The Professional Identity of Primary Mathematics Teachers and Their Intention to Implement STEM Education in Mainland China

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***Abstract*—As mathematics is one of the key disciplines of STEM education, primary mathematics teachers can play important roles in STEM education, and it is generally acknowledged that teachers' professional identity can affect their teaching effectiveness. With the attention paid to STEM education in Mainland China, it is of great significance to find out the primary mathematics teachers' level of intention to implement STEM education. This research was aimed at studying the degree of professional identity of primary mathematics teachers from different cities in Guangdong, the most populous province of Mainland China, and tried to figure out their intentions about implementing STEM education, further exploring whether there is a correlation between the above two variables. The paper mainly adopted quantitative research, through online questionnaires (n = 41), finding that the professional identity of primary mathematics teachers in Guangdong, Mainland China, is at a mid to upper level and they generally have a positive intention to implement STEM education. Through correlation analysis, this study verified that the teachers' professional identity and intention to implement STEM education are significantly positively correlated (r = 0.69, *p* < 0.001), and found that professional identity shows a positive impact in predicting teachers' intention to implement STEM education (b = 0.89, *p* < 0.001). Meanwhile, the gender factor has a significant impact on predicting STEM intention using identity (b = 0.35, *p* < 0.01). Overall, with these findings, this empirical research identified the potential influencing factors for promoting STEM education in Mainland China in the future.**

***Keywords*—teachers' professional identity, intention to implement STEM education, primary mathematics teachers, mainland China**

I. Introduction

STEM education meets the huge demand of our society for science, technology, machinery, etc. in the 21st century. To cultivate a new generation of students who are interested in STEM, it is important to develop integrated interdisciplinary courses and student-centered teaching approaches from an early stage like primary school [1]. Teachers play a key role as curriculum implementers, and the STEM abilities and teaching skills of teachers directly can affect the effectiveness and the quality of education [2]. Studies show that teachers with clear and strong professional identities can better adapt to the work environment and deal with challenges at work [3]. Primary mathematics teachers are usually the main force in implementing STEM education in schools and thus this is not difficult to infer that their professional identity can have an impact on their intention to implement STEM education, thereby affecting the quality of learning and teaching.

In Mainland China, the government released the China STEM Education White Paper in 2017 and initiated the reform measures of the China STEM Education 2029 Innovation Action Plan in 2018 [4]. The policies require new teaching abilities for existing teachers, especially those in STEM-related disciplines. There is a significant gap between the teaching methods of STEM education and traditional classrooms, and the efficient use of integrated STEM teaching approaches poses a challenge for existing teachers who are accustomed to traditional teaching methods [4]. Galanti and Holincheck [5] indicated that only when teachers consider themselves STEM teachers and are willing to implement STEM courses in which students have an opportunity to participate in innovative K-6 STEM courses. Accordingly, it is necessary to figure out the current attitudes and concerns of primary mathematics teachers, the potential implementers, in Mainland China about STEM education. Understanding their professional identity and intention to implement STEM education can help identify the driving forces and challenges for promoting STEM education in Mainland China. The following research questions guide this study:

(1) What is the level of the professional identity of primary mathematics teachers and their intention to implement STEM Education?
(2) Is there a correlation between the level of the professional identity of primary mathematics teachers and their beliefs, understandings, and intentions of implementing STEM education?
(3) What is the contribution of the variable of teacher professional identity to the intention of implementing STEM education? Can it be influenced by gender?

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II. Literature Review

A. Concepts and Theories of Teacher Professional Identity

The professional identity of teachers is an internal understanding of their teaching profession formed through work and social interaction [6]. There are various branches of definition and concepts in the research focusing on the teachers' identity. Studies have simultaneously mentioned several different dimensions of teacher professional identity, and these descriptions cannot be separated from dimensions such as motivation, self-efficacy, task cognition, and job satisfaction [6–8]. Hanna *et al.* [3] proposed a scale for measuring teacher identity, in which teacher identity is divided into four domains: motivation, self-image, self-efficacy, and task perception.

- Motivation

Research suggests that teachers' motivation can be divided into controlled motivation and autonomous motivation. Controlled motivation drives teachers' teaching behavior that they believe can bring external rewards, while autonomous motivation is the intrinsic value that teachers give to teaching behavior [9]. Researchers have found that growth in teachers' motivation levels will bring more professional commitment, having a positive impact on professional identity, indicating whether they are more proactive in teaching and achieving teaching goals [3, 7].

- Self-Image

A teacher's self-image is considered a conceptualization procedure of how an individual views and feels about a teacher's work and values [6]. It is the teacher's perception, understanding, evaluation of oneself, and identification of one's behavior and responsibilities.

- Self-Efficacy

The teachers' self-efficacy is an important psychological process related to the formation and modification of their identity as teachers. It is an awareness of whether they have the confidence to effectively achieve teaching objectives [6]. Teachers with strong self-efficacy perceive themselves as belonging to the teacher group, thereby clarifying their self-image [8].

- Task Perception

Task perception refers to the perception and understanding of a teacher of the tasks they are expected to complete, and how they perceive their responsibilities and attach importance to them [10]. Research has shown that perception of the content and difficulty of tasks, as well as belief in one's ability to complete challenges, are also important factors affecting self-efficacy [9].

B. Measurement of Professional Identity

The measurement of the teachers' professional identity includes qualitative research and quantitative research. In comparison, qualitative research pays closer attention to the development process and influencing factors of teacher identity, especially through interviews, tracking records or other forms [4, 11, 12]. Quantitative research often pays more attention to the dimensions of measuring teacher identity, the effectiveness of tools, and the comprehensive level of teacher identity [3, 8, 13]. The Teacher Identity Measurement Scale (TIMS) for primary school teachers was put forward based on the identity theory, and it was verified that it can be used as a measuring tool and repeated by other studies [3].

C. Intension of Implementing STEM Education (STEM Intention)

Measuring teachers' STEM awareness is crucial, affecting the enthusiasm and confidence of teachers in STEM education [14]. The intention of teachers to carry out STEM education reflects whether they incorporate the new role of STEM educators into their self-awareness [5]. Besides, research has found that perceived usefulness, which means that implementing STEM education can improve students' learning outcomes, and have a significant positive impact on teachers' STEM intentions [15].

D. Measurement of STEM Intention

Most researchers suggest that current teachers have a positive attitude toward implementing STEM education as a whole, believing that STEM education can cultivate students' comprehensive literacy [16, 17]. Moreover, Wijaya *et al.* [15] used the Theory of Planned Behavior (TPB) to predict STEM intentions among middle school teachers. Studies have found that individuals' professional identity as teachers and their feelings about educational experiences as students can predict their intention to enter the STEM education industry [18].

III. Methodology

A. Research Design and Instrument

To explore the relationship between professional identity and STEM intention of primary school mathematics teachers from different cities in Guangdong, the most populous province of Mainland China (Guangzhou, Shenzhen, Zhongshan, etc.), this study mainly adopted the correlational research design. The first part of the study investigated the professional identity of primary school mathematics teachers and their intention to implement STEM education, and processed and analyzed them through descriptive statistics. On this basis, more in-depth exploration was conducted on the relationship between identity recognition and STEM intention through Pearson correlation analysis, to verify whether there is a correlation between them and whether the relationship is positive or negative. The next step aimed to verify whether professional identity can be used to predict teachers' intention to implement STEM education with regression models.

This research was mainly conducted in the form of online questionnaires. The first part measured teachers' professional identity, using Teacher Professional Identity Measurement Scale [3]. It included four dimensions: Motivation, Self-Efficacy, Self-Image, and Task perception, including a total of 46 questions. The motivation part starts with a general question 'What is the main reason for you to become a primary school teacher?', using different statements as the answers to test participants' level of agreement with the statements, which are scored with a 7-point Likert scale to show the importance of this statement as a reason (1 = not important; 7 = extremely important). The Self-Image domain includes some statements that are scored on a 5-point Likert scale (1 = not at all; 5 = very much), and the statements illustrate how teachers perceive their image. The self-efficacy domain mainly describes the teacher's sense of efficacy from the perspectives of strategy, motivation, and classroom, using the 5-point Likert scale (1 = not at all; 5 = very much). The task perception domain measures teachers' sense of their tasks, such as teaching goals, educational methods, etc. with a 5-point Likert scale (1 = totally disagree; 5 = totally agree). Research has shown that the scale is specifically designed for primary school teachers and is psychometric valid, which can be used to evaluate the level of professional identity of primary school teachers [3].

The second section of the questionnaire was about teachers' intention of implementing STEM education, using the Questionnaires of Teachers' Beliefs, Understandings, and Intentions [19], and each part has 5 descriptive questions, which are 5-point Likert scale questions (1 = totally disagree; 5 = totally agree), to indicate the participants' level of agreement with the statement. Specifically, the first part measured whether primary school mathematics teachers have faith in the outcomes and achievements of STEM education. The second part focused on teachers' understanding of how to promote STEM education implementation, such as teacher preparation and leadership development planning. The third part focused on whether teachers believe they have the interest and ability to implement STEM education in the future, and whether they need professional development training support.

B. *Participants*

This study was conducted among the in-service mathematics teachers in primary schools in several southern cities in Mainland China, including 26 female teachers and 15 male teachers. All participants are between the ages of 18 and 50, with 11 participants between the ages of 18 and 25, 27 participants between the ages of 26 and 30, 2 participants between the ages of 31 and 40, and 1 participant between the ages of 41 and 50. All participants who completed the online questionnaire provided an informed consent form, which serves as the first step in completing the online questionnaire.

C. *Statistical Analysis*

A total of 41 valid questionnaires were received, and the data analysis was conducted using quantitative analysis methods in this research.

Firstly, descriptive statistics were conducted. The scores of each participant for the questions about all sub-dimensions of professional identity and STEM intention were averaged to obtain the scores for each dimension. It is worth noting that the Likert scale score on the motivation part was processed individually, and the 7-point Likert scale score was converted into a 5-point Likert scale score using equal proportions, to take the average of the four dimensions of identity as the total score of identity in the subsequent section.

The second step conducted a Pearson correlation analysis, to test whether there is a correlation between teachers' professional identity and their intention to implement STEM education. All sub-dimensions were analyzed in pairs to obtain correlation coefficients and their significance, further analyzing the correlation between variables.

Based on correlation analysis, regression models were implemented to identify variables that can be used to predict teachers' intention to implement STEM, and confirmed whether the hypothesis that teachers with higher levels of identity have higher intentions to implement STEM education is valid. Moreover, in the regression process, the gender and age of teachers were also considered as covariates, in an attempt to determine whether these two variables would have an impact on the results.

IV. Results and Findings

A. *Descriptive Statistics*

Fig. 1 shows the average scores and 95% confidence intervals of the four dimensions of teacher professional identity and the three dimensions of intention to implement STEM education. Overall, among the four dimensions of identity, the average value of self-image is the highest. In contrast, the average score of motivation level is the lowest. Besides, the variable 'Overall identity' is the average of all question scores in the four sub-dimensions, which were used for subsequent correlation and regression analysis.

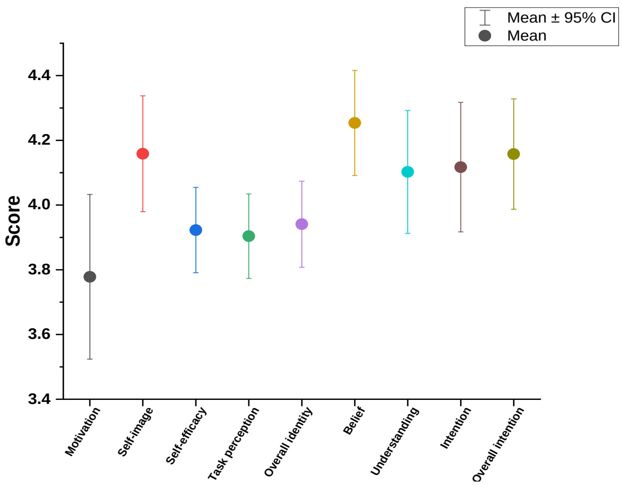

Fig. 1. The average scores and 95% confidence intervals (vertical bars) for variables related to teacher professional identity and intention to implement STEM education in various cities of Guangdong province, Mainland China (n = 41).

In comparison, the average score of teachers' STEM intention is higher, exceeding 4 points, and the score of belief is the highest, indicating that current primary mathematics teachers hold a positive attitude towards STEM education. Overall Intention to STEM is the average score of all questions in three dimensions, indicating the overall intention to STEM education of primary mathematics teachers.

B. Pearson Correlations

Table I shows the correlation coefficients and significance levels between the four dimensions of a teacher's professional identity and the three dimensions of STEM intention. Among the four sub-dimensions of professional identity, there is a significant positive moderate correlation between self-efficacy and self-image (r = 0.52, $p < 0.001$), indicating that teachers with strong self-image have stronger self-efficacy. There is also a significant positive correlation between self-efficacy and task perception (r = 0.51, $p < 0.001$), showing that teachers with strong self-efficacy have a deeper perception and understanding of tasks.

As for the three sub-dimensions of the intention to implement STEM education, overall, there is a significant and strong positive correlation between the three dimensions, with the strongest positive correlation between intention and belief (r = 0.81, $p < 0.001$). When teachers believe that STEM education has a positive effect on students' learning outcomes, their STEM intention is stronger.

As for the correlation between identity and STEM intention, the data presented in the table shows a significant and positive moderate linear relationship between the overall identity and STEM intention variables, with a correlation coefficient of 0.69 ($p < 0.001$). From the perspective of sub-dimensions, variables show a significant positive correlation, with the intention sub-dimension having the highest correlation coefficient with task perception (r = 0.61, $p < 0.001$), reflecting that teachers with a higher level of task perception have a relatively stronger intention to conduct STEM teaching. Compared to others, the correlation coefficient between understanding and self-efficacy is small (r = 0.32, $p < 0.05$), but there is also a significant positive moderate linear relationship between the above two variables, indicating that the level of self-efficacy of teachers and their understanding also affect each other.

TABLE I. PEARSON CORRELATIONS AMONG VARIABLES OF INTEREST (N = 41)

Variable	1	2	3	4	5	6	7	8	9
1. Motivation									
2. Self-image	0.40*								
3. Self-efficacy	0.37*	0.52***							
4. Task perception	0.45**	0.42**	0.51***						
5. Overall identity	0.81***	0.76***	0.72***	0.73***					
6. Belief	0.47**	0.39*	0.49**	0.53***	0.61***				
7. Understanding	0.58***	0.41**	0.32*	0.48**	0.61***	0.76***			
8. Intention	0.55***	0.45**	0.54***	0.61***	0.70***	0.81***	0.79***		
9. Overall intention to STEM	0.58***	0.45**	0.48**	0.59***	0.69***	0.92***	0.92***	0.94***	

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

C. Regression Models

To further explore the relationship between teachers' professional identity and their intention to implement STEM education, a regression model was implemented. Table II shows the results of all regression models with teachers' overall intention as the dependent variable. The interpretation of the analysis results of the categorical variable age is as follows. One category is used as the reference category, and each other category is converted into binary variables. The first category is between 18–25 years old, which is the reference category. On this basis, the second category (Age3) is between 26–30 years old, and the third category (Age4) is between 31–40 years old, the last category is between 41 and 50 years old, defined as Age5, as shown in Table II.

Models 1–3 focused on overall identity as the independent variable, and explored whether the two covariates of teacher's gender and age have an impact on predicting teacher STEM education, while models 4–6 used four sub-dimensions of identity as the independent variable. From the results, Model 2 was the most suitable model for interpreting data, after a comparison of R^2 and adjusted R^2. Model 2 compared to Model 1 by adding gender as a variable, and the results showed that the coefficient of this variable was significant, while R^2 showed a significant increase, $R^2 = 0.58$, $F(2, 38) = 26.2$, $p < 0.001$. Although a new variable of age was added to Model 3, the R^2 value did not increase significantly, and even the adjusted R^2 value decreased, indicating that the addition of this variable did not make the model better fit the data. Additionally, the data from models 4–6 indicated that using the four identity sub-dimensions as independent variables separately did not effectively improve R^2, and some coefficients of the four independent variables were not even significant. The increase in model complexity did not make the model more fitted to the data. However, it is notable that the coefficient of the gender variable was still significant, it further indicated that it is a variable that cannot be ignored.

TABLE II. SIMPLE REGRESSION AND MULTIPLE REGRESSION MODELS PREDICTING TEACHERS' OVERALL INTENTION TO STEM (N = 41)

Predictor	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	B	***SE B***	***B***	***SE B***	***B***	***SE B***	***B***	***SE B***	***B***	***SE B***	***B***	***SE B***
Motivation							0.23*	0.09	0.17*	0.08	0.19	0.09
Self-image							0.11	0.14	0.07	0.12	0.04	0.13
Self-efficacy							0.18	0.19	0.26	0.17	0.27	0.18
Task perception							0.41*	0.19	0.52**	0.17	0.50*	0.18
Overall identity	0.89***	0.15	0.89***	0.14	0.88***	0.14						
Age3 (26–30)					−0.03	0.13					−0.08	0.13
Age4 (31–40)					0.09	0.29					0.10	0.32
Age5 (41–50)					−0.41	0.39					−0.29	0.39
Gender (Female)			0.35**	0.12	0.38**	0.13			0.41**	0.12	0.43**	0.13
(Intercept)	0.66	0.59	0.43	0.54	0.46	0.57	0.54	0.70	−0.08	0.65	0.07	0.68
R^2	0.48		0.58		0.60		0.50		0.63		0.64	
$Adj.R^2$	0.47		0.56		0.54		0.45		0.57		0.55	
$F(df)$	36.1***(1, 39)		26.2***(2, 38)		10.3***(5, 35)		9.09***(4, 36)		11.70***(5, 35)		6.99***(8, 32)	

Note: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

V. DISCUSSION

A. The Levels of Professional Identity and STEM Intention

This study obtained several key results. Firstly, the overall level of teachers' identity of primary mathematics teachers in Guangdong, Mainland China is at a mid to upper level, with potential for development. Taking the Netherlands as a comparison – they have quite encouraged development in STEM education recently. The overall average level corresponded to the findings of Hanna *et al.* [3] in the primary teacher education institutions in the Netherlands, but the level of sub-dimension of teacher motivation in this study (M = 3.78) is much lower than the sample motivation level in Hanna's study (M = 4.40), and the level of teachers' self-image (M = 4.16) significantly exceeded Hanna's sample level (M = 3.56). The differences in findings appear may be because of the characteristics of the targeted teachers. The participants in this study are mostly in-service teachers, while the samples in Hanna's study were selected from primary school teacher education institutions, mostly pre-service teachers. Teachers' teaching and work experience may affect their recognition of their teacher identity, including their level of motivation [4]. Besides, different cultural backgrounds may have different impacts on teachers' motivation. For example, the impact of traditional Chinese culture on teachers' motivation is different from that of Western countries [20]. Han and Yin [20] also mentioned that disciplinary issues, demographic characteristics, and different grades can all have an impact on motivation and cannot be ignored when explaining differences in teachers' motivation. Besides, pre-service teachers tend to think more like students rather than teachers, and their self-image is relatively weak compared to in-service teachers [21, 22].

Another key finding of this study is about the level of intention of teachers to implement STEM education which is relatively high. Compared with Kurup *et al.*'s [23] results of pre-service teachers from Australia, where there are many effective cases of implementing STEM education, the belief level is slightly lower (M = 4.25) than Kurup *et al.*'s [23] results (M = 4.33), but the average level of understanding (M_U = 4.10) and intention (M_I = 4.12) dimensions is higher than the latter (M_U = 3.84, M_I = 3.88). It shows that the existing teachers in Guangdong, Mainland China have a positive intention to implement STEM education. At the same time, the social changes brought by the level of science and technology can also strengthen teachers' beliefs and optimism about STEM education [4]. In addition, whether STEM teachers have the opportunity to engage in professional career development projects can also affect their intention to implement STEM education [19]. The research also provided a reminder for the promotion of STEM education in Mainland China, which requires attention to the construction and maintenance of a teacher career development platform.

B. The Correlation between Professional Identity and STEM Intention

This study found a significant positive correlation between teachers' professional identity and their intention to implement STEM education through Pearman correlation analysis. This result works in concert with the research of Horvath *et al.* [18], suggesting that teachers with high levels of professional identity have stronger educational intentions. When teachers have a higher level of professional identity, they are more inclined to improve teaching quality, and implementing STEM education is also one of the ways [15]. The professional identity of STEM teachers is beneficial for promoting their active participation in training programs and striving to provide students with opportunities to obtain high-quality STEM education [5]. This result also provided empirical evidence for promoting STEM education practice. To promote STEM education, one can start with how to improve the teachers' professional identity. It is important to pay attention to the self-efficacy and self-image of primary mathematics teachers in their teaching and work, try to improve their motivation and task perception, and strengthen their identity as teachers.

C. Predicting STEM Intention with Professional Identity

Through regression model analysis, this study found that the professional identity of teachers can be used as a dependent variable to predict their intention to conduct STEM education. The increase in teacher identity has a positive impact on their intention to put into practice STEM education, and the gender of teachers also has a significant impact on this process. Specifically, when controlling for the identity variable, the average level of STEM education intention of female teachers is higher than that of male teachers. Horvath *et al.* [18] found in their study that teacher identity can affect their decision to enter the education field and choose the education industry. This also confirmed the positive impact of teacher identity on STEM education intentions found in this study. The impact of gender factors has also been mentioned in other studies. Vlasopoulou *et al.* [17] found that compared to male teachers, female primary school teachers have a stronger intention toward STEM education, and suggested that gender differences may affect teachers' teaching experience, social interaction, and education concepts.

D. Limitations

Some limitations in this research can be improved in future research. Firstly, this study used cross-sectional data, and lacked the exploration of temporal relationships, which is unable to study teachers' professional identity and STEM intention from the perspective of development, which should be further explored. Secondly, the study only used quantitative analysis methods. In future research, mixed research methods can be used, combined with qualitative analysis such as semi-structured interviews, to gain a deeper understanding of participants' thoughts and explore their motivations. Thirdly, there was also some room for improvement in sample selection. The samples of this study focused on primary school mathematics teachers, because primary mathematics teachers should be one of the main forces to implement STEM education in the future in Mainland China. But besides mathematics teachers, science teachers are also potential STEM teachers. Studies have shown that science teachers have stronger STEM awareness than elementary school mathematics teachers, and they pay more attention to scientific knowledge and the integration of knowledge [16]. Therefore, further attention should be paid to the identity and STEM intentions of STEM-related teachers such as science teachers, to provide more empirical support for the development of STEM education.

VI. CONCLUSION

This study found that the identity of primary school mathematics teachers in Mainland China and their STEM intention are significantly and positively correlated, and gender factor has a significant impact in using identity to predict teachers' STEM intention. The study provides empirical data from the perspective of mathematics teachers for the promotion of STEM education policies in Mainland China, and calls on policymakers to pay attention to the reasons that affect the formation and development of teacher identity, which is of practical significance. However, there were some limitations in this study such as a small sample size, developed regions of participants, and concentration on a specific group of mathematics teachers, which can be improved and enriched in further research.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Ruoying Xie and Alex Wing Cheung Tse conducted the research, analyzed the data, and wrote the paper; all authors had approved the final version.

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