A Study on the Influencing Factors and Enhancement Strategies of Undergraduates' Research Quality in the Context of Online Education

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Abstract: In the digital age, technological advancements have reshaped the global educational landscape, prompting governments and educational institutions to recognize the critical role of research and innovative talent in driving societal progress and economic growth. Undergraduate education, as a pivotal phase for cultivating future innovators, faces unprecedented opportunities for transformation. The rise of online teaching models has catalyzed a profound pedagogical revolution, offering both flexibility in learning and significant potential for educational innovation. This study investigates the current state and influencing factors of research quality among undergraduates at the Capital University of Economics and Business within the online teaching model. The analysis is structured around four key dimensions: research preparation, research motivation, research communication, and research organization and management. Targeted recommendations are proposed to enhance these aspects, providing valuable insights for the reform of undergraduate education in the context of online learning. The findings underscore the potential of educational transformation as a development opportunity, advocating for the integration of innovative educational models with technological advancements to better align with the talent cultivation needs of the contemporary era.

Keywords: Undergraduates; Online teaching; Research quality; Talent cultivation

1. Introduction

With the rapid development of technology, the global education system has been undergoing profound transformation, particularly in the realm of higher education, which bears the critical mission of cultivating future innovative talents (Zhong, 2007). To meet the demands of the digital age, many universities have begun implementing online teaching models to maintain the continuity of educational activities and broaden the accessibility of education (Liu & Zhang, 2020). This novel teaching approach, with its flexible learning environment and interactive features, presents new opportunities for fostering students' research interests, practical abilities, and innovative spirit (Xue & Guo, 2020). Despite the widespread impact of this shift on educational models, research on the impact of online teaching on undergraduates' research quality remains insufficiently explored. In this context, it is particularly important to examine the cultivation of students' research quality within an online teaching environment.

This study aims to explore the impact of online teaching models on undergraduates' research quality within the specific context of educational transformation and to propose corresponding improvement suggestions. The primary research questions are as follows: What is the current state of undergraduates' research quality in the online teaching model? What are the main factors influencing the research quality? How can the optimization of teaching models enhance the research quality? Strategies were formulated in this study to improve the research

quality of undergraduates to address these questions, thereby enhancing their research capabilities within the online teaching model and promoting their overall development.

The remainder of this study is structured as follows: Section 2 provides a literature review of related fields. Section 3 defines the core concepts and research methods. Section 4 covers the design and reliability analysis of the research tools. Section 5 presents the result analysis. Section 6 concludes this study and discusses future prospects.

2. Related Research

2.1 Definition of Core Concepts

It is essential to clarify the concepts of online teaching and research quality, facilitating the smooth progress of this research.

Originated in the United States in the 1960s, online teaching refers to a new teaching model where learners engage in real-time online learning through internet technology platforms. It involves using the internet to disseminate and provide a comprehensive set of knowledge solutions to create and enhance knowledge performance (Tzeng et al., 2006). In the 2000 Education White Paper (Yang et al., 2022) released by the United States Department of Education, online education has three core elements: (1) implementation of educational and teaching activities via the internet; (2) provision of a new learning method where learners can study anytime and anywhere, altering the relationship between teaching and learning; (3) occurrence within traditional campus teaching environments, unlike traditional distance education. Anderson (2004) posited that online learning is an effective process for acquiring knowledge and skills through an interactive learning model, where both teaching parties utilize the internet to access high-quality online learning resources. Vargas & Tian (2013) pointed out that online learning is a dynamic concept that fully considers social context, culture, ethics, and other issues, transforming the fundamentally one-sided knowledge exchange between teachers and students.

As the name implies, research quality refers to the qualities that researchers should possess. The abilities encompassed by research quality may vary across different fields. Luo (2014) proposed that research literacy is the quality demonstrated by researchers through learning or practice in the research process. Zhao (2006) pointed out that teachers' research literacy refers to their knowledge and cognitive structures in educational research, as well as their specific abilities and scientific qualities for conducting research. Based on the aforementioned literature, the research quality of undergraduates was defined in this study as the qualities that they should possess when engaging in exploratory research, research practice, patent development, and other research activities under the guidance of a mentor. It is a collection of various literacies and abilities, primarily including fundamental qualities such as learning and practice, as well as competencies such as literature retrieval.

2.2 Research Progress

Online teaching, a product of the information age, has evolved from early open courses to the current massive open online courses (MOOC). Yang et al. (2022) pointed out that early online teaching primarily focuses on distance education. With the development of internet technology, it has gradually transformed into a new educational model. Xie et al. (2020) highlighted the advantages of online teaching, such as its flexibility and accessibility, allowing students to learn according to their own schedules and pacing. Additionally, teachers can leverage abundant online resources for instruction. However, online teaching also faces numerous challenges, including low student engagement, insufficient interactivity, and difficulties in ensuring learning effectiveness (Zhao et al., 2018).

Research quality is an indicator that measures the abilities and qualities a student needs to conduct research activities. Tzeng et al. (2006) proposed that research quality encompasses several aspects, including mastery of specialized knowledge, application of research methods, innovative thinking, and teamwork. In recent years, with the continuous deepening of educational reforms, an increasing number of studies have started to focus on the cultivation of undergraduates' research quality (Meng et al., 2013). For example, Zhao (2006) found through survey analysis that the lack of practical opportunities is one of the significant factors affecting undergraduates' research quality. Additionally, Huang & Cao (2002) constructed an evaluation index system to measure the comprehensive quality of research-oriented medical graduate students, which provides a reference for evaluating undergraduates' research quality.

The continuous advancement of technology has greatly propelled the development of online teaching, leading to a technology-driven transformation of the global education system. Particularly in higher education, the application of technology has brought unprecedented changes to teaching models and student learning experiences. Xie et al. (2020) emphasized the widespread application of online teaching, ensuring the continuity of education. Additionally, Kong et al.(2010), through a comparative study of online teaching models in Chinese and American universities, proposed strategies to enhance the quality of online teaching. Although online teaching promotes

flexibility and accessibility in education and provides students with more diverse learning resources and opportunities for autonomous learning, it has unique impacts on undergraduates' research activities. Ma (2021) studied the impact of online teaching on undergraduates' learning engagement and found that those students face numerous challenges in an online learning environment, such as insufficient self-management skills and difficulties in accessing learning resources. These factors may indirectly affect their research quality. Furthermore, due to the limitations of field research, undergraduates have significantly fewer opportunities for research practice, which is particularly detrimental to the cultivation of their research quality (Ye, 2000).

Using "undergraduates' research quality" as the keyword, an index search of all literature in China National Knowledge Infrastructure (CNKI) was conducted in this study to select data from the past decade (2014-2024) for analysis. As shown in Figure 1, academic attention to undergraduates' research quality fluctuated between 2014 and 2019. It reached a peak in 2018, with an overall declining trend in the past five years. As shown in Figure 2, although the academic dissemination of research generally increased over the past decade, it showed a declining trend in the past two years. As shown in Figure 3, the disciplinary distribution of research is mainly concentrated in higher education, medicine, biology, and organic chemistry. As shown in Figure 4, the keywords include research quality, undergraduates, innovation ability, and research capability.

Although existing studies have explored online teaching and undergraduates' research quality to some extent, research on the research quality of those students within this new teaching model remains insufficient in the context of the current digital transformation. Particularly in the face of continuously evolving educational environments and learning methods, effective enhancement of undergraduates' research quality has become an urgent issue. This study aims to fill this research gap by empirically analyzing the current state of undergraduates' research quality in the context of online teaching and proposing enhancement strategies. The goal is to provide references for higher-education teaching reforms and the cultivation of undergraduates' research quality.
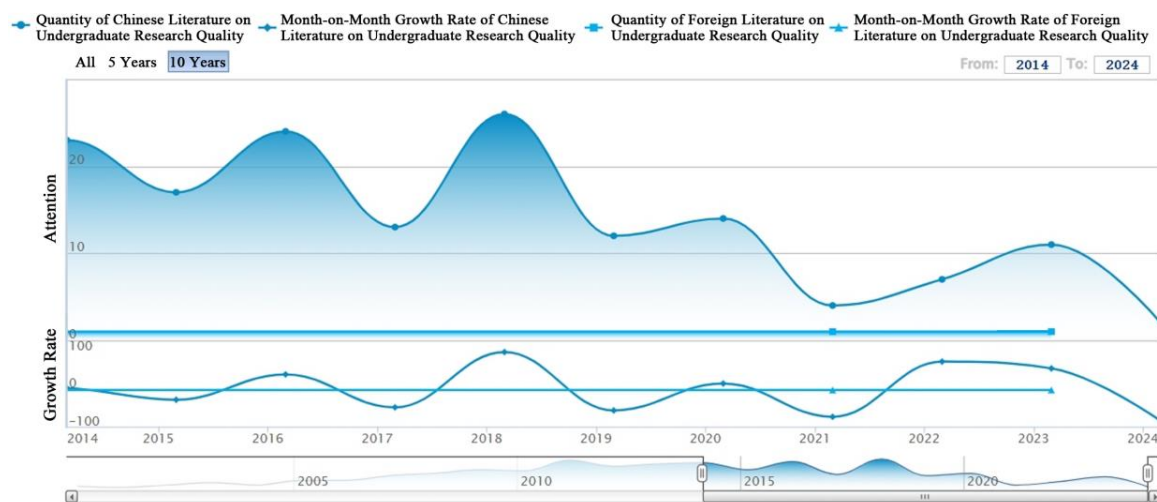

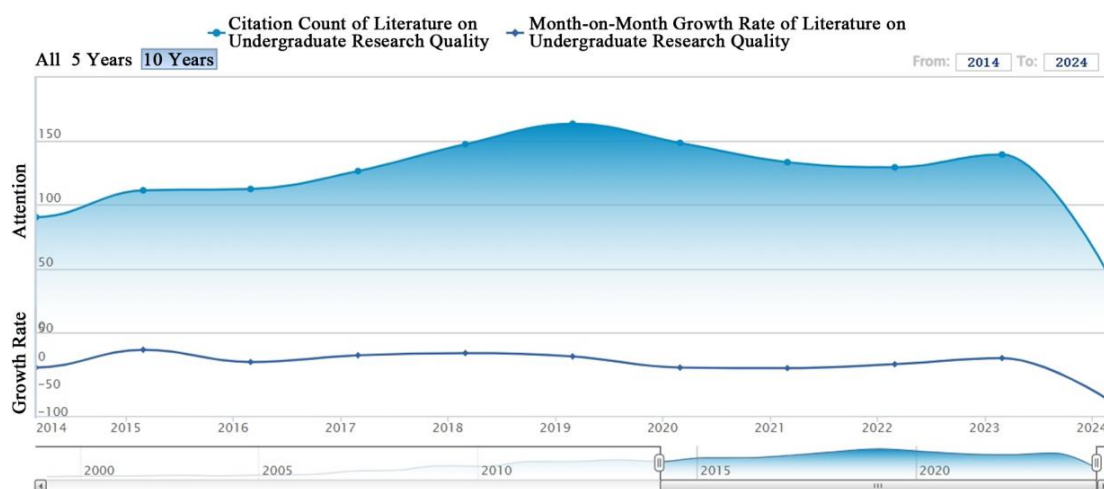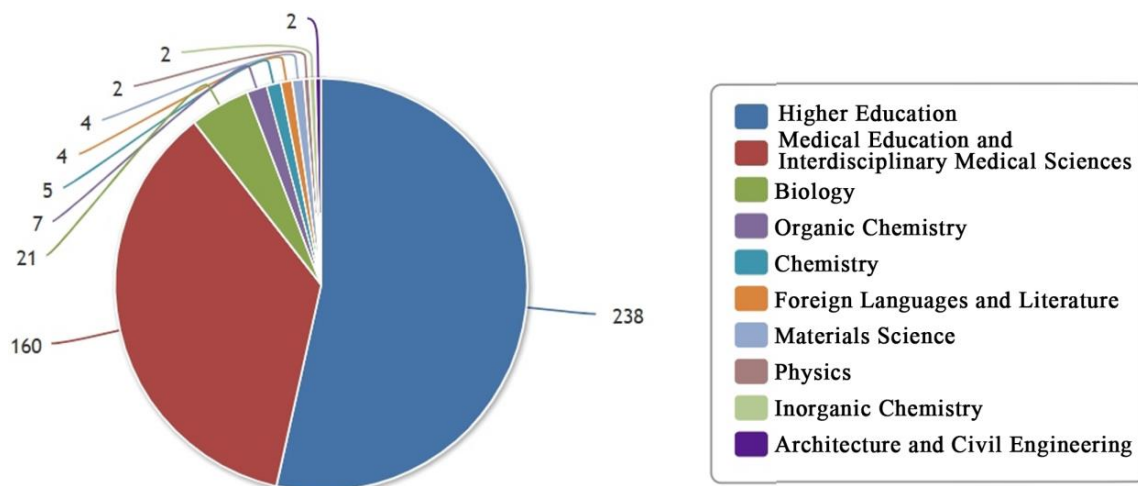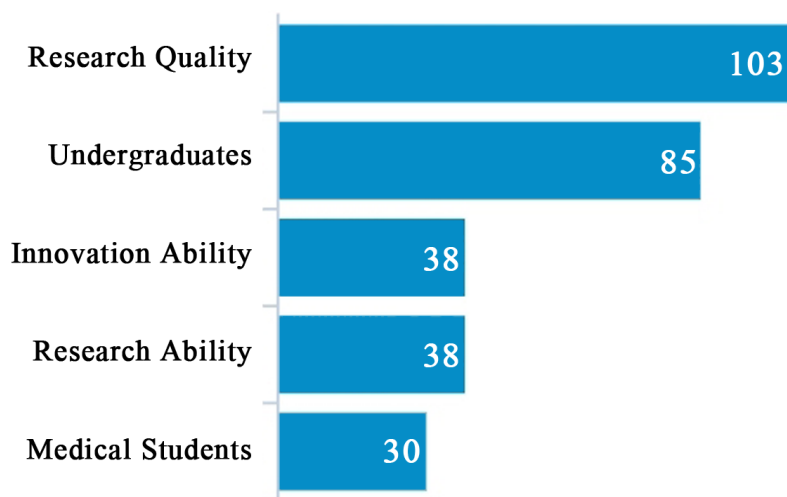**Figure 1.** Academic attention to undergraduates' research quality

Figure 2. Academic dissemination of undergraduates' research quality

Figure 3. Disciplinary distribution of research on undergraduates' research quality

Figure 4. Related terms in research on undergraduates' research quality

3. Research Methods and Design of Research Tools

3.1 Research Methods

Taking undergraduates from the Capital University of Economics and Business as an example, four dimensions were analyzed in this study, i.e., foundational research qualities, research competencies, research outputs, and online learning engagement. The aim is to thoroughly examine the current state of undergraduates' research quality in the online teaching model and explore potential differences across various backgrounds and environments. The main research methods employed in this study include a literature review, a questionnaire survey, and interviews.

(a) Literature review: In line with the research subjects of this study, this method involves extensively collecting and reading master's and doctoral theses, journal articles, books, and other materials related to online teaching models in universities, undergraduates' learning conditions in online teaching, and research quality, both domestically and internationally. The goal is to summarize existing research findings on undergraduates' research quality.

(b) Questionnaire survey: Based on the research theme and the current state of related research, a questionnaire was designed and distributed to undergraduates at the Capital University of Economics and Business. The collected questionnaire data were then statistically analyzed to understand the current state of their research quality and provide a basis for further research on influencing factors.

(c) Interviews: One-on-one interviews were conducted with those undergraduates to understand their actual research quality and their subjective perceptions of factors affecting their research quality. The findings were used to identify factors influencing their research quality in the online teaching model and to propose targeted practical suggestions for improving their research quality.

3.2 Design of Research Tools

3.2.1 Questionnaire design

The questionnaire designed for this study consists of two parts. The first part gathers basic information on the respondents, and the second part investigates the current state of their research quality.

(a) Basic information: This section mainly includes gender, ethnicity, location, age, major, average daily online learning duration, and primary online learning platforms. This information is used to understand the basic profile of the respondents, thereby analyzing the influence of personal background on their research quality in online teaching.

(b) Current state of research quality: This section employs a Likert five-point scale, which covers four dimensions, i.e., foundational research qualities, research competencies, research outputs, and learning engagement. The first three dimensions were determined based on the competency dictionary for talents in the science and engineering system proposed by Zhao (2019) and the comprehensive quality evaluation indicators for research-oriented graduate students proposed by Xu et al. (2004). Using the undergraduates' learning engagement in online teaching during the COVID-19 pandemic in the study by Ma (2021) as a reference, the dimension of learning engagement is used to measure the specific impact of online teaching on undergraduates' research quality.

3.2.2 Determination of the interview outline

The interview scope and questions were determined in this study based on the questionnaire content and survey results, combined with a literature review. The interviews mainly cover the following four aspects: the learners' self-assessment of their research quality; the problems and difficulties encountered in online learning; the main influencing factors and the extent of their impact on learners' research quality in the online teaching model; and the improvement measures taken by learners in response to the aforementioned influencing factors.

4. Design and Reliability Analysis of Research Tools

The questionnaire was distributed online to undergraduates at the Capital University of Economics and Business via the Questionnaire Star platform for a preliminary test. A total of 187 questionnaires were collected, all of which were valid. SPSSAU software was used for reliability and validity analysis.

4.1 Reliability Analysis

Reliability refers to the consistency and dependability of the measurement data. Cronbach's alpha coefficient (Cronbach α) is a commonly used measure of questionnaire reliability. Generally, a value above 0.7 is acceptable, and a value above 0.8 indicates excellent stability and very high reliability. As shown in Table 1, the Cronbach's α coefficient for this questionnaire is greater than 0.8, indicating very high reliability.

Table 1. Confidence statistics

	Cronbach's α Coefficient	Number of Items
Current status	0.954	18

4.2 Validity analysis

Validity refers to the extent to which a measurement accurately captures the construct it is intended to measure. Factor analysis was employed in this study for the structural validity analysis, which extracts common factors from a group of variables and examines the relationships among the variables to test the validity of the structure. The closer the Kaiser-Meyer-Olkin (KMO) value is to 1, the more suitable the data are for factor analysis. As shown in Table 2, the KMO value for the current state section of the questionnaire is greater than 0.8, indicating that it is suitable for factor analysis.

Table 2. KMO and Bartlett's test

	Current Status
KMO value	0.951
Bartlett's sphericity value	1556.229
Degrees of freedom (df)	153
p-value	0.000

The factor analysis method was applied to each of the four dimensions separately to determine the principal components of each dimension. Based on eigenvalues greater than 1, items with factor loadings or communalities less than 0.4 were deleted using the maximum variance method. Taking the first dimension of foundational

research qualities as an example, it includes five items, i.e., *a1*, *a2*, *a3*, *a4*, and *a5*. Each item was individually subjected to factor analysis to test its factor loadings and communalities, all of which are greater than 0.4, indicating no need for deletion or modification. Following this method, the factor analysis was conducted for the other three dimensions, and the results are presented in Table 3.

Table 3. Factor analysis for each dimension

Dimension	Question	Factor Loading Coefficient	Communality	KMO Value	Bartlett's Sphericity Value	p-value
Fundamental Research Qualities	*a1*	0.883	0.780	0.863	382.015	0.000
	a2	0.871	0.759			
	a3	0.878	0.771			
	a4	0.920	0.846			
	a5	0.842	0.709			
Research Competencies	*a6*	0.806	0.649	0.832	248.352	0.000
	a7	0.895	0.802			
	a8	0.904	0.818			
	a9	0.897	0.805			
Research Outputs	*a10*	0.689	0.475	0.505	3.037	0.152
	a11	0.755	0.570			
	a12	0.370	0.137			
Online Learning Engagement	*a13*	0.818	0.670	0.913	416.911	0.000
	a14	0.868	0.754			
	a15	0.885	0.783			
	a16	0.806	0.649			
	a17	0.896	0.755			
	a18	0.871	0.759			

Except for the dimension of research outputs, each of the other three dimensions has only one principal component, with factor loadings and communalities all greater than 0.4, indicating no need to delete any items. In the dimension of research outputs, the communality of item a12 is less than 0.4. However, considering the short duration of undergraduates' exposure to research and the difficulty of patent research, as well as the fact that existing related evaluation systems include this indicator, it was decided to retain this item.

## 5. Result Analysis

5.1 Analysis of Basic Information

The questionnaire link for this study was distributed through teaching WeChat groups, and a total of 200 undergraduates participated in the survey. Among these, 187 valid questionnaires were collected, resulting in an efficiency rate of 93.5%. The basic statistics of the collected questionnaires are shown in Table 4 and Figure 5. The gender distribution of respondents is roughly balanced; the ethnic distribution is skewed towards Han nationality; the location distribution shows a higher concentration in urban areas; the grade distribution is fairly balanced; and the distribution of majors shows a higher proportion of science and engineering disciplines compared to other fields. These distribution patterns are consistent with the actual situation.

Table 4. Basic statistics of the survey questionnaire

Variable	Characteristic	Frequency	Percentage
Gender	Male	101	54.01%
	Female	86	45.99%
Ethnicity	Han Nationality	156	80.75%
	Ethnic Minority	36	19.25%
Location	City	124	66.31%
	Rural	63	33.69%
Grade level	Freshman	34	18.18%
	Sophomore	61	32.63%
	Junior	39	20.86%
	Senior	53	28.34%
Major	Humanities and Social Sciences	41	21.93%
	Science and Engineering	107	57.22%
	Arts	35	18.72%
	Others	4	2.14%
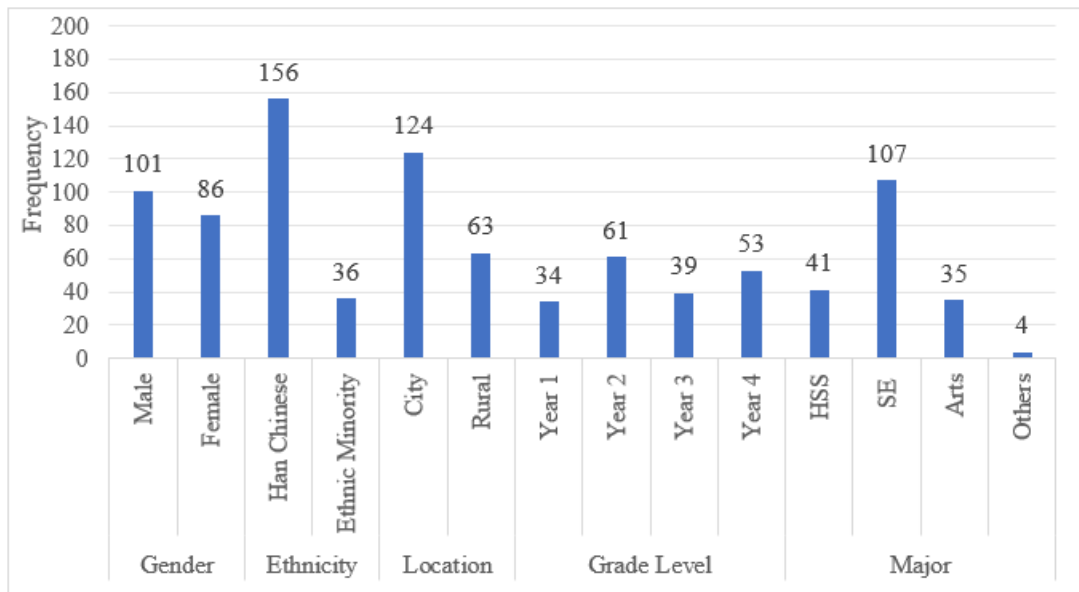
Figure 5. Basic statistics of the survey questionnaire
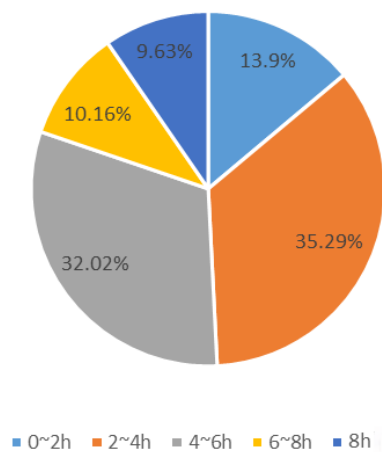
Figure 6. Pie chart of online learning duration
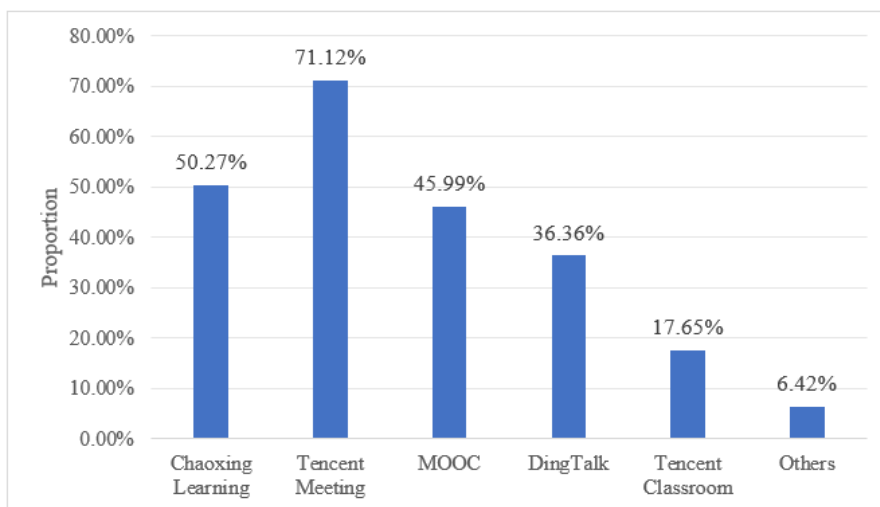
Figure 7. Bar chart of the main online teaching platforms

As shown in Figure 6, the majority of respondents have an average daily online learning duration of two to four hours, followed by those who study for four to six hours. This indicates that online learning has become the primary learning mode for undergraduates, with most students spending no more than six hours per day on their studies.

As shown in Figure 7, over 70% of the respondents use Tencent Meeting for online learning, making it the most popular platform, followed by Chaoxing Learning (50.27%), Chinese University MOOC (45.99%), DingTalk (36.36%), Tencent Classroom (17.65%), and other platforms (6.42%), such as Qihang Education and Bilibili.

5.2 Analysis of the Current State of Research Quality

The statistical scores for each dimension of undergraduates' research quality are shown in Table 5. The dimensions of foundational research qualities, research competencies, and learning engagement have a midpoint of 3 using a Likert five-point scale. The dimension of research outputs consists of binary questions, where 0 represents no and 1 represents yes.

Table 5. Current status of undergraduates' research quality under online teaching mode

Dimension	Number	Minimum Value	Maximum Value	Mean	Standard Deviation
Fundamental research qualities	187	1	5	3.6652	1.1711
Research competencies	187	1	5	3.7741	1.0962
Research outputs	187	0	1	0.3619	0.4805
Online learning engagement	187	1	5	3.6970	1.1818

The statistical results indicate that the mean scores for foundational research qualities, research competencies, and learning engagement are all greater than the theoretical average of 3 on the Likert scale, but are still relatively low. This suggests that under the influence of online teaching, there is room for improvement in undergraduates' foundational research qualities as well as their more specialized research competencies. Additionally, the overall learning engagement in online courses is moderate. Furthermore, the mean score for the research outputs is 0.3619, indicating that undergraduates have limited experience in participating in research projects, publishing research papers, and obtaining patents. Most students maintain a high level of interest and enthusiasm for research activities. Therefore, there is significant room for improvement in the research quality of undergraduates under the online teaching model. The following sections provide an in-depth analysis of the current state of undergraduates' research quality across various dimensions of the online teaching model.

5.2.1 Analysis of foundational research qualities

Foundational research qualities refer to the basic abilities that researchers should possess, including theoretical foundation, practical skills, research attitude, and collaboration abilities. The statistical results for this dimension in this study are shown in Table 6.

The above analysis reveals that the mean score for the foundational research qualities is 3.6652, which is higher than the theoretical average but is still relatively low, indicating that undergraduates' basic abilities need further improvement. The standard deviation is 1.1711, suggesting a low level of dispersion in undergraduates' foundational research qualities. By combining the mean scores of individual items with the overall mean score for this dimension, it becomes evident that undergraduates perform better in theoretical foundation and teamwork, while their practical skills and attitudes toward research are not yet ideal. This indicates that under the online teaching model, educators should focus on enhancing undergraduates' understanding and application of specialized knowledge and emphasize fostering students' motivation and enthusiasm for engaging in research activities.

5.2.2 Analysis of research competencies

Research competencies primarily refer to the abilities that students acquire through learning and practice outside of professional courses, which facilitate the smooth conduct of research activities. These include information retrieval skills, research presentation skills, and data analysis and processing abilities. The statistical results for this dimension in this study are shown in Table 7.

The above analysis reveals that the mean score for research competencies is 3.7741, which is higher than the theoretical average but is still relatively low, indicating that the overall level of undergraduates' research competencies is moderate. By combining the mean scores of individual items with the overall mean score for this dimension, it becomes evident that respondents have relatively strong information retrieval skills. However, when it comes to more specialized research presentation skills and data analysis abilities, undergraduates' performance is less than ideal. This indicates that online teaching should focus on developing students' research presentation skills and data analysis abilities.

5.2.3 Analysis of research outputs

Research outputs refer to the achievements obtained in research activities, which for undergraduates primarily

include research papers, awards from research competitions, and patent inventions. The statistical results for this dimension in this study are shown in Table 8.

Table 6. Statistics of fundamental research qualities

Question	Number	Minimum Value	Maximum Value	Mean	Standard Deviation
(a1) My academic performance is excellent.	187	1	5	3.6845	1.1755
(a2) I can apply professional knowledge flexibly to life.	187	1	5	3.5882	1.1638
(a3) I have a strong interest in scientific research.	187	1	5	3.5775	1.1461
(a4) I am willing to invest more time and experience in scientific research.	187	1	5	3.5989	1.2558
(a5) I can cooperate well with other students in a team.	187	1	5	3.8770	1.0801
Mean	187	1	5	3.6652	1.1711

Table 7. Statistics of research competencies

Question	Number	Minimum Value	Maximum Value	Mean	Standard Deviation
(a6) I can retrieve the information I need on the Internet.	187	1	5	3.8824	1.0683
(a7) I can naturally and smoothly tell others about my research results.	187	1	5	3.7433	1.1034
(a8) I can fully express my ideas through words.	187	1	5	3.7380	1.0500
(a9) I have a certain understanding of mathematical statistics principles and data analysis tools.	187	1	5	3.7326	1.1531
Mean	187	1	5	3.7741	1.0962

Table 8. Statistics of research outputs

Question	Number	Yes	No	Success Rate
(a10) I have received research awards.	187	63	124	0.3369
(a11) I have published research papers.	187	75	112	0.4011
(a12) I have applied for patents.	187	65	122	0.3476
Mean	187	68	119	0.3636

Table 9. Statistics of learning engagement

Question	Number	Minimum Value	Maximum Value	Mean	Standard Deviation
(a13) I use online learning to promote my study in university.	187	1	5	3.7594	1.1658
(a14) The playback, feedback and other functions of online learning can help me better understand the learning content.	187	1	5	3.7487	1.1310
(a15) Using online resources makes course learning more meaningful.	187	1	5	3.7326	1.2030
(a16) In online teaching, teachers can clearly define teaching objectives.	187	1	5	3.7968	1.1335
(a17) In online teaching, teachers guide learning activities through online discussions.	187	1	5	3.6898	1.2061
(a18) I often contact teachers when I learn online.	187	1	5	3.4545	1.2157
Mean	187	1	5	3.6970	1.1818

The above analysis reveals that the average acquisition rate of research outputs is 0.3636, which is significantly lower than the theoretical average of 0.5, indicating a substantial deficiency in undergraduates' research outputs. Only about one-third of the respondents have achieved research awards, research papers, or patent inventions. This suggests that under the current teaching model, mentors should focus on guiding students in their research activities to improve the conversion rate of undergraduates' research outputs.

5.2.4 Analysis of learning engagement

Learning engagement primarily measures the time and effort learners invest in learning activities under the online teaching model. According to the study by Ma (2021), it includes four aspects, i.e., overall learning utilization, in-depth understanding of content, teacher-student interaction, and effective guidance from teachers. The statistical results for this dimension in this study are shown in Table 9.

The above analysis reveals that the mean score for the learning engagement dimension is 3.6970, which is higher than the theoretical average but is still at a relatively low level, indicating that undergraduates' learning engagement in online teaching is relatively low. By combining the mean scores of individual items with the overall mean score for this dimension, it becomes evident that undergraduates perform relatively well in overall learning utilization and content understanding. However, there is a lack of online interaction with teachers and peers. This suggests that teachers should focus on communication and interaction with students during online teaching and provide opportunities for online discussions to enhance undergraduates' learning engagement.

5.3 Analysis of Differences in Research Quality

To understand the differences in undergraduates' research quality under different background conditions, background conditions such as gender, ethnicity, and location were used as independent variables in this study to analyze and summarize the differences in research quality levels (Wang et al., 2018).

5.3.1 Gender difference analysis

Using gender as the independent variable, the collected data were subjected to an independent samples t-test, and the results are shown in Table 10. The results indicate that the p-values corresponding to each dimension are all greater than 0.05, suggesting that there are no significant differences in foundational research qualities, research competencies, research outputs, or learning engagement when gender is used as the independent variable. In other words, gender does not impact the level of research quality.

Table 10. Statistical differences in research quality by gender

Dimension	Gender	Number	Mean	p-value (two-tailed)
Fundamental research qualities	Male	101	3.6139	0.056
	Female	86	3.7256	
Research competencies	Male	101	3.7722	0.756
	Female	86	3.7762	
Research outputs	Male	101	0.3465	0.141
	Female	86	0.3605	
Online learning engagement	Male	101	3.6634	0.685
	Female	86	3.7364	

Note: p>0.05 indicates no significant difference, 0.01<p<0.05 indicates a significant difference, and p<0.01 indicates a highly significant difference.

5.3.2 Ethnic difference analysis

Using ethnicity as the independent variable, the collected data were subjected to an independent samples t-test, and the results are shown in Table 11. The results indicate that the p-values for foundational research qualities and research competencies are 0.001 and 0.007, respectively, which are less than 0.05. The p-values for the other two dimensions are greater than 0.05. This suggests that ethnicity has a significant impact on undergraduates' foundational research qualities and research competencies, but no significant impact on research outputs or learning engagement. Considering the distribution characteristics of ethnic minorities in China, most of them are located in relatively remote areas where the educational level is relatively underdeveloped, leading to weaker research accumulation among ethnic minority undergraduates.

Table 11. Statistical differences in research quality by ethnicity

Dimension	Ethnicity	Number	Mean	p-value (two-tailed)
Fundamental research qualities	Han nationality	151	3.7642	0.001
	Ethnic minority	36	3.2500	
Research competencies	Han nationality	151	3.8543	0.007
	Ethnic minority	36	3.4375	
Research outputs	Han nationality	151	0.3709	0.641
	Ethnic minority	36	0.3241	
Online learning engagement	Han nationality	151	3.7130	0.180
	Ethnic minority	36	3.5741	

5.3.3 Analysis of differences based on family location

Using family location as the independent variable, the collected data were subjected to an independent samples t-test, and the results are shown in Table 12. The results indicate that the p-values corresponding to each dimension are all greater than 0.05, suggesting that using family location as the independent variable, there are no significant differences in undergraduates' foundational research qualities, research competencies, research outputs, or learning engagement. In other words, family location does not impact the level of research quality.

Table 12. Statistical differences in research quality by family location

Dimension	Family location	Number	Mean	p-value (two-tailed)
Fundamental research qualities	City	124	3.6177	0.132
	Rural	63	3.7587	
Research competencies	City	124	3.7601	0.653
	Rural	63	3.8016	
Research outputs	City	124	0.3602	0.913
	Rural	63	0.3651	
Online learning engagement	City	124	3.6438	0.279
	Rural	63	3.8015	

5.3.4 Analysis of differences based on grade level

Using grade level as the independent variable, the collected data were subjected to a one-way analysis of variance (ANOVA), and the results are shown in Table 13. The results indicate that the p-values corresponding to each dimension are all greater than 0.05, suggesting that there are no significant differences in foundational research qualities, research competencies, research outputs, or learning engagement among undergraduates of different grade levels. In other words, the grade level of undergraduates does not impact their level of research quality. It is worth noting that in the research outputs, the mean scores for freshmen, sophomores, juniors and seniors show an increasing trend, indicating that as grade level increases, undergraduates achieve more research outputs.

Table 13. Statistical differences in research quality by grade level

Dimension	Grade level	Number	Mean	p-value (two-tailed)
Fundamental research qualities	Freshman	34	3.5706	0.107
	Sophomore	61	3.6721	
	Junior	39	3.8513	
	Senior	53	3.5811	
Research competencies	Freshman	34	3.6176	0.297
	Sophomore	61	3.8402	
	Junior	39	3.8974	
	Senior	53	3.7075	
Research outputs	Freshman	34	0.3431	0.989
	Sophomore	61	0.3607	
	Junior	39	0.3675	
	Senior	53	0.3711	
Online learning engagement	Freshman	34	3.5882	0.375
	Sophomore	61	3.7896	
	Junior	39	3.7265	
	Senior	53	3.6384	

5.3.5 Analysis of differences based on major

Using major as the independent variable, the collected data were subjected to a one-way ANOVA, and the results are shown in Table 14. The results indicate that the p-values corresponding to each dimension are all greater than 0.05, suggesting that there are no significant differences in foundational research qualities, research competencies, research outputs, or learning engagement among undergraduates of different majors. In other words, major does not impact the level of research quality.

Table 15 and Figure 8 show the combinations of the p-values for undergraduates' research quality across the four dimensions, i.e., foundational research qualities, research competencies, research outputs, and learning engagement, under different background conditions. In the online teaching model, the p-values for the research quality levels of undergraduates based on gender, family location, grade level, and major are all greater than 0.05, indicating no significant differences. This suggests that these background factors do not have a significant impact

on their research quality. However, for undergraduates of different ethnicities, the p-values for foundational research qualities and research competencies are both less than 0.05, indicating significant differences, while there are no significant differences in the other two dimensions. Furthermore, as shown in Figure 8, the scores for undergraduates in different majors are the most balanced across the four dimensions of research quality, indicating that the influence of major background on undergraduates' research quality is minimal compared to other background conditions.

Table 14. Statistical differences in research quality by major

Dimension	Major	Number	Mean	p-value (two-tailed)
Fundamental research qualities	Science and Engineering	107	3.6261	0.704
	Humanities and Social Sciences	41	3.7659	
	Arts	35	3.6686	
	Others	4	3.7526	
Research competencies	Science and Engineering	107	3.7243	0.705
	Humanities and Social Sciences	41	3.8963	
	Arts	35	3.7785	
	Others	4	3.8125	
Research outputs	Science and Engineering	107	0.3582	0.994
	Humanities and Social Sciences	41	0.3577	
	Arts	35	0.3429	
	Others	4	0.3333	
Online learning engagement	Science and Engineering	107	3.6604	0.784
	Humanities and Social Sciences	41	3.7723	
	Arts	35	3.7238	
	Others	4	3.6667	

Table 15. p-values of differences in undergraduates' research quality under different background conditions

	Fundamental research Qualities	Research Competencies	Research Outputs	Online Learning Engagement
Gender	0.056	0.756	0.141	0.685
Ethnicity	0.001	0.007	0.641	0.180
Location	0.132	0.653	0.913	0.279
Grade Level	0.107	0.207	0.989	0.375
Major	0.704	0.705	0.994	0.784
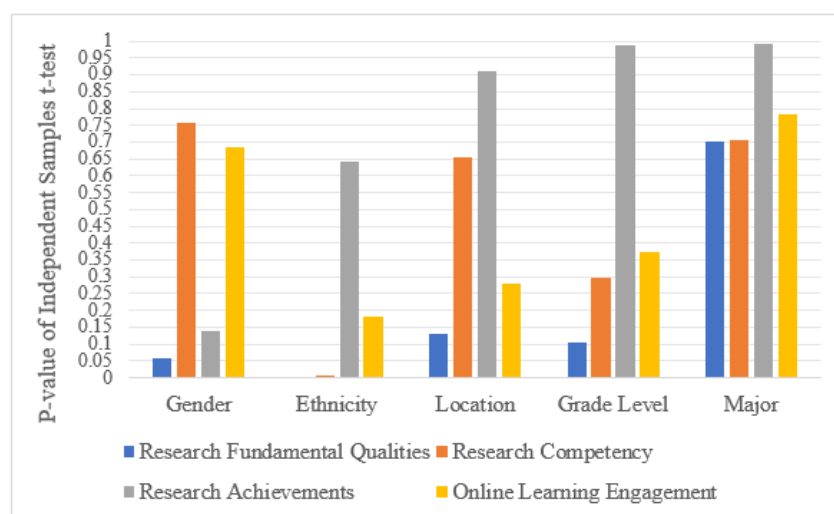
Figure 8. Bar chart of p-values of differences in undergraduates' research quality

5.4 Analysis of Factors Influencing Research Quality

This section summarizes and analyzes the factors that respondents believe influence their research quality, based on the implementation of interviews and the subsequent review and analysis of the interview results. The basic information of the interviewees is shown in Table 16.

Table 16. Basic information on interviewees

Number	Gender	Grade level	Major
A1	Female	Junior	Science and Engineering
A2	Male	Sophomore	Humanities and Social Sciences
A3	Male	Senior	Science and Engineering
A4	Female	Junior	Others
A5	Male	Sophomore	Science and Engineering
A6	Female	Freshman	Arts
A7	Female	Sophomore	Humanities and Social Sciences
A8	Female	Senior	Science and Engineering
A9	Female	Sophomore	Humanities and Social Sciences
A10	Male	Freshman	Science and Engineering

Based on the interview results, the factors mentioned by the respondents can be summarized into three main aspects:

(a) Research preparation: The accumulation of professional knowledge and skills by undergraduates.

(b) Research motivation: The goals and attitudes of undergraduates towards engaging in research work.

(c) Research communication: Interactions related to research activities with mentors or peers.

In addition to these three influencing factors, the state of general education also affects the cultivation of undergraduates' research quality. Du et al. (2016) posited that an emphasis on educational breadth can lead to the flattening of general education. Zhao et al. (2018) mentioned that research training is a new approach to cultivating undergraduates' innovative abilities. It leverages university teachers and research resources to engage students in research activities early, thereby fostering their innovation and research capabilities. Based on the above content, research organization and management were summarized as another factor in this study, which refers to the organization of undergraduate research activities and related policies by institutions such as governments and universities (Xu et al., 2022).

In summary, the factors influencing undergraduates' research quality can be categorized into four aspects: research preparation, research motivation, research communication, and research organization and management. The first three factors are internal, while the fourth factor is external and requires the joint efforts of schools, society, and the government to build a robust research organization and management system.

5.5 Recommendations for Enhancing Research Quality

In the context of the current digital transformation of education, it is particularly crucial to improve undergraduates' research quality. Based on the previous analysis, this study proposes a series of targeted recommendations aimed at comprehensively enhancing undergraduates' research quality through four dimensions: research preparation, research attitude, research communication, and research organization and management.

(a) Regarding research preparation, educational institutions are recommended to incorporate more practical components into the curriculum, such as experiments and projects. At the same time, teachers can organize online seminars to familiarize students with online learning platforms and improve their self-learning abilities. However, this may face challenges such as resource allocation and time scheduling, requiring the joint coordination of educational institutions and teachers to resolve.

(b) In cultivating research attitudes, teachers and schools should jointly set clear research goals, and stimulate students' interest in research through activities such as academic lectures and research competitions. Meanwhile, parents and peers could also help students establish a positive research attitude through encouragement and support.

(c) For research communication, educational institutions could set up online forums or social platforms to encourage students to actively communicate and share research experiences. At the same time, teachers should regularly conduct one-on-one guidance with students to provide professional research advice.

(d) In terms of research organization and management, educational institutions need to provide sufficient research resources, such as experimental equipment and research funds. Also, a research evaluation system should be established to evaluate students' research outcomes in a fair and impartial manner, encouraging more students to engage in research activities.

In summary, the implementation of the above strategies can effectively enhance the research quality of undergraduates. However, this requires the joint efforts and cooperation of educational institutions, teachers,

students, and parents. Undergraduates are expected to make continuous progress in their research journey through these comprehensive measures, laying a solid foundation for their future academic and career paths.

6. Conclusion and Outlook

This study, based on the unique context of the digital transformation of education, comprehensively analyzes and discusses the research quality of undergraduates in online teaching models. It reveals that multiple factors affect the research quality of undergraduates, including research preparation, research motivation, research communication, and research organization and management. Based on these findings, this study proposes a series of suggestions to improve their research quality, aiming to provide useful references and inspirations for undergraduate education and teaching reform and research quality cultivation. In summary, this study not only has important theoretical significance for understanding how to better cultivate students' research abilities in a digital teaching environment, but also provides important references for effective teaching reform and research quality cultivation in practice.

Although this study provides empirical analysis and improvement strategies for the research quality of undergraduates in online teaching models, it still has certain limitations. First, the scope of the study is limited to the Capital University of Economics and Trade, and the research results may not fully reflect the current status of undergraduates' research quality in online teaching models in all educational institutions. Future research could consider expanding the sample scope to include educational institutions of different types and regions to enhance the generality and applicability of the research results. Second, the data in this study are mainly based on students' self-reports, which may involve self-report bias. For example, when answering questions about research motivation and research communication, students may be influenced by social and personal expectations, resulting in subjectivity and deviation in their answers. Future research could consider adopting more objective measurement methods, such as teacher evaluations and peer evaluations, to improve the reliability and validity of the data. Lastly, the data in this study are cross-sectional, precluding the determination of causality. For example, while a positive correlation between research preparation and research quality was identified, it remains unclear whether research preparation enhances research quality or if high research quality encourages better preparation. Future research could adopt a longitudinal design or an experimental design to reveal causality.

Data Availability

The data used to support the research findings are available from the corresponding author upon.

Conflicts of Interest

The authors declare no conflict of interest.

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