

A Guideline to the 21st Century Core Competencies Development of Mathematics Teachers in Higher Vocational Colleges in Sichuan

Hu Yanyan¹, Nuttamon Puchatree^{*2}, Wichian Irtarasompun³

¹*Educational Management and Learning Management Innovation Program, Bansomdejchaopraya Rajabhat University, Thailand*

²*Graduate School, Bansomdejchaopraya Rajabhat University, Thailand*

³*Faculty of Education, Bansomdejchaopraya Rajabhat University, Thailand*
**Correspondence Author*

Abstract: The objectives of this study are to 1) study the current situation of the 21st century core competencies for mathematics teachers in higher vocational colleges in Sichuan. 2) propose a guideline for the development of the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan. This study selected a sample group of 283 mathematics teachers from higher vocational colleges in Chengdu, through random sampling. And conducted interviews with 5 education administrators from the above colleges. The main research instruments were questionnaires and structured interviews. Data statistics covers various statistical measures such as percentages, means, and standard deviations. The research results found that: 1. The state of the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan was at a high level. 2) . Analyze the current status of the 21st-century core competencies for mathematics teachers based on the following five dimensions: 1) civil literacy 2) social literacy 3) communication literacy 4) network literacy 5) teamwork literacy 6) STEM literacy. This study proposes guidelines for the 21st-century core competencies for mathematics teachers.

Keywords: mathematics teacher, 21st century core competencies, vocational colleges.

1. Introduction

"Core competency", as a new concept reflecting the social changes and talent quality requirements of the 21st century, has become an important topic of widespread concern and in-depth exploration by international organizations and governments in education reform and development (Ding Liping, 2021). In 2016, the Chinese Core Competence Framework for Student Development was officially released. This framework not only puts forward new requirements for talent quality but also poses new challenges to the professional quality of teachers (Chen Gang Liansheng, 2016). With the continuous deepening of curriculum reform in China, core literacy education continues to take root and develop rapidly. In 2016, China entered an era of "ability-based" education, with classroom teaching shifting from "knowledge-based" to "ability-based" (Dong Bolin, 2017). In 2018, the Ministry of Education issued and implemented the "2017 Edition of Mathematics Curriculum Standards for Ordinary High Schools", which summarized and proposed the core competencies of mathematics (Huang Rongjin & Cao Yiming, 2021). The change in talent cultivation standards will inevitably lead to the restructuring of the quality structure of teachers. To adapt to the changes in the education industry in the new era, various international organizations and countries have begun to issue a series of educational guidelines, pointing to the formation of core competencies of teachers in the 21st century, gradually transforming teacher education from knowledge to the three dimensions of teachers, namely the improvement of skills and emotions, to the cultivation of core competencies of teachers, and establishing corresponding models or frameworks for teacher core competencies (Li Muhui & Xu Binyan, 2021). This has brought new directional guidance to teacher education in the field of mathematics education. Clarifying the requirements of high-quality mathematics learning for the professional quality of mathematics teachers has become the primary issue in mathematics teacher education and professional development; Defining the connotation of core competencies of mathematics teachers has become a focus of attention in the field of professional development; Clarifying the structure of core competencies of mathematics teachers has become a key indicator and important benchmark for measuring their professional level (Wang Haixia & Tang Zhisong, 2020).

How should teachers in the new era respond to the new changes in education and teaching? How to adapt to the current development and reform of teaching? What are the specific and feasible ways for teacher professional development? These issues are inevitable in the professional development of teachers. Only by answering these questions can the professional development of teachers be achieved with high quality and speed. This study analyzes the current situation, existing problems, and reasons for the 21st-century core

competencies of mathematics teachers in higher vocational colleges in Sichuan. Based on the theories of teacher professional development and teacher role, it finally proposes directions to enhance the 21st-century core competencies of mathematics teachers in higher vocational colleges in Sichuan.

2. Literature Review

2.1 Core Competencies of 21st Century Teachers

In 2015, commissioned by the World Education Innovation Summit (WISE), the China Institute of Education Innovation (CIEI) at Beijing Normal University conducted a comprehensive review of the global experience in implementing core competencies for the 21st century. The research institute has released a research report titled "Towards the Future: Global Experience in 21st Century Core Competence Education", which includes 18 competency dimensions. In 2017, the China Education Innovation Research Institute of Beijing Normal University, together with the 21st Century Learning Partners Organization (P21) of the United States and the China 21st Century Talent Standards Alliance (CP21), jointly launched international cooperation to conduct in-depth research on 21st century core literacy education. As part of this work, the research institute has completed the "21st Century Core Competence 5C Model Research Report". The report proposes the "21st Century Core Competence 5C Model", which includes five aspects: cultural competence, critical thinking, creativity, communication, and collaboration, abbreviated as 5C competence. These abilities constitute the 5C model framework for core competencies.

Sanguoyuan et al. (2017) combined the background of the 21st century and based on the Ministry of Education's "Opinions on Comprehensively Deepening Curriculum Reform and Implementing the Fundamental Task of Moral Education" and "Core Literacy of Chinese Students", published this book "Core Literacy of 21st Century Teachers". This book summarizes the basic framework of teacher core competencies, including three types and eight abilities: moral and conceptual literacy, including ethical literacy and educational conceptual literacy; Knowledge and ability literacy, including knowledge literacy and educational and teaching ability literacy; Comprehensive literacy, including humanistic literacy, information literacy, research literacy, and self-development literacy.

With the development of the times, the significance of enhancing the core abilities of teachers lies in helping students learn and master comprehensive skills. Teachers in the 21st century need to combine education with technology (Chen Gang & Pi Liansheng, 2016). In today's era, students need to master new skills to meet the new needs of society, which also requires teachers of the new era to do so. To better fulfill their responsibilities, teachers must constantly learn and improve their qualities and skills (Chen Liujuan & Lin Qinglan, 2017).

Zhang Xiayu and Yu Ping (2018) believe that teacher core literacy is based on the development of student core literacy, meeting the necessary qualities and key abilities required for education, teaching, and student development. Zhang Ziping (2016) proposed that the characteristics of core literacy have shifted from "knowledge-centered" to "ability-centered", and from "teacher-centered" to "student-centered". Wang Houxiong and Li Meng (2020) proposed a four-dimensional structure of teacher information literacy in their survey of primary school mathematics teachers, including their information awareness, knowledge, abilities, and moral qualities. Zhao Yuanke (2017) and others believe that the abilities required for modern mathematics teachers can be divided into four dimensions: basic abilities, mathematical abilities, mathematical teaching abilities, and expansion abilities. The basic ability dimensions include cognitive ability, language expression ability, interpersonal communication ability, information literacy, and lifelong learning ability; The dimension of expansion ability includes research ability and creative ability. Lu Min et al. (2023) conducted a study on the 21st-century skills of primary school teachers in Guilin, China, and proposed that the skills of primary school teachers in the 21st century include 1) Communication skills 2) Creativity and innovation 3) Information literacy 4) Collaboration 5) Critical thinking 6) Leadership skills.

2.2 Research on the Core Competencies of Mathematics Teachers in Vocational Colleges

Scholars have researched the current status of core competencies of mathematics teachers in vocational colleges and pointed out the existing problems.

Cao Peiyong (2006) surveyed the professional development status and self-development needs of 120 mathematics teachers from more than ten vocational colleges in Jiangsu Province using questionnaire surveys and classroom observations. The survey questionnaire is modified based on existing teacher survey research and divided into four dimensions: teacher's educational beliefs, professional knowledge, mathematics education ability, and professional attitude. Research has found that teachers have a narrow knowledge base, insufficient supplementation of new knowledge, and a low sense of professional identity.

Li Muhui and Xu Binyan (2021) surveyed the professional development status of mathematics teachers in vocational colleges in Yunnan Province and found that the main problems faced by mathematics teachers in

vocational colleges in Yunnan Province are inadequate education levels, insufficient professional motivation, lack of achievement among most teachers, lack of basic knowledge to serve the profession, insufficient ability to apply modern educational technology and mathematics, especially the lack of mathematical modeling ability, and the need to strengthen educational research ability.

Zhang Xiayu et al (2018) proposed that mathematics teachers in vocational colleges are aware of the new requirements of vocational education at the current stage, but they cannot achieve this requirement solely on their own. External guidance and support are needed to promote their career development.

In summary, from the current research perspective, the development of core competencies of mathematics teachers in vocational colleges is uneven and requires greater efforts to improve.

2.3 Core Competencies of Vocational Colleges Mathematics Teachers Improving Strategies

Researchers have conducted multidimensional, multi-level, and multi-perspective discussions on the core elements of mathematics teachers.

Jiang Yu. (2016) believed that the core literacy of teachers is the integration of basic literacy and contemporary literacy. Basic literacy transcends temporality, has relative stability, and does not change with the changing times; Era literacy refers to the literacy that adapts to the changes of the times. In the new era of the 21st century, it manifests as lifelong learning ability, information literacy, research ability, etc. Wang Haiqing and Cao Guangfu (2022) divided the professional competence required for expert mathematics teachers into three dimensions: knowledge, ability, and emotional attitude. Zhang Yuhuan and Wu Jiahui (2022) believe that the core competency structure of mathematics teachers includes three elements and six indicators, including moral and ideological literacy (moral literacy, ideological literacy); Comprehensive knowledge and ability literacy (comprehensive mathematical knowledge, comprehensive mathematical ability); Comprehensive literacy (social literacy, aesthetic literacy).

In modern education, new media is an indispensable teaching tool and an important teaching method. The deepening influence of new media thinking, especially the increasing influence of self-media social platforms on student groups, has put forward new requirements for the skills that teachers need to master and their teaching literacy. Guo Jian and Cao Yiming (2021) summarized the development process of the concept of "media literacy" in the West. The term "media education" in the article is equivalent to today's "new media literacy education"

Communication is also a psychological and social process of conveying ideas, emotions, and values. On the one hand, it is influenced by factors such as the personality, ability, motivation, and emotions of the communicator, and on the other hand, it is also influenced by the social and cultural environment and background in which the communicator operates. Regarding collaborative literacy, the 21st-century Core Literacy 5C model provides the following explanation: Collaboration is the process in which individuals actively assume internal responsibilities based on their recognition of the shared vision of a team or organization. It refers to team members actively cooperating and coordinating with others or groups through equal consultation based on mutual respect and mutual benefit, to achieve common goals. Gu Jingsi et al (2023) proposed through field investigations that communication skills and teamwork are necessary conditions for promoting distinctive development.

Civic literacy refers to the basic qualities that a good citizen possesses and is a requirement of modern society for the subject. This kind of literacy focuses more on the cognition and behavior obtained through postpartum environmental education (Zheng Yuxin, 2022). It emphasizes the cognitive and behavioral influences formed by acquired education and environmental influences. STEM stands for science, technology, engineering, and mathematics, representing a comprehensive educational method (Wang Haixia & Tang Zhisong, 2020). STEM literacy is concentrated in four aspects: scientific literacy, technical literacy, engineering literacy, and mathematical literacy (Zhang Ziping, 2016). Zhu Ningbo et al (2018) analyzed the main practices of international STEM education in the context of STEM education in the United States and suggested that China should learn from the successful experiences of other countries and follow a path of STEM education with Chinese characteristics.

In summary, it can be seen from the research literature of domestic and foreign scholars on the core competencies of 21st-century mathematics that they attach great importance to the connotation and extension of the constituent elements of core competencies, and emphasize the factors that affect the composition of core competencies.

3. Methodology

3.1 The Population and the Sample Group

The Population

The population includes 478 mathematics teachers in 29 vocational colleges in Chengdu.

The Sample Group

The sample group includes 283 mathematics teachers and 5 education administrators from vocational colleges in Chengdu.

3.2 Research Instruments

Questionnaire

The questionnaire consists of two parts:

Part One, Personal Information. Including gender, age, working hours, educational background, etc. The second part is the current situation investigation. The questionnaire was divided into 7 dimensions, with a total of 70 questions. Questionnaire options were based on a Likert scale, and answers were divided into five types: strongly agree, agree, don't know, disagree, and strongly disagree, with scores of 5, 4, 3, 2, and 1 respectively.

Interview

The interview consists of two parts:

Part One, Background Information. Part two consists of 10 open-ended interview questions, aiming to collect participants' opinions on proposing a guideline for the development of the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan.

3.3 Data Collection

The researcher distributed questionnaires to the sample group and 283 pieces of data were collected within the specified time. The researcher conducted an online interview with the 5 interviewees. With the consent of the interviewee, video, and audio recordings were made of the entire interview process. The researcher collected a predetermined number of questionnaires, checked the accuracy and completeness, and analyzed the collected data.

3.4 Data Analysis

The researcher checked the accuracy and completeness of the questionnaire and selected effective questionnaires for data analysis. By analyzing the frequency, percentage, mean value, and S.D. of the data, the researcher further understands the current situation and summarizes the pros and cons of the existing problems. At the same time, proposed guidelines for improving the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan.

4. Results of Analysis

The researcher distributed a total of 283 questionnaires and received 283 questionnaires, with a recovery rate of 100%, meeting the requirement of the data collection.

4.1 Analysis of general information of respondents

The overall data analysis results of the interviewed teachers include gender, age, years of working, and education level. In this study, the researcher conducted data analysis by using frequency distribution and percentages, as shown in Table 4.1.

Table 4.1 General information of the response

(n=283)

Items	Category	Frequency	Percentage
Gender	Male	114	40.34
	Female	169	59.66
	Total	283	100
Age	Less than 30 years old	99	34.98
	31-40 years old	126	44.52
	41-50 years old	51	18.03
	51- 60 years old	7	2.47
	Total	283	100
Years of Working	1-5 years	77	27.22
	6-10 years	106	37.46
	11-15 years	55	19.43
	16-20 years	26	9.18

	More than 20 years	19	6.71
	Total	283	100
Education	College Degree	35	12.32
	Bachelor's s Degree	131	46.21
	Master's Degree	108	38.16
	Dr's Degree	9	3.31
	Total	283	100

According to Table 4.1, among the respondents, there were 169 women, accounting for 59.66%, and 114 men, accounting for 40.34%. Among the respondents, 99 were under 30 years old, accounting for 34.98%, 126 were between 31 and 40 years old, accounting for 44.52%, 51 were between 41 and 50 years old, accounting for 18.03%, and 7 were between 51 and 60 years old, accounting for 2.47%. Among the respondents, 77 people worked for 1-5 years, accounting for 27.22%, 106 people worked for 6-10 years, accounting for 37.46%, 55 people worked for 11-15 years, accounting for 19.43%, 26 people worked for 16-20 years, accounting for 9.18%, and 19 people worked for more than 20 years, accounting for 6.71%. Among the respondents, 35 had a college degree, accounting for 12.32%, 131 had a bachelor's degree, accounting for 46.21%, 108 had a master's degree, accounting for 38.16%, and 9 had a doctoral degree, accounting for 3.31%.

4.2 Results of Questionnaire Data Analysis

The vocational college mathematics teachers who participated in the survey were analyzed from 7 aspects: 1. Media literacy, 2. Network literacy, 3. Teamwork Literacy, 4. Communication literacy, 5. STEM Literacy, 6.Civic literacy,7.Social literacy. The researcher used the mean and standard deviation for the analysis, and the detailed analysis results are shown in Table 4.2-4.9.

Table 4.2 Statistical table for each variable

No.	Dimension	M	S.D.	Level	Rank
1	Media literacy	3.65	0.82	high	6
2	Communication literacy	3.85	0.84	high	3
3	Teamwork literacy	3.72	0.84	high	5
4	Social literacy	3.86	0.85	high	2
5	Network literacy	3.83	0.86	high	4
6	STEM literacy	3.62	0.85	high	7
7	Civic literacy	3.87	0.86	high	1
	Total	3.77	0.85	high	

(n=283)

According to Table 4.2, the study found that the 21st-century teacher core competency questionnaire for mathematics teachers in Sichuan vocational colleges is at a high level (M=3.77, S.D.=0.85). Among them, Civil literacy has the highest level (M=3.87, S.D.=0.86), followed by Social literacy (M=3.86, S.D.=0.85), and Communication literacy (M=3.85, S.D.=0.84), respectively. And the side with the lowest level mean value is STEM literacy (M=3.62, S.D.=0.85).

Table 4.3 Questions classified by variables: Media Literacy

No.	Items	M	S.D.	Level	Rank
1.1	Teachers can discern whether the information in media reports is true and reliable.	3.75	0.86	High	3
1.2	Teachers can evaluate the biases and perspectives in media reports.	3.55	0.78	High	7
1.3	Teachers can properly utilize different media platforms to gather information.	3.51	0.72	High	8
1.4	Teachers can use media resources to address teaching and research issues.	3.61	0.84	High	5
1.5	Teachers I can utilize media tools to create teaching materials.	3.44	0.81	High	9
1.6	Teachers understand the impact of digital media on education.	3.41	0.76	High	10

(n=283)

1.7	Teachers can guide students in correctly using online media to obtain information.	3.57	0.86	High	6
1.8	Teachers can assess students' skills and literacy in media usage.	3.64	0.88	High	4
1.9	Teachers pay attention to the influence and coverage of the media on mathematics education	4.00	0.82	High	1
1.10	Teachers are willing to participate in media education activities and projects.	3.98	0.85	High	2
Total		3.65	0.82	High	

According to Table 4.3, the study found that media literacy was at a high level (M=3.65, S.D.=0.82). Among them, the level " Teachers can pay attention to the influence and coverage of the media on mathematics education" has the highest level (M=4.00, S.D.=0.82).", followed by "Teachers are willing to participate in media education activities and projects"(M=3.98, S.D.=0.85) and " Teachers can discern which information in media reports is true and reliable" (M=3.75, S.D.=0.86),respectively. The side with the lowest level mean value was " Teachers can understand the impact of digital media on education" (M=3.41, S.D.=0.76).

Table 4.4 Questions classified by variables: Network Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
2.1	Teachers can safely use online resources for teaching and learning.	3.84	0.88	High	6
2.2	Teachers can assess students' awareness of risks in online security.	3.86	0.85	High	5
2.3	Teachers can guide students in correctly using internet search engines to gather information.	3.74	0.83	High	8
2.4	Teachers understand the applications of Internet technology in education.	3.89	0.84	High	3
2.5	Teachers can utilize Internet tools for sharing and exchanging teaching resources.	3.81	0.86	High	7
2.6	Teachers can conduct teaching assessments and feedback through online platforms.	3.73	0.83	High	9
2.7	Teachers understand the impact of social media platforms on students' learning behaviors.	3.91	0.86	High	2
2.8	Teachers can guide students in developing good habits for internet usage.	3.88	0.88	High	4
2.9	Teachers, I keep track of the latest developments and research in internet literacy education.	3.92	0.86	High	1
2.10	Teachers can address teaching challenges and issues in the online environment.	3.68	0.87	High	10
Total		3.83	0.86	High	

According to Table 4.4, the study found that network literacy was at a high level (M=3.83, S.D.=0.86). Among them, "Teachers can keep track of the latest developments and research in internet literacy education" has the highest level (M=3.92, S.D.=0.86), followed by " Teachers can understand the impact of social media platforms on students' learning behaviors" (M=3.91, S.D.=0.86), and " Teachers can understand the applications of internet technology in education" "(M=3.89, S.D.=0.84)", respectively. The side with the lowest level mean value was "Teachers can address teaching challenges and issues in the online environment" (M=3.68, S.D.=0.87).

Table 4.5 Questions classified by variables: Teamwork Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
3.1	Teachers can effectively organize and lead a mathematics teaching team.	3.64	0.82	High	7
3.2	Teachers can coordinate with team members to collaborate and complete teaching tasks.	3.76	0.80	High	6

3.3	Teachers can understand the different viewpoints and needs of team members.	3.78	0.83	High	5
3.4	Teachers can engage in effective team communication and negotiation.	3.81	0.81	High	3
3.5	Teachers can motivate and support team members' learning and development.	3.81	0.90	High	2
3.6	Teachers can manage team conflicts and find solutions.	3.61	0.87	High	9
3.7	Teachers can assess the effectiveness and outcomes of team collaboration.	3.52	0.82	High	10
3.8	Teachers can help team members leverage their strengths.	3.80	0.85	High	4
3.9	Teachers can provide the necessary resources and support for the team.	3.63	0.86	High	8
3.10	Teachers can continually improve team cooperation and collaboration skills.	3.88	0.81	High	1
Total		3.72	0.84	High	

According to Table 4.5, the study found that teamwork literacy was at a high level ($M=3.72$, $S.D.=0.84$). Among them, "Teachers can continuously improve team cooperation and collaboration skills" has the highest level ($M=3.88$, $S.D.=0.84$), followed by " Teachers can motivate and support team members' learning and development" ($M=3.81$, $S.D.=0.90$), and "Teachers can engage in effective team communication and negotiation" ($M=3.81$, $S.D.=0.81$), the third is " Teachers can help team members leverage their strengths " ($M=3.80$, $S.D.=0.85$), respectively. The side with the lowest level mean value was "Teachers can assess the effectiveness and outcomes of team collaboration." ($M=3.52$, $S.D.=0.82$).

Table 4.6 Questions classified by variables: Communication Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
4.1	Teachers can express mathematical concepts and ideas clearly and effectively.	3.86	0.86	High	4
4.2	Teachers can listen to others' viewpoints and understand and respond to them.	3.82	0.80	High	9
4.3	Teachers can use different communication methods and tools for teaching and communication.	3.70	0.84	High	10
4.4	Teachers can adapt to the communication needs and levels of different audiences.	3.86	0.85	High	4
4.5	Teachers can address communication barriers and issues in teaching.	3.88	0.86	High	3
4.6	Teachers can establish good communication relationships with students.	3.92	0.85	High	1
4.7	Teachers can utilize communication skills to enhance teaching effectiveness and student engagement.	3.83	0.81	High	8
4.8	Teachers can communicate and collaborate effectively within a team.	3.85	0.85	High	7
4.9	Teachers can express my views and opinions in professional exchanges.	3.91	0.80	High	2
4.10	Teachers can utilize both verbal and nonverbal communication skills to improve teaching quality.	3.86	0.87	High	4
Total		3.85	0.84	High	

According to Table 4.6, the study found that communication literacy was at a high level ($M=3.85$, $S.D.=0.84$). Among them, " Teachers can establish good communication relationships with students" " has the highest level ($M=3.92$, $S.D.=0.85$), followed by " Teachers can express my views and opinions in professional exchanges" ($M=3.91$, $S.D.=0.80$) and " Teachers can address communication barriers and issues in teaching" ($M=3.88$, $S.D.=0.86$), respectively. The side with the lowest level mean value was " Teachers can use different communication methods and tools for teaching and communication" ($M=3.70$, $S.D.=0.84$).

Table 4.7 Questions classified by variables: STEM Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
5.1	Teachers can integrate STEM concepts into mathematics teaching.	3.52	0.86	High	8
5.2	Teachers can design, and conduct mathematics teaching activities related to STEM.	3.45	0.83	High	10
5.3	Teachers understand the importance of STEM education for students' comprehensive literacy.	3.81	0.88	High	1
5.4	Teachers can guide students in conducting STEM project research and practice.	3.63	0.85	High	5
5.5	Teachers can promote the interdisciplinary integration of mathematics with other STEM subjects.	3.56	0.81	High	6
5.6	Teachers can assess students' learning and development in the STEM field.	3.70	0.82	High	4
5.7	Teachers are attentive to the latest concepts and practices in STEM education.	3.80	0.85	High	2
5.8	Teachers can collaborate with teachers from other disciplines to conduct interdisciplinary STEM projects.	3.55	0.89	High	7
5.9	Teachers can utilize STEM resources and tools to support mathematics teaching.	3.51	0.85	High	9
5.10	Teachers am willing to continuously improve my STEM education abilities and level.	3.71	0.88	High	3
	Total	3.62	0.85	High	

According to Table 4.7, the study found that STEM literacy was at a high level (M=3.62, S.D.=0.85). Among them, " Teachers can understand the importance of STEM education for students' comprehensive literacy" has the highest level" (M=3.81, S.D.=0.88), followed by " Teachers can be attentive to the latest concepts and practices in STEM education" (M=3.80, S.D.=0.85) and " Teachers are willing to continuously improve my STEM education abilities and levels" (M=3.71, S.D.=0.88), respectively. And the side with the lowest level mean value was "Teachers can design, and conduct mathematics teaching activities related to STEM" (M=3.45, S.D.=0.83).

Table 4.8 Questions classified by variables: Civic Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
6.1	Teachers can guide students to establish correct civic awareness and values.	3.92	0.88	High	1
6.2	Teachers can promote students' awareness of social responsibility and behavior.	3.85	0.83	High	8
6.3	Teachers can guide students to actively participate in social welfare activities.	3.90	0.88	High	2
6.4	Teachers can encourage students to pay attention to social issues and propose solutions.	3.88	0.85	High	4
6.5	Teachers can guide students to understand and respect different cultures and perspectives.	3.87	0.81	High	6
6.6	Teachers can assess students' development and performance in civic literacy.	3.84	0.89	High	9
6.7	Teachers can cultivate students' civic literacy through mathematics education.	3.89	0.86	High	3
6.8	Teachers can integrate civic education content and activities into teaching.	3.86	0.82	High	7
6.9	Teachers are attentive to the latest concepts and practices in civic literacy education.	3.80	0.85	High	10
6.10	Teachers are willing to discuss social issues and civic responsibilities with students.	3.88	0.90	High	4

	Total	3.87	0.86	High	
--	--------------	-------------	-------------	-------------	--

According to Table 4.8, the study found that civic literacy was at a high level (M=3.87, S.D.=0.86). Among them, " Teachers can guide students to establish correct civic awareness and values " has the highest level" (M=3.92, S.D.=0.88, followed by " Teachers can guide students to actively participate in social welfare activities" (M=3.90, S.D.=0.88), and " Teachers can cultivate students' civic literacy through mathematics education" (M=3.89, S.D.=0.86), respectively. The side with the lowest level mean value was "Teachers can be attentive to the latest concepts and practices in civil literacy education" (M=3.80, S.D.=0.85).

Table 4.9 Questions classified by variables: Social Literacy

(n=283)

No.	Items	M	S.D.	Level	Rank
7.1	Teachers can pay attention to the impact of social development and changes in mathematics education.	3.90	0.85	High	3
7.2	Teachers can assess the influence and role of social factors on student learning.	3.80	0.83	High	9
7.3	Teachers can guide students to apply mathematical knowledge to solve social problems.	3.95	0.82	High	1
7.4	Teachers can collaborate with various sectors of society to carry out mathematics education projects and activities.	3.78	0.89	High	10
7.5	Teachers can guide students to pay attention to the interaction between technology and society.	3.94	0.85	High	2
7.6	Teachers can emphasize the role of mathematics in social development in teaching.	3.86	0.85	High	4
7.7	Teachers can evaluate students' development and performance in social literacy.	3.81	0.82	High	8
7.8	Teachers can utilize social resources to support mathematics teaching and student development.	3.82	0.8	High	7
7.9	Teachers are attentive to the latest concepts and practices in social literacy education.	3.83	0.85	High	6
7.10	Teachers, I am willing to discuss the relationship and significance of mathematics to society with students.	3.84	0.86	High	5
	Total	3.86	0.85	High	

According to Table 4.9, the study found that social literacy was at a high level (M=3.86, S.D.=0.85). Among them, " Teachers can guide students to apply mathematical knowledge to solve social problems" has the highest level" (M=3.95, S.D.=0.82), followed by " Teachers can guide students to pay attention to the interaction between technology and society" (M=3.94, S.D.=0.85) and " Teachers can pay attention to the impact of social development and changes on mathematical education" (M=3.90, S.D.=0.85), respectively. The side with the lowest level mean value was " Teachers can collaborate with different sectors of society to carry out mathematics education projects and activities" (M=3.78, S.D.=0.89).

4.3 Results of Interview Analysis

This study interviewed 5 mathematics education administrators from vocational colleges in Chengdu, with a total of 10 questions. The analysis of the interview results is as follows:

Table 4.10 Summary of the Interview

Issues of Consideration	Opinions of the Interviewee
1. What is your opinion and attitude towards the development of the 21st-century core competencies of mathematics teachers in higher vocational colleges in Sichuan?	All 5 interviewees strongly support the improvement of the 21st-century core competencies of mathematics teachers in vocational colleges in Sichuan.
2. What do you think of the current situation of the 21st-century core competencies of mathematics teachers in higher vocational colleges in Sichuan?	<ol style="list-style-type: none"> 1. Insufficient understanding of the connotation and constituent elements of core literacy leads to imbalanced development of core literacy. 2. The composition of core competencies in the 21st century presents diverse characteristics. 3. Some universities have started to enhance the core

	<p>competencies of mathematics teachers in the 21st century, but the results are not significant.</p> <ol style="list-style-type: none"> 4. It is rare to comprehensively enhance the core competencies of mathematics teachers in the 21st century from a holistic and macro perspective. 5. Low level of emphasis. 6. Insufficient integration of core competencies and mathematics education.
<p>3. Do you have any suggestions or support measures to improve the media literacy for mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. The resourceful role of media helps to enhance the core literacy of mathematics teachers. 2. Consciously acknowledge the impact of the new media era on mathematics education. 3. Actively learn and understand the composition and characteristics of different media platforms. 4. The ability to use media resources to solve problems in mathematics teaching. 5. Guide students to use media resources correctly to improve learning quality. 6. Schools should increase relevant training and resource provision in the field of new media.
<p>4. Do you have any suggestions or support measures to improve the network literacy for mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Weak awareness of the internet and further improvement is needed. 2. Fully recognize the profound impact of network technology on mathematics teaching. 3. Enhance the ability to learn and use network technology. 4. Strengthen the integration of network technology and mathematics teaching. 5. Utilize network technology for teaching innovation. 6. Guide students to effectively utilize network technology to improve learning efficiency. 7. Pay attention to network security and privacy protection. 8. Schools should strengthen software and hardware support for mathematics teachers in network technology.
<p>5. Do you have any suggestions or support measures to improve teamwork literacy for mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Actively join relevant teaching or research teams. 2. Strengthen team cooperation to complete mathematical teaching tasks. 3. Improve team collaboration and problem-solving skills. 4. Encourage mathematics teachers to engage in cross-team collaboration. 5. The school needs to provide relevant resource support for the teaching team and scientific research.
<p>6. Do you have any suggestions or support measures to improve the communication literacy of mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Increase communication skills and skill training. 2. Adopt different communication methods in teaching to improve communication quality. 3. Establish good communication with colleagues. 4. Establish good communication with students. 5. Improve the ability to handle communication barriers 6. Schools need to provide more comprehensive support.
<p>7. Do you have any suggestions or support measures to improve STEM literacy for mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Enhance awareness of STEM literacy. 2. Integrate STEM concepts into mathematics teaching. 3. Guide students to practice STEM projects. 4. Schools should promote interdisciplinary integration between mathematics and other disciplines. 5. Pay attention to the latest concepts and developments in STEM education.

<p>8. Do you have any suggestions or support measures to improve civic literacy for mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Establish correct civic awareness and values. 2. Strengthen social responsibility and awareness. 3. Combine mathematics education with guiding students to establish correct civic awareness and values. 4. Integrate mathematics education into the cultivation of students' civic literacy. 5. Effectively evaluate students' performance in civic literacy.
<p>9. Do you have any suggestions or support measures to improve the social literacy of mathematics teachers in higher vocational colleges in Sichuan?</p>	<ol style="list-style-type: none"> 1. Continuously monitor the impact of social development on mathematics education. 2. Collaborate with various social groups to carry out mathematical education activities. 3. Guide students to pay attention to the important role of mathematics in social development. 4. Utilize various social resources to promote the quality improvement of mathematics education. 5. Continuously monitor the latest concepts and practices in the field of social literacy. 6. Guide students to effectively integrate social practice with mathematics.
<p>10. Do you have any other suggestions?</p>	<p>At the teacher level:</p> <ol style="list-style-type: none"> 1. Actively strengthen the understanding of core competencies in the 21st century. 2. Actively enhance personal 21st-century core competencies and establish a lifelong learning awareness. 3. Strengthen the innovative integration of 21st-century core competencies and mathematics education. 4. Establish an improvement plan for personal 21st-century core competencies and reflect on the problems encountered in the process of improvement. 5. Continuously monitor the development of core literacy concepts in the 21st century and achieve sustainable development of core literacy. <p>At the college level:</p> <ol style="list-style-type: none"> 1. Increase support and guidance in both micro and macro aspects. 2. Establish and improve a platform for cultivating the core competencies of teachers. 3. Further improve the training, evaluation, supervision, assessment, and incentive mechanisms for the core competencies of mathematics teachers in the 21st century. 4. Innovate training methods and provide guarantees in terms of time, funding, resources, and other aspects. 5. Make full use of existing resources and plan for the comprehensive improvement of teachers' core competencies in the 21st century. 6. Through the exemplary role of excellent teachers, drive other teachers to improve together. 7. Teachers, schools, governments, and society work together to create a favorable environment.

Through interviews, research has found that all five interviewees strongly support the enhancement of the 21st-century core competency of mathematics teachers in vocational colleges in Sichuan. They believe this aligns with the requirements of the Chinese Ministry of Education for the improvement of teachers' core competencies and also contributes to the personal and professional development of teachers.

However, this research also identified the following current situation regarding the 21st-century core competencies of mathematics teachers in vocational colleges in Sichuan Province: 1) Some mathematics teachers in vocational colleges lack sufficient understanding of the connotation and constituent elements of core competencies, leading to imbalanced development. 2) Some mathematics teachers do not prioritize the enhancement of 21st-century core competencies and fail to keep pace with the times. 3) Currently, self-study is the primary way for some mathematics teachers to enhance their 21st-century core competencies, lacking systematic improvement, and with a single channel for enhancement. 4) Some vocational colleges have begun to enhance the 21st-century core competencies of mathematics teachers, but the effectiveness is not significant. Some issues include imperfect training course settings, single training modes, and inadequate support, supervision, and guarantee policies. 5) The focus is mainly on the micro-level (specific courses or training), with little comprehensive improvement of the 21st-century core competencies of mathematics teachers from a holistic and macro perspective. 6) There is insufficient integration of core competencies with mathematics education, lacking effective integration based on the characteristics of mathematics education and core competencies. 7) Teachers, schools, government, and society as a whole have not formed a concerted effort to create a conducive environment and atmosphere for teachers to enhance their 21st-century core competencies.

5. Conclusion

The results found that the current situation of the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan in 7 aspects was at a high level. Considering the results of this research aspects ranged from the highest to lowest level were as follows: the highest level was Civic literacy, followed by Social literacy, Communication literacy, Network literacy, Teamwork literacy, and Media literacy. STEM literacy was the lowest level. This study proposes a guideline for improving the 21st-century core competencies for mathematics teachers in higher vocational colleges in Sichuan.

Suggestions for enhancing the media literacy of mathematics teachers in higher vocational colleges in Sichuan) The resourcefulness of media can contribute to the enhancement of mathematics teachers' core competencies. 2) Firstly, there needs to be an acknowledgment of the impact of the new media era on mathematics education. 3) Mathematics teachers should actively learn about and understand the composition and characteristics of different media platforms while reinforcing their ability to use media resources. 4) They need the ability to utilize media resources to address issues in mathematics teaching. 5) Guide students in the correct use of media resources to improve learning quality. 6) Schools should increase relevant training for mathematics teachers in the field of new media and provide resources.

Suggestions for improving the network literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Some mathematics teachers have weak network awareness and need to further enhance their network awareness and adaptability. 2) Fully recognize the far-reaching impact of network technology on mathematics teaching and be prepared to respond. 3) Encourage mathematics teachers to improve their learning and usage abilities in network technology. 4) Support the integration of network technology with mathematics teaching. 5) Innovate in mathematics teaching using network technology. 6) Guide students in effectively using network technology to improve learning efficiency. 7) Pay attention to network security and privacy protection. 8) Schools should strengthen software and hardware support for mathematics teachers in network technology and increase investment.

Suggestions for improving the teamwork literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Support mathematics teachers in actively joining relevant teaching or research teams to further develop personal abilities. 2) Encourage mathematics teachers to strengthen teamwork to complete mathematics teaching tasks. 3) Enhance the internal cooperation and problem-solving abilities of mathematics teachers within teams. 4) Emphasize the power of teams and encourage mathematics teachers to collaborate across teams. 5) Schools should provide relevant resource support for teaching teams and research by mathematics teachers.

Suggestions for improving the communication literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Increase training in communication skills and techniques for mathematics teachers. 2) Encourage mathematics teachers to use different communication methods in teaching to improve communication quality. 3) Encourage mathematics teachers to establish good communication with colleagues. 4) Encourage mathematics teachers to establish good communication with students. 5) Improve mathematics teachers' ability to handle communication barriers. 6) Schools need to provide comprehensive support for improving the communication skills of mathematics teachers.

Suggestions for improving the STEM literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Enhance mathematics teachers' awareness of STEM literacy. 2) Support mathematics teachers in integrating STEM concepts into mathematics teaching. 3) Encourage and support mathematics teachers in guiding students to practice STEM projects. 4) Schools should promote interdisciplinary integration between mathematics and other subjects. 5) Keep up with the latest concepts and developments in STEM education.

Suggestions for improving the civic literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Encourage teachers to strengthen the establishment of correct civic consciousness and values. 2) Strengthen mathematics teachers' social responsibility and awareness, actively participating in social welfare activities. 3) Mathematics teachers should integrate mathematics education with guiding students to establish correct civic consciousness and values. 4) Encourage mathematics teachers to incorporate mathematics education into the cultivation of students' civic literacy. 5) Teachers should effectively assess students' performance in civic literacy.

Suggestions for improving the social literacy of mathematics teachers in higher vocational colleges in Sichuan: 1) Mathematics teachers should continuously pay attention to the impact of social development on mathematics education. 2) Collaborate with various social groups to carry out mathematics education activities. 3) Guide students to focus on the important role of mathematics in social development. 4) Utilize various social resources to promote the quality improvement of mathematics education. 5) Continuously pay attention to the latest concepts and practices in the field of social literacy. 6) Guide students to effectively integrate social practice with mathematics.

Recommendations

Based on the research results on the core competencies of mathematics teachers in Sichuan vocational colleges in the 21st century, suggestions are proposed from the perspectives of teachers and vocational colleges. Specifically, as follows:

1. Mathematics teachers in vocational colleges need to strengthen their global awareness and enhance the comprehensive development of core competencies in the 21st century. The rapid development of society has put forward higher requirements for teachers. Mathematics teachers in Sichuan vocational colleges need to deeply grasp the trend of the continuous development of core competencies in the 21st century, strengthen their overall concept, and comprehensively improve their core competencies, especially in areas that are relatively lacking such as STEM literacy.
2. Universities should provide support and guarantees in terms of policies, environment, training courses, basic facilities, etc. Universities should develop relevant support and guarantee policies based on the policy documents of the Chinese Ministry of Education on improving the core competencies of teachers, increasing investment in manpower, material resources, and funds, and building a targeted development platform for the development of core competencies of mathematics teachers in the 21st century; Further improve the training, evaluation, supervision, assessment, and incentive mechanisms for the core competencies of mathematics teachers in the 21st century; Universities, governments, and society work together to create conditions and create a favorable environment for enhancing teachers' core competencies in the 21st century.

References

- [1]. Ding Liping. (2021). Comparative Analysis of Theory and Practice of Collaborative Learning for Mathematics Teachers. *Journal of Mathematics Education*, (3): 4-11.
- [2]. Dong Bolin. (2017). Teacher Literacy from the Perspective of Student Development Core Literacy. *Reference for Middle School Political Teaching*, (22): 11-12.
- [3]. Cao Peiyang. (2015). Basic Mathematical Thought from the Perspective of Subject Core Literacy and Subject Education Value. *Curriculum and Textbook Teaching Methods*, (35): 40-44.
- [4]. Chen Gang & Pi Liansheng. (2016). From the perspective of science-oriented teaching theory, students' "core literacy" and its system construction. *Journal of Education Science, Hunan Normal University*, (5): 24.
- [5]. Chen Liujuan, Lin Qinglan. (2017). Reflections on Teacher Education and Teaching Based on Mathematical Core Literacy. *Teaching and Management*, (7): 110-111.
- [6]. Gu Jingsi, Nuttamon Puchatree & Wichian Intarasompun. (2023). Guidelines for the Development of characteristics of students program in Broadcasting and hosting at Guangxi Vocational and Technical College. *International Journal of Latest Research in Humanities and Social Science (IJLRHSS)*. (06):227-237
- [7]. Guo Jian & Cao Yiming. (2021). Knowledge and Belief: A Study on Teacher Core Literacy Based on Student Performance. *Journal of Mathematics Education*, (4): 1-5.
- [8]. Huang Rongjin & Cao Yiming. (2021). Theory and Practice of Collaborative Learning for Chinese Mathematics Teachers: An International Perspective. *Journal of Mathematics Education*, (3): 1-3.
- [9]. Jiang Yu. (2016). Approaches and Strategies for Education Reform Based on Core Literacy. *Chinese Journal of Education*, (6): 69-73.

- [10]. Li Muhui, Xu Binyan. (2021). Development path and inspiration for cultivating the ability to propose mathematical problems in China. *Journal of Mathematics Education*, (1): 91-96.
- [11]. Lu Min, Nuttamon Puchatree, Pong Horadal.(2023). The Development of Teachers Skills in the 21st Century at Primary School in Guilin, China. *International Journal of Latest Research in Humanities and Social Science (IJLRHSS)*. 6(09):154-163.
- [12]. Sang Guoyuan, Zheng Liping, Li Jingcheng, (2017). *Core Literacy of 21st Century Teachers*. Beijing Normal University Press.
- [13]. Wang Houxiong & Li Meng. (2020). The connotation, constituent elements, and development path of excellent teacher core literacy. *Education Science*, (6): 40-46.
- [14]. Wang Haiqing, Cao Guangfu. (2022). Basic Principles and Ideas of Problem Driven Mathematics Teaching and Its Implementation Steps. *Journal of Mathematics Education*, (1): 24-27.
- [15]. Wang Haixia & Tang Zhisong. (2020). Research on the Competence of Teacher Core Literacy Education. *Curriculum, Textbooks, and Teaching Methods*, (2): 132-138.
- [16]. Zhang Yuhuan & Wu Jiahui. (2022). A Comparative Study of Chinese and French Figures and Geometry from the Perspective of Knowledge and Core Literacy: Based on the French 2018 and Chinese 2011 Compulsory Education Curriculum Standards. *Journal of Mathematics Education*, (1): 70-78.
- [17]. Zhang Xiayu & Yu Ping. (2018) Development of the Core Literacy Scale for Mathematics Teachers in Vocational Colleges. *Journal of Mathematics Education*, (6): 72-81.
- [18]. Zhang Ziping. (2016). Teaching Reform Based on Core Literacy: Experience and Inspiration from the UK. *Global Education Outlook*, (45): 3-12.
- [19]. Zhao Yuanke. (2017). Connotation and Development Strategies of Teacher Core Literacy with Education as the Goal. *Educational Exploration*, (5): 92-96
- [20]. Zheng Yuxin. (2022). "Two Stage Theory" of Mathematical Thinking Teaching. *Journal of Mathematical Education*, (1): 1-6.
- [21]. Zhu Ningbo & Cui Huili. (2018). Elements and Path Choices for Improving Teacher Quality in the Context of the New Era. *Education Science*, (6): 49-54.