Universal Journal of Educational Research 10(10): 553-569, 2022 http://www.hrpub.org
DOI: 10.13189/ujer.2022.101002

The Influence of Demographic Factors on the Ability to Research and Innovate among Primary and Secondary School Teachers

Guangming Wang[1], Dongli Zhang[2,*], Yueyuan Kang[1], Nan Zhang[1], Jingxian Shen[1], Fenglei Li[1]

[1]Faculty of Education, Tianjin Normal University, Tianjin, 300387, China
[2]Faculty of Mathematics and Statistics, Qinghai Normal University, Xining, 810008, China

Received August 30, 2022; Revised October 15, 2022; Accepted November 14, 2022

Cite This Paper in the Following Citation Styles

(a): *[1] Guangming Wang, Dongli Zhang, Yueyuan Kang, Nan Zhang, Jingxian Shen, Fenglei Li , "The Influence of Demographic Factors on the Ability to Research and Innovate among Primary and Secondary School Teachers," Universal Journal of Educational Research, Vol. 10, No. 10, pp. 553 - 569, 2022. DOI: 10.13189/ujer.2022.101002.*

(b): *Guangming Wang, Dongli Zhang, Yueyuan Kang, Nan Zhang, Jingxian Shen, Fenglei Li (2022). The Influence of Demographic Factors on the Ability to Research and Innovate among Primary and Secondary School Teachers. Universal Journal of Educational Research, 10(10), 553 - 569. DOI: 10.13189/ujer.2022.101002.*

Abstract This study mainly discusses the ability to research and innovate of primary and secondary school teachers in China. Stratified sampling was used to investigate 4,661 primary and secondary school teachers from 36 schools in a selected municipality directly under China's central government. The research team used a survey questionnaire with high reliability and validity to assess teachers' ability to research and innovate. With the demographic data of teachers, this paper analyzes the overall level and group differences of teachers' ability to research and innovate. Descriptive statistics, sample mean comparison T-test and one-way ANVOA were used to determine the factors that affect teachers' ability to research and innovate. The results show that Chinese primary and secondary school teachers have good ability to research and innovate, and the ability to teach and research is higher than that of the ability to innovate in education. Differences in teachers' educational background, history of formal teaching education and professional titles would cause significant difference on teachers' ability to research and innovate, but with a small effect size. There are significant differences in ability to research and innovate among teachers serving different school segments, with a size of effect between small and medium. Gender, age and years of teaching have no significant influence on teachers' ability to research and innovate.

Keywords Primary and Secondary School Teachers, Research and Innovation Ability, Teacher Professional Development

1. Introduction

The change of our times has put forward new requirements for teachers' core competencies. The rapid development of artificial intelligence, the change of means for knowledge dissemination, as well as other trends in our society, raise urgent needs for teachers to be equipped with the ability to research and innovate, to better adapt to social development needs, professional requirements and the progress of teaching as a profession. The Organization for Economic Cooperation and Development (OECD) also specifies the critical role of teaching innovation and professional development innovation [1]. Teachers' ability to research and innovate has been an important component of teachers' core competencies in the new era [2-4].

Teachers' ability to research and innovate emphasizes the ability to explore the natural patterns of education, solve teaching problems, innovate and optimize educational practices in the process of education and teaching [4,5]. It encourages teachers to continuously advance their performance and pursue excellence, thus making the regenerative force of teachers' professional development [6]. The key to improve teachers' ability to

research and innovate is to improve the ability to teach and research, and the ability to innovate in education. The former refers to teachers using educational theories to refine, analyze and solve teaching problems and natural patterns of teaching [1], serving as a pre-requisite for the ability to research and innovate [1]. The latter refers to teachings exploring new frontiers in the process of education and teaching, and the transformation and application of it to education and teaching practices [7], serving as a guarantee to the ability to research and innovate. In October 2020, the General Plan for Deepening the Reform of Educational Evaluation in the New Era, issued by the CPC Central Committee and the State Council required "by 2035, an educational evaluation system that meets the needs of our times, highlights Chinese characteristics, and reflects world leading capabilities shall be established preliminarily… it is important to reform the teachers evaluation mechanism…" [8]. However, at present, some teachers are still facing a big gap between their capabilities and the requirements of the new era, where their competencies and abilities need to be further improved. Where do teachers stand in terms of abilities? How to improve teachers' ability in a more targeted way? These questions cannot be answered without diagnostic evaluation research. International teachers' professional development paths also show that accurate teacher diagnosis is the cornerstone of high-quality development of teachers [9].

The level of teachers' ability to research and innovate is closely related to professional and scientific assessment. In order to cultivate highly-competent and innovative teachers, there is an urgent need to carry out accurate and scientific assessment on teachers' ability.

Teachers' ability to research and innovate and the ability to innovate in education complement each other. OECD has clearly pointed out that "educational research" is one of the six driving forces of "innovation", and that "engaging in educational research is a key element in the educational innovation ecosystem" [1]. Teachers mastering the methods, steps and pathways of educational research are able to engage in educational innovation activities in a more scientific and efficient way. Ability to teach and research is the basis of teachers' core ability to research and innovate. On the other hand, teachers are required to constantly update their professional knowledge and skills reserve with the ability to innovate in education, on the basis of researching of teaching. OECD proposes that an important part of innovation is to produce "significantly different" or "novel" content [10]. In the field of education, it is to discover new things, new patterns, new theories in the process of education and teaching, to ensure that educational activities are keeping pace with the times, and ensure their relevance.

At the same time, OECD (2018): Guidelines for Collecting, Reporting and Using Data on Innovation also pointed out that innovation ability is about transforming how new things are applied [11]. In the field of education, it is about further processing and transforming new things, new patterns and new theories in their application in education and teaching practices, to improve education quality. Ultimately, it will help to address the challenges faced by education in the new era, ensure the quality of educational and teaching activities, and make sure such activities comply with the natural pattern.

Regarding teachers' ability to educate and research, Caingcoy's research [12] shows that there has been more attention paid to teachers' ability to educate and research by international scholars. Many countries have institutionalized teachers' ability to educate and research and encouraged teachers to participate in the process, by supporting evidence-based practice, project development, etc. [1].

Chow et al. [13] believe that teacher research is a process, in which educators notice "problems" in their own school and classroom context, and propose the right methods to solve the problems. Educators also systematically observe and analyze the results based on their expertise, share them with others, and implement changes in their own classrooms [13]. Cai et al. [14] emphasize the importance of teachers' ability to educate and research, pointing out that attention should be paid to "How can we improve the impact of research on practice?" [11]. Teachers' research on education and teaching are not two completely independent activities. The purpose of research on education is not to increase the burden on teaching, but to enable teaching in a more effective way, so that teachers can guide students to achieve better development in a limited time [14].

With regard to teachers' ability to innovate in education, the studies of Kırışoğlu [15] and Artut [13] believe that everyone has the ability to innovate more or less. This creativity is congenital, as people have the ability to innovate and excellent intelligence from birth [16]. On the other hand, the ability to innovate can also be acquired through experience. Teachers can develop their ability to innovate through continuous reflection and training in teaching practice. Cropley [17] believes that teachers' ability to innovate in education is very important to cultivate students' innovation ability, and teachers can achieve this by carrying out more flexible, novel and appropriate teaching activities, e.g., keeping an open mind to creative ideas or behaviors, showing a human-centered approach when controlling students, flexible thinking and behaviors, and attaching importance to independent thinking [17-19].

Previous studies have shown that teachers' ability to educate and research and the level of innovation in teaching have a far-reaching impact on teachers' classroom teaching outcomes and the cultivation of students' innovative thinking. However, there are few studies on the assessment of teachers' ability to research and innovate and the behind-the-scene factors that affect this ability. In addition, there are few studies on the differences in teachers' ability to research and innovate based on

demographic factors. In order to better understand the current situation and existing problems of primary and secondary school teachers' ability to research and innovate, this research project aims to profile the pattern of practice in terms of ability to research and innovate among primary and secondary school teachers based on demographic factor analysis, in order to provide a reference for teachers to improve their ability to research and innovate.

This study aims to answer two research questions:

RQ1. What is the overall level of primary and secondary school teachers' ability to research and innovate in China?

RQ2. Do different background factors affect primary and secondary school teachers' ability to research and innovate? What is the degree of such influence?

2. Materials and Methods

2.1. Theoretical Framework

A double helix model of teachers' core literacy and capacity has been built by the research group "Research on Teachers' Core Literacy and Capacity-Building", which is the 2017 Key Tendering Project of the National Social Science Foundation of China for Pedagogy. And the group set a three-level indicator system framework of "Level I dimension, Level II indicators and key behavior performance". Based on their previous research and a reference to CCIT, The instrument of Core Competencies for Innovative Teaching of Zhu, C et al. the group constructed the measurement indicator system of teachers' research and innovation ability (see Figure 1), and the questionnaire includes 11 key behaviors (see Appendix A).

The assessment matrix of teachers' ability to research and innovate includes two Level II indicators: the ability to teach and research, and the ability to innovate in education, of which the former has three Level III observation points: the ability to identify teaching problems, ability to analyze teaching problems and the ability to solve teaching problems; the latter has 2 Level III observation points: the ability of educational innovative thinking, and the ability of educational innovation and transformation. The survey addresses 11 key behaviors (see Appendix A).

2.2. Participants

The municipality directly under the Central Government is one of the administrative divisions in China. The municipality directly under the Central Government has a clear geographical scope, with an important role to play in China's development of politics, economy, science, culture, transportation, etc. They are advantageous in many fronts, including a leading position in its strengths in economy, ecological environment, education and special education among China's major cities. To a certain extent, they can represent the faculty of China's regions with a higher level of teachers. In order to ensure a good representation of the sample, the stratified sampling method was used to survey 4903 teachers from 36 schools in a selected municipality directly under the central government (the Municipality). With reference to the educational statistics of the Municipality, the total number of general primary and secondary school teachers is about 104,126 by 2022. Using the sampling formula of limited population: $n \geq \frac{N}{(\frac{\alpha}{k})^2 \frac{N-1}{P(1-P)}+1}$ (N is the total number of samples, P is usually set to 0.5, α is 0.05 and k is the quantile of normal distribution), the sample number of primary and secondary school teachers shall not be less than 383. The questionnaires were collected through online data with consideration of the epidemic policy and response rate. After eliminating invalid questionnaires through lie-detector questions, we totally got 4,661 copies of the valid questionnaire with an effective rate of 95.06%. Among all participants in the study, the teachers in primary school, junior high school and senior high school were respectively 1969, 1520, 1116 in number (56 missing data) of them, 809 were men and 3794 were women (58 missing data). See Table 1 for other information about the samples.

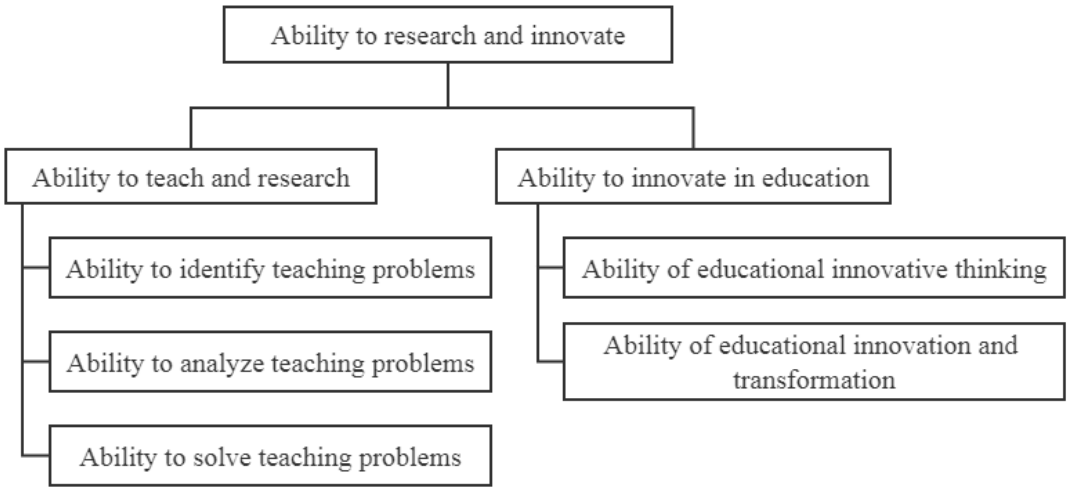


Figure 1. Structure of the indicator system for the measurement of teachers' research and innovation ability

Table 1. Demographic variables of the samples

Demographic variable	Description	Number of people	Percentage
Gender	Male	809	17.4%
	Female	3794	81.4%
	Missing	58	1.2%
Age	years	909	19.5%
	31-40 years	1385	29.7%
	41-50 years	1653	35.5%
	51+ years	691	14.8%
	Missing	23	0.5%
Years of teaching experience	1-10 years	1359	29.2%
	11-20 years	1225	26.3%
	21-30 years	1397	30.0%
	31+ years	643	13.8%
	Missing	37	0.7%
Teacher education background	None	440	9.4%
	Teacher education in some phases	905	19.4%
	Full process of teacher education	3216	69.0%
	Missing	100	2.2%
Educational level	Below bachelor's	201	4.3%
	Bachelor's	3612	77.5%
	Master's	788	16.9%
	Doctorate	28	0.6%
	Missing	32	0.7%
Professional titles	Unrated or junior grade	896	19.2%
	Medium grade	2433	52.2%
	Senior grade	1275	27.4%
	Professorate senior grade	34	0.7%
	Missing	23	0.5%

Table 1 Continued

School segments served	Primary	1969	42.2%
	Junior	1520	32.6%
	Senior	1116	23.9%
	Missing	56	1.3%

Note: Professional title refers to the grades granted based on the professional technical capability, ability and achievement of professional technical personnel, which serves as a symbol of the technical level and working ability of the professional technical personnel. There are four grades of professional titles in primary and secondary schools in general: professorate senior grade, senior grade, medium grade and junior grade. The evaluation criteria include teachers' moral character, ability, contribution, etc

2.3. Instrument

The questionnaire used in this study includes two parts. The first part aims to collect the teachers' demographic information, including gender, age, years of teaching experience, teacher education background, educational level, job title, and teaching period, with seven questions in total. The second part is the scale of teachers' research and innovation ability. The development and validation of the instrument had four phases.

Phase 1: Based on a literature review and extensive discussions with experts in the field of education and teacher education, we developed an instrument of teachers' research and innovation ability.

Phase 2: In order to check its content validity and consistency with the theoretical framework, consultations were conducted with 10 teachers and educational researchers. Based on their suggestions, some items were modified to be more theoretically sound and suitable for the real situation of teaching and learning in secondary school settings.

Phase 3: A pilot test with approximately 3007 people was conducted to check the understanding of the instrument by primary and secondary teachers. Small adjustments of language and wording were made based on the feedback and suggestions of these primary and secondary teachers.

Phase 4: The validation study was conducted to test the reliability and validity of the instrument.

The final version of the scale had 14 questions including two dimensions: ability to teach and research (including 3 sub-dimensions, i.e., the ability to identify/analyze/solve teaching questions)，with a total of 6 questions, and ability to innovate in education (including 2 sub-dimensions, i.e., ability of educational innovative thinking and ability of educational innovation and transformation), with a total of 8 questions. The questionnaire adopted the 4-point Likert scale (see Appendix B).

The Cronbach's α coefficients of the Level I dimension and Level II indicators of ability to research and innovate are 0.822, 0.786 and 0.690, respectively, indicating that the internal consistency of the dimension and indicators of ability to research and innovate is good, with a high reliability. In terms of validity, during the revision of the questionnaire, we consulted the opinions of scholars in the field of mathematics education and mathematics teachers to ensure the validity of the questionnaire content. Then, in the aspect of structural validity, the Spearman correlation analysis was carried out with SPSS26 for each dimension of the scale and its sub-dimensions.

It is found that the correlation coefficients between ability to teach and research and the total scale is 0.870, and the coefficient between the ability to innovate in education and the total scale is 0.923. The correlation coefficient between the two abilities is 0.621, indicating that the two dimensions are highly related to the total scale, with relative independency. The correlation analysis of the sub-scale are shown in tables 2 and 3, indicating that the scale has good structural validity. Finally, the structural validity was tested by AMOS21, and the fitting indexes basically reached the standard (see Table 4). The above analysis shows that the questionnaire has good reliability and validity.

2.4. Data Analysis

To answer research question 1, we made descriptive statistics on the score of each dimension and calculated the scoring rate to understand the current situation of teachers' research and innovation ability. The scoring rate refers to the percentage corresponding to the ratio of the obtained score divided by the full score (scoring rate = obtained score / full score for the dimension). A higher scoring rate indicates a higher level of the teacher in the dimension.

Table 2. Correlation analysis among Level I dimension and Level II indicators

	ability to teach and research	ability to innovate in education	ability to research and innovate (Level I)
ability to teach and research (Level II)	1		
ability to innovate in education (Level II)	0.621**	1	
ability to research and innovate (Level I)	0.870**	0.923**	1

Note: ** p<0.01 (two-tailed test)

Table 3. Correlation analysis among Level II indicators and Level III observation points

	Ability to teach and research (Level II)	Ability to identify teaching problems	Ability to analyze teaching problems	Ability to solve teaching problems
Ability to teach and research (Level II)	1			
Ability to identify teaching problems	0.854**	1		
Ability to analyze teaching problems	0.838**	0.566**	1	
Ability to solve teaching problems	0.849**	0.640**	0.558**	1
	Ability to innovate in education (Level II)	Ability of educational innovative thinking		Ability of educational innovation and transformation
ability to innovate in education (Level II)	1			
ability of educational innovative thinking	0.801**	1		
ability of educational innovation and transformation	0.919**	0.500**		1

Note: ** p<0.01 (two-tailed test)

Table 4. Fit Indices for Confirmatory Factor Analysis

χ2	Df	RMSEA	IFI	TLI	NFI	GFI	CFI
9727.055	10	0.083	0.986	0.965	0.985	0.989	0.986

Table 5. Descriptive statistical analysis of Level I dimension

	Mean (M)	*SD*	Skewness	Kurtosis	Full score	Scoring rate (S)
ability to teach and research	3.2778	0.5068	-0.411	-0.485	4	81.94%
ability to innovate in education	2.6147	0.5078	-0.237	-0.396	4	65.37%

To answer research question 2, T-test and one-way ANOVA were used to test the influence of eight factors (i.e., gender, age, years of teaching experience, teacher education background, educational level, job title, teaching period, and awards of teaching) on teachers' research and innovation ability, to explore the differences of levels among different teachers. Furthermore, the effect size was calculated to measure the difference. Specifically, η^2=0.01 (or d=0.2), η^2=0.06 (or d=0.5), and η^2=0.14 (or d=0.8) correspond to the effect size of small, medium, and large, respectively, which indicate small, medium, and large differences between different groups, respectively (Cohen, 1988).

3. Results

Descriptive statistical analysis was performed on the collected questionnaires in order to understand the overall situation of teachers' research and innovation ability. In general, the scoring rate for teachers' research and innovation ability was 72.47%,54.8% of the teachers have an average score on each question between 203 points, indicating teachers ability to research and innovate is good. The analysis of the Level I dimension (see Table 5) showed that the average score of teachers' ability to teach and research was 3.2778 with a scoring rate of 81.94%, which was higher than that of the ability to innovate in education (M=2.6147, S=65.37%), indicating that teachers' ability to teach and research is better than the ability to innovate in education.

3.1. Analysis of Level II Indicators for Research and Innovation Ability

As can be seen from the table, except for the ability of educational innovation and transformation, the average scores of teachers on other indicators are over 3 points, indicating that teachers perform well on most of the Level II indicators of their ability to research and innovate. The average score of the ability of educational innovation and transformation is 2.3496, with a scoring rate of 58.74%, a skewness higher than 0, or data skewed to the right, indicating that most of the sampled teachers have a relatively low score at the observation point of the ability of educational innovation and transformation. Teachers' weak ability for educational innovation and transformation is yet to be improved (upgraded).

Table 6. Descriptive statistics of Level II measurement indicators for research and innovation ability

	Mean (M)	*SD*	Skewness	Kurtosis	Full score	Scoring rate (S)
Ability to identify teaching problems	3.3502	0.5845	-0.633	-0.121	8	83.75%
Ability to analyze teaching problems	3.0495	0.6251	-0.277	-0.265	8	76.24%
Ability to solve teaching problems	3.4336	0.5969	-0.942	0.4910	8	85.84%
Ability of educational innovative thinking	3.0565	0.6173	-0.422	-0.276	12	76.41%
Ability of educational innovation and transformation	2.3496	0.5612	0.0260	-0.532	20	58.74%

Table 7. T-Test results about the research and innovation ability of teachers of different genders

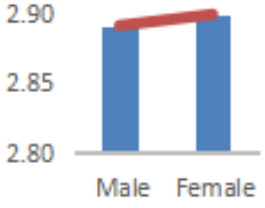
Gender	Mean	*t*	*p*	*d*	Bar Chart
A. Male	2.8916	-0.456	.649	.0134	
B. Female	2.8997				

Table 8. Variance analysis results about the research and innovation ability of teachers of different age groups

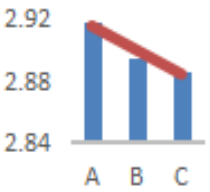
Years	Mean	F	*p*	η^2	Bar Chart
A.30- years	2.9174	1.976	0.115	0.001	
B.31- 50years	2.8948				
C.51+ years	2.8863				

Table 9. Variance analysis results about the research and innovation ability of teachers with different years of teaching experience

Years of teaching experience	Mean	*F*	*p*	η^2	Bar Chart
A. 1-10 years	2.9072	1.377	0.239	0.001	
B. 11-20 years	2.8927				
C. 21-30 years	2.8850				
D. 31+ years	2.9161				

It is worth noting that the mean score of teachers on ability to solve teaching problems is 3.4336, The ability to identify teaching problems 3.3502, the ability of educational innovative thinking 3.0565, the ability to identify teaching problems 3.0495, and the ability of educational innovation and transformation 2.3496. Their ability to identify and solve teaching problems has a mean score higher than that of all Level II indicators of ability to teach and research, while their ability to analyze teaching questions has a score lower than that of all Level II indicators of ability to teach and research. Specifically, teachers have a better ability to solve teaching problems, indicating that teachers are able to find flexible solutions, by using 4 or more methods, among changing teaching methods, developing students learning habits, addressing learning loopholes, providing learning resources, giving timely feedback and evaluation, home-school cooperation; On the other hand, the ability to analyze teaching problems and ability of educational innovation and transformation are weak, showing that teachers are unable to analyze the reasons behind teaching problems from the perspectives of pedagogy, psychology and subject-based teaching theory; unable to transform the problems in education and teaching practice into high-level achievements.

3.2. Analysis of the Influence of Demographic Factors (Demographic and Group Characteristics) on the Research and Innovative Ability of Teachers

3.2.1. Gender Influence of Teachers on Research and Innovative Ability

To verify whether there are significant differences in the ability to research and innovate between male and female teachers, an independent sample t-test was performed on the data. It is found that there is no statistically significant difference in the average score of ability to research and innovate between male and female teachers ($p>0.05$, $d=0.0134$). Based on assessment matrix of effect size, the result is of small effect, namely the difference of ability to research and innovate between male and female teachers is very small.

3.2.2. Analysis of the Differences between Teachers of Different Ages in Research and Innovation Ability

The variance test (see table 8) shows that there is no significant difference in the ability to research and innovate of teachers in different age groups ($F=1.976$, $p>0.05$, $\eta^2=0.001$), as different age groups score more or less the same. As for the level II indicators, there are significant differences in ability to teach and research ($p<0.05$, $\eta^2=0.002$) and ability to innovate in education ($p<0.05$, $\eta^2=0.002$), but with small sized effects, indicating that age has an effect on teachers' ability to research and innovate. Through multiple comparisons, it is found that teachers aged 31-50 score significantly lower than those aged 30 and under in terms of the ability to teach and research but score significantly higher than those aged 51 and above in terms of ability to innovate in education.

3.2.3. Analysis of the Differences between Teachers with Different Years of Teaching in Research and Innovation Ability

The results of one-way ANOVA showed that there was no significant difference in the research innovation ability of the teachers of the four teaching ages ($F=1.377$, $p > 0.05$), that is, the scores of teachers of different teaching ages were the same. The same is true of teachers' educational innovation ability, and there is no significant

difference among different teaching ages (F=1.412, p> 0.05). However, regarding the teaching and research ability of teachers, the average value of teachers with 31 years of teaching age and above is significantly higher than that of teachers with 11-20 years of teaching age (F= 3.783, p < 0.05).

Table 10. Variance analysis results about the research and innovation ability of teachers with different teacher education backgrounds

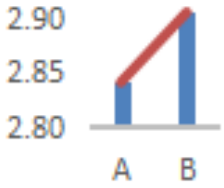
Teacher education background	Mean	*F*	*t*	*p*	*d*	Bar Chart
A. None	2.8405	.163	-2.804	.005	0.0831	
B. Those with complete formal teachers' education	2.9048					

Table 11. Variance analysis results about the research and innovation ability of teachers with different educational levels

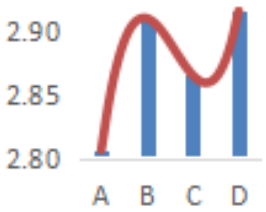
Educational level	Mean	*F*	*p*	Post-Hoc (LSD)	η^2	Bar Chart
A. Below bachelor's	2.8064	3.749	0.005	B>A B>C	0.003	
B. Bachelor's	2.9112					
C. Master's	2.8658					
D. Doctorate	2.9171					

Table 12. Variance analysis results about the research and innovation ability of teachers with different job titles

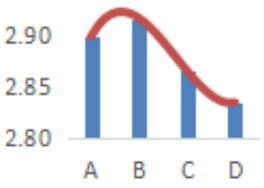
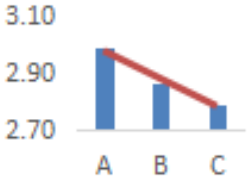
Job title	Mean	*F*	*p*	Post-Hoc (LSD)	η^2	Bar Chart
A. Unrated or junior grade	2.8980	3.660	.012	B>C	0.002	
B. Medium grade	2.9157					
C. Senior grade	2.8649					
D. Professorate senior grade	2.8340					

Table 13. Variance analysis results about the research and innovation ability of teachers with different teaching periods

Teaching period	Mean	F	*p*	Post-Hoc (Tamhane)	η^2	Bar Chart
A. Primary	2.9848	72.026	.000	A>B>C	0.030	
B. Junior	2.8648					
C. Senior	2.7908					

3.2.4. Analysis of the Differences between Teachers with Different Teacher Education Backgrounds in Research and Innovation Ability

The variance analysis showed (see Table 10) that there were significant differences between teachers with different teacher education backgrounds in research and innovation ability ($p<0.05$, $d=0.0831$), but the effect size was small, which suggested that the factor of teacher education background has an influence on teachers 'research and innovation ability, but the influence is not significant. Specifically, teachers without formal teaching education score significantly lower than those with the background.

3.2.5. Analysis of the Differences between Teachers with Different Educational Levels in Research and Innovation Ability

The variance test showed (see Table 11) that there were significant differences between teachers of different educational levels in the scores of research and innovation ability ($p<0.05$, $\eta^2=0.003$), and the effect size was small, which suggested that the factor of teacher education background has an influence on teachers 'research and innovation ability. Post-Hoc analysis on LSD reveals that the score of teachers with bachelor's degrees is significantly higher than that of teachers with junior college degrees and master's degrees, and teachers with junior college degrees and below rank the last. Teachers with doctorate degrees scores significantly higher than the other three groups.

3.2.6. Analysis of the Differences between Teachers with Different Job Titles in Research and Innovation Ability

The variance analysis found that there were significant differences between teachers with different job titles in the scores of research and innovation ability ($p<0.05$, $\eta^2=0.002$), but the effect size was small, which implied that job titles have an influence on teachers' research and innovation ability. Post-Hoc analysis on LSD reveals that the scores of senior professional teachers are significantly lower than those of unrated or junior-, intermediate- and senior-level teachers, while the scores of intermediate- and senior-level teachers are significantly lower than those of junior-level or unrated teachers.

3.2.7. Analysis of the Differences between Teachers with Different Teaching Periods in Research and Innovation Ability

The variance analysis showed (see Table 13) that there were significant differences between teachers with different teaching periods in the scores ($p<0.05$, $\eta^2=0.030$), but the effect size was between small and medium, which meant the factor of teaching period is a major factor that influences the differences between teachers in research and innovation ability. The specific differences are: the score of senior high school teachers is significantly lower than that of junior high school and primary school teachers, and the score of primary school teachers is significantly higher than that of secondary school teachers.

4. Discussion and Conclusions

According to the results of the analyses, the overall ability to research and innovate of Chinese primary and secondary school teachers (S=72.47%) is good. Teachers in general, perform well in the first-level dimension of the ability to teach and research (S=81.94%). As for the three Level II indicators, the average scores of "the ability to identify teaching problems", "the ability to analyze teaching problems" and "the ability to solve teaching problems" are all above points (out of 4). The scoring rates of the ability to identify teaching problem (S=83.75%) and the ability to solve teaching problems (S=85.84%) are higher than the overall scoring rate of the assessment. On the other hand, teachers are relatively weak in the ability to innovate in education (S= 65.37%), with a gap between the ability to teach and research, thus the ability to innovate in education is yet to be improved. Among the two Level-II indicators of the ability to innovate in education, the ability of educational innovative thinking (S=76.41%) is significantly higher than the ability of educational innovation and transformation (S=58.74%). The low score of the latter has affected the overall level of the ability to innovate in education. This shows that primary and secondary school teachers have a full understanding of teaching research and educational innovation; most teachers have grasped the methods of educational research and innovation, able to carry out continuous research. Primary and secondary school teachers have much space for improvement, in transforming innovation into academic papers or monographs. It is found that educational background, history of formal teaching education, school segment served, and professional titles are all important factors that affect teachers' ability to research and innovate. Below provides a full picture of the correlations.

4.1. Teachers with Doctorate Degrees Have the Best Ability to Research and Innovate, Especially the Ability of Educational Innovation and Transformation, while Teachers with Master's Degrees Have Lower Ability to Research and Innovate than Those with Bachelor's Degrees

The overall difference between teachers with different academic backgrounds in the ability to research and innovate is significant. Those with doctorate degrees score the highest (M=2.9171), followed by teachers with bachelor's degrees (M=2.9112), and teachers with master's degrees (M=2.8658). Teachers with junior college degrees

or below rank the last (M=2.8064). In terms of level II indicators, teachers with bachelor's degrees have the highest level of ability to teach and research ($F=9.757$, $p<0.05$, $\eta^2=0.008$), and those with doctorate degrees have the highest level of ability to innovate in education ($F=3.379$, $p<0.05$, $\eta^2=0.003$). They also score the highest in ability of educational innovation and transformation ($F=7.053$, $p<0.05$, $\eta^2=0.006$). The assessment shows that teachers with doctorate degrees show obvious advantages in the ability of educational innovation and transformation. This is highly consistent with the reality of education. However, teachers with master's degree score lower than that of teachers with bachelor's degree in ability to research and innovate, which is not consistent with the general perception that the higher the teacher's education, the higher their level of ability to research and innovate. The results show that teachers with bachelor's degrees are paying more attention to improving their ability to research and innovate [20]. The reasons may be as follows: 1) some teachers with master's degrees have professional backgrounds in arts, science, industries, agriculture and other disciplines, of which some have no formal teaching education; 2) teachers with higher academic qualifications upon graduation, after years of working in fields, are tired of teaching practice and educational research, which makes their own professional development in dilemma; 3) when pursuing a master's degree, some teachers might have limited experience in teaching practices, or fewer hours of field teaching. As a result, it is difficult for them to effectively transition from research on teaching theories, to research on teaching activities. The ability to research and innovate of teachers with master's degrees is not high, which is consistent with the existing research findings - teachers with master's degrees score lower than those with bachelor's degrees in the ability to teach and research

4.2. The Abilities of Teachers with Formal Teaching Education are Significantly Higher than Those without. The Deeper Such Education is, the Stronger the Ability to Research and Innovate is

Teachers with formal teaching education show better permanence compared with those without ($t=-2.804$, $p<0.05$, $d=0.0831$), in the level I dimension and level-II indicators of ability to research and innovate, indicating that formal teaching education is critical for the establishment and development of teachers ability to research and innovate. The assessment shows that the deeper the formal teaching education is, the higher the level of teachers' ability to research and innovate. At present, there has been a comprehensive and diversified normal education system in place in China. Education for teachers is geared towards high academic qualifications and better competencies, and to connect well with teachers continuous professional development, as a comprehensive system. In 2016, the Ministry of Education issued the Opinions on Strengthening the Educational Practice of Normal University Students, to enhance the innovation and practice of university students, and comprehensively improve the quality of teacher training [21]. In 2018, the CPC Central Committee and the State Council issued the Opinions on Comprehensively Deepening the Reform of the Teachers Team Building in the New Era to ensure the quality of teacher training [22]. The promulgation and implementation of relevant policies have raised the requirements for normal university students' in educational research and educational practice, and effectively enhanced teachers' ability to research and innovate. This also proves again that formal teachers education has an important role to play in the cultivation and development of teachers' ability to research and innovate.

4.3. The Ability to Research and Innovate of Primary School Teachers is the Best, Followed by Teachings Serving Junior High School Students. The Quality of Teachers in Compulsory Education Segment Schools is More Balanced, while the Level of Senior High School Teachers Varies A Lot

The results show that there are significant differences in the ability to research and innovate of teachers serving different school segments ($p<0.01$, $\eta^2<0.2$). Primary school teachers' ability to research and innovate is the highest (M=2.9848), junior high school teachers the second (M=2.8648), and senior high school teachers the last (M=2.7908). Junior and senior high school teachers both score lower than primary school teachers in the ability to teach and research ($p<0.01$, $\eta^2<0.2$) and the ability to innovate in education ($p<0.01$, $\eta^2<0.2$), the two level I dimensions. Primary school teachers have the highest average scores in all fronts. To analyze the phenomenon, it is found that in recent years, China has strengthened the construction of backbone teachers team in primary and secondary schools, as an effort to promote the balanced development of compulsory education. As a result, teacher resources become more balanced in distribution, and the ability to research and innovate of primary school teachers significantly improved.

Compared with junior and senior high school teachers, primary school teachers have fewer teaching tasks and less pressure of entrance exams, therefore they can afford more time on teaching research and educational innovation. This is consistent with the findings of previous studies [23]. The main reasons for this phenomenon are: 1) Secondary school teachers spend more time on teaching practice, leaving them with little energy for teaching research, thus failing to strike a balance between teaching and educational research. 2) Their knowledge or skills on educational and scientific research is lacking, resulting in few research outcomes.

4.4. The ability to Research and Innovate of Teachers with Higher-level Professional Titles does not Show Better Performances

Intermediate-level teachers score the highest (M=2.9157) in the ability to research and innovate, followed by those with no titles or junior-level teachers (M=2.8980). Senior-level teachers rank third (M=2.8649), while senior professional teachers score the lowest (M=2.8340). There were significant differences in the ability to research and innovate of teachers with different professional titles ($p<0.05$, $\eta^2<0.2$). In the Level I dimension, those with no titles or junior-level teachers score significantly higher than senior-level teachers in the ability to teach and research ($p<0.01$, $\eta^2<0.2$), but their ability to innovate in education is significantly lower than that of senior professional teachers. This phenomenon shows that teachers with senior professional titles fail to play an exemplary and leading role in their ability to teach and research, and unrated, junior- and intermediate-level teachers are better at education and teaching practices. This phenomenon reflects that there may be problems in the assessment and recruitment of professional titled teachers in secondary schools in China, that is, teachers awarded higher professional titles do not necessarily play a leading role in the ability to teach and research, but only show a lack of motivation [24]. There have been reports and researches exploring the challenges faced by primary and secondary teachers in professional title awarding and recruitment [25]. The core competencies of middle school teachers lie in their ability to research and innovate, making it necessary to link the assessment and recruitment criteria of teachers' professional titles with the level of teachers' ability to research and innovate alongside effective teaching. Secondary school teachers' professional title awarding shall give full play to teachers' ethics, ability, achievements and contribution [26].

In summary, Chinese primary and secondary school teachers have a good ability to research and innovate, and the ability to teach and research better than the ability to innovate in education; An in-depth look into the demographic differences on teachers' ability to research and innovate, found that there is no significant difference in ability to research and innovate among teachers of different genders, ages and years of teaching. There are significant differences in teachers' educational background, history of formal teachers education and professional titles in terms of the ability to research and innovate, but the degree of difference is small. The assessment found that the ability to research and innovate of teachers with doctorate degrees is the best; the level of ability to research and innovate among teachers with formal teachers education history is higher; in terms of professional titles, the ability to research and innovate of intermediate-level teachers is the best. There are significant differences in the ability to research and innovate among teachers serving different school segments, whereas primary school teachers rank first. This study constructs and implements assessment matrix of teachers' ability to research and innovate, which serves as a theoretical input for building assessment criteria for primary and secondary school teachers' ability to research and innovate. The findings of this research confirm the need to strengthen formal teachers educations in normal universities as the core curriculum. They can also be used to guide the training of primary and secondary school teachers, promote best practices and address gaps, to effectively promote the development of primary and secondary school teachers' ability to research and innovate in a more targeted way.

The main objective of this research is to explore the current situation of Chinese primary and secondary school teachers' ability to research and innovate and the factors that affect such ability. Efforts have been made to consider differences in geographic locations, school levels and other factors when sampling. However, due to the differences in teachers' professional levels in different regions of China, it is necessary to expand the sample size and use artificial intelligence to test the conclusions of this study based on big data. Furthermore, although China is building an open system for teachers and education, normal universities are still the main channel to train and educate teachers. 81% of on-duty primary and secondary school teachers graduate from normal universities, and the background of receiving formal teaching education provided by Chinese normal universities is an important and unique factor that differentiate Chinese teachers as a group, from teachers in the United States and other countries in terms of their educational backgrounds. Finally, this study is not reaching the granularity of specific subjects and disciplines, nor will it be able to reflect the characteristics of disciplines. This is an area in need of future research to better characterize.

Funding

This research was funded by the "Research on the Construction of Teachers Core Qualities and Abilities", project from the key project of the National Social Science Foundation of China, grant number AFA170008.

Acknowledgements

We are very grateful to experts for their appropriate and constructive suggestions to improve this framework. We thank the reviewers who helped us improve the manuscript.

Appendix A

Table 1. Teachers' research and innovation ability measurement indicators system and key behavior

	Level I dimension	Level II measurement indicators	Key behaviors
Teachers' research and innovation ability	Ability to teach and research	Ability to identify teaching problems	Teachers can use a variety of methods such as observation, listening, communication, survey, reflection, teaching experiment to identify teaching problems
			Teachers are often able to sort out and extract teaching problems, and raise questions on curriculum implementation, design of teaching plans, homework, exams for evaluation, etc
		Ability to analyze teaching problems	Teachers systematically master a variety of methods to analyze teaching problems, such as dissembling, key analysis, systematic analysis, empirical analysis, etc
			Teachers are often able to analyze the reasons behind teaching problems from the perspectives of pedagogy, psychology and subject-based teaching theory
		Ability to solve teaching problems	In view of different teaching problems, teachers can find flexible solutions, such as changing teaching methods, developing students learning habits, address learning loopholes, providing learning resources, giving timely feedback and evaluation, home-school cooperation, etc
			Teachers are following solutions to address teaching problems
	Ability to innovate in education	Ability of educational innovative thinking	Teachers can systematically master many types of innovative thinking, such as extrapolation, aggregation, critical thinking, intuition, etc
			Teachers can construct new strategies, new models, new methods or new viewpoints in education and teaching, and deliver milestones in innovative teaching
		Ability of educational innovation and transformation	Teachers can transform the problems encountered in education and teaching practice into academic papers, research projects, cases, examples, consultation advice and other outcomes
			Teachers can apply the educational and scientific research outcomes of theirs or others to the teaching reform
			Teachers can transform and apply educational technologies to heuristic, inquiring, experiential, discussion-based or participatory education and teaching activities

Appendix B

Survey on Teachers Ability to Research and Innovate

Dear teachers:

Hope this letter finds you well. The Research Team on Teachers' Core Literacies and Capacity Building of Tianjin Normal University has developed the survey on teachers' ability to research and innovate, aiming to accurately understand the current level of research and innovation abilities among primary and secondary school teachers in the selected municipality directly under the central government (the Municipality). This survey is only for the purpose of developmental evaluation, with nothing to do with reward performance. The information you provide will only be used for research, not for other purposes. If you could answer truthfully according to the actual situation, that wouldill be great. Thank you for your participation in advance.

I. Basic information

1. Gender: A. Male B. Female
2. Age: A. 30 or below B. 31～40 C. 41～50 D. 51 or older
3. Years of teaching: A. 10 years or shorter B. 11～20 years C. 21～30 years D. 31 years or longer
4. Highest degree: A. Junior college or lower B. Bachelor's degree C. Master's degree D. Doctorate degree
5. Do you have formal teachers education (with degrees related to primary and secondary education) in your education experience (in secondary vocational schools, junior colleges, undergraduate or graduate studies, etc.):
   A. None
   B. Some formal teachers education
   C. Complete formal teachers education
6. Professional titles: A. None or junior B. Intermediate C. Senior D. Professional senior
7. School segments: A. Primary school grades B. Junior high school grades C. Senior high school grades

II. Survey Questions

1. How many ways can you adopt to identify teaching problems, among observation, listening, communication, survey, reflection, teaching experiment?
   A. None
   B. 1-2 ways
   C. 3-4 ways
   D. 5 or more
2. After the teaching problems are identified, in raising questions on curriculum implementation, design of teaching plans, homework, exams for evaluation, which of the following best describes your actual situation?
   A. I barely raise teaching questions on top of the identified questions
   B. In most cases (for over 50% of questions identified), I will not further extract the specific teaching questions
   C. In most cases (for over 50% of questions identified), I will further extract the specific teaching questions
   D. I always (for over 80% of questions identified) further extract the specific teaching questions
3. How many of the following analytical methods you can you master to analyze teaching problems?
   - Empirical analysis
   - Dissembling
   - Key analysis
   - Systematic analysis
   - Perspective changing
   - Brainstorming
   - Analogue
   - Transference
   - 5W2H Analysis - Why, what, who, when, where, how, how much
   - Mind-mapping

   A. 0~2
   B. 3~5
   C. 6~8
   D. 9 or more
4. Which of the following best describes your situation in analyzing the reasons behind teaching problems from the perspectives of pedagogy, psychology and subject-based teaching theory?
   A. In the face of teaching problems, I barely make an effort to analyze the reasons behind them
   B. In most cases (for over 50% of teaching problem analysis) I won't try to explain it with theories
   C. In most cases (for over 50% of teaching problem analysis) I will use the theories that I've learnt to analyze it
   D. I'm always (for over 80% of teaching problem analysis) able to use the theories that I've learnt to analyze it
5. Which of the following best describes your situation in finding flexible solutions, such as changing teaching methods, developing students' learning habits, addressing learning loopholes, providing learning resources, giving timely feedback and evaluation, home-school cooperation for teaching problems?
   A. I don't know how to find solutions
   B. I will try to find a solution, but don't know where to start
   C. I will find solutions by 1-3 above-mentioned ways, but with limited scope of thinking

D. I can flexibly useing 4 or more above-mentioned ways to formulate solutions in theeh face of different teaching questions

6. In solving teaching questions, ( ) out of 10 I can follow solutions and implement the actions as needed
   A. None
   B. 1~4 times
   C. 5~7 times
   D. 8 times or more

7. How many of the following innovative thinking can you master to analyze teaching problems?
   - Aggregation
   - Critical thinking
   - Logical thinking
   - Intuitive thinking
   - Extrapolation
   - Remote association
   - Abstract thinking
   - Visualized thinking
   - Reversed thinking
   - Positive thinking

   A. 0~2
   B. 3~5
   C. 6~8
   D. 9 or above

8. Which of the following best describes your situation in constructing new strategies, new models, new methods or new viewpoints in education and teaching?
   A. I'm very focused on everyday teaching, barely able to identify new strategies, new models, new methods or new viewpoints different from my own practice
   B. I can identify new strategies, new models, new methods or new viewpoints in my everyday teaching practice, but have no chance to look in-depth about them
   C. Only only would I identify new strategies, new models, new methods or new viewpoints, I also research independently to learn more about them
   D. I can identify and learn in-depth about the new strategies, new models, new methods or new viewpoints, and I can share, discuss and communicate them to others

9. Which of the following best describes your contribution to your team's delivery of a unique and iconic educational innovation logo?
   A. I barely participate in the team's educational innovation (contribution less than 10%).
   B. I complete the assigned work as arranged by other team members (10%-40% contribution).
   C. I actively discuss with team members, provide important innovative ideas or thinking, actively participate in the team's teaching innovation practice, with important contribution (40%-70% contribution).
   D. I design the overall road map of educational innovation and organize the team to practice back and forth, as the core strength of the team and make an irreplaceable contribution (over 70% contribution).

10. In the past 5 years, which of the following best describes your situation in transforming questions from teaching practices into academic papers and communicating the outcomes (as independent or the first author)?
   A. I haven't finished my academic paper. Or I have an academic paper finished but not widely communicated.
   B. I've finished my academic paper, but only published it on self-media such as blog.
   C. I've finished my academic paper, and have won awards or presented it in education society conferences at or above the provincial (municipality or autonomous region) level. However, it was not published on periodicals with formal serial numbers.
   D. I've finished my academic paper, and have published it on periodicals with formal serial numbers.

11. In the past 5 years, which of the following best describes your situation in transforming problems in teaching practices into research projects (as leader/manager or top 3 contributors)? Please think of the project that reached the highest level.
   A. School level or below (including no research project)
   B. District level, education bureau or teaching&research department endorsed projects
   C. Municipal level or higher, education society endorsed projects
   D. National level projects

12. In the past 5 years, which of the following best describes your situation in transforming problems in teaching practices into consultation advice (referring to providing consultation and advisory for government at different levels)? Please think of the project that reached the highest level.
   A. None
   B. Advice approved by authorities below ministerial and provincial-level (not including ministerial and provincial-level), or adopted as internal reference for authorities below ministerial and provincial-level (not including ministerial and provincial-level)
   C. Advice approved by authorities at the ministerial and provincial-level, or adopted as internal

reference for authorities at the ministerial and provincial-level

D. Advice approved by authorities at the national level, or adopted as internal reference for authorities at the national level such as the Central Committee of the Communist Party of China, or the State Council

13. How many of the following describe your experience in applying the educational and scientific research outcomes of yours or others to teaching practices?
    - I can accurately understand the national curriculum plan and standards, and implement them well.
    - I carry out research on local curriculum and school-based curriculum development, to enrich the school curriculum system and meet the diversified development needs of students.
    - I conduct comprehensive and practical teaching researches
    - I conduct research on homework design, innovate on different forms of homework, and improve the level of homework design.
    - I conduct research on the reform of exam-based assessment, improve the quality of question setting in exams, and promote the establishment of a scientific assessment system guided by competency-based education.

    A. 0~1 item
    B. 2 items
    C. 3 items
    D. 4 items or more

14. Which of the following best describes your situation in transforming and applying educational technologies to heuristic, inquiring, experiential, discussion-based or participatory education and teaching activities?
    A. I don't use ed-tech
    B. I know the basic functions of ed-tech, and can operate them with the guidance from ed-tech books, internet resources or other helpers
    C. I can operate ed-tech proficiently, without the help of ed-tech books, internet resources or other helpers. I can apply ed-tech to 1-2 types of teaching activities mentioned above
    D. I can flexibly operate ed-tech, integrate it with 3 or more types of teaching activities mentioned above, and share experience with others

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