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Elementary Teachers' Perceptions of Their Professional Teaching Competencies: Differences Between Teachers of Math/Science Majors and Non-math/Science Majors in Taiwan

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Abstract The purpose of this study was to probe the differences of perceived professional teaching competence between elementary school math/science teachers in Taiwan who are majored in math/science and those who are not. A researcher-developed Math/Science Teachers' Professional Development Questionnaire was used in a nationwide survey, using a two-stage stratified random sampling involving 556 elementary schools and 1374 math/science elementary school teachers. The original questionnaire consisted of a total of 105 Likert scale questions distributed unevenly among four subscales. In this study, the authors selected a subset of 63 items from the above questionnaire and analyzed the available data in order to find out whether there is any

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significant difference in the perceived professional teaching competencies between the two groups of elementary school math/science teachers. The internal reliability of the selected items as measured by Cronbach's alpha was .97, while the result of a factor analysis indicated that the selected subset of items contained 10 key factors. ANOVA tests were conducted subsequently, and the results indicated that there were 9 key factors in which significant difference between the two groups of teachers existed. Considering their practical significance, two factors focusing respectively on teachers' self-efficacy in inquiry skills and abilities to provide students a learning environment that helps them understand the nature of math/science were identified as areas in which professional competencies for non-math/science majors need to be strengthened.

Keywords Elementary mathematics/science teacher · Professional teaching competencies · Teacher professional development

Background Related to Math/Science Teachers' Preparation and Professional Competence

Science education plays important roles in preparing an adequate supply of competent work force and in preparing citizens for the twenty-first century, which is characterized by a globalized science and technology-driven society. The achievements of scientific discoveries and technological inventions bear significant influences on our everyday lives. At work and at leisure times, we may need to utilize information of science and technology to help us make a judgment, make a decision and solve problems. Knowledge and skills in science and technology are also critical to our participation in discussions and debates on public issues (National Research Council (NRC), 1996). Indeed, science education is a focal point of the educational reform in science and technology advanced countries such as the USA (Carnegie Corporation of New York and Institute for Advanced Study, 2009; NRC, 1996, 2007), and in Taiwan as well.

Concurrent with reforms in science and mathematics education worldwide, there is a general call in the teaching of science and mathematics at schools in recent years that emphasizes, for instances, (1) students' understanding of key concepts rather than rote memorization; (2) knowledge and skills that are relevant to students' daily lives; (3) the importance of key competence such as scientific inquiry skills, problem solving skills, communication skills, critical thinking skills and so on; and (4) the importance of fostering scientific literacy for all students, rather than focusing on the preparation of future scientists and engineers. The Grade 1–9 Curriculum Guidelines (Ministry of Education, 2000) took these matters into account, and they were followed by textbook writers in the development of commercially available textbooks. However, whether classroom teachers are capable of teaching science and mathematics according to the new curriculum guidelines, and what kind of support and professional development they need are questions that need to be investigated. Since teachers who teach science and mathematics courses at elementary schools may or may not be math/science majors while attending preservice teacher preparation programs, the answers to the above questions may be different for teachers of math/science majors and for those who are not. In fact, there are approximately 3/4 teachers who teach science or mathematics courses at elementary schools in Taiwan are not math/science majors whose learning experiences and subject matter knowledge of science and mathematics are limited (Wu, Cheng, Tuan & Guo, 2011). It is therefore of practical significance to have a nationwide survey of elementary school teachers' perceptions of their professional teaching competence and to find out whether there are any differences between the math/science majors and non-majors. The research findings are expected to be informative for school administrators, for teacher professional development providers and for policy decision makers.

Changing Practices of Preservice Math/Science Majors and Non-math/Science Majors Elementary Teachers' Preparation in Taiwan

Significant changes in the preparation of preservice elementary teachers' in Taiwan occurred in the past half decade or so. As a result of the prevailing political ideologies which shape the educational policies, the goals and practices in teacher education changed accordingly, leading to changes in the selection criteria for admission, the course requirements for the preservice teachers, the provisions of teacher education programs, and the establishment of teacher education institutions (Peng, 2011). From the 1960s to 1987, elementary school teachers in Taiwan were prepared primarily by a number of Junior Teachers' Colleges offering 5-year programs for students finishing junior high schools. In addition to a solid foundation in educational courses and method courses, students taking math/science as a major were expected to have average learning experiences in science and math roughly equivalent to their freshmen counterparts in other 4-year universities. In terms of subject matter knowledge in math/science, the stories for non- math/science majors were quite different. In their first 3 years of study, they were required to take courses on natural history, chemistry, and physics at a level more or less equivalent to similar courses offered for non-math/science track students in high schools (Lee, 2009). However, it was criticized that in many Junior Teachers' Colleges these courses were delivered in lecture sessions only, the students lacked laboratory experiences, and being preoccupied in other activities, their basic knowledge and skills in science were far behind the average high school students (Yang, 1988). Other concerns about the lack of adequate scientific literacy of elementary school teachers arise because there were very few students who opted to take science-related courses in their fourth and fifth years of study; in addition, there was a lack of stable supply of professors to teach these courses in the Junior Teachers' Colleges (Hsiung, 2010, January; Yang, 1988).

As part of an educational reform movement, the original Junior Teachers' Colleges were transformed into 4-year Teachers' Colleges in 1987 with a few newly established ones. Incoming students into Department of Science and Mathematics Education were from graduates of senior high schools intending for science and technology-related careers in the future. These math/science majors accounted for about 14~20% enrollments in the nine Teachers' Colleges all over Taiwan (Lee, 2009). science major teachers,/science majors were required to take 18~22 credits of math/science courses including mathematics, physics, chemistry, and biology. However, the contents covered in the science courses were at the senior high school level, because the non-math/science majors only studied general science in grade 7 (Chang, 1989; Lee, 2009). A survey result using the Basic Competence in Chemistry Questionnaire indicated that of the non-math/science majors at the Teachers' Colleges fell far behind the math/science majors at the Teachers' Colleges and the graduates from Junior Teachers' Colleges (Chen & Shu, 1990).

The changing government policy dealing with teacher education was affected again by the enactment of the Teachers Education Law in 1994, which opened multiple channels for teacher preparation and allowed all public and private universities offering certified teacher preparation programs to prepare teachers. The original requirements of 18~22 credits of math/science courses for non-math/science majors were no longer required in the teacher education preparation programs. The end result is that there are a significant portion of elementary school teachers who may be assigned to teach science courses, yet their subject matter knowledge in science is limited to senior high school level (Lee, 2009). The instructional goals for colleges and universities offering teacher programs are to prepare their students for passing the Preliminary Teacher Qualification Certification. The preparation of elementary school teachers in these programs tend to focus on students' general teaching competence, and their subject matter knowledge in specialized domains are no longer emphasized (Hsiung, 2010, January; Ministry of Education, 2013).Consequently, courses such as Introduction to Natural Sciences and Methods Course in Science Teaching are no longer required. Without the subject matter knowledge and pedagogical competence provided by such courses, and without adequate personal experiences in using scientific methods and ways of thinking, it is doubtful that beginning teachers will have adequate professional competencies to skillfully arrange science learning activities for the elementary students and to guide them to carry out science inquiries and to think critically. The future development of science education in elementary schools appeared to be gloomy (Hsiung, 2010, January; Wang, 2007).

Implications from Studies on How Students Learn Science and Mathematics

Schools cannot be improved or changed without improving the skills and abilities of the teachers who work in them (Darling-Hammond, 2009; Hargreaves, 1997). Therefore, professional development processes must address their needs and concerns (Darling-Hammond, 2010). In the field of science and mathematics education, research on the knowledge, skills, and beliefs of effective teachers is a field that has been extensively studied over the years (Bransford, Derry, Berliner & Hammerness, 2005; Cakiroglu, Capa-Aydin & Woolfolk, 2012; Fraser, 2007; Jones & Carter, 2007; Michalsky, 2012; NRC, 1996; National Science Teachers Association (NSTA), 2003; Shulman, 1986). In addition, assessment tools to evaluate the performance of science and mathematics teachers and their needs for professional development have been developed and used in many large scale research projects (Council of Chief State School Officers and Wisconsin Center for Education Research, CCSSO, and WCER, 2004; Horizon Research, Inc, HRI, 2000, 2003). While the insight and suggestion from a wide range of literature on science and mathematics teacher education and professional development are consulted in this study, it is particularly noteworthy to focus our attention on the desired professional competence for the elementary math/science teachers in response to findings and suggestions from recent studies on how students learn science and mathematics (Bransford, Brown & Cocking, 2000; NRC, 2007).These reports summarized recent studies on how students learn in science and mathematics, as well as in many other subjects, from a wide range of research perspectives, and offered new insights for practice and research in science education.

It is also noteworthy to mention the learner-centered psychological principles advocated by the American Psychological Association (APA, 1997), which is expected to provide a framework that can contribute to educational reform and school redesign efforts.

The 14 learner-centered psychological principles influencing learners and learning are divided into those referring to cognitive and metacognitive, motivational and affective, developmental and social, and individual difference factors. For example, within the cognitive and metacognitive factors, it is emphasized that the learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience, and that successful learner can link new information with existing knowledge in meaningful ways (APA, 1997). The important roles of preconceptions, scientific inquiry, and meta-cognition in students' science learning are implied. Also, the principles are intended to apply to all learners—from children, to teachers, to administrators, and so on. Therefore, it is imperative that elementary school math/science teachers be equipped with the professional competencies to teach math/science using strategies and methods which are in line with these principles.

Purpose and Research Question

It is a common practice in Taiwan that elementary school teachers who teach science and/or mathematics need not be math/science majors in their preservice teacher education programs. Apart from some case studies and small-scale studies, focusing typically on teachers' subject matter knowledge, there is a lack of more comprehensive study as to how confident the non-math/science majors are while teaching math and/or science at schools, and what kind of professional development support they would need. Being an elementary school science teacher for more than 10 years and having close contacts with the non-math/science major teachers, Wu (2017) knows well the difficulties and challenges they encounter and realizes intuitively the importance of exploring this matter with the availability of data collected from a nationwide survey.

Considering the course requirements of the current teacher education programs in Taiwan, a close examination of the findings and suggestions from recent studies on how students learn science and mathematics together with 14 learner-centered psychological principles as mentioned above indicates that teachers who are math/science majors tend to have more favorable learning contexts and experiences to learn and to practice the necessary knowledge and skills in teaching elementary math/science than those who are non-math/science majors. Therefore, we came up with a research question focusing on whether there are any differences between elementary teachers with math/science majors and non-math/science majors in their perceived professional teaching competencies, pertaining to the teaching of mathematics and science using student-centered approach. In addition, with the improvement of teacher development programs in mind, this study also aimed at identifying the most important professional competencies that teachers with non-math/science majors would need to develop.

Method

Participants and Sampling

Information obtained from the Ministry of Education indicated that there are a total of 69,555 teachers teaching some classes on mathematics and science at the elementary schools. A two-stage stratified random sampling method was used in this study, in order to ensure that a representative sample of the nationwide population of elementary mathematics and science teachers was obtained. The first stage involved a stratified cluster sampling of schools within the 25 cities and counties, taking school sizes into consideration. Nationwide, for the elementary schools with school size categorized as large, medium, and small, the proportions of schools selected in the first stage were 27, 26, and 20%, respectively. The second stage involved an equal allocation sampling of 3 teachers (1 math teacher, 1 science teacher, and 1 class teacher) from the sampled schools of the first stage, using a random number table. Such a sampling procedure ensured that teachers of different backgrounds were included. The final result was a sample of 1617 elementary math and science teachers.

Finally, we obtained from 556 schools a sample of 1617 math/science elementary schools teachers. The valid questionnaire sample is 1374, accounting for 2% of the population all over Taiwan, which is relatively high for this type of survey. The participating teachers represented an 85% response rate, and they included 372 (27.1%) math/science majors and 966 (70.3%) non-math/science majors. There were 36 (2.6%) teachers who did not select the categories they fitted in, and their corresponding data were considered as missing.

Selection of Items from the Original Questionnaire

As mentioned earlier, a researcher-developed Math/Science Teachers' Professional Development Questionnaire was used previously in a nationwide survey on teachers' perceptions of their professional teaching competence in math/science teaching. The rationales for the development of the questionnaire and the procedures for its validation were discussed at length in the doctoral thesis of Wu (2017), and for want of space, they will not be repeated here. For the main purpose of the present study, it suffices to say that since elementary school math/science teachers are expected to have a wide range of professional competencies, the questionnaire developed in the above mentioned study focused on four major dimensions, namely, instructional design (ID), instructional activity (IA), new constructivist learning environment (NCLE), and self-efficacy toward inquiry teaching and pedagogical content knowledge (PCK) for math/science (SE) teaching. Table 1 shows the names of the subscales, together with brief descriptions and a few sample items.

The above mentioned questionnaire also covered a range of potential influencing factors, including teachers' gender, teachers' roles as subject teachers or as class teachers, teachers' administrative positions if any, previous educational background in terms of majoring in math/science or not, years of teaching science/math courses, learning experiences from previous professional development opportunities, school sizes and locations, and so on. However, due to space limitation, this study will examine the question and report the findings as to whether there are any differences between elementary teachers with math/science majors and non-math/science majors in their perceived professional teaching competencies.

There were a total of 105 Likert scale questions in the original questionnaire distributed unevenly in four subscales. Each of the 5-point Likert scale questions asked the teachers whether he/she strongly disagrees, disagrees, has no comments, agrees, or strongly agrees with the given statement regarding to his/her teaching competence. For

Table 1 Descriptions of teacher teaching competence scales and sample items

Subscales	Descriptions	Sample items
ID	Teachers assess whether the lessons designed are based on grade 1–9 curriculum frameworks in Taiwan	Adequate time and structure were provided for "sense-making"
IA	Teachers estimate the relative amount of time a typical student in class will spend when engaged in each activity over the course of a school year	Work in pairs or small groups
NCLE	Teachers assess the extent of constructivist learning environment in the math/science class regarding: students' attitude concerning instruction, cooperative learning, meaningful understanding, and scientific processes	I help the students understand the relevance of current and previously learned content
SE	Teachers assess self-efficacy on various dimensions including scientific inquiry skills, knowledge of instructional orientations and strategies, knowledge of learners' understandings of math/science, information and communication technology (ICT) teaching skills, etc.	I am knowledgeable of the applications of various math/science instructional strategies

questions dealing with teachers' instructional practices, the responses were replaced by alternatives such as never, little, some, moderate, and considerable; or never, rarely, occasionally, often, and always. Numerical values from 1 to 5 were assigned to these categorical responses. The negatively worded items were scored in the reverse direction.

Using the SPSS Base 17.0 software, a MANOVA was conducted to determine the overall effects of the background variables on teachers' perceptions of their professional competence using the original questionnaire. The results indicated that there were no significant differences on interaction effect but teacher's assigned role (as major teacher of the class or as a teacher who teaches a particular subject), gender, assigned administrative positions, and educational background (math/science majors or non-math/science majors) were the most influential factors which led to significant differences in the overall results ($p < .05$), with $\eta 2$ equal to .115, .030, .027, and .026, respectively. For the main purpose of the current study, the results indicated that although difference in teachers' educational background led to significant difference in the overall scores, it implied a practical significance in the little to low moderate range (Cohen, 1988). Table 2 were obtained from subsequent ANOVA as follow-up tests to determine in which subscale teachers' educational background would lead to significant statistical difference in their mean scores, and what would be the effect size in terms of Cohen's *d*. It is noted that in the ID (instructional design) subscale there was no significance between the two groups of teachers, while there were significant differences at $^*p < .0125$ in the other three subscales, namely IA, NCLE, and SE. However, the corresponding effect sizes for the latter three subscales were 0.18, 0.26, and 0.32. According to Cohen (1988), the difference in mean score is considered to be "small" at d equals to or less than 0.20, and "medium" at .50. The practical significance of the above results was low moderate.

It was realized that since the original questionnaire was not particularly designed for exploring the difference of teachers' perceptions of their professional competencies between the two groups of teachers, it contained many items which were not

Table 2 Difference in the perceived professional competencies as measured by the 4 subscales

Subscale	Math/science majors (n = 358)		Non-math/science majors (n = 926)		ANOVA		Statistical power
	Mean	SD	Mean	SD	F	d	
ID	3.70	0.55	3.66	0.54	1.413	.07	.37
IA	3.05	0.60	2.94	0.62	7.639**	.18	.90
NCLE	3.72	0.52	3.57	0.52	22.676***	.26	1.00
SE	3.90	0.40	3.77	0.41	25.961***	.32	1.00

*p < .0125(=.05/4), **p < .01, ***p < .001

particularly relevant to teachers being math/science majors or not. In order to look for potential differences of teachers' perceptions of their professional competencies between teachers with different educational background, and to discuss their implications for preservice teacher education as well as continuing professional development programs, an attempt was made to select from the original questionnaire a subset of 63 items having significant different mean scores between the two groups of teachers based on results from ANOVA analysis of individual items. Among the selected items, there was only 1 item from the ID subscale, 6 items from the IA subscale concerning guided inquiry, 18 items from NCLE and 38 items from SE subscale.

Data Analysis

A factor analysis was conducted in order to search for key factors comprising the selected subset. The Cronbach's alpha for each key factor was calculated. So did the inter-key factor correlation coefficients. ANOVA tests were conducted in order to determine in which key factor teachers' educational background led to significant difference between their mean scores and what the corresponding effective size would be.

Results and Discussions

Results from Factor Analysis

The final result obtained from a principal components factor analysis with varimax rotation indicated that the selected 63 items from the original questionnaire contained 10 key factors, with 69.93% total variance explained (Appendix 1). The Cronbach's alpha reliability coefficient for the selected subset of items was .97, and as shown in Appendix 1, the corresponding values for the 10 key factors ranged from .78~.95. Table 3 shows descriptions of the 10 key factors, together with the number of items and a sample item for each factor. The inter-key factor correlation coefficients for the 10 key factors are shown in Table 4. The mean inter-key factor correlations between a given key factor and the rest 9 key factors ranged from .34~.47, with an average value of .42, indicating the moderate discriminant validity among the key factors. A close examination of the contents of items included in the key factors indicated that the 10 key factors were either concerned primarily with teachers' self-efficacy in various aspects or

Table 3 Descriptions, number of items, and sample item for the 10 key factors

Key factor	Descriptions	Number of items	Sample item
1. ISSE	Self-efficacy in inquiry skills	11	I can provide reasonable argument to support my research findings.
2. CLE	Providing students a cooperative learning environment	8	I guide my students to discuss with others on how to interpret experimental results.
3. GISE	Self-efficacy in guiding students to develop inquiry skills	7	I am capable of guiding my students to use laboratory equipment with adequate manipulative skills,
4. ITSE	Self-efficacy in instructional skills for inquiry teaching in math/science.	9	I am able to design extended inquiry activities in order to help students learn.
5. ATLE	Capable of raising students' attitudes toward math/science	6	Students in my class indicate that the topics and the ways I teach are very interesting to them.
6. GILE	Providing students an environment to learn math/science through guided inquiry	6	I guide my students to read outside reading materials in math/science, including books, magazines, and journal articles.
7. SUSE	Self-efficacy in the knowledge of students' understandings of math/science	4	I am knowledgeable of helping students to overcome their potential difficulties in learning the topics covered in a given unit.
8. ISSE	Self-efficacy in the knowledge of math/science instructional strategies	4	I am knowledgeable of the methods and/or procedures in the application of various math/science instructional strategies (for example, learning cycles, analogy, conceptual change teaching and learning, etc). (Continued)
9. IOSE	Self-efficacy in the knowledge of instructional orientations in math/science	4	I have my own opinions or viewpoints on the use of instructional approaches in math/science teaching at the elementary school level (for example, focusing on knowledge transmission, process skills, or inquiry).
10. UNLE	Providing students a learning environment that helps them understand the nature of math/science	4	I help students understand that knowledge in math/science (e.g. the gravitational force Newton proposed) needs evidence to support it.

with teachers' math/science instruction and the learning environment they provided. This is reflected in the descriptions for the key factors as shown in Table 3.

Difference as Indicated by Mean Scores of the Key Factors

Results from the use of ANOVA to analyze the 10 key factors are shown in Table 5.

As shown in Table 4, except for factor 7 (SUSE), significant differences between the two groups of teachers existed in the rest 9 key factors. Focusing on the effect size for the difference of mean scores between the two groups of teachers in the 10 key factors,

Table 4 Correlation coefficients of 10 key factors

Key factor	1	2	3	4	5	6	7	8	9	10
1. ISSE	–									
2. CLE	.48**	–								
3. GISE	.59**	.56**	–							
4. ITSE	.66**	.46**	.64**	–						
5. ATLE	.44**	.56**	.44**	.50**	–					
6. GILE	.37**	.57**	.33**	.35**	.48**	–				
7. SUSE	.40**	.32**	.42**	.53**	.39**	.19**	–			
8. ISSE	.46**	.38**	.42**	.59**	.43**	.34**	.59**	–		
9. IOSE	.46**	.35**	.42**	.56**	.42**	.24**	.63**	.62**	–	
10. UNLE	.47**	.64**	.47**	.46**	.50**	.51**	.37**	.41**	.41**	–
Mean	.43	.43	.43	.47	.41	.34	.38	.42	.41	.42

$^{**}p < .01$

it is noted from Table 4, that the largest two *d* values were associated with factor 1 (ISSE) and factor 10 (UNLE), being 0.46 and 0.38. They are slightly less than 0.5 which is considered to be a medium effect size according to Cohen (1988) and may imply moderate practical significance. Factor 1 is related to teachers' self-efficacy in inquiry skills to identify research problems, to develop research design and procedures, to collect data using appropriate instruments and procedures, to analyze and interpret data collected, to justify and communicate research findings, etc. While factor 10 refers to teachers being able to provide students with a learning environment that helps them understand the nature of math and science, including questions such as I help student understand that math/scientific theories are inferred from evidences, I help student understand that scientific theory can be used to design new experiments, and so on. It appears that for non-science majors their professional competencies along directions associated with these two key factors may need further improvement.

On the other hand, there are 5 key factors, ranging from factor 4 to factor 8, for which the corresponding *d* values are either slightly larger than or even less than 0.2. Since $d = 0.2$ is considered as small according to Cohen's effect size convention, the differences observed in these 5 key factors are of little practical significance.

As shown in Table 4, the *d* values for factor 2 (CLE), factor 3 (GISE), and factor 9 (IOSE) were respectively 0.28, 0.29, and 0.32. They are related to teachers being able to provide students a cooperative learning environment, teachers' self-efficacy in guiding students to develop inquiry skills, and self-efficacy in the knowledge of instructional orientations in math/science, respectively. The *d* values are less than 0.5 and larger than 0.20. Their practical significance is toward the low moderate end, at best.

As pointed out earlier, there was no significant difference between the mean scores of the two groups of teachers in factor 7 (SUSE). A closer examination of the items covered by the key factor SUSE indicated that it referred to teachers' self-efficacy in the knowledge of students' understandings of math/science, for instance, that the teacher is capable of understanding how difficult the contents in each unit are for the students, where students' potential difficulties and misconceptions might be, and how to help students overcome these learning difficulties. Whatever the reasons might be, it occurred that teachers' perceptions of their self-efficacy in the knowledge of students'

Table 5 Comparisons of 10 key factors mean scores

Key factor	Math/science majors (n = 356)		Non-math/science majors (n = 921)		ANOVA		Statistical power
	M	SD	*M*	SD	*F*	d^a	
1. ISSE	3.86	0.49	3.60	0.57	56.23***	0.46	1.00
2. CLE	3.65	0.72	3.44	0.74	20.07***	0.28	.98
3. GISE	3.95	0.53	3.78	0.60	23.19***	0.29	.99
4. ITSE	3.90	0.44	3.79	0.48	17.04***	0.23	.95
5. ATLE	3.60	0.60	3.46	0.62	14.11***	0.23	.90
6. GILE	2.81	0.71	2.68	0.72	9.14**	0.18	.70
7. SUSE	3.92	0.54	3.86	0.53	2.99	0.11	.21
8. ISSE	3.65	0.64	3.50	0.67	13.80***	0.22	.96
9. IOSE	3.83	0.62	3.63	0.61	29.61***	0.32	1.00
10. UNLE	3.80	0.63	3.54	0.69	39.34***	0.38	1.00

**$p < .01$, ***$p < .001$

[a] Effect size using Cohen's *d*

understandings of math/science were nearly equally positive for both math/science majors and non-math/science majors, the mean scores being 3.92 and 3.86. Incidentally, it is noted from Table 4 that for non-math/science majors their mean score in factor 7 (SUSE) was the highest one among the 10 key factors (Fig. 1). Also, there is a general tendency that teachers' mean scores for key factors related to their self-efficacy were relatively high, in fact, somewhat higher than those related to the learning environment they provided, except for Factor 8 (ISSE) concerning teachers' self-efficacy in the knowledge of math/science instructional strategies. It included questions asking teachers whether they knew the procedures, methods, and characteristics involved in various instructional strategies (for example, learning cycles, analogy, and conceptual change teaching) in math/science teaching; whether they knew how to adopt effective instructional strategies for different instructional goals and orientations; and whether they were able to proficiently practice different instructional strategies in math/science teaching.

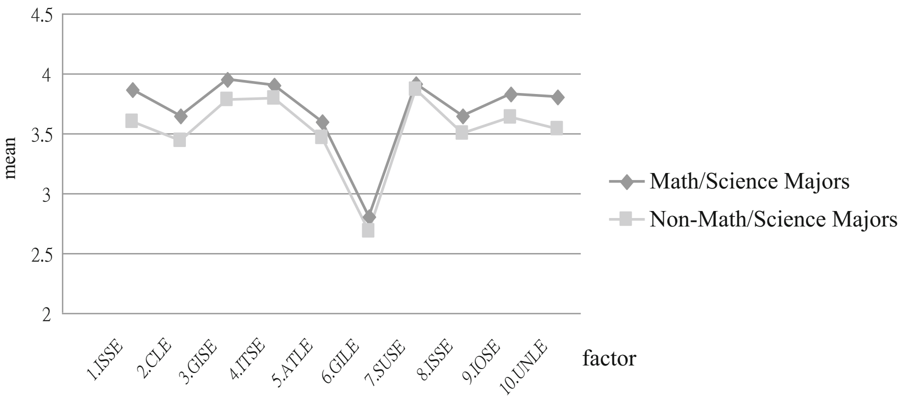

Fig. 1 Comparisons of 10 key factors mean scores

For factor 6 (GILE), the mean scores for both groups of teachers were respectively 2.81 and 2.68, being much lower than the mean scores of the rest 9 key factors (Fig. 1). Factor 6 refers to teachers' perceptions about providing students an environment to learn math/science through guided inquiry. It included questions asking teachers whether in their classes students were guided to learn the scientific process skills, to read outside readings about math/science in books/magazines/articles, to work on a project over an extended period of time, to collect data (other than laboratory activities), to write about science in a report, and so on.

Conclusion and Implication

Through the selection of a subset of 63 items from the original questionnaire used in a nationwide survey, we are able to identify key factors concerning math/science teachers' perceived professional competencies in which there are significance differences between the math/science majors and non-science majors and to assess their practical significance according to Cohen's *d* value conventions. Except for factor 7 (SUSE, self-efficacy in the knowledge of students' understandings of math/science), significant difference was found between mean scores for the two groups of teachers in the rest 9 key factors. However, among these 9 factors, it was noted that the identified differences were of moderate practical significance only for factor 1 (ISSE) and factor 10 (UNLE). These two factors focused respectively on teachers' self-efficacy in inquiry skills and abilities to provide students a learning environment that helps them understand the nature of math/science, and they appear to be areas in which the professional competencies for non-math/science majors need to be strengthened, either in their preservice or continuing professional development programs. On the other hand, the practical significance for the other key factors was either of low moderate or little practical significance. It is noteworthy that for factor 6 (GILE), referring to teachers' perceptions about providing students an environment to learn math/science through guided inquiry, the mean scores for both groups of teachers were much lower than those of the rest key factors. Math/science teachers' professional competency in this area is relatively weak for both math/science majors and non-math/science majors. This finding is somewhat unexpected, yet it seems to bear important implications for teacher education institutions and elementary schools.

Limitations of the Study

This study is part of a national survey with a large number of sampled subjects. With the use of self-report instruments in collecting data, there were incurring limitations. Also, we focused only on teachers' educational background in terms of whether they are math/science majors or not. It is possible that confounding variables existed, yet their potential influences were not explored. As it was reported elsewhere that teachers with high-levels of self-efficacy might perform less efficiently in their teaching practices (Saka, Bayram & Kabapınar, 2016), there are indications from our results that this phenomena might also have happened in this study.

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