards. While some after-school tutoring institutions employ retired "famous teachers" as a draw, little is known about whether their teaching style and educational philosophy meet the new requirements of the reformed curriculum.

The primary effect of shadow education on students' families is an increase in educational expenses. Xue (2021) concluded from his research that excessive emphasis on children's education has resulted in a significant increase in family educational expenditure in China. Half of the families involved in shadow education spend between

2,000 and 10,000 CNY per year on each primary or secondary school student, and 13.7% spend more than 20,000 CNY. Economically advantaged families are most willing to spend money on supplemental education for their children with mediocre academic performance (Zhi & Ding, 2020).

Numerous studies conclusively demonstrate that shadow education jeopardizes educational equity. Because shadow education is a for-profit endeavor, it necessitates economic reserves on the part of participants. Parents' economic circumstances influence their decision to enroll their children in after-school tutoring, resulting in unequal opportunities for different students to receive shadow education (Fan, 2008). Hu and Fan (2021) discover that socioeconomically advantaged families invest significantly more in remedial tutoring than low-income families, based on a sample analysis of Shanghai students in 2012. Participating in shadow education converts their economic capital to cultural expenditure, enhancing their competitiveness in school progression and exacerbating academic achievement disparities between children from diverse family backgrounds. Besides that, it is believed that the prevalence of after-school tutoring reduces public school teachers' commitment to and preparation for teaching, thereby impairing the learning outcomes of non-participants, whereas students from wealthy families can easily obtain compensation from private tutoring services (Husslein, 1997).

Apart from the aforementioned negative influences, numerous scholars have discussed the positive effects of shadow education. The large-class teaching style prevalent in mainstream education is typically well-suited to middle-level students but cannot meet the needs of every student. The teaching content may be too simple for high-achieving students, while it may be too difficult for low-achieving students. Shadow education can compensate for this shortcoming by providing students with customized instruction, allowing students with varying aptitudes to maximize their learning effectiveness. In this sense, shadow education has incorporated some of the more advanced concepts advocated in China's new curriculum reform in response to public demand for a higher standard of education (Huang, 2019). According to Loyalka and Zakharov (2016), shadow education has a beneficial effect on students' mental health. Effective after-school private tutoring increases students' confidence in academic competition; the broader and more in-depth knowledge gained through supplementary tutoring increases students' interest in the school curriculum. Per some scholars, shadow education has a beneficial effect on employment from a socioeconomic standpoint. It supports a substantial number of private training institutions and provides employment opportunities for a large number of college students and graduates. Furthermore, the substantial profits it generates assist in promoting local economic development (Liu, 2020).

Whether or not shadow education has a beneficial effect on student academic progress is a point of contention at the moment. Some researchers maintain that shadow education significantly improves student academic performance (Dang & Wells, 2007); others maintain that shadow education has a detrimental effect on student academic achievement (Lee et al., 2004); still others maintain that it has no discernible effect on student learning outcomes (Smyth, 2009). When examining the effect of shadow education on time differences, Xu (2020) observes that private tutoring between Monday and

Friday has the potential to degrade student academic performance by depriving students of time for relaxation, whereas extra tutoring on weekends has the potential to improve student academic achievement by properly utilizing weekend time. Smyth (2009) corroborates the preceding finding by arguing that student academic performance is not only related to their participation in shadow education but also to the time period during which they participate; from Monday to Friday, students should focus on the learning tasks assigned by teachers and be guaranteed adequate time for relaxation and recreation. Additionally, some research indicates that the duration of private tutoring is related to the academic achievement of students to varying degrees. When compared to no tutoring, private tutoring of more than three hours per week has been shown to significantly improve student academic performance; weekly supplementary tutoring of 1-2 hours has no significant effect on student academic results; and weekly tutoring of less than one hour has been shown to significantly degrade student academic achievement (Wang & Li, 2014). From their investigations into rural after-school tutoring at the compulsory education level, Pang et al. (2017) conclude that private remedial tutoring cannot effectively improve rural student mathematics results. They attribute this to a lack of high-quality educational resources and ineffective instruction methods used by rural tutors.

Suggestions for Regulating Shadow Education

Researchers agree that the goal of regulating shadow education is to optimize the educational service system in such a way that it can meet students' needs for additional instruction without jeopardizing the equity and fairness of compulsory education. It is critical to enhance the quality of mainstream education and to equalize access to high-quality educational resources while also establishing an effective regulatory mechanism to steer shadow education in a positive direction. They are the diametric opposites of one another.

Bray (2013) summarizes the global regulatory framework for shadow education and proposes six modes: laisse faire, supervision without intervention, adaptation with control, encouraging, blended, and prohibitive. He suggests that when developing policies and regulations for shadow education, relevant authorities should take into account the history and current state of the practice in their respective countries.

Despite the fact that the majority of countries in East Asia have issued broad guidelines for the management of after-school tutoring institutions, Li (2015) notes that there are no detailed regulations governing their specific management operations. To ensure effective regulation and governance in the shadow education sector, the country should issue a set of unified regulatory policies aimed at strengthening approval of and oversight of after-school tutoring institutions. The primary regulatory targets are teaching and training qualifications, charging standards, and teacher qualification certificates issued by tutoring institutions. The other critical step that should be taken at the national level is to define the roles and responsibilities of various regulatory authorities in order to eliminate "blind spots" in supervision and to close down unqualified institutions in the shadow education industry (Yang, 2012).

According to certain studies, the primary strategy for regulating shadow education is to improve the quality of public education. As a secondary means of preventing the excessive expansion of shadow education, the educational community should work to improve formal public education by identifying its shortcomings and conducting extensive educational and teaching research. To increase access to high-quality public educational resources and close the gap between demand and supply of quality public education, teacher exchange and rotation in urban and rural areas should be encouraged, as should various forms of inter-school collaboration such as school alliances and educational conglomerates (Gao, 2020). Huang and Xing (2020) propose that public schools should facilitate cross-school teacher exchanges or advanced in-service training in order to strengthen teachers' professional capabilities, address inequitable distribution of high-quality educational resources, and reduce parents' distrust of public schools and excessive reliance on tutoring institutions.

As previously discussed in this paper, middle-and high-income families enjoy distinct advantages when it comes to accessing shadow education resources, whereas low-income families face significant disadvantages. As a result, the government is expected to play a critical role in balancing educational resources in order to counteract the detrimental effects of shadow education. Baker et al. (2002) argue that the government can provide reasonable educational compensation to students from low-income families and expand access to learning resources and educational opportunities. For instance, in the United States, the government-funded After-School Program promotes students' personalized development and educational equity through a variety of after-school activities. Similarly, in the *Guiding Opinions on After-School Services for Primary and Secondary School Students*, the Chinese government advocates for free tutoring and assistance for students experiencing learning difficulties, as well as after-school services for children who are left behind or who migrate with their migrant-worker parents, in order to safeguard the rights and interests of the vulnerable population (Xue, 2016). Furthermore, the rapid growth of the Internet has aided in the advancement of educational equity. The educational community should make full use of "Internet+" and other integration mechanisms. For instance, a comprehensive subject-based teaching resource library could be established to enable students to learn and communicate online, allowing students with learning disabilities to receive assistance whenever necessary.

Moreover, Liu (2020) believes that educational reform is necessary to address the issue of shadow education. Educational development is guided by the educational evaluation system. At the moment, the primary method of selection in China and other East Asian countries is examination-based evaluation. The overemphasis on summative assessments inevitably results in an extreme situation in which test scores and school rankings are all that matter. We can use shadow education rationally only if we encourage the transformation of the mainstream education evaluation system and incorporate formative assessment into overall student assessment. Likewise, various forms of parent education can be used to guide parents toward a scientific perspective on education, such as parent meetings and community-based education activities. Parents who are anxiety-free and equipped with reasonable educational concepts can contribute to the development of a healthy educational environment.

Limitations of Existing Studies of Shadow Education

The review of existing literature on shadow education in China and abroad also identifies the subject's limitations and clarifies the prospects for future research. The majority of studies on shadow education use data from large-scale questionnaire surveys, which may limit the depth of the investigations due to insufficient coverage in the question design or a lack of rigorous definitions of major concepts. In terms of sampling, the majority of analyses use compulsory education students as subjects, rarely including parents, teachers, or college students, jeopardizing the completeness and objectivity of the investigations. Additionally, there are few studies on public school teachers' involvement in off-campus tutoring and in shadow education regulatory policies. In future studies, researchers should employ a broader range of analytical techniques and a broader range of subjects in order to obtain more pertinent and effective results.

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REVIEW

Reflections on Education Groups at Basic Education Level in China

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Abstract: *In the context of China's education reform, the education group emerges as a new form of school organization designed to equalize access to high-quality educational resources. While this increasingly popular mode of school running has achieved notable results in Beijing, Shanghai, and Hangzhou, among other cities, there are concerns about the problems it engenders, such as severe homogenization and poor group management. The purpose of this paper is to examine the causes, outcomes, and problems of education groups and to propose solutions to existing problems, as well as to provide references for future school alliance development.*

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AMONG the many negative repercussions of urbanization, "school picking" (the practice of enrolling in a school outside one's allotted school district) has developed into a severe issue that confounds the entire community. The primary cause of school selection is an imbalance in the development of advantaged and disadvantaged schools. Educational equality has become a critical objective for the government and the entire population. Numerous changes and strategies have been tested around the country to maximize the efficacy of existing high-quality educational resources. The most effective of these is the establishment of education groups in Beijing, Shanghai, and Hangzhou, among other places. In China, an "education group" is an association of two or more schools that share common educational concepts, are contractually tied, and were formed to achieve a certain scale effect. Based on a review of current statistics and literature, this study provides an overview of the causes, outcomes, and challenges facing educational groups with the goal of eliciting additional observations on educational equity.

Causes of Education Groups

Disparities in the quality of basic education exist throughout China, and the "siphon" phenomenon is so pervasive that it even operates between different districts within a city. In education, the siphon effect refers to the movement of students and teachers from economically depressed places to those with a high concentration of superior educational resources (Wan & Chen, 2022). For example, Beijing and Tianjin, as the dual core cities of the Beijing-Tianjin-Hebei Economic Zone, have amassed unique economic conditions and high-quality educational resources, creating a powerful siphon effect on Hebei Province's instructors and pupils. As a result of the continual inflow of competent teachers and bright students, the prestigious schools in Beijing and Tianjin have become stronger, while the less advantaged schools in Hebei Province have lost professors and students, exacerbating the disparities between different places (Yan, 2016). In this context, education groups are formed to foster collaboration between affluent and impoverished schools in order to ensure the balanced development of basic education.

In major cities, an education group is often organized around a prestigious school (also known as a "core school"), with other member schools (also known as "ordinary schools") serving as branch campuses. Throughout the cooperation period, the core school will send a few administrators and anchor teachers to its branch campuses to provide teaching guidance and teacher training. Teachers will be able to broaden their horizons, update their ideas, and improve their professional level through exchanges with peers in other schools organized by the group. As a result, the availability of high-quality educational resources is increased, and the overall quality of member schools is raised.

The Outcomes of Education Groups

Enhancing the Overall Education Quality of Member Schools in the Group

Education groups facilitate the sharing of high-quality resources, the interchange of management skills, and the coordination of instructional research. To begin with, government backing helps to increase the effectiveness of education organizations. For example, to ensure the organizations' effective operation, the Shanghai government has published a variety of laws regarding funding, performance appraisal, and teacher recruitment. Second, school grouping unifies the resources of all member schools and facilitates the sharing of high-quality educational resources, collaborative teaching research and curriculum change, and teacher rotation. For instance, X Education Group in Shanghai utilizes the group's curriculum research center to coordinate curriculum research, implementation, and evaluation, with the goal of developing an advanced curriculum system for the entire group. Finally, education groups' principal objective is to raise the educational quality of their member schools. School grouping significantly lowers educational gaps between schools and contributes to regional education quality balance; the group's quality assessment center can monitor student academic performance and learning processes by standardizing evaluation techniques for all member schools (Zhang & Chen, 2018).

Improving Teachers' Job Satisfaction and Professional Competence

The majority of teachers have a strong sense of identity with the group and confidence in its future, and their personal planning is closely aligned with the group's development vision, which considerably enhances the alliance's cohesion. Through positive interactions, they are able to maintain harmonious relationships with their peers at other member schools, and the group also serves as a learning community for teachers and has significantly increased their development space, alleviating competition among teachers in a single school and significantly improving interpersonal relationships. Additionally, the education organization can leverage anchor teachers' effects throughout all member schools. The anchor teachers' skills and experience can be shared throughout schools through demonstration lessons, teaching research programs, cooperative lesson preparation, and other activities. This benefits other teachers' professional growth. Tu (2018) examined 175 instructors representing three distinct educational groupings in Shanghai's Jing'an District. The findings indicate that more than 90% of teachers believe their teaching and research abilities have improved since their schools joined the group; 89.7% believe their disciplinary knowledge has increased; 88.6% believe their teaching performance has improved; and 86.9% believe their educational concepts have changed. Additional research demonstrates that membership in educational groups benefits teachers' instructional approaches and outcomes as well as their professional knowledge and competence.

Facilitating Student Comprehensive Development

The education group spreads the core school's reasonably sophisticated educational philosophy and modern classroom culture to other member schools. Under the guidance of innovative teaching approaches, teachers will place a greater emphasis on the development of students' higher-order thinking skills rather than only on their test scores. Inter-school contacts have dismantled long-standing barriers to resource sharing, allowing students to access a variety of learning modes and high-quality courses, as well as participate in extracurricular activities with their peers (Zhang, 2019). Additionally, inter-school communication strengthens students' sense of belonging to the educational community, accelerating the formation of group culture. For instance, Zhengzhou No. 96 Middle School and Zhengzhou Huimin Middle School collaborate to form a school district alliance. To increase student interaction and develop their overall competence, the two schools co-hosted the first-ever middle school student maker culture festival in Zhengzhou City. The festival featured five major competitions, including robotics innovation, aircraft models, small inventions, original microfilms, and innovative sports and art. The festival provided students with a big display platform, an opportunity to participate in practical activities, discover their passions, exercise their creativity, and feel the joy that comes from the marriage of modern technology and creativity (Zhengdong Platform, 2016).

Relieving the Fever of "School Picking"

With urbanization, the demand for high-quality education increases, worsening the fever of school choice. Major cities in China have employed education groups to address a lack of high-quality education resources, significantly alleviating public anxiety about child schooling. According to Zhou (2005), the establishment of education groups has made "prestigious schools" accessible to ordinary people in Hangzhou's Xiacheng District. The change benefited 90 percent of the district's students and significantly reduced the gap between supply and demand for high-quality education.

Problems Faced by Education Groups

The Imposition of Core Schools' Culture on Non-Core Schools in the Education Group May Obliterate the Latter's Individualities

Certain educational facilities attempt to mechanically recreate the culture of core schools in non-core schools, eventually eradicating the latter's cultural heritage, great traditions, and historical traces (Zhang, 2019). Eliminating the distinctive characteristics of non-core schools will result in an undue homogenization of the group's member schools.

Ordinary Schools Have Difficulty Applying the Educational Philosophy of Prestigious Schools

The education group's primary aim is to enhance the professional competence of ordinary school teachers. Coordinated teaching research, cooperative lesson preparation, teacher exchange, and job rotation among member schools are common strategies used by the core school to support the professional development of non-core school teachers. These measures, however, are ineffective due to disparities in teacher ability and student competence among member schools. It takes time for ordinary school teachers to fully grasp the core school's frontier educational theories. Likewise, the lack of autonomous learning ability among ordinary school students makes it difficult for their teachers to apply the advanced teaching methods learned through coordinated teaching research and cooperative lesson preparation to classroom instruction. Without a connection to the actual circumstances or needs of regular schools, the core school's experience will benefit neither teachers nor students at non-core schools (Li, 2016).

The Management of the Core School Lacks the Motivation to Sustain the Running of the Group

The education group is frequently founded by the principal of the core school, who is driven by his or her objectives for the cause of education, namely, to universalize high-quality education and to support the balanced development of fundamental education (Zhu, 2006). However, several complications may occur as a result of the education group's foundation. Blind expansion disperses the core school's resources and may degrade educational quality; the primary objective of the education group is to expand access to high-quality educational resources, which requires significant financial investment and human capital input from the core school. The government evaluates an education group primarily on the basis of the core school's performance, which adds an additional burden to the core school's management. These obstacles put their fortitude to the test.

Suggestions for Systematic Improvement of Education Groups

To Establish Equal and Democratic Relationships among Member Schools of the Group

The core school's equitable and democratic connection with the group's other ordinary schools is critical for inter-school engagement and cooperation. By making member schools less sensitive to the disparity in their strengths, it is possible to increase each school's passion and initiative in contributing to the group's progress. It is strongly recommended that a standing committee be formed. Composed of the leaders of member schools, it can act as the group's main decision maker, writing the charter and overseeing the organization's general planning, as well as facilitating collaboration among group members. As the educational group's originator, the core school must also strengthen its teamwork, communication, and negotiation skills. It should have a specialized information transmission mechanism in place to quickly reply to inquiries from non-core institutions. Moreover, the core school should raise awareness of the importance of involving other schools in significant decision-making so that they can play a constructive and proactive part in the group's reform (Cao, 2018).

To Strengthen Team Building for the Whole Education Group

Excellent teachers are the group's and school's most valuable assets. The group should develop incentive systems to promote teacher rotation between schools. While sending anchor instructors to member schools helps improve the group's overall teaching quality, it is equally critical for teachers from less advantaged schools to receive training at the core school in order to master advanced teaching models and methodologies. Moreover, an education group founded around a prominent school has the benefit of attracting highly qualified teachers to bolster the group's teaching staff. Additionally, by leveraging current educational technologies, the education group may optimize the impact of the anchor teaching team. It can develop an online resource sharing platform that incorporates high-quality courses from all member schools and allows students to access them at any time and from any location regardless of their school affiliation (Li & Meng, 2016).

To Win Government Support for Education Groups

Education groups are formed to equalize access to basic education for the general good. The government owes them policy and financial support. Most crucially, the government should cover a portion of the group's operational costs to alleviate pressure on the core school, which is in charge of the group's overall operation. It should recognize teachers who devote their careers to developing underprivileged schools with prizes or welfare benefits. Local educational authorities should provide special financing to principals who have made significant contributions to the development of educational groups (Zhang, 2017).

Conclusions

China encourages the establishment of basic education groups, and cites it as a critical tool for achieving educational equity and equality. Modern education necessitates more collaboration and exchange between schools. In comparison to past inter-school "shallow cooperation," the education group is a form of contractual "deep cooperation" between prestigious and non-prestigious schools, a novel experiment in school administration. How to foster cooperation among member schools without jeopardizing the distinctive characteristics of each individual school and creating motivation for the education group's continuous development warrants more study.

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