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The Relationship between STEM Teachers' Beliefs and Knowledge: A Qualitative Meta-Analysis

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ABSTRACT

The Characterized the 38 documents that were finally included in the analysis from 405 studies, the characteristics, mechanism, and result of research on the relationship between STEM teachers' beliefs and knowledge are examined. As far as the research object is concerned, STEM related subject teachers have gradually become an important object of teachers' beliefs and knowledge relationship research. As far as data collection and processing is concerned, the collection of STEM teachers' beliefs data is simpler than STEM teachers' knowledge data collection methods, mainly based on the questionnaire scale method. In the data analysis method, most of the research used correlation analysis to explore the interaction between the two. However, most of the studies using other diverse statistical analysis methods (such as path analysis and regression) use STEM teachers' knowledge as a factor influencing teachers' beliefs. As far as the research content is concerned, the beliefs about themselves and its relationship to knowledge (content knowledge) are the most frequently discussed. In terms of research results, half of the studies found a significant positive correlation between STEM teachers' beliefs and teachers' knowledge, especially the relationship between beliefs about themselves TPACK. However, some studies have found that the relationship between STEM teachers' beliefs and knowledge is complex, and even very few studies have found that the two are irrelevant or negatively correlated.

1. Introduction

The relationship between teachers' beliefs and knowledge has always concerned by researchers. This is because teachers' beliefs and knowledge are important components of the multi-dimensional construct of teachers' competence (Dunekacke, Jenßen, Eilerts, & Blömeke, 2016). Attempts to understand what contributes to teaching quality have been channeled in different directions, with two main research streams focusing on either teachers' beliefs or knowledge (Charalambous, 2015). As Caderhead (1996) suggested, research on teachers' beliefs and knowledge constitutes the essence of teaching. If researchers want to conduct a comprehensive study of teachers, they must study the beliefs of teachers as well as the knowledge that teachers have. Only when teachers' beliefs and knowledge fit together can teachers be expected to draw on their knowledge and be able to successfully master the demands of the classroom (Weinert, 2001).

However, less research have attended to both the affective and the cognitive domain together, trying to unpack how both jointly contribute to teaching quality (Charalambous, 2015), especially little empirical evidence exists as to the interplay between teachers' beliefs and knowledge (Drageset, 2010). This may be because there is a cross between teachers' beliefs and knowledge, extremely confusing (Five & Buehl, 2010). Generally speaking, knowledge is often based on the members of particular community, which are considered to be more factual and verifiable; but belief is more inclined to subjective, personal and cannot be validation (Caderhead, 1996; Pajares, 1992; Richardson, 1996). In particular, Nespor (1987) distinguish between beliefs and knowledge from the following three points: in the degree of confirmation, belief encompasses the assumptions of physical existence, the ideals of personal aspirations, and the episodic memory of personal experience, but knowledge is the reality at hand; on the content component, belief has emotional and evaluation components, but knowledge has no emotions and evaluation components; in the way of structure, belief is organized by random storage, the structure is not very strict, but knowledge is mainly stored in a meaningful network, consisting of logical principles or propositions.

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2. Literature Review

The research on teachers' beliefs has been more than 60 years (Oliver, 1953), but there are disputes over the definition of the concept of teacher beliefs (Pajares, 1992; Kagan, 1992). A series of studies have shown that teachers' beliefs will affect teachers' teaching practices and student learning outcomes. Caprara and his collaborators mainly use the questionnaire method to investigate Italian junior high school teachers, exploring the relationship between teacher efficacy belief and job satisfaction, student academic achievement. It turns out that teachers' self-efficacy beliefs and collective efficacy beliefs can significantly affect teacher job satisfaction (Caprara, Barbaranelli, Borgogni, Petitta, & Rubinacci, 2003); in the case of controlling the student's previous academic performance, teacher self-efficacy beliefs will still significantly affect students' academic performance (Caprara, Barbaranelli, Steca, & Malone, 2006). Sadaf, Newby and Ertmer, (2012) conducted research on the belief that pre-service teachers use Web 2.0 in the classroom through open questionnaires, semi-structured interviews, and reflective records. The results show that teachers' value beliefs in students' learning and participation level, behavioral beliefs of technology ease of use, subjective normative beliefs to meet the needs and expectations of students, self-efficacy beliefs in technology use, and control beliefs in students' learning at any time and place, affect the intent of teachers to use the technology. Chan (2015) conducted research on the belief in the use of dynamic geometry software for 30 in-service math teachers using an open questionnaire also supports the findings.

In addition, there may be consistency between several beliefs within the teacher belief system. In general, teachers with relativistic epistemological beliefs tend to be more inclined to constructivist teaching beliefs. They often use computers as cognitive tools to support student learning (Deng, Chai, Tsai, & Lee, 2014). Tsai (2002) has studied the teaching beliefs, learning beliefs and scientific knowledge beliefs of 37 Taiwan science teachers. It is found that more than half of the teachers agree with each other on these three beliefs. Tsai (2002) calls this phenomenon Nested epistemologies. Besides, teacher education can change teachers' beliefs to a certain extent. Chai, Teo and Lee (2009) tried to change the teacher's epistemological beliefs and teaching beliefs through the teacher's career preparation project, and achieved the desired effect.

According to the existing research literature, Five and Buehl (2012) classify teachers' beliefs into the following five categories: (1) beliefs about themselves (BT), that is, teachers' beliefs in self-efficacy, identity, and teacher roles; (2) beliefs about context or environment (BCE), that is, the teacher's beliefs in the school atmosphere/culture, relationships with others (colleagues, executives, and parents); (3) beliefs about content or knowledge (BCK), that is, the teacher's beliefs in teaching students' knowledge or different carriers of their own knowledge (such as mathematics, science, etc); (4) beliefs about specific teaching practices (BSTP), that is, teachers' beliefs on topics such as cooperative learning, science teaching, and the use of inquiry strategies; (5) beliefs about teaching approach (BTA), that is, teachers' beliefs in constructivism, developmental appropriate practices and so on; (6) beliefs about students (BS), that is, the teacher's beliefs in students' diversity, particularity, language differences, ability, learning and development. The fourth and fifth categories refer to teachers' beliefs about teaching, but they are different according to the specific research content (Five & Buehl, 2012).

The research path of teachers' knowledge originated from the classification of teacher knowledge by Shulman and his research team. Shulman divided the teacher knowledge into a presidential speech at the American Education Research Association (AERA) 1985 Annual Meeting: subject matter knowledge, pedagogical content knowledge, curriculum knowledge (Shulman, 1986). Subsequently, Shulman further developed a classification of teacher knowledge, dividing teachers' knowledge into content knowledge; general pedagogical knowledge; curriculum knowledge; pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; knowledge of educational ends, purposes, and values, and their philosophical and historical grounds etc. seven types (Shulman, 1987). Among the above-mentioned teacher classifications, pedagogical content knowledge (PCK) is most concerned by researchers and is a dividing line between novice teachers and expert teachers (Wilson, Shulman, & Richert, 1987).

On the basis of Shulman (1986; 1987) on PCK, Koehler and Mishra (2005a, 2005b) conducted a series of empirical studies on Teachers learning technology by design, and in 2006 proposed a new teachers' knowledge framework, called Technological Pedagogical Content Knowledge (TPACK; Mishra & Koehler, 2006). Among them, technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) are three types of core knowledge, and four types of knowledge, namely PCK, technological pedagogical knowledge (TPK), technological content knowledge (TCK) and TPACK, are generated from these three core knowledge. The knowledge of the three types of knowledge exchanges is called TPACK, which may be regarded as a direct promotion of PCK. Considering the importance of TPACK, Koehler and Mishra (2009) regard it as the knowledge base of using technology for effective teaching. TPACK is becoming a required area of expertise for teachers in new learning environments in the 21st century (Joo, Park, & Lim, 2018).

Teachers' beliefs and knowledge complement each other but are distinct constructs (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; Pajares, 1992), but it seems clear that a relation exists between teachers' beliefs and knowledge, the directionality of this relation is uncertain (Corkin, Ekmekci, & Papakonstantinou, 2015). The specific relationship between the two is waiting for us to analyze the existing research. Therefore, the questions of this study are as follows:

1) What is the basic characteristics of the research on the relationship between teachers' beliefs and knowledge (publishing time, research design, the country, gender, teaching experience, teaching section, and teaching subject of research object)?

2) What is the research mechanism of the relationship between teachers' beliefs and knowledge (data collection methods, data processing methods, and what kind of teachers' beliefs are related to teachers' knowledge)?

3. Research methods

3.1. Literature collection

First, search for relevant literature on databases such as Web of science, Academic Search Complete, ERIC, and PsycINFO. The search term of teachers' beliefs is teach* belief* or teach* efficacy, and the search term of teachers' knowledge is teach* knowledge or TPACK. The screening criteria at this stage include: (1) published in peer-reviewed academic journals; (2) the language is English; (3) published in 1985-2018 (as of July 25, 2018). 405 valid articles are obtained. Then, in the second stage, read through the title, abstract or full text of the above documents, and then filter the literature again according to the following criteria: (1) the research subjects are K-12 grade teachers; (2) the research content must include a discussion of the relationship between teachers' beliefs and knowledge. 50 valid articles are obtained. Then, in the third stage, the full text of the above documents is carefully read and the literature is further screened according to the following criteria: (1)

consistent with the classification of teachers' beliefs (Five & Buehl, 2012) and knowledge (Mishra & Koehler, 2006) in this research framework; (2) collect quantitative data on teachers' beliefs and knowledge. During the period, 12 articles with incorrect or unclear knowledge types and 3 articles with qualitative research were deleted, and 35 valid articles were obtained. Finally, the references of the above articles were searched and screened according to the above criteria, and three valid articles were obtained. Therefore, the final number of valid articles is 38 (see Figure 1 for the specific process).

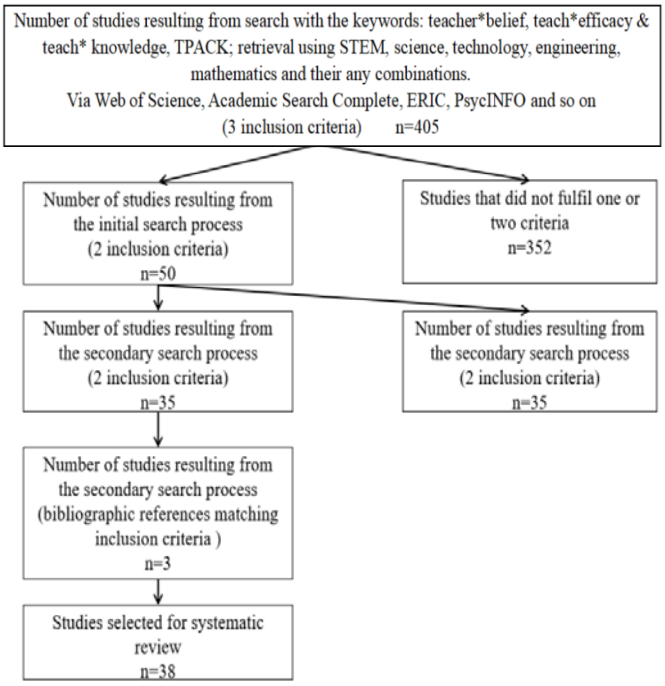

Fig. 1. Literature search and screening flow chart.

3.2. Coding analysis

Characterized the 38 documents that were finally included in the analysis, including the following variables: (1) published time (including 1985-2018); (2) research design (including quantitative research, mixed research); (3) the country of the research object (such as the United States, Germany, China, etc.); (4) the gender of the research object (including male and female); (5) the teaching experience of the research object (including pre-service teachers and in-service teachers); (6) the teaching section of the research object (including preschool, elementary school, junior high school, and high school); (7) the teaching subjects of the research object (such as language arts, mathematics, science, etc.); (8) data collection methods for teachers' beliefs and knowledge (such as questionnaires, tests, etc.); (9) data statistical analysis methods (such as correlation analysis, regression, etc.); (10) the relationship between the dimensions of teachers' beliefs and the dimensions of teachers' knowledge (including positive correlation, negative correlation, irrelevance, and mixing). Before the formal coding, the two researchers independently coded 10 randomly selected documents. After the consistency of the two researchers' scorers reached more than 90%, one of the researchers was asked to encode the remaining documents. At the end of the coding, the inconsistent coding of the two researchers or the doubts of the researchers in the subsequent coding are discussed and agreed upon after the negotiation.

3.3. Basic situation of articles for meta analysis

On the whole, the research on the relationship between teachers' beliefs and knowledge has been paid more and more attention in recent years, and the number of research shows a significant growth trend. From the publication time of the literature (see Figure 2), the vast majority (84.21%) of the studies were published after 2012; especially in 2017, the highest point was reached, with a total of 9 articles, accounting for 23.68% of the total.

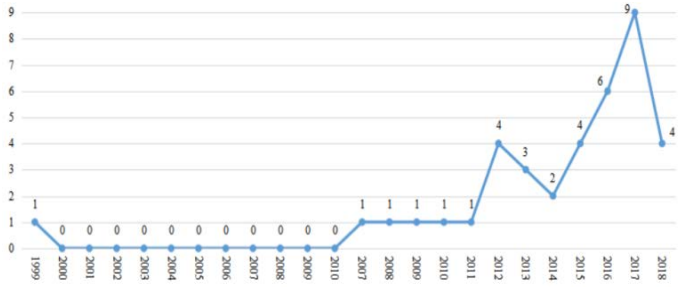

Fig. 2. Year of publication of the document.

In terms of research design and object, 32 of the 38 documents were quantitative studies, accounting for 84.21% of the total; another 6 were mixed studies, accounting for 15.79% of the total. From the country of the research object (see Figure 3), the United States is a large country in the study of teachers' beliefs and knowledge relations. There are 15 articles, accounting for 39.47% of the total; followed by Germany and Turkey, each with 5 articles, respectively. It accounts for 13.16% of the total. As far as the continent is concerned, scholars in North America (represented by the United States) are the most active, with 16 articles, accounting for 42.11% of the total; followed by Asia (represented by Turkey), with 12 articles, accounting for 31.52 of the total; Once again in Europe (represented by Germany), a total of 8 documents accounted for 31.52% of the total.

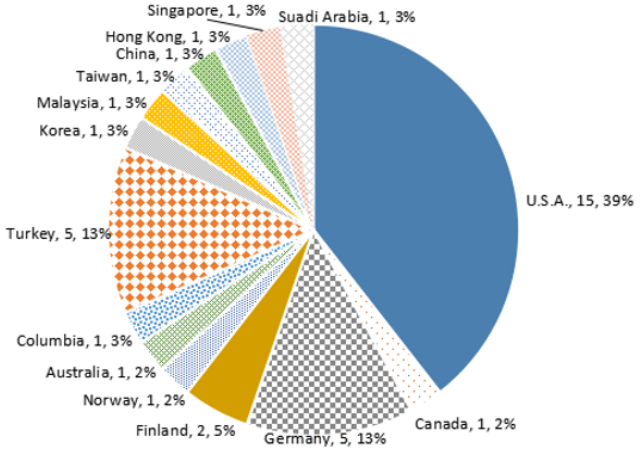

Fig. 3. Country to which the document belongs.

Among all 38 articles, only 57.89% of the literature (22 articles) completely reported the gender of teachers, and 4 (10.53%) of the literature were partially missing the description of teacher gender. In another 12 articles (31.58%), teacher gender was not reported. Among the teachers who have reported gender (total 4263), 29.09% are male, a total of 1240; 70.91% are female, a total of 3,023, female teachers are significantly more than male teachers. Of all the 38 articles, only two were related to pre-service teachers and in-service teachers [29] [30], accounting for 5.26% of the total. The vast majority (94.74%) of the literature only covered one type teacher. A total of 6,592 teachers were included, of which 2,966 were pre-service teachers (44.99% of the total) and 3,626 were in-service teachers (55.01% of the total), both of which were basically equal in

number. As shown in Figure 4, except for 8 (21.05%) articles that did not report the semester, 17 (44.74%) of the literature only involved one semester, and 6 (15.79%) of the literature involved two semester, 7 (18.42%) of the literature covers three segments simultaneously. Among them, a total of 24 articles related to primary school teachers, the highest proportion (63.16%); followed by secondary schools, involving 13 articles, accounting for 34.21% of the total.

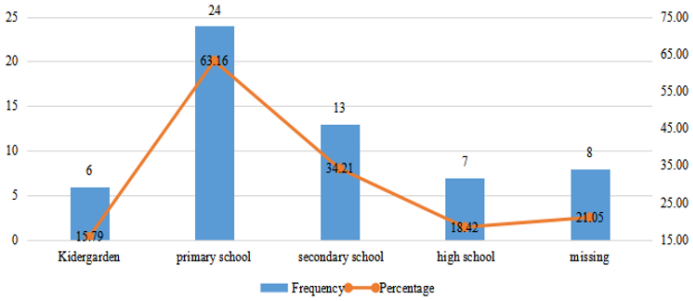

Fig. 4. Distribution of teacher's teaching section.

As shown in Figure 5, except for 10 (26.32%) articles not reported, 21 (55.26%) of the literature only cover one subject, and 1 (2.63%) of the literature covers two subjects, 3 (7.89%). of the literature covers three disciplines, and three more (7.89%) of the literature cover four or more disciplines. Among them, mathematics and science are the most involved, each with 13 articles, accounting for 34.21% of the total; followed by language arts, a total of 7 articles, accounting for 18.42% of the total.

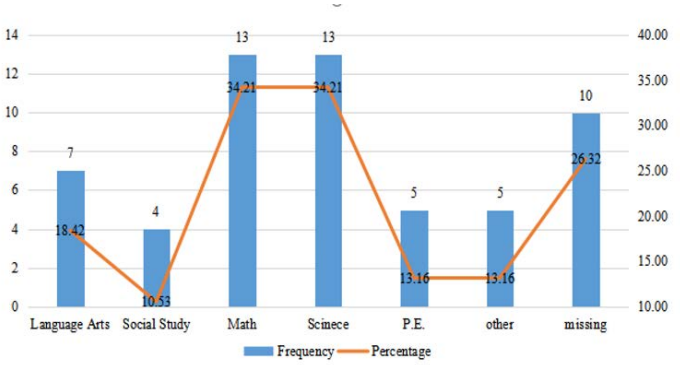

Fig. 5. Distribution of teachers' teaching subject.

In terms of data collection methods for teachers' beliefs, these 38 articles (100%) used the questionnaire scale method. The more common data collection tools include Mathematical Teaching Efficacy Beliefs Instrument [27] [31][32] Swars, Hart, S. Z. Smith, Smith, & Tolar, 2007; Swars, S. Z. Smith, Smith, Carothers, & Myers, 2018; Newton, Leonard, Evans, & Eastburn, 2012; Thomson, DiFrancesca, Carrier, & Lee, 2017), Mathematics Beliefs Instrument (MBI; M. E. Smith, Swars, Smith, Hart, & Haardörfer, 2012; Swars et al., 2007; Swars et al., 2018) and so on. As far as the data collection method of teachers' knowledge is concerned, 35 papers only use one data collection method, accounting for 92.11% of the total; in addition, three papers have adopted two data collection methods, accounting for 7.89% of the total. Among them, the test method is the most, there are 23 articles, accounting for 60.53% of the total. A more common tool is the Learning Mathematics for Teaching Instrument (LMT; Corkin et al., 2015; Drageset, 2010; Smith et al., 2012; Swars et al., 2007; Swars et al., 2018). Followed by the questionnaire scale method, there are 13 articles, accounting for 34.21% of the total. The more common tools are TAPCK (Cheng & Xie, 2018; Joo et al, 2018; Oskay, 2017; Semiz, 2012). In addition, there were 4 (10.53%) literatures using the scenario to collect teachers' knowledge data, and 1 (2.63%) literature using concept maps to collect teacher knowledge data.

As far as statistical methods are concerned, the vast majority (94.74%) of the studies used correlation analysis with a total of 36 articles. Followed by the regression, there are 11 articles, accounting for 28.95% of the total. Again, it is a structural equation model or path analysis. There are 8 articles in total, accounting for 21.05% of the total. Another (2.63%) article uses HLM. A total of 20 articles use regression, structural equation modeling, path analysis and HLM to explore the causal relationship between teachers' beliefs and knowledge. Three of them (15.00%) use teachers' beliefs and knowledge as independent variables and dependent variables; Three articles (15.00%) used teachers' beliefs as the independent variable and teachers' knowledge as the dependent variable; but the vast majority (70.00%) of the literature was based on teachers' knowledge as the independent variable and teachers' beliefs as the dependent variable, a total of 14 articles. This shows that most scholars believe that teachers' knowledge is the reason for explaining the result of teachers' beliefs.

4. Results

4.1 A holistic study of the relationship between teachers' beliefs and their knowledge

Overall, in 38 studies, a total of 84 teachers' beliefs and knowledge were discussed. Among them, the relationships between BT and knowledge were the most frequently discussed, 46 times, accounting for 54.76% of the total; followed by the relationships between BSTP and knowledge were discussed 20 times, accounting for 23.81% of the total; again, the relationships between BTA and knowledge were discussed 10 times, accounting for 11.90% of the total. In addition, the relationship between BCK, BS and knowledge were discussed four times respectively, each accounting for 4.76% of the total; no research (0.00%) explored the relationship between BCE and knowledge. Specifically (see Figure 6), the relationship between BT and CK is the most (20.24%), up to 17 times; secondly, the relationship between BT and PK, a total of 7 times; again, the relationship between BT and TPACK and PCK, respectively, 6 times, each accounting for 7.14% of the total.

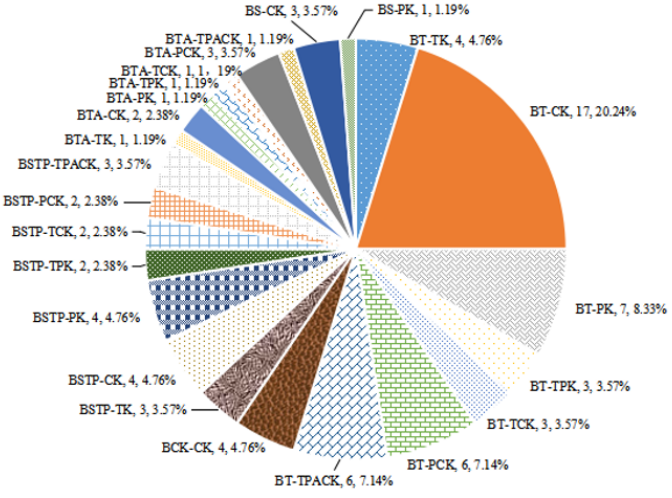

Fig. 6. Distribution of the relationship between teachers' beliefs and knowledge dimensions.

Among the results of 84 beliefs and knowledge relationships with teachers, 50.00% (42 times) resulted in a positive correlation between teachers' beliefs and knowledge; followed by a mix of 22 times, accounting for 26.19% of the total; the two have nothing to do, a total of 18 times, accounting for 21.43% of the total. In addition, only two (2.38%) results have a negative correlation between teachers' beliefs and knowledge. The specific

relationship between the dimensions of teachers' beliefs and the dimensions of teachers' knowledge is shown in Table 1.

Table. 1. Relationship between the dimensions of teachers' beliefs and the dimensions of knowledge.

	BT-TK	BT-CK	BT-PK	BT-TPK	BT-TCK	BT-PCK	BT-TPACK	BCK-CK	BSTP-TK	BSTP-CK	BSTP-PK	BSTP-TPK	BSTP-TCK	BSTP-PCK	BSTP-TPACK	BTA-TK	BTA-CK	BTA-PK	BTA-TPK	BTA-TCK	BTA-PCK	BTA-TPACK	BS-CK	BS-PK	total
positive correlation	4	5	5	3	2	2	6	3	3	1	1	2	2	0	2	0	0	0	0	0	0	0	1	0	42
negative correlation	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Irrelevant	0	4	1	0	1	2	0	0	0	2	3	0	0	2	1	0	0	0	0	0	0	0	2	0	18
Mixing	0	8	1	0	0	2	0	1	0	0	0	0	0	0	0	1	2	1	1	1	3	1	0	0	22
Total	4	17	7	3	3	6	6	4	3	4	4	2	2	2	3	1	2	1	1	1	3	1	3	1	84

4.2 The relationship between teacher self-efficacy beliefs and knowledge

In 38 articles, there were 46 conversations about BT (mainly teacher self-efficacy beliefs) and knowledge. Among them, most (58.70%) of the results were significantly positively correlated, up to 27 times; followed by differences in their internal results, a total of 11 times, accounting for 23.91% of the total; only 8 times (17.37%) of the results It shows that there is no significant relationship between the two. The specific relationship between BT and the dimensions of knowledge is shown in Figure 7.

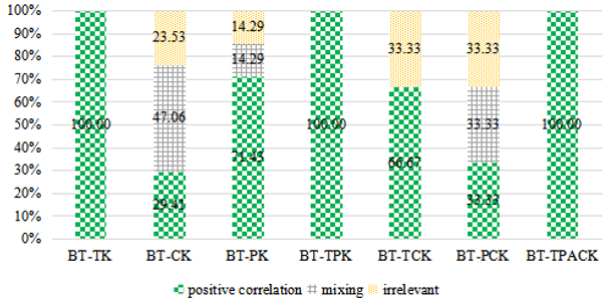

Fig. 7. The relationship between BT and different dimensions of knowledge.

A total of 4 articles [29][30][31] Hsu, Tsai, Chang, & Liang, 2017;López-Vargas, Duarte-Suárez, & Ibáñez-Ibáñez, 2017; Oskay, 2017) explored the relationship between BT and TK, and the results were all significantly positively correlated (100%). A total of three papers explored the relationship between BT and TPK (Abbitt, 2011; Hsu et al., 2017; Oskay, 2017), and the results were all significantly positively correlated (100%). A total of three papers explored the relationship between BT and TCK. The results of two (66.67%) literatures indicate a significant positive correlation (Abbitt, 2011; Hus et al., 2017); only one (33.33%) of the literature indicates that the two are irrelevant (Oskay, 2017). On the whole, the beliefs in this part of the study mainly refer to teachers' self-efficacy beliefs about technology integration and technology use. These beliefs are closely related to technology-related knowledge (TK, TPK, TCK). For example, Abbitt (2011) found that pre-service teachers' self-efficacy beliefs about technology integration had a significant positive correlation with TPCK, TPK, TCK, and TK in both pre- and post-tests; the study also found that in the pre-test TK and TPCK can significantly predict self-efficacy with an interpretative rate of 0.76. And in the post-test, TK, PK, PCK, and TPK can significantly predict self-efficacy with an interpretation rate of 0.83.

A total of 17 papers explored the relationship between BT and CK, and the results were somewhat different. Eight of them (47.06%) have differences in their internal results (Effeney & Davis, 2013; Ekstam, Korhonen, Linnanmäki, & Aunio, 2017; Fung el al., 2017； Leader-Janssen & Rankin-Erickson, 2013; Martinussen, Ferrari, Aitken, & Willows, 2015; Menon & Sadler, 2016; Newton et al, 2012; Smith et al., 2012). On the one hand, teachers' efficacy beliefs in different aspects will affect the relationship between the two. Ekstam et al (2017) found that the mathematics subject knowledge of pre-service special education teachers is only significantly and positively related to efficacy beliefs about teaching, but not related to efficacy beliefs about adjusting teaching for individual needs and efficacy beliefs about stimulating students. The study also found that teachers' mathematics subject knowledge can be indirectly influenced by teacher interest through teacher efficacy beliefs. Second, personal teaching efficacy is more closely related to CK than outcome expectancy. Newton et al (2012) found that pre-school and primary school pre-service teachers had a moderately significant positive correlation between math content knowledge and personal teaching efficacy, but did not have a significant relationship with outcome expectancy. Similarly, Smith (2012) also found that the knowledge of mathematics content of pre-service teachers can significantly predict personal mathematics teaching efficacy, but cannot significantly predict mathematics teaching outcome expectancy. In addition, the study of pre-service primary school teachers also shows that the acquisition of science concept knowledge is significantly positively correlated with the acquisition of personal science teaching efficacy beliefs, but it does not have a significant relationship with science teaching outcomes expectancy (Menon & Sadler, 2016). On the other hand, the relationship between teachers' efficacy beliefs and CK is also influenced by the nature of knowledge. Compared to measured knowledge, perceived knowledge is more closely related to teachers' efficacy beliefs. Effeney and Davis (2013) found that efficacy for teaching sustainability of primary school science teachers was significantly related to perceived knowledge, but not significantly related to measured knowledge. This result is consistent with Martinussen et al (2015) study of pre-service language arts teachers, and the study further points out that perceived knowledge was a significant mediator of the relationship between opportunities to observe phonemic awareness instruction and efficacy beliefs.

Second, the results of five (29.41%) literature indicates a significant positive correlation (Derscheid, Kim, Zittel, Umoren, & Henry, 2014; Oskay, 2017; Inaltun & Ates, 2015; López-Vargas et al., 2017; Oppermann, Anders, & Hachfeld, 2016). Derscheid et al (2014) found that preschool teachers' knowledge of healthy nutrition and physical activity practices can significantly predict their efficacy beliefs. Oppermann et al (2016) further points out that mathematical content knowledge can significantly predict teacher sensitivity in a positive way; mathematical content knowledge can significantly predict mathematical ability beliefs; and the former predictive effect is stronger than later. Furthermore, the results of four (29.41%) literature indicates that the two are irrelevant (Swars, 2018; Thomson, 2017; Sharp, 2016; Swars, 2007). Sharp (2016) three tests of literacy knowledge required to teach those skills and confidence levels in teaching specific literacy skills showed that there was no significant

correlation between the two; the study further pointed out that pre-service teachers CK does not predict self-efficacy beliefs, while teachers' self-efficacy beliefs do not predict teacher content knowledge. In comparison, the five studies that showed positive correlation in the former were mainly in-service teachers, and the latter showed that the four studies that were unrelated were pre-service teachers. The relationship between the two may be influenced by the teaching experience. Compared with pre-service teachers, in-service teachers have been at the teaching site, and their use of CK and the possibility of CK may be challenged higher than that of pre-service teachers. The CK of in-service teachers is more closely related to their BT.

A total of 7 papers explored the relationship between BS and PK. Among them, the vast majority of the literature (71.43%) results are significantly positively correlated (Abbitt, 2011; Oskay, 2017; Schriver & Czerniak, 1999; Shahali, Halim, Rasul, Osman, Ikhsan, & Rahim, 2015; Yildirim & Ates, 2012), a total of five articles. Schriver and Czerniak (1999) discovers when type of school organization and type of certification are controlled for, knowledge of developmentally appropriate curriculum and instruction was the best predictor of professional science teaching efficacy for both middle and junior high school science teachers with secondary certification and for middle school science teachers with elementary certification. The results of one (14.29%) literature indicates that the two are irrelevant (Depaepe & König, 2018). Depaepe and König (2018) found that there was no significant correlation between the general pedagogical knowledge and self-efficacy of pre-service teachers, and the results of the structural equation model also showed that there was no significant relationship between the two, and the two could not interact. There is also one (14.29%) literature showing that there are differences in their internal results (Lauermann & König, 2016). Lauermann and & König (2016) found that the general pedagogical knowledge of in-service teachers has no significant relationship with general self-efficacy, but has a significant positive correlation with teacher self-efficacy. At the same time, the study also found that general pedagogical knowledge negatively predicted teacher burnout both directly, as well as indirectly via its positive association with teaching self-efficacy.

A total of 6 papers explored the relationship between BT and PCK, and the results were somewhat different. Two of them (33.33%) reported that the two were significantly positively correlated (López-Vargas et al., 2017; Oppermann et al., 2016). Oppermann et al (2016) found that there is a moderately significant positive correlation between preschool teachers' mathematical self-efficacy and sensitivity to mathematics in play-based situations (one of PCK), and a weak significant positive correlation between mathematical self-concept and their sensitivity. Two (33.33%) literatures differ in their internal results (Abbitt, 2011; Thomson et al., 2017). Thomson et al (2017) found that in the three measurements, only STEM pre-service teachers, science PCK (time 1) and mathematics outcome efficacy (time 1), were significantly correlated, and there was no significant relationship between other time and other variables. Abbitt's (2011) study found that the pre-intervention teacher's efficacy beliefs about technology integration and PCK did not have a significant relationship, but the intervention was moderately positively correlated with the two; this indicates that the intervention improved teachers' self-efficacy and PCK, and can promote the relationship between the two. Two more (33.33%) literature shows that the two are irrelevant (Corkin et al., 2015; Oskay, 2017). The relationship between BT and PCK is more complicated and needs further study.

A total of 6 papers explored the relationship between teachers' self-belief and knowledge of technical teaching content (Abbitt, 2011; Hus et al., 2017; Joo et al., 2018; López-Vargas et al., 2017; Semiz, 2012; Oskay, 2017), and the results are Significant positive correlation (100%). Joo et al (2018) found a moderately significant positive correlation between pre-service teacher TPACK and technology use self-efficacy; Meanwhile, the direct effects of preservice teachers' TPACK on teacher self-efficacy was statistically significant.

4.3 The relationship between BCK and the dimensions of knowledge

A total of 4 articles explore the relationship between BCK and CK. Among them, 3 (75.00%) literature shows that teachers have a significant positive correlation with BCK and CK (Corkin et al., 2015; Smith et al., 2012; Swars et al., 2007). Corkin et al (2015) found that there is a significant relationship between the two. The better the knowledge of the in-service teachers' mathematics content is, the more availing is their epistemological belief. At the same time, the beliefs of black teachers and teachers' beliefs about mathematics can significantly predict the mathematics knowledge of teachers. Another 1 (25.00%) literature indicates that BCK and CK differ in their internal outcomes (Drageset, 2010). Drageset (2010) found that mathematics in-service teachers have a significant negative correlation with the beliefs of mathematics as rules construct, and specific content knowledge and common content knowledge, but no significant relationship between the beliefs about mathematics as reasoning construct, and specific content knowledge and common content knowledge. This shows that the type of teacher's beliefs about content or knowledge affects the relationship between the two.

4.4 The relationship between BSTP and the dimensions of knowledge

Of the 38 papers, 22 were devoted to the relationship between BSTP and knowledge. Among them, most (55.00%) results show that the two are significantly positively correlated, up to 11 times; secondly, the two are not related, a total of 8 times, accounting for 40.00% of the total; again negative correlation, a total of 1 Times, accounting for 5.00% of the total. The specific relationship between BSTP and the dimensions of knowledge is shown in Figure 8.

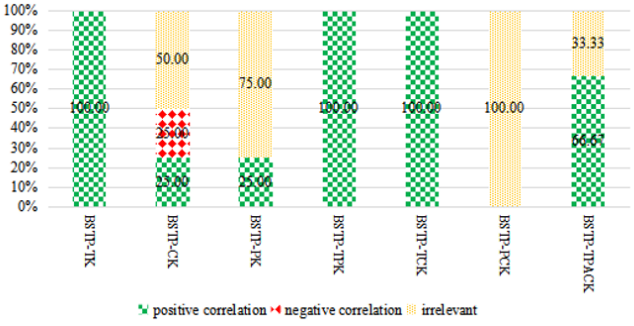

Fig. 8. The relationship between BSTP and the dimensions of knowledge.

A total of three papers explored the relationship between BSTP and TK (Cheng et al., 2018; Hus et al., 2017; Lehtinen, Nieminen, & Viiri, 2016), and the results were all significantly positively correlated (100%). Two papers explored the relationship between BSTP, and TPK and TCK (Cheng et al., 2018; Hus et al., 2017), and the results were also significantly positively correlated (100%). The beliefs involved in these studies are all teachers' value beliefs about use of technology, and these beliefs are closely related to technology-related knowledge (TK, TPK, and TCK).

A total of 4 papers explored the relationship between BSTP and CK and the results were somewhat different. The results of half (50.00%) of the literature indicates that the two are not related (Cheng et al., 2018; Lehtinen et al., 2016), a total of two articles. The results of one paper indicate that the two are significantly

positively correlated (Inaltun & Ates, 2015). The first two articles discuss the value beliefs about technology use for the unrelated literature, and the latter is the positive correlation literature that explores the beliefs about subject teaching. Relatively speaking, the beliefs of the latter are more closely related to CK. A further (16.67%) literature shows a significant negative correlation between the two (Wilkins, 2008). Wilkins (2008) found that the mathematics content knowledge and teaching beliefs of in-service teachers in primary schools were significantly negatively correlated; meanwhile, teachers' content knowledge was found to have a significant negative direct effect on teachers' beliefs about effective instruction.

A total of 4 papers explored the relationship between BTSP and PK. The results of most (75.00%) literature indicates that there is no significant relationship between the two (Cheng et al., 2018; Lehtinen et al., 2016; Shahali et al., 2015), a total of three articles. However, the results of one (25.00%) literature indicate a significant positive correlation between the two (Soliman & Alenazi, 2017). A total of 2 papers explored the relationship between teachers' beliefs in specific teaching practices and knowledge of teaching content (Cheng et al., 2018; Oskay, 2009), and the results were not significantly correlated (100%). This may be because the beliefs in both documents are related to the use of technology, and the relationship with the knowledge of teaching content is not very close. A total of three papers explored the relationship between BSTP and TPACK. The results of two (66.67%) literature indicates a significant positive correlation between the two (Cheng et al., 2018; Hus et al., 2017). Cheng et al (2018) found that the value beliefs of in-service teachers can significantly predict TPACK across both settings; the study also found that in the non-intervention setting, the relations between personal characteristics and TPACK are also moderated by teacher Value beliefs. However, the results of one (33.33%) literature indicate that there is no significant relationship between the two (Lehtinen et al, 2016).

4.5 The relationship between BTA and the dimensions of knowledge

In 39 papers, there were 10 conversations about the BTA and knowledge, and 9 of them (90.00%) showed that the relationship between the two had differences results. A total of 1 literature explores BTA and their relationship with TK, PK, PTK, TCK and TPACK (Chai, Chin, Koh, & Tan, 2013). Chai et al (2013) found that constructivist beliefs are more closely related to TPACK than traditional beliefs, and have a significant positive correlation with TPK, TCK, TPACK, CK, PK, PCK, and TK. A total of two papers explored the relationship between BTA and CK, and found that there are differences in their internal results (Chai et al., 2013; Lui & Bonner2016). Lui and Bonner (2016) found that among pre-service teachers, teachers with higher scores on conceptual knowledge are more likely to hold constructivist beliefs, but in-service teachers do not have a significant relationship between the two. This may be because of mathematics beliefs and beliefs about teaching and learning are two different belief clusters. Although teachers have constructive beliefs about teaching and learning at the moment, their belief about mathematics may also be traditional. Besides, the conceptual knowledge of pre-service teachers and in-service teachers and its relationship to traditionalist beliefs is not significant; the relationship between pre-service teachers and in-service teachers in process knowledge and traditionalist beliefs and constructivist beliefs is also not significant. This shows that the relationship between the two may be influenced by teachers' teaching experience, different orientations of teaching approach, and different types of content knowledge. A total of three papers explored the relationship between BTA and PCK. Two of them (66.67%) found that there were differences in their internal results (Blomeke, Buchholtz, Suhl, & Kaiser, 2014; Mercedes, Fiebranz, Möller, & Steffensky, 2017). Blomeke et al (2014) found that in three measurements, the initial mathematics pedagogical content knowledge would affect the subsequent teacher's belief, the first time teachers who measure mid-high mathematics pedagogical content knowledge scores tend to hold constructivist beliefs in subsequent measurements, but previous beliefs cannot predict subsequent mathematics pedagogical content knowledge. Another 1 (33.33%) literature found a significant positive correlation between the two (Chai et al., 2013).

4.6 The relationship between teachers' belief about students and teachers' knowledge

In 38 articles, there were 4 conversations about the relationship between BS and knowledge. Among them, three articles explored the relationship between BS and CK, and two of them (66.67%) showed no significant relationship between them(Inaltun & Ates, 2015; Smith, 2012). And one (33.33%) article shows that there is a significant positive correlation between the two (Swars et al., 2007). This may be related to the teaching experience. The first two articles are in-service teachers and the latter one is a pre-service teachers. A total of 1 discussion of BS and its relationship to PK showed (Hu, Fan, Yang, & Neitzel, 2017) that there was a significant negative correlation between the two. Hu et al (2017) found that there is a moderately significant negative correlation between kindergarten teachers' beliefs about students and knowledge of effective teacher-student interactions; in addition, teachers' beliefs about students play a mediating role in the relationship between knowledge and classroom organization and teaching support practices.

5 Discussion

As far as the research object is concerned, STEM related subject teachers have gradually become an important object of teachers' beliefs and knowledge relationship research. Since the second half of the 20th century, primary and secondary education in the United States has significantly strengthened its emphasis on mathematics and science. In the past 20 years, the concept of STEM education has gradually taken shape and was determined by legislation in the Bush administration in 2007. Since then, the various governments have continued to provide various types of protection and support for STEM education in the form of legislation. As a weather vane for educational practice and educational research, the US's attention to STEM has also made it increasingly popular in the world. For example, Thomson et al (2017) uses pre-service teachers enrolled in an elementary education teacher preparation program with a STEM focus at a large research university in the United States, to discuss the relationship between mathematics and scientific efficacy beliefs and pedagogical content knowledge and content knowledge. One of the common goals in the reform of the education system of governments, especially in the STEM field, is to improve the quality of teachers through teacher education and teacher professional development, thereby promoting student learning outcomes (Thomson et al., 2017). As an important factor affecting the quality of teachers and teaching achievements, the status of teachers' beliefs and knowledge and the relationship between them have become topics that STEM research has to pay attention to.

As far as data collection and processing is concerned, the collection of STEM teachers' beliefs data is relatively simple, mainly based on the questionnaire scale method. Although the questionnaire method is more convenient to collect a large amount of information about teachers' beliefs, as a subjective

report, this method also has certain defects. Although studies have suggested that STEM teachers' beliefs can be detected through multiple methods such as interviews, metaphors, and concept maps, these methods have not been adopted in the literature analyzed in this study, which may be due to the limitation of quantitative data. Relatively speaking, STEM teachers' knowledge data collection methods are more abundant. In addition to questionnaires, tests and other mainstream methods, it also involves scenario, concept maps and other methods. For example, Inaltun et al (2015) uses concept map technology to ask pre-service teachers to write the 12 most commonly used core electric current concepts, then go to construct network concept maps, and finally the scorer will perform evaluation according to the rationality of the concept map and the scoring criteria.

In the data analysis method, most of the research used correlation analysis to explore the interaction between the two. However, most of the studies using other diverse statistical analysis methods (such as path analysis and regression) use STEM teachers' knowledge as a factor influencing their beliefs. Despite the beliefs of how individuals interpret new information and experiences, and teachers' knowledge acquisition depends on their beliefs (Five & Buehl, 2012), some series of studies have shown that STEM teachers' knowledge is the influencing factor and precondition for the formation and development of teachers' beliefs. For example, Blömeke et al (2014) finds that it is a certain level of mathematics pedagogical content knowledge is needed before it is possible for future teachers to value constructivist approaches. In addition, having the necessary knowledge is one of the prerequisites that teachers' beliefs can be truly embodied in practice (Buehl, & Beck, 2015). Some researchers have found that the belief between STEM pre-service teachers and in-service teachers is different from practice because they lack knowledge of mathematics (Bray, 2011) and science (Kang, 2008),or teaching knowledge about how to carry out teaching practice activities (Teague, Anfara, Wilson, Gaines, & Beavers, 2012).

As far as the research content is concerned, the beliefs about themselves and its relationship to knowledge are the most frequently discussed, especially the relationship between beliefs about themselves and content knowledge. Fives (2003) pointed out that teachers' efficacy beliefs occupy an important place in STEM teachers' beliefs research and are closely related to teachers and their teaching. Subject content knowledge refers to the knowledge of the subject profession of teachers. The knowledge about what teachers teach and what students learn is the basis of all teachers' knowledge. Other knowledge is built around this part of knowledge. A qualified STEM teacher must first master the knowledge of the subject content he teaches, and at the same time have a positive efficacy beliefs, so that knowledge can be effectively taught to students. But the relationship between BT and CK is more complicated.

In terms of research results, half of the studies found a significant positive correlation between STEM teachers' beliefs and their knowledge, especially the relationship between BT and TK, BT and TPK, BT and TPACK, and BSTP and TK. However, some studies have found that the relationship between STEM teachers' beliefs and knowledge is complex, and even very few studies have found that the two are irrelevant or negatively correlated. This may be due to factors such as teachers' STEM teaching experience, teaching sections, teaching subjects and other factors as well as different types of teachers' beliefs and knowledge. Therefore, future research should pay more attention to the relationship between the two, improve STEM teachers' knowledge and change their beliefs through relevant courses, so that they can meet the requirement of educational reforms, and thus improve teaching quality of teachers and the STEM learning outcomes of students.

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