



Reimagining Pedagogical Practices in Teenage Science Education: A Post-COVID-19 Perspective

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Abstract. The global landscape of educational provision has witnessed a momentous turning point with the advent of the COVID-19 pandemic. The “emergency remote teaching” responses have revealed a remarkable educational gap for teenagers and spurred the demand for advanced pedagogical methods and disruptive remote learning technologies. Focusing on scientific research education, this study examines teenagers' receptivity to online scientific research education, evaluates their preferences for new educational platforms post-epidemic, and explores the future potential and importance of scientific research education. Utilizing survey data from 600 Chinese and American teenage students enrolled with ZY Education Technology Co., Ltd. between 2019 and 2022, we evaluate the influence of the COVID-19 epidemic and technological advancements on shifts in science education. In this dynamic market, we outline potential strategic directions for education firms and highlight the challenges in this specific sector of modern education. This study highlights the increasing demand for science education reform in the post-pandemic era to align advanced teaching methods with students' inherent interests and the utilization of advanced digital technology.

Keywords: Science Education; Education Equity; Distance Learning; COVID-19 Epidemic

1 Introduction

The COVID-19 pandemic, which started in early 2020, had a profound impact on the educational landscape around the world and compelled an unprecedented transition to remote learning and online learning. Schools and institutions were forced to quickly acclimate to “emergency remote teaching” [1] in reaction to the virus's broad propagation and the accompanying lockdowns. This pattern suggested a sudden shift from conventional classroom-based instruction to digital platforms [2][3]. The implications of this sudden change have been profound, with millions of students and teachers having to rapidly familiarize themselves with new tools and techniques. The effectiveness of

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online education, issues surrounding digital access and equity, and the psychological impact of remote learning are just a few of the areas that have come under scrutiny.

As we navigate through the pandemic and begin to look towards a post-COVID world, it is of critical significance to take the time to reflect on what we have learned from this dramatic shift in teenage science education practice. Science education for teenagers entails disseminating scientific principles and knowledge to a range of target audiences [4], typically including middle and high school students. The teaching of scientific material is just one aspect of this area, which also includes the processes of scientific research, facets of social science, and components of educational methods. The benchmarks for students' comprehension growth throughout their K–12 schooling and beyond are determined by science education standards. These standards often encompass a wide range of academic fields, including the physical, biological, earth, and space sciences, as well as the humanities. In 1867, the British Academy for the Advancement of Science (BAAS) issued a report advocating for the instruction of "pure science" and the cultivation of a "scientific mindset." [5] This early advocacy made clear the importance of encouraging pupils to deeply understand scientific concepts and to cultivate the analytical attitude necessary for scientific inquiry. Despite such long-standing support for the importance of science education, its advancement has regrettably lagged behind that of other academic disciplines. Current educational systems frequently downplay the crucial role that scientific research education plays in society, partially leading to some degree of education equity in modern times.

In the post-epidemic era, the fully developed online platform has provided students with unprecedented precious opportunities and greatly promoted the development of scientific research and education. Leveraging distance learning platforms and tools, a student in China can now collaborate remotely with leading researchers at Harvard University, a feat challenging in times before advanced digital technology. Considering the sustained impact of the coronavirus on remote education, we speculate that the COVID-19 pandemic has accelerated the growth of online and distance learning, broadening the scope of research and educational opportunities. To test this hypothesis, we randomly selected 600 young Chinese and American students enrolled in ZY Education Technology Co., Ltd., to conduct a questionnaire survey to understand how the epidemic and technological progress change scientific research and teaching. We introduce a strategic framework for educational institutions to navigate future changes in science education, addressing challenges, innovations, and opportunities. We then analyze post-epidemic research and education trends to provide actionable development insights.

2 Data and Methodology

2.1 Research Design

In this study, questionnaire survey was used to collect data, which can effectively collect the subjective thoughts of the student group and has been widely used in education research [6]. Questionnaire survey can collect data from large-scale samples and has the advantage of strong representativeness [7]. The scientific setting of survey questions directly affects the reliability of the results, so the selection of questionnaire survey can

effectively control the design and standardization of questions, deriving unique insights from the questionnaire on how the COVID-19 outbreak and advances in online technology are affecting the teaching practices of science education for young people. According to Finkelstein's EIA methodology, when the sample size is greater than 400, the reliability of the data reaches 95% [8][9]. To ensure representative data, we collected 600 samples from teenage students registered at ZY Education Technology Co., Ltd between 2019 and 2022.

2.2 Selection Criteria and Sources of Data

To investigate the evolution of remote science education for teenage students in China and the United States, and how it has been affected by the pandemic, we utilized survey results from teenage students in the United States and China. A total of 600 students (300 male and 300 female) are randomly selected, with 25 male and 25 female students for each grade (grade 7-12) in China and the United States, respectively. This survey aims to examine (1) the impact of COVID-19 on remote or in-person learning; (2) the preference for various educational platforms and methods after the epidemic; (3) the importance of scientific research and education for future development; and (4) potential factors that may contribute to the difference in choice between Chinese and American teenage students. Relevant data sorting, analysis, and visualization are performed by utilizing Microsoft Excel and Origin. The list of survey questions can be found at <https://doi.org/10.5281/zenodo.8240481>.

3 Result and Discussion

3.1 Adolescent students' understanding of scientific research education

Based on the survey data, Fig. 1 shows teenage students' comprehension and participation in scientific research and education. In terms of students' online and offline preferences, we identify that country, gender, and grade differences affect their choices. American students prefer online education, consistent with an earlier study [10], and this preference rate increases with grade level. From a gender perspective, male students prefer online education and are more adaptable to it. As shown in Fig. 1b, students' understanding of youth research education is also different. American students demonstrate a noticeably deeper grasp and greater exposure to this domain in comparison to the comparatively limited understanding of scientific research education among Chinese students. Furthermore, as students' progress through grades, their comprehension of scientific research and education naturally advances, concurrently expanding their appetite for external knowledge. It's worth noting that gender differences appear to have a less pronounced influence on this matter.

In contrast to Chinese students, teenagers attending American schools exhibit a heightened interest in scientific research and education, as depicted in Fig. 1c. Their cognitive flexibility and openness to ideas position them as more receptive to scientific research and educational content. Notably, male students also display heightened interest, introducing a gender element to the dynamic. An intriguing observation emerges:

Chinese students exhibit elevated enthusiasm for scientific research and education at lower grade levels, which gradually wanes as they progress through higher grades. Given that schools serve as hubs for education, we incorporated a school-focused questionnaire on the proliferation of scientific research education. Analyzing the data (Fig. 1d) reveals a contrast: American students engage more actively with scientific research education within the school setting compared to their Chinese counterparts. In the broader scope, a positive trend emerges: students' interactions with scientific research education in schools increase congruently with grade advancement, signifying an encouraging trajectory.

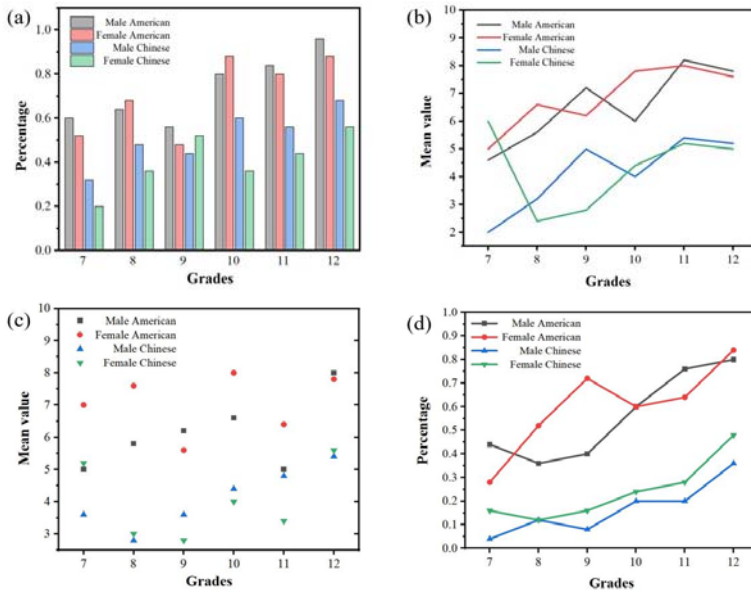


Fig. 1. Teenage students' comprehension of research education. a) The number of people choosing online mode and offline mode accounted for the proportion of each group. b) Students' knowledge of research education on a scale of 1-10. c) Students' interest in research education (1-10 points). d) Proportion of students in each group who are exposed to research education in school.

3.2 The impacts of COVID-19 on teenage students' education

The global COVID-19 pandemic has significantly disrupted various spheres of life, encompassing human communication, transportation, and particularly, education [10]. Through the feedback collection of the questionnaire survey, we found that the epidemic did have a great impact on the scientific research and education of young people. As shown in Fig. 2, most Chinese students believe that the epidemic has had a great impact on them. During the outbreak of the epidemic, Chinese students were forced to take remote classes, which indirectly promoted their preference for online education. In addition, most scientific research education in China is rarely accessible except for

graduate students and later stages, and online education is a good communication platform for scientific research education. Consequently, due to the pandemic's influence, a significant portion of students have shifted their preference towards engaging with scientific research education via online platforms. This shift underscores the pandemic's undeniable impact on China's conventional education paradigm, which is undoubtedly a good trend to promote students' scientific research and education in China.

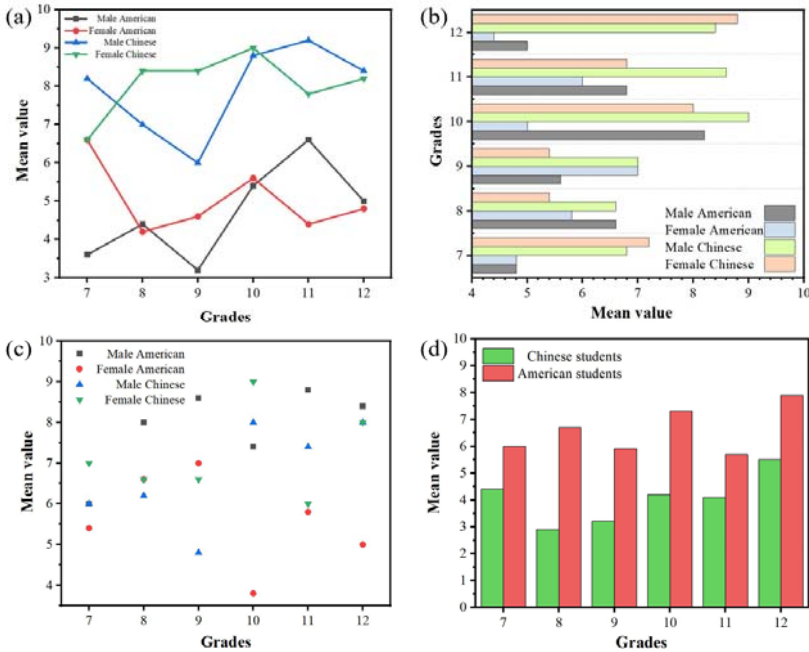


Fig. 2. The impact of the epidemic on teenage students. a) The impact of the epidemic on students' study and life (1-10 points). b) Under the influence of the epidemic, students' tendency to online education. c) Under the influence of the epidemic, students' tendency to scientific research and education. d) The difference of Chinese and American students' interest in scientific research.

Due to differing epidemic management approaches in the two countries, American students' feedback contrasts significantly with that of Chinese students. While most American students feel the pandemic has had minimal impact on their lives and studies, it has spurred a heightened emphasis on online education. Like their Chinese counterparts, American students also participated in remote classes during the pandemic. Regarding the pandemic's influence on scientific research and education, a notable divergence emerges. Chinese students show increased interest, whereas American students tend to perceive little change. The pandemic's transformative effect on research and education seems less pronounced in the United States. However, our analysis reveals interesting trends: male students demonstrate a stronger affinity for online education and a preference for scientific research education, distinguishing them from their fe-

male peers. Additionally, older students exhibit greater adaptability to online and research education compared to their younger counterparts. In essence, the pandemic has influenced education delivery methods in both countries. However, due to divergent epidemic control strategies, Chinese students have experienced a more substantial impact, leading to increased emphasis on online and scientific research education. This emphasis indirectly contributes to developmental progress in China's educational landscape. In our pursuit to understand differences in scientific research interests among children from both nations, we compiled data for cross-country education comparisons (Fig. 2). Evidently, American students demonstrate a generally higher interest in scientific research than their Chinese counterparts, across various grade levels. This observation reaffirms the influence of national education approaches on students' scientific research enthusiasm.

3.3 Students' preference for educational platforms in the post-pandemic era and the impacts of scientific research education

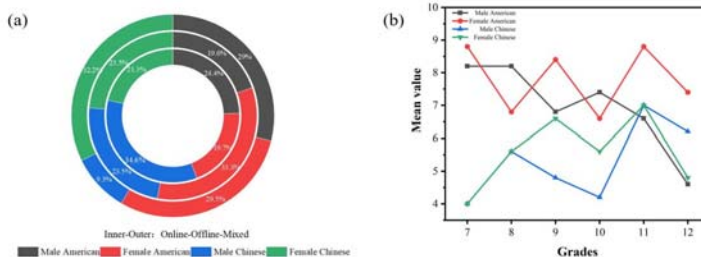


Fig. 3. Teenage students' tendency towards education platform, research education and future career planning in the post-epidemic era. a) Students' choice of educational platform and method. b) Students' cognition of scientific research education for future career planning.

The coronavirus pandemic is fading from people's minds, but its impact continues to the present. After the outbreak of the epidemic, due to the timeliness, stability, and durability of online education, students began to pay more attention to online scientific research and education platforms. We investigated the educational platforms and models that students prefer to conduct research education after the COVID-19 pandemic. Through visualization and analysis of the data (Fig. 3a), it can be concluded that American students are more willing to conduct scientific research education on the Internet platform than Chinese students. Chinese students are more likely to choose offline platforms compared to American students, which may be related to the traditional Chinese culture's emphasis on offline education and institutional factors [11]. Chinese students prefer a hybrid mode more than American students, and there is no significant gender difference in the choice of mixed mode. Notably, students from different countries have different preferences for educational platforms and models, which requires us to formulate more reasonable and efficient scientific research and education programs according to the characteristics and demands of students.

As science and technology advance alongside societal growth, an increasing recognition is dawning upon individuals regarding the crucial role of scientific research education in shaping the future career trajectories of adolescent students [12]. The core of scientific research education lies in the ability to inspire students to think, explore and innovate independently, so as to conduct scientific research with real practical application. Especially in the context of the pandemic, the development of online science education provides students with a new way of learning, while drawing more attention to science education.

Against this background, we investigated students' views and attitudes about the future career development of young people in science education. Fig. 3b shows that American students score significantly higher than Chinese students on this question, suggesting that American students are more accepting of the usefulness of science education. Furthermore, senior students exhibit a stronger belief in the significance of science education, often awarding higher grades, while gender does not appear to play a substantial role in this aspect. Owing to diverse national backgrounds and cultural influences, students possess varied levels of knowledge and awareness regarding science education. As a result, meticulous data analysis is essential to comprehensively grasp students' thoughts and attitudes. This detailed examination enables us to draw precise, scientifically-grounded conclusions that can effectively shape and direct future educational planning.

3.4 Advancement of Private Educational Institutions in the Post-Pandemic Era

There is no denying that private educational institutions, including but not limited to ZY Education, play an important role in online and research education during and after the pandemic. During the epidemic period, online education witnessed significant growth, enabling students to engage in scientific research activities. This offered a means for students to pursue their research interests during a time when offline scientific research faced limitations. Students' research directions, tutorial support, and customized services were tailored according to their specific needs. This approach aimed to assist students impacted by the epidemic in completing their research processes, enhancing their skills, and preparing applications for their desired universities. This model garnered considerable appreciation from students. However, the online mode also presented challenges such as inadequate communication between students and tutors, temporal disparities in information access, and discrepancies in experimental progress due to asynchrony in work processes.

In response to these challenges, there has been a proactive effort to innovate education models and adopt diverse developmental strategies. This includes a focus on deepening scientific research education and enhancing the comprehensiveness and scope of scientific research educational services. A key aspect of this endeavor involves the introduction of specialized and advanced courses, such as innovative research projects, guidance on research paper composition, and training in research methodologies. These initiatives aim to provide students with a more immersive and thorough research learning experience. Moreover, the scope of educational services could potentially extend

beyond the realm of scientific research and education. There is an opportunity to broaden the institution's reach by offering interdisciplinary online courses and academic guidance in various subject fields. This expansion would cater to the needs of students from diverse disciplinary backgrounds, ultimately contributing to an expanded market presence. Efforts to optimize the online learning experience are also underway. This entails the provision of personalized learning recommendations, tailor-made study plans, and a wealth of enriched learning resources and tools. Technological innovation will play a pivotal role in this enhancement process. Through a diversified and customer-centric approach, along with strategic partnerships, technology integration, data utilization, and responsive feedback, there is potential for significant growth, improved service quality, and enhanced market competitiveness in high-quality online research and education services in the post-pandemic era.

4 Summary

This article presents the evolution of online education and scientific research learning in the post-pandemic era. Based on thorough data analysis, it is evident that the aftermath of the COVID-19 pandemic has led to a widespread adoption of remote learning, creating abundant opportunities to enhance and expand scientific research education. Subsequently, we delve into a comparative exploration of Chinese and American students, dissecting the underlying factors contributing to their differences. Furthermore, the article sheds light on the trajectory and potential hindrances for private educational institutions in the post-pandemic era, preparing them for upcoming challenges. These insights are anticipated to offer fresh perspectives and innovative ideas for the advancement of online platforms within the realm of private education institutions.

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