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How a Beginning Science Teacher Deals with Practical Work: an Explorative Study Through the Lens of Identity

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Abstract

Through the lens of teacher professional identity, in this case study, we examine how a beginning science teacher deals with practical work in a physics classroom. We explore how various interactions occurred between personal, interpersonal, and situational dimensions of his identity as a beginning physics teacher when dealing with practical work. Various kinds of data were collected over a period of 10 months: 3 semi-structured interviews, 26 classroom observations, 32 brief interviews, as well as various artifacts and lesson plans. The analysis was done through a constant comparative method, and it was grounded within the three-dimensional framework of professional identity: personal, social, and situational. Four main themes emerged through the analysis of the data that represent the main features of the participant's identity enactment as a beginning physics dealing with practical work: (a) personal characteristics, (b) sense of agency, (c) contextual constraints, and (d) ongoing interpretation of experiences with practical work. These findings are presented through a narration of the participant's identity with regard to practical work alongside authentic extracts and quotes from the data. Drawn upon these findings, we offer a set of recommendations for future research.

Keywords Case study · Beginning science teachers · Practical work · Teacher identity

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Introduction

The initial years of teaching, or the induction period, has proved to be the most difficult stages of teachers' careers (Luft and Patterson 2002). This is the time that novices strive to adapt ideas from teacher preparation programs to the realities of classrooms and school contexts and the time that they learn to socialize into the culture of the school to form new identities of practicing school teachers (Luft 2007; Saka et al. 2013). As a matter of fact, a series of research studies showed that teachers deal with many difficulties during the induction period, including discipline and classroom management, contextual contradictions, poor administrative support, limited resources, lack of time due to an overloaded schedule, and contradictions between theory and practice (Davis et al. 2006; Henry et al. 2011; Luehmann 2007; Luft and Patterson 2002). For a long period of time, school science is featured with practical work, which generally refers to *prac* or *pracs* used in science teaching (Wallace 2015) and usually includes teacher demonstrations and the experiments conducted by the students cooperatively or individually (Hofstein 2015). Compared with other subject areas, therefore, practical work has constituted a challenge for beginning science teachers. Moreover, reform-driven science curriculums have placed much emphasis on scientific inquiry, which is often connected with practical work (Osborne 2014). Conducting inquiry-oriented practical work is another challenge for beginning science teachers (Davis et al. 2006).

Given that the enactment of practical work interrelates with various other constructs such as teachers' epistemological beliefs, subject knowledge, pedagogical content knowledge (PCK), teachers' orientations and positioning, as well as factors relating to the context and school culture (Hofstein et al. 2013), there is a need for adopting a comprehensive lens in examining teachers' enactment of practical work. Such comprehensive and multidimensional lens can been found in the construct of teacher identity (Avraamidou 2014a). For the purpose of this study, identity is used to refer to the "ways in which a teacher represents herself through her views, orientations, attitudes, content knowledge, knowledge, and beliefs about science teaching, and the ways in which she acts within specific contexts" (Avraamidou 2014b, p. 2). In this study, we use Zheng (a pseudonym) as a case to explore how the interactions between his identity as a beginning physics teacher, the school context, and his personal dispositions influenced his actions in dealing with practical work during the first 2 years of his teaching career. Specifically, the research question that guided this study is as follows:

- How does Zheng view, represent himself, and act within a specific school context when dealing with practical work?

In responding to this question, we aim to shed light on how beginning science teachers' negotiate and enact their identities related to practical work in the classroom. As such, we aim to contribute towards an improved understanding of science teacher identity and its enactment in relation to practical work and scientific inquiry.

Theoretical Framework

Theoretically, this study is framed within Gee's (2000) conceptualization of identity as "the kind of person one is seeking to be and enact in the here and now" (p. 13). Identity-based research has a long tradition in the field of education, and it has begun to make its presence in

science education as well in the past decade (Avraamidou 2014a; Lee 2012). Avraamidou (2014a) argued that identity provides an invaluable lens to studying teacher learning and development for the following reasons:

- Identity offers a powerful and multidimensional lens to studying teacher learning and development that goes beyond knowledge and beliefs.
- Identity highlights the role of the context in teacher learning and development.
- Identity has the potential to shed light on teachers' personal histories in relation to science.
- Identity allows us to examine the impact of social markers on teacher learning and development (p. 164).

As for the nature of teacher identity, it is widely recognized among the research community that it is dynamic, holistic, comprehensive, and multifaceted (Akkerman and Meijer 2011; Beauchamp and Thomas 2009; Luehmann 2007; Varelas 2012). As argued by Avraamidou (2014a), beyond what a teacher knows and is able to do, the value of the construct of identity can be found in its potential to capture the intersection of a teacher's knowledge and skills, beliefs, emotions, orientations, and positioning. With teachers' professional development as a major concern, most research studies have used *professional identity* (Beijaard et al. 2004). In their review of the literature, Beijaard et al. (2004) identified the following aspects as essential characteristics for teachers' professional identity: (a) Identity is an ongoing process of interpretation and re-interpretation of experiences; (b) it implies both person and context; (c) it consists of sub-identities; and (d) agency is central, which refers to the need of teachers to be active in the process of professional development. In particular, the notion of agency has drawn many scholars' attention, and quite a few studies have explored the interplay between identity and agency in the field of teacher education (V h santanen 2015). Moreover, as empirical studies showed, personal motivations, desires, and emotions are interwoven into the development of professional identity and play a key role in constructing teachers' identity (e.g., Akerson et al. 2014; O'Connor 2008). These aspects of identity as well as the factors that may be influencing its development have been taken into consideration when designing this study.

According to Coldron and Smith (1999), the construction of a teacher's identity is determined by a wide array of possibilities, such as subject traditions, prevailing pedagogic traditions, the practices of the various professional communities to which he or she belongs, and external constraints brought into critical relation to teaching. This implies how teacher identity is a dynamic personal process, which is constantly under formation and reformation. As Flores and Day (2006) argued, the development of a professional identity is an ongoing and dynamic process which "entails the making sense and (re)interpretation of one's own values and experiences" (p. 220). That is to say, the identity is based on a self-evaluation of traits, likes, dislikes, interests, and so on (Brewer and Gardner 1996). Moreover, relationships are thought to be an essential factor in constructing the identity because "one must be recognized as a particular kind of person by others" (Rodgers and Scott 2008, p. 735). The interpersonal identity is based on relational concepts of the self, including views of friends, colleagues, and students (Day and Kington 2008). Third, as identified by many researchers, a teacher's identity is situation relevant (Avraamidou 2014a; Beijaard et al. 2004; Gee 2000). Specifically, a teacher's identity is usually located in a specific school and context and affected by local conditions, leadership, support, and feedback (Day and Kington 2008). Grounded within this literature, in this study, we view teacher identity as made up of the following three dimensions; personal, social, and situational. Obviously, these three dimensions are complex and not

independent of one another. Moreover, they are connected to the operations of personal, interpersonal, and institutional factors that influence the construction of the identity as a kind of teachers in a school setting. For the purpose of this study, these dimensions were used as an analytical framework for examining the ways in which Zheng represented himself as a beginning physics teacher when dealing with practical work. First, we used the personal dimension to examine Zheng's inborn personal traits, expectations, beliefs, and dispositions regarding practical work and physics teaching. Second, the social dimension was used to examine Zheng's practical work shared with colleagues with similar interests and their interactions with students with respect to practical work. Third, we used the situational dimension to examine Zheng's professional work related to practical work in school context while paying attention to the factors that supported or hindered the enactment of practical work.

Methods

This study has the characteristics of a single case study (Yin 2009), which allowed us to explore in detail the phenomenon under study (i.e., enactment of practical work in the science classroom) through detailed descriptions and in-depth data collection from multiple sources of information in school context.

The Participant and the Context

The study reported in this paper is part of a larger project with a cohort of six beginning physics teachers, who participated on a voluntary basis over 2 years. Zheng is a 23-year-old man, a graduate from the department of physics of a typical teacher university in a province in western China, where pre-service physics teachers study physics subject matter and pedagogy (both general and subject specific) for 4 years. Zheng was identified as one of the most excellent graduates with strong preparation in physics and pedagogy and successful teaching experiences during his 2-month internship in a high school. After graduation, Zheng was employed in a junior high school in this province teaching physics for grade 8 students (approximately 14 years old). Zheng was recommended by his university lecturer for this research because he was one of the most skillful students who liked hands-on activities, practical work, and scientific investigation in his class.

Zheng's school is located in a sub-urban area of the capital of this province and mainly enrolls students from surrounding towns and villages. This school is a junior high school with grades 7 to 9. Also, according to educational administrative authorities, this school is a *typical* one, which means that the academic performances of the students enrolled in this school are not very high, and hence, the school is representative of the larger population of students. To ensure the rate of admission into senior high schools, the school leader adopted the method of dividing all the classes into two levels and grouped the high ability students into a few classes, which were called *key classes*. In grade 8, where Zheng taught, there are 16 classes, including seven key classes and nine ordinary ones. The academic performances of the students in the seven classes were better than those in the typical classes. The key classes were taught by experienced teachers, while the ordinary classes were usually taught by beginning teachers. Zheng taught three ordinary classes with nine teaching sections in each week, and he was also the master-teacher of one class. Like other sub-urban schools in China, the class was big in size, normally accommodating 60 students.

Data Collection

This research project went through a rigorous ethics review at the first author's university before the data were collected. All of the participants signed consent letters for a number of research activities and were explicitly informed about the purpose of this project and their rights during the process of participating in this study. The data collection started in the early autumn semester, which was Zheng's second year of teaching, and continued in the spring of next year, a total period of 10 months. In order to examine Zheng's dispositions, emotions, and actions related to practical work, data were collected in an extensive way, including semi-structured interviews, classroom and laboratory observations, informal interviews and observations (field notes) at the school site, and lesson plans, and artifacts (practical aids).

During the period of data collection, a total of 26 classroom lessons were observed and most of them were related with practical work. The classroom observations were often accompanied by pre- or post-class interviews, which were used to clarify the intents and expectations of the participant on practical work. Moreover, three semi-structured interviews were conducted with Zheng in the beginning, middle, and end of this study, respectively. The interviews were guided by these questions: (a) What are your thoughts on the roles and responsibilities of a teacher? (b) what are the characteristics of a physics teacher compared with teachers of other subjects such as English or Mathematics? (c) compared with your colleagues in the department of physics, what are the features of your practical work teaching? (d) how do you think your students view your practical work and how do you respond to their needs? (e) what are the factors that facilitate or impeded the teaching with practical work in your class and school? In the later stage of this study, the interviewing was often accompanied by observed instances, in which the interviewee dealt with practical work. Each interview lasted approximately 60 min, totaling 180 min for the three interviews.

Data Analysis

For the purpose of the data analysis, the interviews, lesson plans, classroom observations, and field notes were first organized in a narrative format (i.e., descriptions of lesson plan activities, descriptions of classroom events). Encoding these data collected from multiple sources was the first step of data analysis. Given that this is a qualitative study, theories were generated from empirical data; however, the existing literature concerning the dimensions and theories of professional identity was also taken into account when the encoding work was conducted (Charmaz 2006). The analysis of the narrative type of data was grounded within the three-dimensional framework emphasizing three aspects of professional identity: personal, social, and situational. That is, these three dimensions guided the open coding of the data: In the process of data analysis, we looked for evidence about the participant's personal beliefs, values, dispositions and practice, his interactions with others, and the context within which practical work was enacted. Specifically, we used a line-by-line analysis to highlight the codes and sorted them in different dimensions. Within each dimension, open codes were regrouped, merged, and redefined to produce sub-categories, totaling 12. Examples of open codes are the following: teaching belief, the nature of physics teaching, the role of practical work, students' interest, scientific inquiry, communication with colleagues, and students' examination scores. The 12 sub-categories and examples of open codes, and the three dimensions are shown in Table 1.

Table 1 Data analysis scheme

Dimensions	Sub-categories	Examples of open codes
Personal	Loving handwork from childhood	Making toys, fond of all kinds of practical, practical aids
	A scientific inquiry-minded person	The idea of scientific inquiry, exploratory/scientific activity, funny physical experiments
	Unfeasible scientific inquiry in reality	The function of practical work, a distinction between scientific inquiry and practical work
	Teaching philosophy on practical work	Teachers' responsibilities, the features of physical knowledge, the assumed role of practical work in physics learning
Social	Promoting practical work among colleagues	Creating an atmosphere of practical work, making achievement in practical work, introducing hand-made practical aids to other teachers
	Seeking comrades	Communicating with these teachers, learning from colleagues, using colleague's practical aid
	Inspired by students' positive feedback	Eager to learn science in a new way, eager to do experiments, students' admiration, and respect
	Shifting to extracurricular activities	Normal classrooms, an extracurricular club, making an investigation freely
Situational	Annoying exam scores	"Immature" young teachers, unfair evaluation system, students' exam scores
	The invisible obstruction of textbooks	Following textbooks, "no any sense of investigation," getting away from textbooks
	Restrictions of time	Teaching hours, "delaying in class," "catching up with the class"
	Being a physics teacher of ordinary classes	Bad academic performance, unconfident in improving academic achievement, teaching all students

These 12 sub-categories combined provided the basis for characterizing Zheng's identity and its enactment in relation to practical work. In order to identify the features of his enacted professional identity when he dealt with practical work, we grouped these 12 sub-categories under the following broader categories adopted from Beijaard et al.'s (2004) framework: (a) personal characteristics, (b) contextual limitations, (c) sense of agency, and (d) ongoing interpretation of the experiences with practical work (Table 2).

These four categories and the 12 sub-categories were used to analyze and characterize the interactions of the personal, interpersonal, and situational factors that influenced Zheng's actions with practical work at the outset of his professional career in next section.

Table 2 Zheng's identity as a beginning physics teacher when dealing with practical work

Categories	Sub-categories
Personal characteristics	Loving handwork from childhood Teaching philosophy on practical work A scientific inquiry-minded person
Sense of agency in enacting practical work	Promoting practical aids among colleagues Seeking comrades
Contextual limitation	Annoying exam scores The invisible obstruction of textbooks Restrictions of time
Ongoing interpreting the experiences with practical work	Inspired by students' positive feedback Being a physics teacher of ordinary classes Unfeasible scientific inquiry in reality Shifting to extracurricular activities

Findings

Based on Table 2, Zheng's professional identity is elucidated by four categories: (1) personal characteristics, (2) sense of agency, (3) constraints of the school context, and (4) ongoing process of interpretation and reinterpretation of experiences with practical work. These four categories are presented in four themes, respectively. For each theme, two to four factors are exemplified.

Personal Characteristics

Loving Handwork from Childhood

As Zheng recalled, he was interested in observing natural phenomena and enjoyed making handworks from his early childhood. For example, as he shared in the interview, he used to make toys using iron wires and bamboo tubes and tried to explore the principles of farm machinery. As he stated, he was fond of all kinds of practical instruments. In an interview, he shared that he was proud of himself that he could drive a tractor when he was a junior high school student and could even be able to dismantle and assemble an engine when he was a grade 3 student at primary school. Because of these inborn personal characteristics, Zheng was enthusiastic in making practical aids by hand after he began to teach. In the interview, he stated that these skills of making practical aids were important for physics teachers because physics is a physical science. In his own words, "if physics teachers were skillful at hands-on activities and had strong manipulative abilities, they could make practical aids by themselves and thus present physical theories in a more effective manner." As a physics teacher, Zheng emphasized, "one should have some kind of interest in fiddling with these stuff and instruments, otherwise he can only download digital videos from the website and play them to students in class."

Teaching Philosophy About Practical Work

Zheng's teaching philosophy included several elements, which are related to practical work, as follows: teachers' responsibilities, the features of physical knowledge, and the assumed role of practical work in physics learning. In one of the interviews, Zheng stated that the responsibility of a teacher lay not only in imparting knowledge and skills, but also in cultivating of virtues, both of which are usually summarized in a combined phrase in Chinese, "imparting knowledge and educating people." According to Zheng, the subject matter of physics is more rational than that of other subjects, and thus, physics teachers should focus more on teaching rational things, such as how to help students understand physical formula and explain some daily phenomena. Zheng thought that physical knowledge has close associations with experiments, and thus, it was necessary to conduct practical work in class. Some physical theories are difficult to understand, but these theories could be comprehended with ease by students with demonstration and experiments. Besides knowledge, Zheng was convinced that experimental skills are also very important for students in physics learning, and some basic knowledge and skills, such as manipulations of equipment, experimental methods, and security issues during experiments, should also be taught to students.

As a beginning science teacher, Zheng stated that he wished students were interested in physics learning through practical work. As he indicated in an interview, teachers' behaviors had a great impact on the attitudes of students towards the subject especially at junior high schools; students may get interested in the subject just because of the affinity or appearance of the teacher, and also, the interests of students towards the subject could be stimulated through practical work. Thus, Zheng made the following assertion:

> *Without practical work, students may be good with the teacher and then get interested in the subject. But with the conduction of practical work, the students may be interested in physics and then like their teacher.*

As evident in this extract, Zheng places emphasis on the importance of practical work in support student interest in the subject.

A Reform-Minded Teacher

As Zheng recalled, he first got the idea of scientific inquiry when he was enrolled in a practical work–based course in the third year of his college study. This course aimed to train pre-service teachers' practical skills in conducting practical work at secondary schools, and the visions and teaching models of scientific inquiry were introduced in this course. The two lecturers were keen on scientific inquiry and used to provide various exploratory activities for those prospective teachers, and one of them later become Zheng's tutor in the teaching internship. During the period of teaching internship at a high school, besides routine teaching in class, this lecturer instructed Zheng and his classmates to organize an exhibition of funny physical experiments and conduct several inquiry-oriented activities in the school. These activities were popular among school students, and Zheng himself enjoyed and appreciated these activities very much. This experience had exerted a great impact on Zheng, and he began to develop an interest in scientific inquiry since then. After the internship, Zheng attempted to learn the principles and practices of scientific inquiry consciously by attending lectures relevant to this topic, participating in a scientific inquiry club, making practical aids, designing scientific activities, and conducting these activities in science museums or schools regularly under the supervision of the two abovementioned lecturers. With these participations, he recalled, he got more understanding about scientific inquiry and was convinced that scientific inquiry should be combined with physics teaching to help students learn this subject interestingly and effectively.

Sense of Agency

Promoting Practical Work Among Colleagues

Zheng was confident in his hands-on abilities and wanted to make use of his personal characteristics to make "some influences" in his school. As he stated in an interview, "there was a desire for change and innovation in my heart, and hoped that I can bring some breakthroughs to the school and create an atmosphere of practical work in it." This was the thought that Zheng had when he started to work in this school. Zheng wished to make an attainment in teaching; meanwhile, he would like to lead other science teachers to move

forward along the way of teaching with practical work. He stated, "as a new teacher, I dared to try new things… at the time I graduated from college, I did have the desire to bring some new ideas to change the outdated teaching practice in this school." This statement was reflected in Zheng's actions, as evident throughout our observations. For example, he was actively involved in organizing inquiry-based activities and practical demonstrations in his classes. Meanwhile, he was keen to share his ideas with colleagues and hoped to promote inquiry-based methods among the group of physics teachers. Moreover, Zheng often introduced his hand-made practical aids to other teachers and invited them to visit his classes. The promotion played an active role in stimulating the application of practical aids in classes among physics teachers. For instance, in the class of introducing dispersion of light, the weather was not good enough, and thus, the demonstration of breaking down the sunlight could not be carried out. The light of the projector was utilized by Zheng to replace the sunlight, and a similar result could be observed finally. He recommended this practice to other teachers, who acknowledged that it was quite simple and convenient, and adopted it later. In an interview, Zheng proudly mentioned that he was the first teacher who conducted this demonstration with a projector in his school, "without my promotion, other colleagues would not demonstrate this experiment to students," Zheng added.

Seeking Comrades to Improve Practical Work

When he began working in this school, as Zheng recalled, he had found that practical work was rarely used in teaching, physics classes were dominated by "teaching talking and students listening" strategies, and few teachers were interested in conducting practical work let along improving it. After a period of time, influenced by Zheng, some young teachers became interested in practical work and Zheng began to communicate with them consciously and learned from one another. At the time of a collective lesson preparation in the department of physics teaching, which was held every 2 weeks in this school, it was observed that Zheng discussed with his colleagues about the teaching issues, and for most of the time, the issues were relevant to the improvement of practical aids and strategies of using practical work. Moreover, as we observed, almost every time after parallel classes (different teachers teach the same content in different classes), in which practical work was involved, Zheng came to ask the colleagues what and how they used practical work in their classes, and sometimes he was inspired by their practices.

An episode is described here to illustrate Zheng's eagerness in seeking comrades in improving practical work. In the class on image formation in plane mirrors, Zheng prepared and shared the practical aids with one colleague. As Zheng recalled, he used to take a burning candle as the object and asked the students to find the image of the candle in the mirror. But this semester, he used a flashlight to irradiate on a waste battery instead of the burning candle, avoiding the unpleasant smell and the danger of playing fire. This practice was learned from a colleague who taught in the same grade. There is another instance, where he improved his practical aids in demonstrating the phenomena of light refraction after the communication with that colleague. He recalled the experience of sharing with this colleague, "when I communicated with that teacher about his practical aids and found that his was more simplified than mine." He used his colleague's practical aid directly in his class after he found it was more convenient. After class, he also discussed with that colleague about the improvement of his own designs.

The Constraints of the School Context

Annoying Exam Scores

In Zheng's school, the academic performances or exam scores of students were related with teachers' achievement and played an important role in evaluating teachers. The teachers, who were evaluated as excellent, could acquire some corresponding rewards. As mentioned earlier, a special situation in this school was that students at the same grade were distributed into two different types of classes, key, and ordinary classes, according to their learning capacities. Zheng thought that this evaluation system was unfair because the results of evaluations of teachers were determined by the number of students who scored in the first ranking, regardless of the type of the class. However, he complained that new teachers seldom had the opportunities to teach key classes because of their "immaturity." Since the evaluation system was based on the number of students who graded in the first level, it was rare for new teachers to obtain good results from evaluation. As Zheng commented, the evaluation system had impacted the enthusiasm of new teachers because "it is not the same thing to teach ordinary and key classes." Zheng took his case as an example: He taught three ordinary classes, and there were only a few students who could score in the first level. The number of first-ranking students in his class was not comparable to that in key classes, and thus, he could not achieve among the best in the evaluating system even though he had tried his best. Even though Zheng had made a lot of efforts in conducting practical work in class, the academic performances of students still could not be improved. This made him very anxious. Every time after the examination, he said, he had to reflect on his teaching philosophy. In an interview, he indicated as follows:

> *When I graduated from university, I had a strong motivation in conducting scientific inquires, carrying out practical work, and organizing interest groups. But now the driving force is shaking and I realized that my own strength was rather weak.*

On another occasion, he reflected on the effectiveness of his practices in relation to students' exam scores:

> *The results of my effort to carry out practical work were not ideal, that is, students' exam scores were not satisfactory. Yes, indeed, students had become interested in practical work, but their exam scores were not improved accordingly. I am wondering whether it's because of my incorrect teaching method or lack of insistence.*

For Zheng, the emphasis on students' exam scores was annoying and made him question the effectiveness of teaching with practical work.

The Obstruction of Textbooks

The main responsibilities recognized by most of the teachers in the context of this study were to impart knowledge from textbooks. In Zheng's school, the textbooks published by People's Education Press, the national educational press with publishing primary and secondary textbooks as its focus, were adopted. The teachers prepared lessons and arranged teaching progressions according to the textbooks. Also, the

students attended the classes and did homework on the basis of textbooks. Zheng thought it was the responsibility of a physics teacher to assist the students in learning physics knowledge and to demonstrate physical phenomenon according to the textbooks. Thus, the content and sequence of practical work in class was mainly decided by those prescribed in textbooks.

With the science curriculum reform in the country, much more practical work had been incorporated in textbooks. For almost every section, practical work was involved, including both demonstrations and "exploratory activities." This change was noted by Zheng. He mentioned that the difficulty level of physical knowledge in physics textbooks was much lower compared to that when he was a junior high school student. However, Zheng pointed out that the students had already known the procedures and results of practical work, which are clearly presented in the textbook, because they had read the textbooks in advance. When using these kinds of textbooks, he stated, "it is not a process of exploration but repetition because few space was left for the students to make exploration in class." In sharing an episode from the classroom, he said that an explorative experiment was arranged to let students investigate the factors that may influence the magnetism of the electromagnet; however, to his disappointment, most of the students have acquired the information from textbooks, and therefore, "there were no any sense of investigation eventually." As Zheng said, he tried to get away from the textbooks and provide students with other kinds of learning experiences. But, his attempt ended up with a failure:

> *As required in my school, teaching cannot be separated from textbooks. I was criticized by school leaders, they said my attempt was breaking the normal teaching order.*

As evident in this extract, the textbooks and the rigid system of textbook uses in his school were factors obstructing Zheng from adopting investigative practical work.

Time Restrictions

The phrases, such as "teaching hours," "delaying in class," and "catching up with the class," occurred for many times during the interviews, which indicated that one more factor that hindered his practice of conducting practical work was the lack of time. As Zheng stated, if practical work was adopted, students should spend lots of time in exploring and thinking; in this case, the content settled in the textbooks could not be completed, and the final examination scores would be finally impacted. The highly tight schedules prompted Zheng to change his teaching practice related to practical work over a period of time. As he described in a semi-structured interview:

> *I conducted practical work almost every class in my first year of teaching and gradually, practical work was only adopted when it was difficult to present theoretical knowledge orally, and now, as you see, if I am able to explain clearly, I will not use practical work.*

As acknowledged by Zheng, practical work could indeed engage students in scientific inquiry, which is consistent with his teaching philosophy, but in the reality of the school context of pursuing students' high exam scores, he had to make some adjustment in his teaching practice.

Ongoing Interpreting Experiences with Practical Work

Inspired by Students' Positive Feedback

As mentioned earlier, one of Zheng's goal as a new teacher was to support students in developing an interest in physics through practical work. To achieve this goal, in the first months of his teaching in this school, he tried his best to carry out practical work in a variety of ways, including demonstration and students' group work in the laboratory. As he stated, his initial effort on practical work was not only because of his teaching goal but because of his understanding of students' needs as well. While interacting with students, Zheng felt that students were eager to learn scientific knowledge in a new way and practical work was a kind of events that students expected from physics classes. Zheng described a related episode:

> *I brought an airplane model to the class when teaching the section of 'atmosphere pressure'. Once I entered the classroom, I heard hailing! They [students] got excited at the sight of the model. They thought they saw the real plane with their own eyes!*

Moreover, Zheng found that students were eager to do experiments by themselves. Actually, as commented by Zheng, there had been very few opportunities for students to do practical work in the laboratory before. To change this situation, he organized two more laboratory activities in the first semester than other colleagues who taught at the same grade. His effort of teaching with practical work was recognized by students, and in turn, students' recognition inspired him to do more practical work. To his encouragement, he found that not only his own students but those students from other classes admired and respected him. Zheng was proud of this and described his experience in an interview as follows:

> *On more than one occasion, I walked in the corridor with my practical aids and overheard the admirations expressed by the students from other classes to the practical aids that would be demonstrated in my class… When I stepped into my own class with new practical aids, my students were also very excited and curious about what they were going to learn and what I had made for the class demonstration. They admired me for my innovations and gradually they became interested in physics.*

These sentences portray Zheng's joyous mental state when he received positive feedback from his students.

Being a Physics Teacher of "Ordinary Classes"

As a new teacher, Zheng was assigned to teach three ordinary classes (see description of context offered earlier in the paper) and the academic performances in his classes were introduced as this: There were 62 students in one of the three classes, and only half of them were able to pass the mid-term examination; the highest score was 90 and lowest score was only 20 or 30; some students even had a score of ten; the pass rate was even less than 50% in another class. This was the reason that Zheng was upset when talking about academic achievements of his students. Zheng pointed out that only a few of students in his classes

might be admitted to the key senior high schools. He added, however, the admission was not decided by students' performances on a single subject; that is to say, the improvement of academic performances in physics alone could not change the situation. As a consequence, Zheng was unconfident in improving enrolment rate or academic achievement of his students.

Even worse, as indicated by Zheng, the students that were regarded as low achievers were not interested in learning without practical work. When talking about the class, where he was the master teacher, Zheng stated that of a class with 65 students, about 20 would rather choose to sleep during regular classes. However, he expressed that he would not abandon these students. Instead, he felt that it was his responsibility to teach all of the students in his classes. Facing such a situation, Zheng stated he had no choice but took practical work as a strategy to solve this problem. As he stated, it was practical work that could somewhat stimulate the interests of these students to learn physics. His teaching practice was based on the following understanding:

> *If you only focus on high achievers and teach complicated things, other students cannot understand what you are talking about at all. But if practical work is used, these students are able to learn something, at least, it [practical work] can help them observe some phenomena, which is beneficial to improve their academic performances.*

It is important to notice in this extract Zheng's view about the importance of the use of practical work for engaging and supporting *all* students' learning.

Unfeasible Scientific Inquiry

As mentioned earlier, Zheng was enthusiastic about scientific inquiry and had accumulated experiences of organizing investigative activities for high school students. After a period of working in the school, he thought that it was unrealistic to apply scientific inquiries into physics teaching. This thought was mainly based on his reflection on the experiences of teaching at the real school context. As he stated, "scientific inquiry conducted by scientists were exploratory, and thus, a real inquiry should be done in a similar manner; that is, it should be explored from unknown to known." However, he said, "physical teaching in reality was a process from known to known, and it just explained and presented the physical theories and phenomena that had been proved by previous researchers or scientists." Therefore, he continued, "the function of practical work at school was assisting students to understand concepts and theories but not a real exploration." Moreover, he made a distinction between scientific inquiry and practical work in the following way:

> *Scientific inquiry occurs in a situation where students are unaware of the content in textbooks, and they should be able to explore a phenomenon without teachers' instructions. It is only called practical work when the students have read the textbooks before and made preparations for classes. More importantly, in my school, the abilities of students cannot afford to implement scientific inquiry.*

In Zheng's view, as illustrated in this extract, practical work could be implemented but scientific inquiry needed some special conditions and could not be implemented in his "ordinary" classes.

Shifting to Extracurricular Activities

Over a period of working in this school, Zheng became aware that scientific inquiry in normal classrooms was constrained by a variety of factors, many of which were beyond his control. In the context of his school, Zheng stated, "although scientific inquiry was difficult to implement, it can be accomplished as extracurricular activities, which can be conducted and arranged flexibly in both content and timing and are supported by school leaders." With the assistance of some colleagues, Zheng had gathered a group of students who were interested in practical work and scientific inquiry and organized an inquiry club. Also, he was successful in applying for a spare classroom from the school and established an inquiry studio for the club. On a voluntary basis, the students regularly participated in the activities to make practical aids and to conduct some inquiry-oriented activities. As Zheng explained, the primary purpose of this club was to engage the students in authentic activities and let them experience the processes of scientific practice. For the operation of this club, he described:

> *In most cases, I provide them with a task and they make a design and carry investigation to provide an answer. During the whole process, they may encounter some problems, for example, the airplane that they made could not fly. Then, I guide them to figure out a solution from the underlying theories instead of just telling them what to do. More importantly, there is no time limitation as in class, and they are permitted to struggle with a problem over a long period of time.*

Zheng enjoyed the fun nature of the club. Moreover, the potential that the students showed in this club impressed him and made him recognized the fundamental responsibilities of a physics teacher. He made the following comments in an interview:

> *As a physics teacher, my role was not just to help students obtain higher exam scores but to also develop investigative abilities and skills. This is my teaching philosophy and this is what I really want to do.*

For the future, he stated that he would improve himself in the idea and pedagogy of scientific inquiry and create a better environment for the students, and he added that "it was the club that nurtured my passion for practical work."

Discussion

In this study, we adopted a case study approach to examining Zheng's identity as a beginning physics teacher on the basis of three dimensions of identity, which considers the personal, social, and situational nature of teacher professional development. As a single case, the findings of this study are limited because they cannot be generalized beyond the context of this study. However, the findings might be transferable to other contexts. In order to achieve transferability, we provided detailed contextual information (i.e., context, nature of activities, characteristics of the participants) for the reader to make such a transfer (Lincoln and Guba 1985). In examining Zheng's identity, we employed Beijaard et al.'s (2004) framework of professional identity, which provided an analytical framework and a means to examine and organize the influences on the development of Zheng's identity as a beginning physics teacher

when dealing with practical work. As the findings revealed, Zheng's professional identity was shaped around four interrelated categories with two to four factors included in each category:

(a) Personal characteristics: loving handwork inherently, teaching philosophy on practical work, inquiry minded.
(b) Sense of agency: promoting practical aids and seeking comrades.
(c) Constraints of the school context: annoying exam scores, the invisible obstruction of textbooks, time restrictions.
(d) Ongoing process of interpretation and reinterpretation of experiences with practical work: encouraged by students' positive feedback, being a physics teacher of ordinary classes, unfeasible scientific inquiry in reality, and shifting to extracurricular activities.

These factors contribute to further theorizing about teacher identity as they point to specific experiences drawn out from evidence found in a classroom context. Specifically, the processes shed light on the changes in the teacher's perceptions of the effectiveness of scientific inquiry in school as well as changes in his attitudes towards his role and responsibilities as a science teacher. This directly relates to the role of agency in the development of identity for practical work as well as the ways in which recognition from students shapes teacher identity development.

The findings contribute to existing knowledge base on teacher' professional identities and enrich existing frameworks by offering a set of concrete categories and factors that shape the formation and reformation of teachers' professional identities as well as their enactment. The role of agency, context, and recognition, as shown in this study, was crucial in shaping the participant's identity for practical work. The factors revealed in the findings provide meaning through concrete examples for each of the categories found within the *enactment* of identity, which remains largely unexplored. As Avraamidou (2018) argued, an examination of how teachers view themselves (identity) and what teacher do (enactment of identity) holds promise for our understanding of place, identity, and practice and their implications for each other. In what follows, we discuss in further detail how each of the categories and factors found their place in Zheng's professional identity.

First of all, Zheng had a natural affinity towards handwork; his teaching philosophy about practical work was positive, and he had embraced the idea of scientific inquiry. When interacting with colleagues, he was zealous to promote practical aids and seek comrades so as to be recognized as a physic teacher with a good personality of doing practical work. However, over a period of time, Zheng's efforts in promoting practical work had not helped to improve students' exam scores. This made him feel that he was in a disadvantaged position because of the school evaluation system. Moreover, Zheng had recognized the limitation of the common practice of strictly following the textbook in this school, but as a new science teacher, he could not be able to break it. Even though the unified class schedule was not conducive to teaching with practical work, as a new teacher, Zheng had no choice but to follow it. Therefore, the combination and interactions of personal, interpersonal, and situational factors made him continually interpret his experiences and adjust his actions in relation to practical work. When analyzing the processes of Zheng's wrestling with practical work, we found that these four categories are not parallel; instead, causal relationships exist among them. These causal relationships are illustrated in Fig. 1.

It is also interesting to notice in the findings critical episodes that took place in different points in time, on Zheng's formation and reformation of this professional identity for practical work.

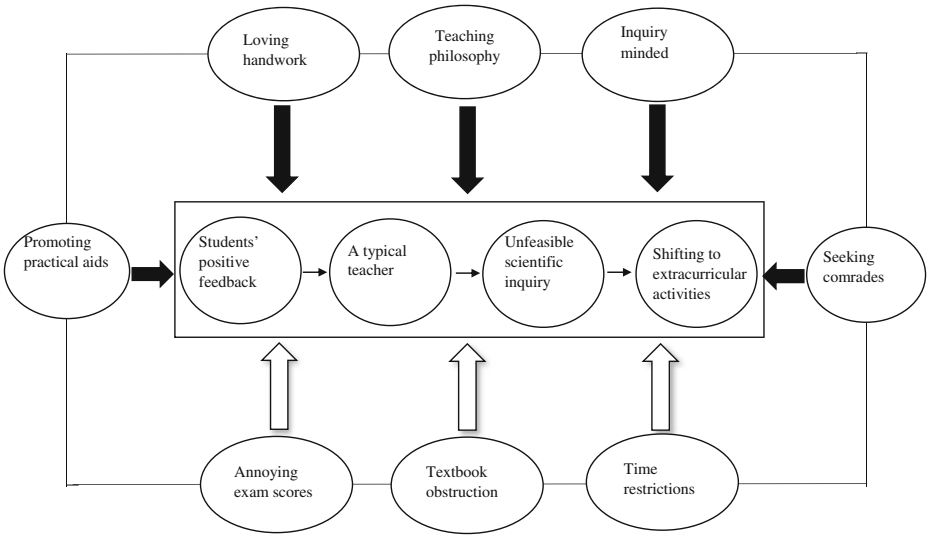

Fig. 1 Factors influencing Zheng's interpretation and reinterpretation of his experience on practical work

As Zheng's story illustrates, during his first 2 years of teaching, he had experienced four "turning points" with practical work. First, his enthusiasm for and teaching philosophy about practical work were echoed by students' positive feedback shortly after he started working. A period of time later, he recognized that practical work was a "feasible" strategy to teaching unable students who were placed in ordinary classes. At this point, practical work had nothing to do with his teaching philosophy or his inherent interest on handwork but just a "have-to" strategy to deal with those students who had no interest in learning. With his familiarity of norms, routines, and rules of physics class, he became aware that scientific inquiry was unfeasible in normal classes in the school setting, which was contradictory to his original mind he had formed in his pre-service training program. However, Zheng did not give up but shifted his efforts to extracurricular activities, by which he had realized his teaching philosophy and his enthusiasm with practical work retained. What becomes obvious in these findings is that Zheng's interaction with practical work entailed a process of re-examining with his own knowledge, beliefs, emotions, aspirations, others' expectations, as well as the characteristics of the school contexts. From a theoretical perspective, this is important because it points to the fact that professional identity is a relational phenomenon that is both individually and socially constructed (Wenger 1998), where the interaction between the *personal*, *social*, and *situated* factors is central (Day and Kington 2008). As the findings of this study revealed, it is precisely this interaction of factors found within different episodes that rendered Zheng to continually interpret his experiences with practical work and which essentially influenced the development of his professional identity. His inherent enthusiasm, his perceptions of the roles of practical work in helping students' learning, and his instilled education on scientific inquiry provided positive influences on his interpretation and reinterpretation of his experiences with practical work—even though the enactment of practical work had not proceeded as smoothly as he expected, he did not give up but was insistent on it. Importantly, his sense of agency with practical work played a critical role in the process, which was evidenced in his willingness on promoting practical aids and seeking comrades among colleagues. Moreover, Zheng's case reveals the crucial impact of the cultural context in shaping one's experiences, which is in line

with arguments put forward by other researchers as well (Avraamidou 2018; Saka et al. 2013). The cultural context of the school, including the norms and expectations operating in this context (i.e., exam scores, the invisible obstruction of textbooks, time restrictions), were part of Zheng's experiences and served as barriers to the enactment of his professional identity. The way that norms and expectations were communicated to and interpreted by Zheng shaped his actions within the school context. Finally, he figured out "a way out," that is, in normal classes, he went with the mainstream practices (less or no practical work) but he made use of the "extracurricular activities" to create the club of scientific inquiry and realized his values and aspirations in it.

Conclusions and Implications

This case study contributes to existing theory and knowledge base of science teacher identity by offering a concrete example of the processes through which a teacher's identity for practical work developed and how different episodes and experiences impacted its development as well as its enactment. In what follows, we discuss the implications of the findings of this study and we offer recommendations for future research.

One main finding of this case study is the close relationship between practical work and scientific inquiry and how that influences the development of a teacher's identity, which remains underexplored in science education research. We maintain that practical work, which has intimate connection with the experimentation of natural sciences, is an inherent part of subject matter of physics while scientific inquiry is an external initiative, representing a kind of a direction of curriculum and instruction reforms. As evidenced in the findings of this study, the formation of Zheng's identity was closely associated with practical work. This was manifested in his philosophy of and expectations on the roles of practical work in physics teaching and was reinforced with his inbred interest in handwork. Without this aspect of subject matter of physics, it would not have been possible for Zheng to proceed further along the way of adjusting his own knowledge and beliefs with the demand of school contexts. However, Zheng's experiences with scientific inquiry constituted another story.

Another main finding of this case study is that Zheng's attempts to enact his identity for practical work were constrained by contextual factors, such as accountability, textbooks' constrains, and tight time schedules. This is not at odds with the extant literature on the enactment of scientific inquiry, which has indicated that science teachers face various kinds of barriers and dilemmas when they attempt to move to inquiry-oriented science teaching (Adams and Krockover 1997; Anderson 2002, 2007; Davis and Krajcik 2005; Davis et al. 2006; Wei 2010). What is interesting of our findings is that Zheng affirmed that scientific inquiry was "unfeasible" in reality based on his personal experiences. However, his persistence for implementing practical work had never changed. Even though what Zheng did in the laboratory and the inquiry club or the activities he claimed as "inquiry" did not actually represent "scientific inquiry" as defined in science education reform documents (e.g., NRC 1996), it definitely belonged to the realm of "practical work." Zheng's persistence for implementing practical work was obviously a combined result of his interactions with his own personal knowledge beliefs, interest in handwork, others' expectations, and institutional supports and constrains.

Among a wide array of the factors that influenced Zheng's identity, the most important one was his affinity with practical work. As Hobbs (2012) stated, secondary school teachers usually have a historical engagement with a subject and discipline from school, university study, or the workplace; thus, they may bring some certain attitudes and preferences that have been established to this subject into the classroom. Since many science teachers of secondary schools are educated in science departments, where experiments were given a high priority in both epistemological and pedagogical ways, they have developed strong identifications, recognition, and dependency with practical work or experimentation. For them, practical work seems the "natural" and "right" thing to do, which means that "many teachers see its use as the basic modus operandi for the teaching of science" (Abrahams 2011, p. 2). Through this study, we have consolidated Helms's (1998) contention that subject matter exerts influence on the professional identity of science teachers.

Concluding, we acknowledge that Zheng is not a typical beginning science teacher given his inherent interest, understanding, and passion for enacting practical work and inquiry in his practices. In addition, the findings of the study are restricted in terms of context. Hence, we call for future research with a larger sample of participants in a diverse set of contexts, which includes teachers with different interests and propositions, to address the following questions: What constitutes a teacher identity that emphasizes practical work? What are the characteristics of such an identity and how can teachers be supported in developing an identity that allows them to implement practical work? An important step forward in this field could involve identifying specific activities in teacher preparation that support teachers in developing the science teacher identity for teaching with practical work in general and scientific inquiry in particular and supporting them in overcoming the challenges and boundaries (e.g., contextual factors) that have to overcome in enacting their professional identities.

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