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ORIGINAL ARTICLE

An Analysis of the Representation of Practical Work in Secondary Chemistry Textbooks from Different Chinese Communities

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ABSTRACT

This study analyzed representations of practical work in 10th grade chemistry textbooks and associated experimental workbooks from different Chinese communities. In the field of textbook research, science education textbooks research is unbalanced between regions. In the case of chemistry textbooks analysis within the Chinese context, textbook studies are even more limited. To close the gap, this paper contributes to the current body of knowledge of how practical work in secondary chemistry education is suggested to be applied in Chinese educational contexts. A total of 508 representations related to practical work were identified in seven sets of textbooks from Mainland China, Taiwan, and the Chinese sector in Malaysia. The goal was to gain basic insights into the features associated with suggested approaches to practical work in the textbooks. Our focus was on the suggested type of learning, intended learning outcomes, inquiry level, and aspects of students' engagement with practical work. The results indicated a prevalence of prescribed experiments. This preference was then followed by illustrations of facts and laboratory operation processes. Only a limited amount of scientific inquires with at least some amount of openness were located among the list of preferred items. The intended learning outcomes mainly aim at learning facts. Most textbooks suggest using a structured learning approach. Some suggestions of inquiry-based learning using either guided or open inquiry approaches do occur, but they are relatively limited in the textbooks and do not appear frequently. The results of this study may provide a view for science textbook editors and curriculum designers to identify areas for further improvement.

KEY WORDS: chemistry education; textbook analysis; practical work/laboratory

INTRODUCTION

Performing science is about gathering evidence from nature (Watson et al., 2004), or, more specifically as described by Millar (2004), science is an endeavor to gain an evidence-based body of knowledge about the natural world. Ways to generate evidence from nature include observations of natural phenomena, both in nature or in a laboratory context. That is why observations in nature and practical work have achieved their distinctive role in science education. They have maintained this central role until today (Hofstein, 2017).

Most educational standards and traditions in science education state the importance of practical work for the teaching and learning of science (Hofstein, 2017). We use the term practical work in a broader sense, which includes many other notions such as laboratory work, laboratory activity, investigation, inquiry, and experimentation. In this paper, it refers to any kind of teacher or student interaction either with equipment or materials to produce or observe phenomena, from which students achieve a better understanding of the natural world (Hofstein & Lunetta, 2004).

As stated by Millar et al. (1999), practical work can help in communicating information and ideas about the natural world to students. In the classroom, there are basically two sources which lead students into practical work, i.e., teachers and textbooks. The focus of this paper is on textbooks, because textbooks are teaching aids where students may obtain knowledge (Devetak & Vogrinc, 2013). Furthermore, textbooks represent the intended curriculum, which teachers adapt and re-structure towards implemented teaching practices (Chen et al., 2019). Scientific textbooks play an important role in science education in general (Aldahmash et al., 2016), and in chemistry education in particular (Rusek & Vojíř, 2019). The importance of quality textbooks is especially high in countries where teaching tends to center around a selected textbook, such as in the People's Republic of China (Wang et al., 2015). There is a growing body of literature emphasizing the important role of critically analyzing textbooks (Clement, 2008). It is suggested that textbooks aim at defining school subjects (Devetak & Vogrinc, 2013), representing the intended curriculum (Khaddoor et al., 2017; Aldahmash et al., 2016; Tamir & Pilar-Garcia, 1992), promoting conceptual learning and helping in achieving scientific literacy (Upahi & Ramnarain, 2019; Wei & Chen, 2017), and presenting proper content for guiding teaching and learning (Kim & Kim, 2013; Abd-El-Khalick et al., 2008; Stern & Roseman, 2004). In this study, we focus on how textbooks from different Chinese communities in Mainland China, Taiwan, and the Chinese

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sector in Malaysia, introduce and represent practical work in chemistry education. A careful look was given to the suggested type of learning, the intended learning outcomes, the inquiry level, and students' engagement with practical work.

THEORETICAL FRAMEWORK

Practical work in the laboratory or in nature is widely (Katchevich et al., 2013; Abrahams & Reiss, 2012; Jones et al, 2000; Millar et al., 1999) suggested as a tool to provide students with opportunities to experience the natural world for the sake of learning (Kim & Song, 2006). This is also the case when it comes to helping students develop links between their observations and ideas (Abrahams & Millar, 2008). In the current study, we apply the term "practical work" to all intended or represented hands-on processes, which help with a better understanding of evidence-based science performed inside and outside the laboratory. It covers any activity or associated reference where students can personally see or interact with materials and equipment to observe and understand the natural world. More specifically, the term refers to what students do or potentially can do, rather than to the location where the learning may take place. So practical work in our study concerns:

a. Any suggested experimental activities in class,
b. All suggested scientific investigations either in or out of the laboratory, and
c. Relevant pictures or sketches of experiments which potentially can be performed in the laboratory or beyond.

According to Katchevich et al. (2013), practical work builds a bridge between science and the learner by actively performing science. Practical work is seen as an integral part of science education in schools since it supports learning and is popular among students (Jones et al., 2000). Such work has the potential to promote higher-order cognitive skills if it is structured properly. It also provides chances for collaboration, deliberation, and communication with peers (Katchevich et al., 2013). Hofstein and Lunetta (1982) have suggested, based on their review of research, that practical work can also be considered as an effective teaching medium for achieving many of the stated goals of science education. They point out that practical work can facilitate students' learning and development and that it should play an important role in the achievement of the goals of science education. Practical work enables science teachers to facilitate both student learning and development to gain an understanding of what science is.

Practical work can encompass purposeful observations or scientific inquires by manipulating equipment and materials (Lederman & Lederman, 2012). Such work is driven by questions, predictions, observations, analyses, and interpretations. The positive role of practical work for science learning is, however, not self-evident (Hofstein, 2017). Watson et al. (2004) suggested that students' discussions and decision-making processes in scientific inquiry often lag behind, if no clear emphasis is placed on a procedural understanding of scientific inquiry, instead of merely assessing individual practical skills and processes. Kim and Song (2006) promoted the use of more effective ways to organize practical work to promote students' thinking and to develop their argumentation abilities, such as the critical "peer review" of reports and arguments. The "thinking" part, for example, the negotiation of meaning in practical work, should, therefore, be emphasized more than the "doing" part. This resonates with work published by Newton et al. (1999).

In 2008, Abrahams and Millar described that teachers put greater emphasis on the interpretation of scientific content, instead of student inquiry, and practical tasks were seen to be deficient in helping students to make these links. Hofstein (2017) also pleaded recently for a deeper reflection on practical work, since the implementation of practical work seems not to have changed much over the past years. His arguments call for paying more attention to higher-order thinking skills and for starting new developments in laboratory teaching strategies and in teacher professional development. This call includes a rethinking of the goals of learning in and from practical work, including how it is presented to students.

Today, the most popular strategy suggested for practical work in science education is an inquiry. Inquiry-based practical work asks students to think of problems, formulate hypotheses, design experiments, gather data, and draw conclusions from scientific phenomena (Hofstein, 2017). There are, however, different levels of inquiry with respect to learners' mind-on involvement. A common typology of inquiry-based science education is related to the degree that students can influence scientific investigation. Banchi and Bell (2008) discussed four levels of inquiry-based learning in science education: Confirmatory, structured, guided, and open inquiry. The higher levels are believed to challenge students' thinking more and allow them to better construct meaning from a scientific investigation (Table 1).

In the practice of science, teaching factors such as time, equipment, and goals come into play, aside the textbook, when practical work is introduced. They determine whether teachers will choose guided or open inquiry or whether they will simply demonstrate an experiment to illustrate a scientific fact for their learners. Although there is a growing body of literature emphasizing the important role of textbooks in science teaching (for example Devetak & Vogrinc, 2013) and various facets of learning were analyzed with reference to textbooks (Upahi &

Table 1: Categorization of inquiry-based level (Banchi and Bell, 2008)

Category	Inquiry level	Question	Method	Answer
1	Confirmatory learning	Given	Given	Given
2	Structured inquiry	Given	Given	Open
3	Guided inquiry	Given	Open	Open
4	Open inquiry	Open	Open	Open

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Ramnarain, 2019; Khaddoor et al., 2017; Wei & Chen, 2017; Aldahmash et al., 2016; Abd-El-Khalick et al., 2008; Stern & Roseman, 2004; Tamir & Pilar-Garcia, 1992), not much is known about how practical work is presented in secondary chemistry textbooks, especially in the context of secondary chemistry education in Chinese communities. This is why the current study focuses on how textbooks from different Chinese communities present practical work in chemistry education.

SAMPLE

The sample consists of seven sets of 10th grade (students aged about 15 years old) secondary chemistry textbooks and the accompanying experimental workbooks from Mainland China, Taiwan, and the Chinese sector in Malaysia.

In People's Republic of China, there have been two major rounds of curriculum reforms over the past 20 years. In 2003, new national Upper Secondary School Chemistry Curriculum Standards were released by the Ministry of Education (Ministry of Education, 2003), and corresponding textbooks were reviewed and published (Wang, 2010). The latest round of standards was released in 2017 and was meant to be implemented officially in the fall semester of 2018 (Ministry of Education, 2017). Since the textbooks corresponding to the newest 2017 standards are still under revision, the Ministry of Education has asked upper secondary schools to continue using the textbooks based on the 2003 standards (Ministry of Education, 2018). For this study, we chose three widely-used 10th grade chemistry textbooks and their workbooks, which were suggested by the Ministry of Education. These textbooks are published by People's Education Press (further named CN1), Shandong Science and Technology Press (CN2), and Jiangsu Education Press (CN3) (Appendix 1). As one of the most developed cities in China, Shanghai is allowed to operate education under its own standards and choose its own textbooks. Textbooks for Shanghai are edited under the review of the Shanghai Primary and Secondary Curriculum and Teaching Materials Reform Commission (Sun et al., 2016). In this study, we chose the chemistry textbooks from Shanghai Scientific and Technical Publishers (CN4, Appendix 1), as suggested by the Shanghai Municipal Education Commission (2018). In the case of Taiwan, we chose two sets of 10th grade chemistry textbooks and experimental workbooks (TW1 and TW2, Appendix 1) which are widely used in Taiwan and were recommended by the National Academy for Educational Research (National Academy for Educational Research, 2018). In addition to Mainland China and Taiwan, Malaysia is a country that operates a complete Chinese educational system from primary school all the way through to college. The country has about 23% ethnic Chinese out of a total of 32.4 million citizens (Xia et al., 2018; Xu & Xu, 2016). Independent Chinese Secondary Schools (ICSSs) are segregated into a separate branch using Mandarin Chinese as the main instructional language (Vivien, 2018). Official bodies supporting the Chinese educational system in Malaysia are the United Chinese School Committees' Association (UCSCA or Dong Zong), together with the United Chinese School Teachers' Association (UCSTA or Jiao Zong) (Dong, 2018). In this study, we chose the Malaysian upper secondary chemistry textbook and the associated experimental workbook which is published by the United Chinese School Committees' Association of Malaysia (MY, Appendix 1).

Table 2: Basic overview of features of practical work (adapted from Millar et al., 1999)

Practical work concerns
C1: Type of learning
C1.1: Operating a given experiment
C1.2: Picture/sketch illustrations
C1.3: Picture/sketch illustration on a laboratory technique
C1.4: Scientific investigation with an open approach
C2: Intended learning outcomes
C2.1: Identify objects and learn a laboratory technique
C2.2: Learn fact (s)
C2.3: Learn concept
C2.4: Learn a relationship
C2.5: Learn a theory/model with reference to the sub-microscopic level
C3: Inquiry level of practical work
C3.1: Confirmatory learning without hypothesis
C3.2: Confirmatory inquiry learning
C3.3: Structured inquiry learning
C3.4: Guided inquiry learning
C3.5: Open inquiry learning
C4: Students' engagement
C4.1: Context
C4.2: Performance
C4.3: Application

METHODS

All of the textbooks were examined page by page. Each representation of practical work was carefully collected and listed. The collection considered suggestions for practical work, descriptions of laboratory procedures, and sketches,

Table 3: Types of learning (inspired by Millar et al., 1998)

Type of learning	Illustration
Operating a given experiment	Tasks ask either the student or teacher to perform a given experiment
Picture/sketch illustration	Picture or sketches showing any experiment or practical activity to illustrate fact(s)
Picture/sketch illustration on a laboratory technique	Picture or sketches to illustrate a laboratory technique or the proper use of an apparatus
Scientific investigation with an open approach	Tasks that ask students to conduct (potential) experiments with an (at least partially) open approach

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or pictures showing examples of practical work. This led to an overall total sample of 508 representations from the seven selected sets of textbooks and experimental workbooks.

Analysis of the data was performed using qualitative analysis inspired by Mayring (2014) in a combination of inductive and deductive formation of categories. For the general rating grid, four categories (C1-C4) were identified: Type of learning, intended learning outcomes, inquiry level, and students' engagement. Each category was also subdivided into 3-5 sub-categories (Table 2). Table 2 was modified several times. The pilot trial analysis was performed until the final version sufficiently matched the data. Detailed rating schemes were developed that finally led to an inter-rater agreement of above 85% for the initial coding and above 95% with the second round of joint coding and negotiating the cases of disagreement.

The final analyzing instrument was inspired by Millar et al. (1998), who looked at practical work involving learning activities to prepare students for specific learning outcomes (Table 3). Later, Millar et al. (1999) explored the variety of practical work and came up with different intended learning outcomes which were used as the basis for developing the coding grid found in Table 4. Concerning the inquiry level, we selected the model by Banchi and Bell (2008). Then, we extended it by adding a category called "confirmatory learning without hypothesis" based on findings that the former four levels did not cover all of the cases in our sample (Table 5). To compare levels of students' engagement presented by practical work, we refer to Tiberghien et al. (2001) to explore how given tasks engage students in practical work (Table 6).

FINDINGS

Overall References to Practical Work

A total number of 508 representations related to practical work were collected from the seven selected sets of textbooks and associated experimental workbooks. The numerical breakdown

Table 4: Intended learning outcomes/objectives of practical work (inspired by Millar et al., 1999)

Intended learning outcomes	Explanation	Examples
Identify objects and learn a laboratory technique	Support students in identifying chemical objects and understanding a laboratory technique.	Filtration Distillation Decanting The proper use of a burette/separating funnel/centrifuge
Learn fact(s)	Support students in learning fact(s) at the phenomenological level so that they are able using them later for understanding.	Pure water boils at 100°reat standard atmospheric pressure Color change during chemical reactions Flame color test
Learn concept	Support students in relating two or more observable facts to understand a certain scientific idea leading to a concept inferred from observations.	Redox reactions, chemical bonds Molar mass Forces Electrolysis Oxidation and reduction of iron and its compounds
Learn a relationship	Support students in learning how to link a set of observations with properties or substances to understand a correlation dependent on variables.	Collecting data and drawing a diagram showing the relationship between potassium nitrate solutions and temperature The reaction speed of the alkali metals increasing with an increasing period in the periodic table of elements Substances in distillations evaporating dependent on their evaporation temperatures Solubility varying with temperature
Learn a theory/model with reference to the sub-microscopic level	Support students' data collection and interpretation skills using a specific theory based on unobservable entities, and hence help students to develop their understanding of the theory and how it can be applied.	Law of definite proportions Law of conservation of mass The model of chemical reactions as a rearrangement of atoms to form new groups

Table 5: Levels of scientific inquiry (inspired by Banchi and Bell, 2008)

Inquiry level	Explanation
Confirmatory learning without hypothesis	Learner given information or procedure without hypothesis, for example, laboratory technique operation manual
Confirmatory inquiry learning	Verification/confirmatory activities providing a question and detailed instructions to get a result explained in the text
Structured inquiry learning	Activities that provide a question and detailed instructions, but students have to find the answer
Guided inquiry learning	Activities that provide a question and the students have to design their own method to find the answer
Open inquiry learning	Activities that start from a fact or claim and students have to come up with a question, then design the method to find the answer

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of the representations was as follows: 98 from CN1, 75 from CN2, 70 from CN3, 61 from CN4, 43 from TW1, 45 from TW2, and 116 from MY.

Table 6: Students' engagement in practical activities (inspired by Tiberghien et al., 2001)

Context	Detailed operation process
	Picture/sketch aiding learning
	Chemical equation writing
	Safety operation tips
	Chemical recycle and waste disposal
	Sub-micro level explanation
Performance	Hands-on
	Hands-free
Application	Apply finding in a new context

Type of Learning

In the category labeled "type of learning," we can observe a wide variety (Figure 1). Figure 1 indicates that most of the practical work representations used in Mainland China and Malaysia focused on operating a given experiment. The Taiwanese textbooks had the lowest number of references to practical work. These were primarily pictures or sketches of experiments, either for illustration purposes or for introducing laboratory techniques. A scientific investigation employing at least a partially open approach could only be found in the textbooks from China and Malaysia to a varying degree. There were a total of 5 from CN4 and 23 in CN1. This was out of 61 to 98 representations of practical work in total, with having the highest numbers in CN1 and CN2 (23 and 17), correspondingly. Most of these were, however, taken from the

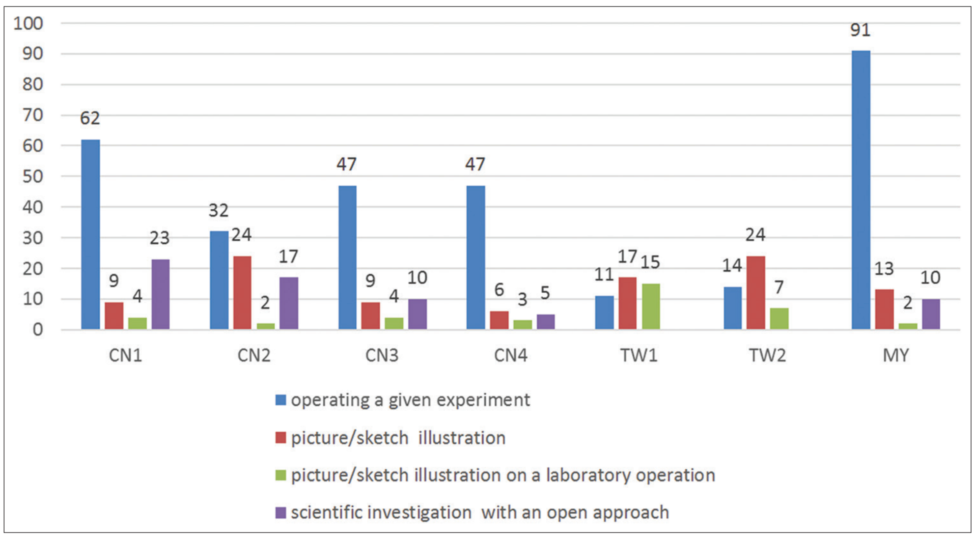

Figure 1: Type of learning suggested in presentations of practical work

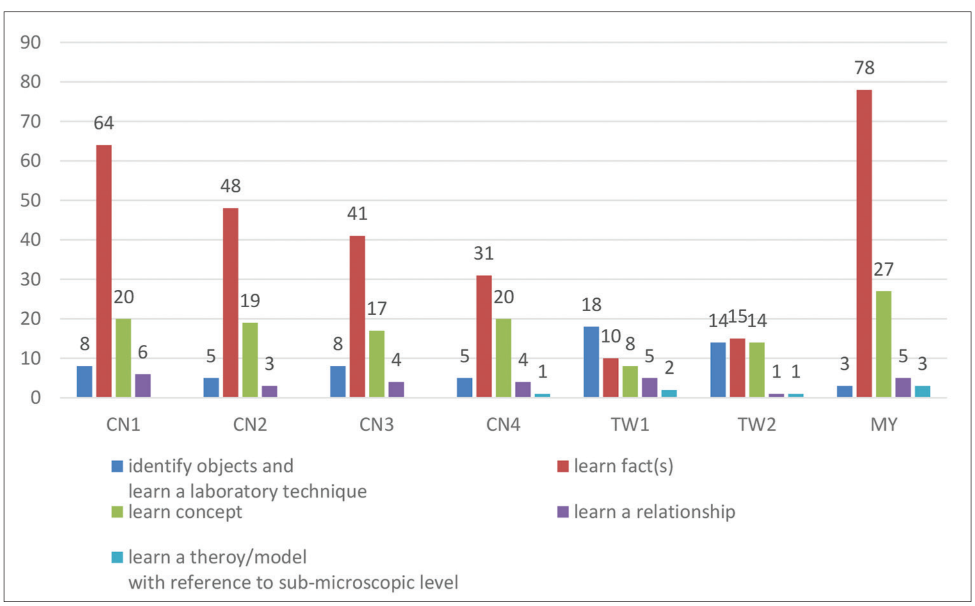

Figure 2: Intended learning outcomes suggested in presentations of practical work

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associated experimental workbooks, not from the textbooks themselves.

Intended Learning Outcomes

In terms of intended learning outcomes related to representations of practical work, we found a trend of "learning fact(s)" (Figure 2), which was quite pronounced in the textbooks taken from Mainland China and Malaysia (CN1, CN2, CN3, CN4, and MY). In the textbooks from Taiwan, which had lower numbers of figures in total, this category was not so predominant. The learning of a concept category made up roughly 20–30% of the representations of practical work found in all the books. The use of practical work for learning relationships between factors and concepts tended to be 10% or less in all the textbooks. Learning about theories or models was only connected to practical work in 7 out of the 508 representations identified in the whole sample, thereby only hovering around the 1% mark.

Inquiry Level of Practical Work

Looking more closely at the data concerning levels of inquiry, we can see that textbooks from Mainland China and Malaysia tended to suggest more inquiry-based activities. Most examples consisted of structured inquiry learning, although a certain proportion also suggested guided inquiry learning approaches (Figure 3). Confirmatory inquiry learning appeared in all of the above-mentioned textbooks, with the Shanghai textbook (CN4) containing the smallest number (7) of examples. In the textbooks from Taiwan, confirmatory inquiry learning dominated suggestions for structured or guided inquiry learning, making up about 75% of the references to practical work. This proportion was much smaller in the textbooks taken from Mainland China and Taiwan, which had roughly 15–30% as many references, correspondingly. The Taiwanese textbooks referred more often to practical work with the use

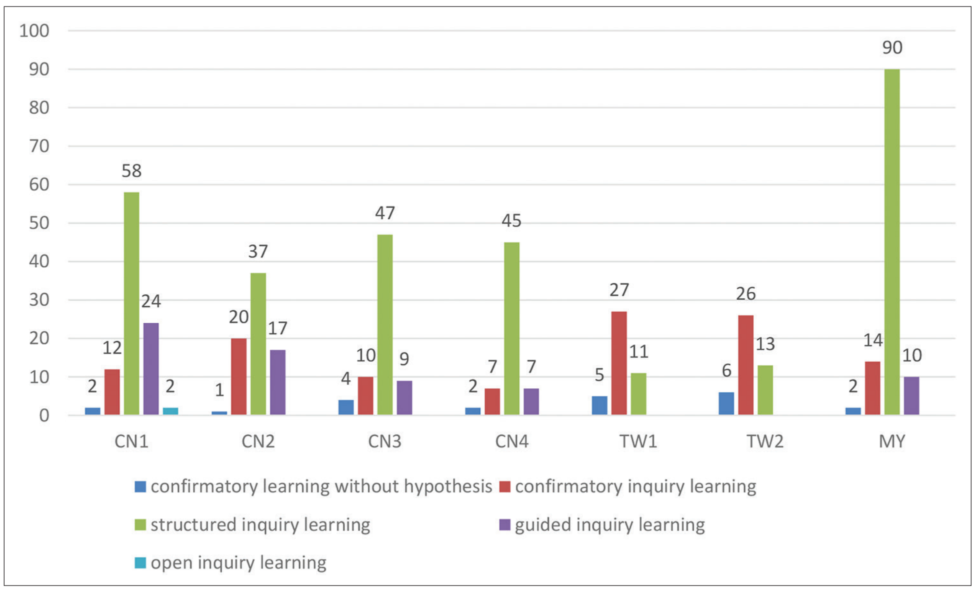

Figure 3: Inquiry level suggested in presentations of practical work

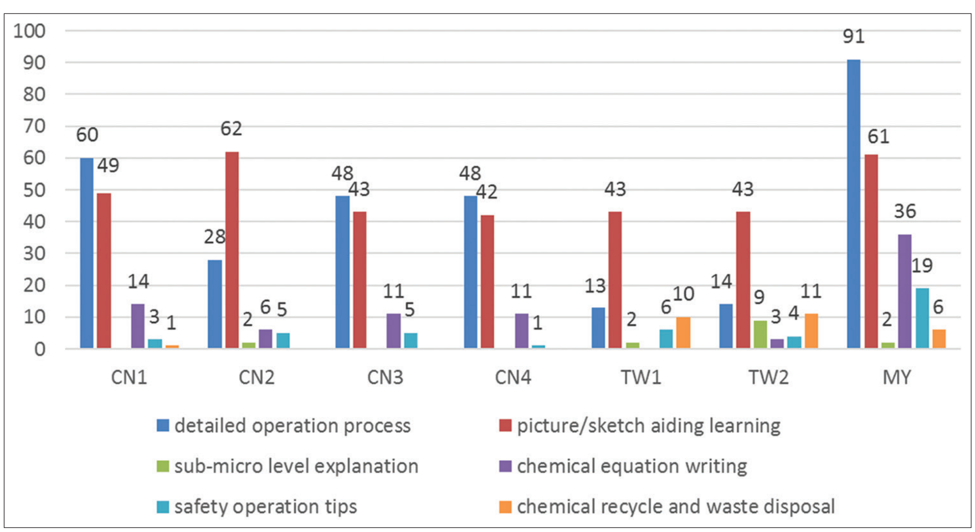

Figure 4: Students' engagement: Context related to presentations of practical work

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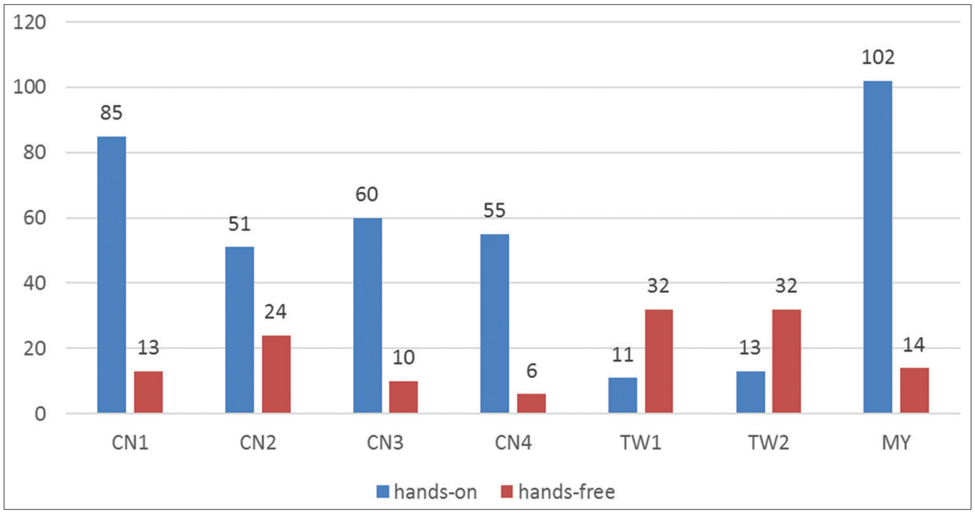

Figure 5: Students' engagement: Performance related to presentations of practical work

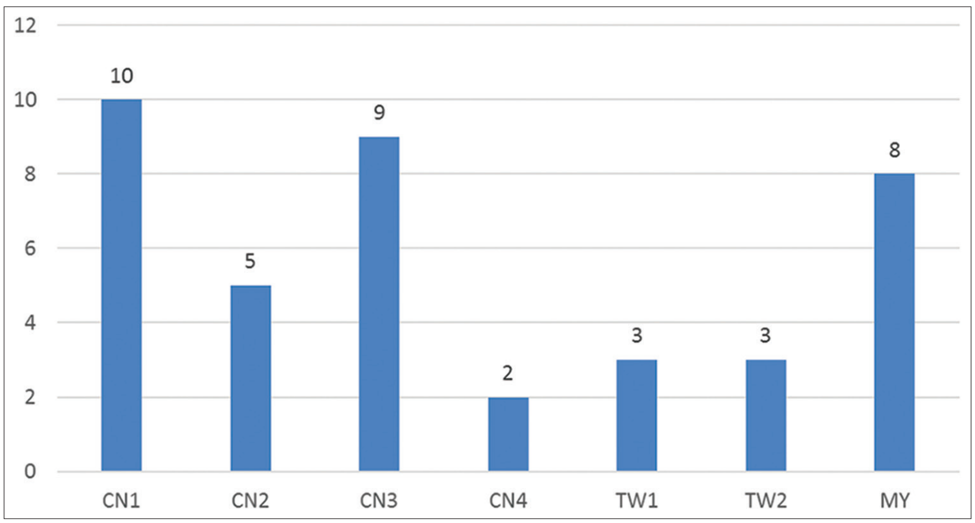

Figure 6: Students' engagement: Application of practical work to a new task

of pictures and sketches to illustrate the observation level. Confirmatory learning without a hypothesis tended to refer to the proper use of apparatus and essential operational processes such as filtration, distillation, and so on. There were, however, two suggested activities related to an open approach in one of the Mainland China textbooks (CN1). These were presented in an optional module in the experimental workbook.

Students' Engagement with Practical Work

The level of students' engagement with practical work varied widely in the different textbooks, as was the case in the other focuses of this study (Figure 4). In the textbooks from Mainland China and Malaysia, most references to practical work started with detailed instructions or using pictures or sketches to support learning. The highest number of detailed instructions could be found in the textbook from Malaysia. In Taiwan, there were much fewer detailed instructions; pictures and sketches to support learning dominate. All of the other categories played only a minor role. A focus on chemical recycling and waste disposal played a prominent role in the textbooks selected for Taiwan, making up roughly 25% of the references to practical work in both of the textbooks. It was also notable that hands-on activities were more often explicitly suggested in the textbooks from Mainland China and Malaysia than in the textbooks from Taiwan (Figure 5). Figure 6 shows that all of the textbooks provided references to practical work, asking students in certain situations to apply their findings in a new context. One example is that after students learn about the zinc-copper galvanic cell, extra tasks are given to them, which demand that they build a fruit battery with a tomato or a lemon. This is the case to a varying degree in only two or three up to ten tasks total (Figure 6).

DISCUSSION AND CONCLUSIONS

The purpose of this study was to examine Chinese 10th grade chemistry textbooks and their associated experimental workbooks. We examined representations of practical work taken from

Mainland China, Taiwan, and the Chinese sector in Malaysia. The study concentrated on the textbook analysis in four domains: Type of learning, intended learning outcomes, inquiry level, and aspects of students' engagement. There were similarities and differences in the chemistry textbooks of this sample. There were larger differences occurring in textbooks between different Chinese communities than within them. This could also be seen when we compared the use of visual representations in Chinese communities in the specific case of redox reaction content (Chen et al., 2019). The textbooks from Malaysia showed similar characteristics to those selected from Mainland China. This is in no way astonishing since educators from Mainland China take part in Malaysian ICSS chemistry textbook editing. The textbooks from Taiwan looked different in terms of the lower overall number of references to practical work, less representations of higher levels of inquiry learning, and in the number of references giving detailed instructions on how to carry out practical work.

In general, practical work in the textbooks from this sample refers to operating given experiments in all textbooks, except for Taiwan. In Taiwanese textbooks, more picture/sketch illustrations were used at the observational level. Confirmatory inquiry learning was quite dominant in Taiwanese textbooks, since they contained the highest proportion of picture/sketch resources that referred to corresponding tasks. This means that students observe pictures, instead of carrying out the whole experimental process for themselves. The other textbooks we examined tended to direct teachers and students more thoroughly toward a structured learning approach, which leads to an open answer for students to find by themselves. Guided inquiry learning could be found in all of the textbooks, except for Taiwan, but open inquiry learning only appeared as an optional module in one of the textbooks (CN1).

It is widely believed (Chiappetta & Fillman, 2007) that textbooks represent publishers' and authors' choices on reflecting the nature of science. It has been suggested that if laboratory activities in textbooks are properly developed, they have the potential to develop both students' meaningful learning and their conceptual understanding. There is a gap in research in many countries to know exactly how teachers are using textbooks, both in terms of intensity and their pedagogical approach. It is suggested, however, that in many centralized educational systems, such as in Mainland China, curricula, and textbooks are officially reviewed and published to serve as the main educational resource for the teachers (Zhang & Gao, 2013). In these countries, teachers rely heavily on the official curriculum, the associated textbooks, and any available teacher guidebooks when conducting their lessons. This was reported by Aldahmash et al. (2016) in the Saudi-Arabian context, where 100% of the teachers uniformly follow the same textbook in school step by step. Their data showed that this close adherence to the textbook led to a quite teacher-centered pedagogy. Similar claims that teachers are closely following the curriculum and textbook have also been made in the case of Mainland China (Wang, 2010). Reasons for this include the fact that a given educational system is a combination of physical settings (e.g., class size and class resource) and social settings (e.g., learners' background, local community, school principle, nation policy, and local education authority) (Watson et al., 2004). Another factor is the dominant role of centralized national college entrance exams in China, which focus more on rote learning of knowledge than on inquiry skills (Davey et al., 2007). This clear focus on final exams has already been described as a hindrance to educational reform toward more open teaching approaches (Chai & Cheng, 2011). Similar claims might also be assumed for the Chinese sector in Malaysia. Peen and Arshad (2014) stated that in Malaysian secondary schools, students get used to relying on their teachers for all information and instructions. They mostly listen passively to the teachers with occasionally limited questions being asked. If the teacher follows the textbooks step by step, there is a clear line for how practical work is introduced by the textbook to how it, therefore, effects students.

In other countries, it might be possible to find more openness for teachers to combine textbooks use with other media, for example, worksheets or internet resources, if such media are available. Countries with higher average levels of socio-economic development might expect their teachers to possess more resources than just the textbook, for example, digital media. Internet access should be available more broadly to enrich the learning experience in schools. Evidence has already shown that technology-aided learning in science education has become a popular trend in Taiwan (Lin & Tsai, 2016) and was also introduced in secondary chemistry education (Chen, 2018). This might be one reason for the lower number of representations of hands-on practical work suggestions in the textbooks from Taiwan if the textbook is being combined with other resources. To answer whether this is the reason, however, further research would be needed on how teachers in Taiwan rely on the textbook for lesson planning. It also needs to research in which manner textbooks are being combined with other resources.

This study is limited to chemistry education in three Chinese communities and only looks at one certain grade level. It also only deals with one aspect of textbooks and cannot say how these textbooks are being used, either as stand-alone tools or in combination with other resources. Answering these questions opens up further possibilities for research in the future. It also can stimulate further research into how textbooks develop over time. Malaysia recently implemented new chemistry textbooks and Mainland China will do so in the near future. Thus, the analysis of textbooks presented here can only be a snapshot in time, which needs to be revisited and deepened after the next round of curriculum reform and its implementation take place.

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APPENDIX

Appendix 1: Overview of the textbooks

Textbook	References	Pages
CN1	Song, X.Q. (Ed.). (2007). *Chemistry 1*. 3rd ed. Beijing: People Education Press.	111
	Song, X.Q. (Ed.). (2007). *Chemistry 2*. 3rd ed. Beijing: People Education Press.	112
	Song, X.Q. (Ed.). (2007). *Chemistry Experiment*. 4rd ed.. Beijing: People Education Press.	26 out of 81
CN2	Wang, L. (Ed.). (2007). *Chemistry 1*. 3rd ed. Shandong: Shandong Science and Technology Press.	139
	Wang, L. (Ed.). (2007). *Chemistry 2*. 3rd ed. Shandong: Shandong Science and Technology Press.	103
	Wang, L. (Ed.). (2007). *Chemistry Experiment*. 2nd ed. Shandong: Shandong Science and Technology Press.	39 out of 126
CN3	Wang, Z.H. (2014). *Chemistry 1*. 6th ed. Nanjing: Jiangsu Education Press.	111
	Wang, Z.H. (2015). *Chemistry 2*. 6th ed. Nanjing: Jiangsu Education Press.	109
	Wang, Z.H. (2009). *Chemistry Experiment*. 2nd ed. Nanjing: Jiangsu Education Press.	36 out of 106
CN4	Yao, Z.P. (Ed.). (2007). *Chemistry*. 1st ed., Vol. 1. Shanghai: Shanghai Scientific and Technical Publishers.	99
	Yao, Z.P. (Ed.). (2007). *Chemistry*. 1st ed., Vol. 2. Shanghai: Shanghai Scientific and Technical Publishers.	86
	Yao, Z.P. (Ed.). (2007). *Chemistry Workbook*. 1st ed., Vol. 1. Shanghai: Shanghai Scientific and Technical Publishers.	4 out of 40
	Yao, Z.P. (Ed.). (2007). *Chemistry Workbook*. 1st ed., Vol. 2. Shanghai: Shanghai Scientific and Technical Publishers.	10 out of 49
TW1	Huang, D.S. (Ed.). (2010). *Basic Chemistry 1*. 1st ed. Taiwan: LungTeng Cultural Co., Ltd.	189
	Huang, D.S. (Ed.). (2010). *Basic Chemistry 1-Experimental Manuscript.* 1st ed. Taiwan: Lungteng Cultural Co., Ltd.	77
TW2	Yeh, M.C.P. (Ed.). (2010). *Basic Chemistry 1*. 1st ed. Taiwan: Nan I Book Enterprise.	192
	Yeh, M.C.P. (Ed.). (2011). *Basic Chemistry 1*-Experimental Manuscript. 1st ed. Taiwan: Nan I Book Enterprise.	47
MY	Wang, C.K. (2017). U*pper Secondary School Chemistry*. 1st ed., Vol. 1. Malaysia: United Chinese School Committees' Association of Malaysia.	447
	Wang, C.K., & Lin, Y. (2018). *Chemistry Experiment Manuscript*. 1st ed., Vol. 1. Malaysia: United Chinese School Committees' Association of Malaysia.	126