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OP-ED

Designing a primary science curriculum in a globalizing world: How do social constructivism and Vietnamese culture meet?

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Abstract The implementation of social constructivist approaches to learning science in primary education in Vietnamese culture as an example of Confucian heritage culture remains challenging and problematic. This theoretical paper focuses on the initial phase of a design-based research approach; that is, the description of the design of a formal, written curriculum for primary science education in which features of social constructivist approaches to learning are synthesized with essential aspects of Vietnamese culture. The written design comprises learning aims, a framework that is the synthesis of learning functions, learning settings and educational expectations for learning phases, and exemplary curriculum units. Learning aims are formulated to comprehensively develop scientific knowledge, skills, and attitudes toward science for primary students. Derived from these learning aims, the designed framework consists of four learning phases respectively labeled as Engagement, Experience, Exchange, and Follow-up. The designed framework refers to knowledge of the "nature of science" education and characteristics of Vietnamese culture as an example of Confucian heritage culture. The curriculum design

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aims to serve as an educational product that addresses previously analyzed problems of primary science education in the Vietnamese culture in a globalizing world.

Keywords Social constructivist approach to science learning · Primary science education · Vietnamese culture · Confucian heritage culture · Design · Curriculum

Tóm tắt Việc thực hiện phương pháp dạy học môn khoa học theo tư tưởng kiến tạo xã hội trong các nhà trường tiểu học ở Việt Nam—một ví dụ cho nền văn hóa kế thừa Nho giáo—vẫn tồn đọng nhiều vấn đề và là một thách thức. Bài viết này mô tả một thiết kế chương trình dành cho môn khoa học cấp tiểu học trong đó các đặc điểm của hoạt động học theo lối kiến tạo xã hội được tổng hợp cùng với những đặc điểm cơ bản của nền văn hóa Việt Nam. Thiết kế gồm có mục tiêu học tập và khung chương trình. Khung chương trình bao gồm các pha học tập với các chức năng, hình thức, hoạt động, và các điều mong đợi tương ứng. Mục tiêu học tập của thiết kế này là nhằm phát triển một cách toàn diện kiến thức, kĩ năng khoa học và thái độ học tập tích cực cho học sinh tiểu học. Từ những mục tiêu ấy, bốn pha học tập được thiết kế là: *Thu hút, Trải nghiệm, Trao đổi,* và *Tiếp nối* được liên hệ đến những tri thức về giáo dục "bản chất của khoa học" và đặc điểm của nền văn hóa Việt Nam—được dùng như một ví dụ cho nền văn hóa kế thừa Nho giáo. Thiết kế chương trình dạy học này là một sản phẩm giáo dục của thời đại toàn cầu hóa. Nó cũng được coi là một giải pháp cho những vấn đề còn tồn đọng trong hoạt động giáo dục môn khoa học ở cấp tiểu học tại Việt Nam.

Education in many Asian countries has been deeply influenced by Confucian heritage culture (Hofstede, Hofstede, and Minkov 2010), with a characteristic teaching style in which the teacher is always right and the students are not entitled to ask about the sense or purpose of the content of learning activities, to inquire into the reasons for these activities, or to ask questions (Chan 1999). Science teaching in Confucian heritage culture (CHC) is criticized by its knowledge-centered approaches with passive students in the classrooms (Liu and Littlewood 1997), but also praised for the importance it gives to family values and collectivistic roots (Phuong-Mai, Terlouw, and Pilot 2005). Although there is debate in recent literature (Tran 2013; Ryan and Louie 2007) on why Confucian heritage culture is or is not appropriate as a descriptor for all student learning in group of Asian countries/regions (China, Hong Kong, Taiwan, Korea, Japan, Vietnam and others) with different linguistic, political and religious backgrounds, we acknowledge that Confucianism is still a kind of regional culture that influences teaching and learning by "situation specific factors of teaching methodologies, learning requirements, learning habits and language proficiency" (Tran 2013). We support the proposition that teaching and learning styles are contextual (Bulte, Westbroek, De Jong, and Pilot 2006) and learners are highly adaptive (Biggs 1996). In this way, we reinforce values of social constructivism, which stresses roles of culture and contexts to teaching and learning (Vygotsky 1978), and foster the application of social constructivist perspective into teaching and learning. This view forms the main argument for our paper on designing a social constructivist curriculum for primary school science in Confucian heritage cultures. The paper is also supported by the ideas that the application of any teaching and learning theories should be culturally appropriate (Phuong-Mai et al. 2005) to avoid a false universalism and to reduce practical difficulties (Serpell 2007). To avoid over-generalization of the idea of Confucian heritage culture and the Confucian-Western dichotomy (Ryan and Louie 2007), this paper focuses on Vietnamese primary education; from that point it is related to the broader context of the Confucian heritage culture.

Culture is considered as the mental program which is referred to all those patterns of thinking, feeling, and acting that were learned throughout the person's lifetime (Hofstede et al. 2010). It is acknowledged that culture has hierarchical levels, from small scales that are individual culture, group culture to larger scales such as national culture, regional culture, and global culture (Hofstede et al. 2010). Confucianism has existed in the Asian countries like China, Taiwan, Japan, Korea, and Vietnam for 1000 of years (Phuong-Mai et al. 2005). These countries may have differences in their own national cultures and globalization may have made them change significantly. Confucianism and Confucian classical philosophers may have "lived 1000 of years and thousands of miles apart" and Confucian education for the last 2000 years should not be treated as a philosophy that stays more or less the same (Ryan and Louie 2007), Confucianism is believed to have maintained its influences on these cultures. This is because of its deep and long generic existence which does not easily disappear in decades of modern and global years. As a consequence, Confucianism can be viewed as a regional culture. The evidence for this was exposed in the work of Hofstede and his colleagues in which Confucian heritage countries were found to have more similarities than non-Confucian heritage ones in term of the dimensions: power distance, individualism versus collectivism, masculinity versus femininity, uncertainty, avoidance, long-term orientation versus short-term orientation, and indulgence versus restraint (Hofstede et al. 2010). Accordingly, to a large extent, Confucian heritage countries have common teaching and learning styles (see Hofstede et al. 2010). Such characterizing aligns with what is reported by many scholars, i.e. Purdie, Hattie, and Douglas (1996) and Subramaniam (2008), and with the findings of Hằng et al. (2015).

Present-day globalization has been inducing a modernization process in many of the Asian countries by the introduction of new materials, production and jobs, new means of communication and issues like climate change and sustainability. Consequently this poses new requirements for the labor force (Hoan 2002). These developments challenge educational policy makers who have put more emphasis on developing skills and attitudes appropriate to cope with the socio-economic changes while recognizing the special features of Confucian heritage culture. Educational programs in the Asian countries have revised and reformed their curricula by often adopting western innovative educational theories. However, despite such efforts of reforming, teaching and learning of science in primary schools still remains problematic (Hằng et al. 2015). The application of western innovative educational theories is perceived as challenging. Beyond perspectives on Asian learning approaches, it is recommended to focus on applying and refining educational theories that should be made appropriate with Asian context (Örtenblad, Babur, and Kumari 2012) to avoid a cultural mismatch (Nguyen, Elliott, Terlouw, and Pilot 2009). In this paper, we aim to present enriching possibilities for the learning of science for different cultures.

Social constructivist approaches were considered as a paradigm change in science education (Tobin 1993), and an outcome of a growing line of critique against approaches in science education that tend to overemphasize the individual's learning and neglect social aspects in knowledge-construction processes (Duit and Treagust 1998). It is viewed that students need help to acquire and build on not only knowledge but also skills and attitudes toward science. Teaching approaches should involve the whole person: thought, emotion, and action (Beck and Kosnik 2006). According to Richard Coll and Neil Taylor (2012), the

1980s and 1990s witnessed “explosive” curriculum reforms world-wide with origins in constructivism and its variants. These reforms could also learn from recognizing the special features in science education in other cultures, like Confucian heritage cultures (e.g. family values and collectiveness).

The introduction of social constructive approaches to learning science in other cultures remains challenging (Hằng et al. 2015). According to Yair Neuman and Zvi Bekerman (2000), it is difficult to apply such approaches to a community in which students have taken a rather passive role in teacher-centered teaching styles (as is the case in many countries). Implementation in Vietnam has been considerably influenced by the traditional culture (Hằng et al. 2015). Primary education in Vietnam is partly in alignment with social constructivism and partly there are divergences (Hằng et al. 2015). Findings from these studies reinforced the proposition that there is a need for a design framework for primary science education in which elements of social constructivism are appropriately aligned with Vietnamese culture. In this design, a social constructivist approach and Vietnamese culture should complement and supplement each other in a synthesis of a meaningful, life-oriented and engaged primary science education.

However, there is a lack of design knowledge on how to synthesize elements of social constructivism with characteristics of the Vietnamese culture. This lack provides a rationale for the authors to develop a formal, written curriculum (Van den Akker 2003) for primary science education with elements of social-constructivism, which are appropriate for the Vietnamese culture. To do that, we chose to follow a design-based research approach (Bulte, Westbroek, De Jong, and Pilot 2006) with the explicit formulation of the written curriculum as a first essential step. Then it is feasible to incorporate educational issues and cultural aspects that address the challenges of primary science education in the Vietnamese culture. This design-based approach takes the divergences between social constructivist approaches and the Vietnamese culture into consideration and provides new educational guidelines promising for educational progress. This paper therefore is a description of the formal, written curriculum, which forms the initial phase of design-based research. Before coming to the empirical stage of enactment of new materials in class, we think it is essential to describe the theoretical arguments that form the basis of these new and innovative materials.

Characteristics of the social constructivist approach and of the Vietnamese culture

Social constructivist approach to learning science

The multiple roots of social constructivism in science learning are based on the research of Jean Piaget and Lev Vygotsky. Piaget’s research is understood to be about cognitive constructivism, in which the development of human intellect to proceeds through adaptation and organization; learning therefore is defined as a process of accommodation, assimilation, and equilibration. Rejecting Piaget’s assumption that it is possible to separate learning from its social context, Vygotsky argued for the importance of culture and context in forming understanding; hence, learning was defined not to be a purely individual process but a social construct mediated by language via social discourse (Pitsoe 2007). Beyond this, a social constructivist view considers the social context in which learning occurs as central to learning itself (Pitsoe 2007). It encourages all members of a learning community to present their ideas strongly, while remaining open to the ideas of others (Beck and Kosnik 2006). The common idea of the two perspectives of constructivism is the notion that the individual is "active"; accordingly, human cognitive development is fostered by engaging, grappling, and seeking to make sense of things based on utilizing prior knowledge and experiences (Pitsoe 2007).

According to Clive Beck and Clare Kosnik (2006), social constructivism encourages students to be active in learning and to present their ideas strongly, while remaining open to the ideas of others. The key features and indicators of social constructivist approaches to learning are synthesized and presented in Table 1.

At the level of primary science education, social constructivist approaches have been increasingly applied in many countries connected to western cultural traditions through the predominance of inquiry-based approaches that emphasize the "nature of science" education (Abd-El-Khalick and Lederman 2000). This is because "what is called inquiry learning is very similar to what others call constructivist learning" and "as with inquiry, the constructivist label can be applied to the nature of science, learning and teaching" (Anderson 2007b, p. 809). More recently, the historical, tentative, empirical, logical, and well-substantiated nature of scientific claims and the value of open communication and the interaction between personal, societal, and cultural beliefs in the generation of scientific knowledge were captured within "nature of science" education (Abd-El-Khalick and Lederman 2000). In this paper, the term "western educational philosophy" is used mainly to refer to the social constructivist perspective and knowledge of "nature of science" education in which inquiry-based learning is emphasized.

Confucian heritage and Vietnamese culture

The countries strongly influenced by Confucianism include Greater China, Taiwan, Korea, Japan, Vietnam, and Singapore (Phuong-Mai et al. 2005), although recent changes have influenced the settings in parts of these Confucian heritage countries in different ways and

Table 1 Features and indicators for the social constructivist (SC) approach as applied in this study

SC feature	Indicator
Learning is social	Students work in whole class, and/or Students work in small groups Students actively share ideas
Knowledge is experience-based	Students' experiences are provoked Students interpret experiences
Knowledge is constructed by learners	Students are immersed in realistic learning situations Students elaborate interpretations of their experiences Students test interpretations of their experiences Students make meanings
All aspects of a person are connected	Students' attitudes and emotions are revealed in learning Students take part in hands-on activities Students' values are employed and capitalized in learning
Learning communities should be inclusive and equitable	Types of communities, e.g., families, organizations, institutions, etc., are involved to support students' learning Interactions of teacher-student and student–student should be equitable rather than hierarchical

to different extents concerning free or censored information, network technologies and economic situation. The features briefly characterizing the Confucian heritage culture include the following:

a. *The collectivist root* Confucian heritage countries share characteristics of a collectivist society (Phuong-Mai et al. 2005) with an agriculture-rooted culture that requires individuals to live a settled life with a fixed residence and value collectivism and solidarity as well (Thêm 1997).
b. *The harmony and stability preference as a cultural and human value* Individuals in Confucian heritage cultures prefer stable lifestyles (Thêm 1997) and like to remain in harmony with their natural and social environments (Berthrong and Berthrong 2000). This preference may have been influenced by an agriculture-rooted culture of Confucian heritage countries that originally promoted settled cultivations and fixed residences which required individuals to depend on nature (see Thêm 1997). Harmony is supported and recommended by Confucianism to help individuals obtain a consensus that can lead to a common peace and a stable life (Đạm 1994).
c. *The virtue focus* The cultivation of virtue is emphasized with the aim that the individual be *a good person*. Benevolence, righteousness, civility, knowledge, and loyalty are strongly stressed in Confucianism (Doãn 1999). Accordingly, personal interests of *I* should be limited to the interests of *We*.
d. *The support of hierarchical order* Confucianism stresses a hierarchical order with its core objective of building a stable and well-ordered society (Berthrong and Berthrong 2000). In Confucian heritage culture, hierarchical relationships are manifested by respect for age, position and family background. Accordingly, two kinds of subjects, including superior and inferior, are determined for human interactions and social communications. In the support of hierarchical order of Confucian heritage culture, sacrilege is avoided and patriarchal behaviors are promoted (Đạm 1994).
e. *The family value* Confucianism considers the family to be a foundation community from which societal communities are expanded (Đạm 1994). Confucianism also considers family as a miniature version of the country and cannot be separated from society as a whole (Doãn 1999). Confucian individuals are required to keep the family at the center of their life and family relationships are regarded to be more valuable than the law of the land (Đạm 1994). In Confucianism, family is viewed as an educational environment for individuals to cultivate virtue and to have significant influence on the stability of society (Doãn 1999).
f. *The emphasis on theoretical knowledge* Theoretical knowledge in ancient classics is traditionally appreciated and considered permanently correct. Along with this, the method of *educating by ancient classic works [giáo dục lục nghệ]*, and the method of quoting and citing of classics and examples, which has been largely applied in social communications and also in teaching and learning, has stimulated rote learning (Doãn 1999).

These Confucian values do not all align with those espoused by adherents of social constructivism. Hằng et al. (2015) has shown three main divergences between Confucian heritage culture and this approach to social constructivism learning of science.

1. Confucianism emphasizes stability and harmony among its human values, whereas Western educational philosophy emphasizes rationality (Totten, Sills, Digby, and Russ 1991) that supports argumentation and conflict in discussion and helps students to be prepared for citizenship (Kolstø 2001). Conflicts and argumentation are necessary

elements in the “nature of science”, and this diverges from the tendency to prefer harmony in Confucian heritage culture.
2. Confucian heritage culture emphasizes theoretical knowledge, considering “classical” knowledge and theory as permanently correct, whereas western educational philosophy emphasizes empirical knowledge and well-substantiated scientific claims, believing that there is no complete truth and that every aspect of theoretical knowledge is changeable (Dekkers 2006).
3. Confucianism emphasizes hierarchical order in which the teacher is considered superior and the transmitter of knowledge to students, whereas western educational philosophy emphasizes equitability: the teacher is considered a more advanced learner (Vygotsky 1978) who facilitates students to learn in order to achieve not only knowledge but also the skills and attitudes used to study science (Bybee, McCrae, and Laurie 2009).

With a case study on primary science education in Vietnam about the implementation of approaches with the features for social constructivist learning of science as indicated in Table 1, Hằng et al. (2015) revealed that the characteristics of Confucian heritage culture, including the collectivist root and the family value, is in alignment with the features of social constructivism; whilst the other characteristics, including (i) the harmony and stability preference, (ii) the virtue focus, (iii) the support of hierarchical order, and (iv) the emphasis on theoretical knowledge, diverge from social constructivism. The investigation of the cultural characteristics uncovered a cultural tension between the social constructivist approach and Confucian heritage culture.

There was alignment between social constructivism and Confucian heritage culture when primary students would prefer to learn in small groups, have high expectations of cooperative experimental tasks in their science lessons, and families and fieldwork are included for science education (Hằng et al. 2015). Primary teachers in Vietnam appreciated the application of group learning for science lessons (Hằng et al. 2015).

For developing a written, formal science curriculum, we follow the socio-cultural tradition in the research of science education (Anderson 2007a). Although social constructivism has been criticized as resulting sometimes in relative low content knowledge (Benson 2001), it is reported as an effective learning approach enabling students to be fully engaged, to find their learning process meaningful, and to relate new scientific ideas to the real world (Beck and Kosnik 2006).

A design-based research approach to curriculum development

The term *curriculum* can be considered at different levels: the ideal, the formal, written, the operational, the experiential and the learned curriculum (Van den Akker 2003). The present paper focuses on the initial phase of a design-based study; in which the theoretical arguments that form the basis of these new and innovative materials are presented. In a subsequent phase, the developed framework is to be tested in classrooms with students and teachers; empirical findings often lead to adjustments. This paper describes the initial phase: the design of the formal, written curriculum, and documents the essence of the synthesis of social constructivist approaches to science learning with Vietnamese culture. This focus leaves the curriculum in the making that takes place between teachers and students beyond the focus of this paper at the moment. We think that the documentation of the synthesis in its written form is an important theoretical construct in itself.

In this paper, we use the term ‘framework’ for primary school science in the Vietnamese culture. This term expresses the commonplace theory about “intentions as specified in curriculum documents and/or materials”, defined by Van den Akker (2003) as formal representation of the curriculum. Through exploring the development of science curricula, several terms are used by educational researchers including *didactical structure* (Lijnse and Klaassen 2010), *curriculum materials* (Krajcik, McNeill, and Reiser 2008), and *framework* (Meijer, Prins, Bulte, and Pilot 2008). For our theoretical argument, we prefer the term framework, because we intend to bring forward a format that goes beyond the use of single curriculum units. Therefore, the written documentation includes: instructional aims, instructional phases which are constructed by functions, activities of teaching and/or learning, and educational expectations.

Learning aims are necessary to provide a direction for designing an instructional framework in which four main components are aligned: learning phases, functions, learning settings, and educational expectations. These components are strategic and emerged from existing curricula of science education (Bulte et al. 2006). Functions are defined as instructional theories that are prescriptive in nature and were set up for a transition between the learning phases and learning settings. In this study, the learning setting comprises the *learning activities* and *learning forms*. Learning activities are a chain of actions that can be realized through operations. The learning form includes the description of the teaching method; that is learning individually, in small groups, or in the class as a whole. The design of learning activities and learning forms provide a strategic structure to shape corresponding science units for teaching in classroom practice. The design of the learning settings led to the establishment of educational expectations, which were defined as important predictors of educational attainment. All of the components and sub-components of the designed instructional framework are presented in Fig. 1.

In this paper, educational expectations are the link between the formal curriculum and the operational curriculum (Van den Akker 2003). The operational curriculum can be observed in the actual teaching and learning through the enactment of science units in classroom practice and is needed for the evaluation of the formal curriculum. For that reason, educational expectations play an important role and are considered as hypotheses of what the curriculum is expected to bring about.

Design of the formal curriculum

The total design consists of three interrelated parts: 1) learning aims, 2) the instructional framework, and 3) exemplary curriculum units (Fig. 1). Based on the design framework (Fig. 1), a specific and detailed formal curriculum based on a social constructivist approach is developed as below.

Learning aims

To meet the new requirements for the future labor force in modernizing Asian countries, primary science education in the Vietnamese culture aims to develop flexible science knowledge that is useful in the future; it should foster scientific thinking skills, and develop critical attitudes towards science. Therefore the aims for primary science students are defined as follows the development of:

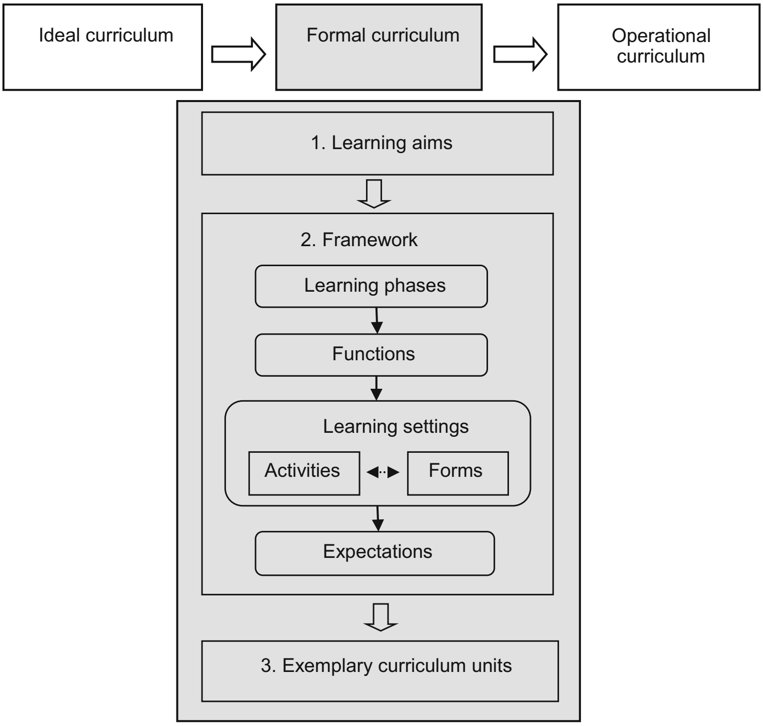

Fig. 1 Overview of the design-based approach of the study with a focus on the formal representation of the curriculum

1. *Scientific skills* observing, hypothesizing, experimenting, reasoning, arguing, questioning, and applying
2. *Appropriate attitudes* curiosity and interests in science
3. *Scientific knowledge* relevant to students' daily lives

The above learning aims are consistent with the goal of science education recommended by science educators (Duschl, Schweingruber, and Shouse 2007) as well as with the constructivist principles as introduced by Sunal and Haas (2002). These learning aims also align with the goals of primary school education in Vietnam: to help students to know how to develop self-directed learning and to be cooperate in learning, to remain proactive, active, and creative in finding and solving problems in order to master new knowledge (Hoan 2002).

The framework

The authors' design is influenced by Dewey's Instructional Model and the BSCS 5E Model (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, and Landes 2006). All of these models emphasize and employ students' experiences, inquiry activities, and curiosity to help students to learn science. Dewey's Instructional Model comprises 6 phases: (1) Sensing Perplexing Situation; (2) Clarifying the Problem; (3) Formulating a Tentative Hypothesis; (4) Testing the Hypothesis; (5) Revising Rigorous Test; and (6) Acting on the

Solution. Though John Dewey is considered as one of the pioneers of social constructivism, Dewey's Instructional Model does not explicitly manifest active social and constructivist roles of students for learning as it focuses on the instructional role of teacher. Also, it cannot provide an instruction detailed enough to set up corresponding social constructivist units. The BSCS 5E Model comprises the phases: (1) Engagement; (2) Exploration; (3) Explanation; (4) Elaboration; and (5) Evaluation. It is considered as a representative for the conceptual change tradition other than a socio-cultural tradition (Guzzetti, Snyder, Glass, and Gamas 1993). The 5E Model was designed without description of functions, learning settings, and educational expectations for each of the phases so it might be hard for teachers to adhere for designing corresponding units. Both of the above models were designed for application to Western science education.

In the design of the formal curriculum based on a social constructivist approach, four learning phases were determined and labeled as *Engagement*, *Experience*, *Exchange*, and *Follow-up*, all of which were considered to reflect explicitly an appropriate synthesis of elements of social constructivism and the Vietnamese culture. These learning phases are composed of the alignments of learning functions, learning settings and educational expectations. The designed instructional framework is summarized and presented in Table 2.

Phase 1: Engagement

The word *Engagement* was chosen for this phase from various terms, such as: *orientation, attention, ice-breaking,* and *engagement*, which can be used to indicate the starting activity of learning. It was chosen because of its stronger focus on the direct and active involvement of students to avoid the tendency of leaving students passive in the hierarchical order between teacher and student (Hằng et al. 2015). The phase *Engagement* has one main function: to provide students with a motivation to learn (*Function A;* Table 2).

Motivation is defined as the force that arouses enthusiasm for and persistence in pursuing a certain course of action (Daft and Marcic 2000). It is considered to affect students' participation in science classrooms and have consequences for the quality of their learning (Duschl et al. 2007). Motivation is necessary for students to achieve the learning goals (Gagne and Medsher 1996). Learning motivation can foster the more equal communication between the teacher and students, anxiety associated with learning can decrease, and active engagement in learning becomes more evident (Wlodkowski 1999). Evidence of student learning with motivation comes from observations of students' willingness to take part in activities organized for them to learn, such as discussing, experimenting, arguing, questioning, answering, writing, and so on. It is also manifested in students' excitement and concentration while they are learning.

In the Vietnamese culture intrinsic motivation for learning is considered important (Doãn 1999). Traditionally, individuals in Confucian heritage culture were encouraged to become as knowledgeable as possible, as in a style of *a full knower* (a person who knows everything). This traditional motivation was rather about *learning to know*. Today this motivation has been changed and shifted influenced by modernization and globalization (Hoan 2002). If Vietnam wishes to find its place in a global economy, then this searching may require a creative stance in the whole process of the global economy and industrialization requiring a search for the type of education for the future work force, and for future citizenship. In the current primary school curriculum in Vietnam, the motivation of *learning to know, learning to do, learning to live together, learning to be*, as integrated into the educational goals determined by UNESCO, are stressed in raising and nurturing

Table 2 The designed framework of the social constructivism-based curriculum for primary science education in the Vietnamese culture

Phase	Function	Learning setting		Educational expectations
		Activity	Learning form	
Engagement	To provide students with a motivation to learn	Doing a small hands-on task with a relevant example related to scientific subject matter Answering questions about *What*, *How*, and *Why* on a relevant example related to scientific subject matter	In small groups and/or in the class as a whole	Students are interested in scientific subject matter
Experience	To evoke attitudes towards science To acquire procedural knowledge To acquire conceptual knowledge To acquire argumentative skills	Predicting: Observe and discuss in order to answer questions: *What do you observe? What will happen if…? Why do you think so?* Hands-on: Do experiment and discuss in order to answer questions: *What did you observe? How to explain? Why do you think so?* Questioning: Formulate questions related to scientific subject matter	In small groups	Students are curious about learning representative examples of scientific subject matter Students are active in learning representative examples of scientific subject matter Students use their intuitive knowledge to learn about scientific subject matter Students argue with each other to attain consensually agreed knowledge on representative examples of scientific subject matter
Exchange	To build on attitudes towards science To build on procedural knowledge To build on conceptual knowledge To build on argumentative skills	Presenting results to other groups Discussing results with other groups Answering formulated questions related to scientific subject matter	In the class as a whole and/or in combined groups	Students are interactive in learning scientific subject matter Students argue with each other to attain consensually agreed knowledge on scientific subject matter
Follow-up	To acquire cognitive flexibility To develop motivation for further learning	Providing answers and/or solutions for questions and/or problems related to scientific subject matter	In the class as a whole	Students can provide proper answers and/or solutions on applying attained knowledge Students show their desire to learn more about scientific subject matter

students (Hoan 2002). Students can be motivated by using real-world problems and by leaving them to reconsider their own understanding in light of new experiences (Harkness, Morrone, and D'Ambrosio 2007). Therefore, in this phase, two activities are set up for students including:

- Doing a small hands-on task with a relevant example related to scientific subject matter (*Activity 1,* Table 2)
- Answering questions about *What*, *How*, and *Why* on a relevant example related to scientific subject matter (*Activity 2,* Table 2)

Hands-on activities and relevant examples along with the opportunity to ask questions are considered to provoke in students emotional or personal information through which motivation can be aroused (Morrone, Harkness, D'Ambrosio, and Caulfield 2004). We recommend that the activities in this phase remain rather flexible in learning form: in small groups and/or in the class as a whole (*Form 1*). These learning forms are aligned with the social constructivist feature *Learning is social* (Table 1). Also, the use of these learning forms is supported by the collectivist root of the Confucian heritage culture with the tradition of learning together and peer learning (Hằng et al. 2015). The application of small groups and whole class grouping in this way are avoids the application of pair grouping for reproductive tasks, which has been shown to hinder Vietnamese students' progress towards active learning (Hằng et al. 2015).

The function of learning motivation leads to the educational expectation determined for this phase, that is: Students are interested in scientific subject matter (*Expectation a;* Table 2) because they realize that they do not yet know enough to be able to explain the problem. Thus, students develop a content-related motive for further learning, which is carried out in the next phases.

Phase 2: Experience

From all the terms that could be used to refer to student-based experimental and hands-on activities: *exploration*, *experimentation*, *practice*, and *experience*, *Experience* was chosen because it better indicates experience-based activities as an essential element of social constructivism. Experience-based learning aligns well with a Confucian method of teaching called *individual-oriented instruction [nhân tài thi giáo]* and the appreciation to experiences for learning (Lê 1992).

The phase *Experience* is determined to have four functions (Table 2), including:

- To evoke attitudes towards science (*Function B*)
- To build procedural knowledge (*Function C*)
- To build conceptual knowledge (*Function D*)
- To build argumentative skills (*Function E*)

Science is not simply a body of knowledge. Skills and attitudes towards science play an important role in scientific literacy (Bybee et al. 2009). Students should learn science by doing scientific activities like observing, describing, discussing, hypothesizing, questioning, arguing, experimenting, following procedures, judging, evaluating, concluding, writing and reporting (Lemke 1990). Such activities reflect methodical activities in the "nature of science" education (Abd-El-Khalick and Lederman 2000) upon which scientific argumentation is centered. The utilization of cooperative inquiry activities, as manifested by the organization of hypothesizing and experimental tasks and discussing activities, aims to promote empirical knowledge, social interactions and scientific argumentation. The design should be strong enough to meet the requirements reflected in the new learning aims, since at these points Confucian heritage culture diverges with social constructivism: in line with the harmony and stability preference and the virtue focus of Confucian heritage, students tend to avoid argumentation and conflicts during discussions (Hằng et al. 2015). Furthermore, the employment of cooperative inquiry tasks should avoid rote learning, as influenced by the traditional emphasis on theoretical knowledge (Hằng et al. 2015).

In phase *Experience*, students are organized to work with representative examples of scientific subject matter and do the following interrelated activities (see Table 2):

- *Predicting* Observe and discuss in order to answer the questions: *What do you observe? What will happen if…? Why do you think so?* (*Activity 3*)
- *Hands-on* Do experiments and discuss in order to answer the questions: *What did you observe? How to explain? Why do you think so?* (*Activity 4*)
- *Questioning* Formulate questions related to scientific subject matter (*Activity 5*)

These activities are designed to support argumentation in science classes (Driver, Newton, and Osborne 2000). In attempting to answer the questions posed, students are recommended to work in groups so that they can use their own language to discuss the concepts being examined (Von Glasersfeld 1989). For this reason, it is recommended that the activities in this phase take place in small groups (*Form 2,* Table 2).

Based on the above learning functions and activities, four educational expectations were determined for this phase (Table 2) including: students are curious about learning representative examples of scientific subject matter (*Expectation b*), students are active in learning representative examples of scientific subject matter (*Expectation c*), students use their intuitive knowledge to learn about scientific subject matter (*Expectation d*), and students argue with each other to attain consensually agreed knowledge on representative examples of scientific subject matter (*Expectation e*).

Curiosity is a basic emotion and quality in science learning that generates actions to answer questions that lead to new questions (Minstrell and Van Zee 2000). Curiosity along with questioning-based learning is emphasized by the Vietnamese culture, as expressed in the Vietnamese idiom: *To know, you have to ask questions. To be good, you have to learn [Muốn biết phải hỏi, muốn giỏi phải học].*

Intuitive knowledge plays an important role in science learning (Driver, Guesne, and Tiberghien 1998). It can provide beliefs that are attained by personal experiences and that are the source of biases due to a lack of scientific justification. Intuitive knowledge enables students to respond quickly and is often appropriate to teachers' questions about the subject matter. These responses are raw, but primary sources need to be utilized to help students in constructing their new knowledge (Watson 2001). Intuitive knowledge can be considered prior knowledge or existing experience that students already have when they get into lessons. The emphasis on experience for learning, as a typical feature of the social constructivist approach (see Table 1) is encouraged by Confucius, who spent years as a traveller in order to learn about human life and world affairs (Lê 1992). Experience-based learning might be appreciated in Vietnam, where there are many proverbs and idioms stressing the value of experience.

Phase 3: Exchange

The term *Exchange* was chosen for this phase from various terms such as *presentation*, *discussion*, *explicitness*, *interpretation* and *exchange*. Compared to the other words, *exchange* better reflects social interactions that require oral activities, such as presenting, sharing, discussing, explaining, arguing, and negotiating, as the ones stressed by the social constructivist perspective. Additionally, the term aligns with the collectivist roots of Confucianism that are focused on coming to a consensus, because exchanging of perspectives is a necessary prerequisite for reaching consensus.

The functions in the phase *Exchange* are determined so as to build on the ones in the previous phase, *Experience*. Therefore, this phase is determined to have four functions (Table 2), as follows.

- To build on attitudes towards science *(Function F)*
- To build on procedural knowledge *(Function G)*
- To build on conceptual knowledge *(Function H)*
- To build on argumentative skills *(Function I)*

Based on these functions, three learning activities, which are interconnected with the ones in the phase *Experience*, are set up for students to do in this phase:

- Presenting results to other groups (*Activity 6*)
- Discussing results with other groups (*Activity 7*)
- Answering formulated questions related to scientific subject matter (*Activity 8*)

According to Hand, Treagust, and Vance (1997), social interactions among students should not be limited to small group discussion but extend to whole class settings. In addition, scientific argumentation on science requires students to negotiate meaning both publicly and privately (Hand 2011). By presenting and discussing the results with other groups, which are the outcome of the inquiry activities in the phase *Experience*, students can develop scientific argumentation, thereby acquiring a deeper and broader knowledge, skills, and attitudes towards science. These activities are to take place in the class as a whole and/or in combined groups (*Form 3*). The use of these learning forms is not only consistent with the first feature of the chosen social constructivist approach (Table 1) but also appropriate with characteristics of Confucian heritage culture, which values collectivism, and the tradition of learning together (Hằng et al. 2015).

Since science is about finding and justifying the best possible answers to questions on scientific subject matter (Dekkers 2006), this phase is determined to have two educational expectations (see Table 2) including: students are interactive in learning a scientific subject matter (*Expectation f*) and students argue with each other to attain consensually agreed knowledge on scientific subject matter (*Expectation g*).

Phase 4: Follow-up

For this phase the term, *Follow-up,* was chosen from a variety of terms including *correction, reinforcement, application*, *transferring, reflection*, *connection,* because it provides an indication that the science lessons should be continuous and involved with other learning communities outside schools. This definition of *Follow-up* is supported by the social constructivist feature, which focuses on developing equitable and inclusive learning communities (Table 1). The possibility of the involvement of families in student learning, as manifested through the open-ended approach of the designed curriculum, can be included in this phase and this application is supported by the family value of Confucian heritage culture (feature e).

This phase has two functions (Table 2):

- To acquire cognitive flexibility (*Function J*)
- To develop motivation for further learning (*Function K*)

Nurturing student motivation is important because it is a critical factor for the development and sustainability of self-regulated learning that helps students to become lifelong learners (Wolters 2011).

Students must acquire flexibility to their thinking in order to use their new knowledge in other contexts. Cognitive flexibility is the mental ability to switch between thinking about two different concepts, and to think about multiple concepts simultaneously (Scott 1962). The emphasis on the importance of cognitive flexibility suits Confucian heritage culture where learning emphasizes the development of cognitive flexibility. The mission of the contemporary schooling education in Vietnam is also affirmed to train students to become citizens who have the skills and flexibility to cope with and adapt to the rapid changes of modern life (Hoan 2002).

We accept that cognitive flexibility and motivation can be gained through answering a variety of formulated questions or solving various problems which involve the use of relevant knowledge. Motivation is also enhanced when students perceive themselves as capable of learning new knowledge (Hammond, Austin, Orcutt, and Rosso 2001). The learning activity for this phase is: providing answers and/or solutions for questions and/or problems related to scientific subject matter (*Activity 9,* Table 2). We recommend that students conduct this activity in a whole class structure (*Form 4*).

The Follow-Up phase has two educational expectations (Table 2): students can provide proper answers and solutions on applying attained knowledge about scientific subject matter (*Expectation h*) and students show their desire to learn more about scientific subject matter (*Expectation i*).

Exemplary curriculum units

Criteria for the choice of the scientific themes

Explicit criteria are needed for the choice of themes for science units that make them fit the designed framework (Table 2). The three main criteria for choosing of scientific themes were as follows:

a. *Assessable* According to Vygotsky (1978) students need to develop their knowledge based on their potential through social interactions within the Zone of Proximal Development. On the one hand the scientific theme therefore should not be too difficult, that is, too complex or too abstract. On the other hand, the theme should not be too easy and too simple; then the theme lies too much within the Zone of Actual Development.
b. *Relevant* (Stuckey et al. 2013) The theme must be chosen such that students find the scientific knowledge interesting and meaningful so they build a desire to learn more about it; the theme should potentially impact students' interests in science and should have consequences for their own personal lives.
c. *Experimental* As argued, experiments are essential for this approach to address the challenges of science education in Vietnam (Hằng et al. 2015).

Design of exemplary curriculum units

With the aforementioned criteria being established, many curriculum units can be designed with appropriately chosen themes. Next step is to apply the designed framework into the design of teaching and learning activities; therefore, lessons of curriculum units should be adaptable to the practice of science classrooms. Vietnamese primary teachers and students are familiar with traditional teaching and learning methods informed by Confucian heritage culture (Hằng et al. 2015). In order to accommodate the participants to the innovative curriculum, more than one curriculum unit is needed. When more than one curriculum is taught by more than one Vietnamese teacher, the teachers can learn from each other. Therefore, the designed curriculum can be evaluated for its feasibility.

Vietnamese teachers are restricted by institutional constraints of time and workload and cannot be involved in long-term design-based research. Therefore, three curriculum units were designed with the goal of illustrating the designed framework (Table 2) and which could consequently be taught in the practice of science classrooms in Vietnam in the next step of the study. Three scientific themes, *Air Pressure*, *Plant Roots*, and *CO_2 Reactions*, were selected to design exemplary curriculum units for students aged 9–10. These scientific themes were inspired by several science websites, for example: http://www.science20.com and http://antoine.frostburg.edu, and from physics, biology and chemistry lecturers who work at Utrecht university. The extent to which these themes meet the criteria for the choosing of themes is presented in Table 3.

With these chosen scientific themes, three corresponding curriculum units were designed using the curriculum framework (Table 2). These exemplary curriculum units were designed with specific learning activities for each of the phases and are presented in Table 4.

Table 3 The selected themes meeting the criteria

Theme	Assessable	Relevant example	Experimental
Air pressure	Students know that air can move and can be compressed	Wind is air in motion	Pressing two connected cylinders
Plant roots	Students know that: Plant root systems have different types, i.e. fibrous system and taproot system with many variations. These types of root systems have different characteristics Plant root systems have different functions, i.e. anchorage in soil, storage of energy resources, absorption of water and minerals from the soil, and conduction of water and minerals to and from the shoot, and vegetative reproduction	Most of the trees need to be watered to stay alive	Interacting with real plants to learn about root systems
CO_2 reactions	Students know that: CO_2 is released when Mentos, a white peppermint candy, is mixed with soft drinks, such as Coca Cola and Pepsi A bubble fountain is produced	Eating Mentos and drinking coke at the same time can make the human mouth hurt	Putting Mentos into a Coca Cola bottle

Table 4 The designs of exemplary curriculum units

Phase	Unit air pressure	Unit plant roots	Unit CO_2 reactions
Engagement	Answering: *What will happen if we blow air into the inflated balloon? Why do you think so? What will happen if the inflated balloon is released at once? Why do you think so?* Blowing air into the inflated balloon and releasing it, and answering: *What happened? Explain what was observed?*	Drawing a complete plant Answering: *What did you draw? Why did you draw the plant roots like that? How could you know the plant has such a root system?*	Answering: *What will happen if we blow air through a straw into a water bottle? Why do you think this happens?* Blowing air through a straw into a water bottle and answering: *What happened? Explain what was observed?*
Experience	Predicting (Exercise 1): Connect two cylinders by a plastic tube. Discuss with peers and answer the following questions: *What will happen if one cylinder is pressed down?* *Why do you think this will happen?* Hands-on (Exercise 2): Press one of the connected cylinders down. Discuss in your group an answer to the following questions: *What did you observe?* *Explain what was observed* Questioning (Exercise 3): Write down questions or ideas related to the subject matter that you want to discuss	Predicting (Exercise 1): Choose a wild plant in the school garden to observe. Discuss in the group the answers to the following questions: *What do you think the plant root looks like? Draw them* *Why do you think they look like this?* Hands-on (Exercise 2): Pull out the wild plant in the school garden. Discuss in the group the answers to the following questions: *What does the plant root system look like? Draw it.* *Why does this plant have a root system like that?* *What are the functions of the plant root system? Why do you think so?* Questioning (Exercise 3): *Write down questions or ideas related to the subject matter that you want to discuss*	Predicting (Exercise 1): Given a Coca Cola bottle and Mentos. Discuss in your group the answer to the following questions: *What will happen if all Mentos are dropped into the coke bottle?* *Why do you think so?* Hands-on (Exercise 2): Drop all the Mentos into the coke bottle. Discuss in your group the answers to the following questions: *What did you observe?* *Why did it happen?* Questioning (Exercise 3): Write down questions or ideas related to the subject matter that you want to discuss
Exchange	Presenting results to other groups Discussing results with other groups Answering formulated questions related to subject matter	Presenting results to other groups Discussing results with other groups Answering formulated questions related to subject matter	Presenting results to other groups Discussing results with other groups Answering formulated questions related to subject matter
Follow-up	Answering the questions: *What did you learn from the lesson today? Can you provide some examples related to air pressure and explain why you think so? How can you relate this knowledge to a natural phenomenon, for example, the wind?*	Answering questions: *What did you learn from the lesson today? Can you provide some examples of root types and explain why you think those plants have such root types?* Determining type of root for some plants	Answering questions: *What did you learn from the lesson today? Can you provide some examples on carbon dioxide reaction and explain why you think like that?*

Discussion

The curriculum design described in this paper originated from a problem analysis studying the implementation of approaches with social constructivist features in primary science education in the Vietnamese culture (Hằng et al. 2015). This paper has provided a description of a detailed design of a curriculum in which elements of social constructivism and Confucian heritage culture are synthesized into a written formal representation of a curriculum for primary science education. In this paper, we describe the development of an instructional framework for the curriculum (see Table 2), and outlines of curriculum units (see Table 4), using knowledge of the "nature of science" education and the Vietnamese culture. We provided arguments explaining why the designed formal curriculum is appropriate for Vietnamese students, and how these students should be adequately prepared for their lives as citizens in the globalized world when they are afforded a fuller understanding of the nature of science (McComas, Almazroa, and Clough 1998). The curriculum we proposed is needs-based (Coll and Taylor 2012) for Vietnam where students are expected to become future members of a work force, well equipped with knowledge, skills, and attitudes to cope with the challenges and changes of modern life (Hoan 2002). Taking into consideration the influences of the Vietnamese culture on the implementation of approaches with social constructivist characteristics, the design is also a response to a call for interactive teaching strategies for transcending cultural borders in science education (Jedege and Aikenhead 1999) to teach science in Vietnamese contexts.

The synthesis of Confucian and social constructivist ideals presented in this paper might provide opportunities for enriching both the Confucian heritage culture approach and social constructivist approaches to learning science. On the one hand, values from Confucianism can be of importance for social constructivist approaches; on the other hand western-style can approaches may enrich Asian education. To avoid over-generalization of the idea of Confucian heritage culture and the Confucian-Western dichotomy (Ryan and Louie 2007), this paper focuses on the results of our empirical study on Vietnamese primary education that has shown the present state of primary science education is not considered a good fit for preparing students for the changing and globalizing world (Hằng et al. 2015); however, we aim to relate this study to the broader context of the Confucian heritage culture. In the framework with four phases and 11 functions (Table 2), we presented an alignment between the social constructivist approach (Table 1) and the characteristics (i.e., a0–f0) of a Vietnamese culture strongly influenced by Confucian heritage. Some of these characteristics may be more specific for Vietnamese culture (like features of Confucianism, including (a) *the collectivist root* with an agriculture-rooted culture, and (f) *the emphasis on theoretical knowledge* and cannot be generalized to all primary science education in other Asian countries. The other characteristics, including features (b)–(e) are considered to be quite influential for primary education in general but maybe not for all Asian students in secondary or higher education, as discussed in the studies of Tran (2013) and Ryan and Louie (2007) with students in higher education in Hong Kong and Australia. The curriculum units presented in section "Exemplary curriculum" units should be considered as exemplary and limited to the practice of science classrooms in Vietnam.

With the detailed design with a specific framework, this paper presents a first step to reduce gaps between what is designed as a written intended formal curriculum, the socially constructed operational curriculum that manifests itself between teachers and students, and the attained curriculum in terms of learning results. It makes the expectations of the design explicit for the further study of classroom practice. With its details, this article moves beyond more general and abstract designs of curricula. Moreover, it provides curriculum units that can be applied and evaluated in the practice of science classrooms in Confucian heritage culture, more specifically in Vietnam. These science units are different from those of the conventional primary school science in Vietnam (Hằng et al. 2015) and considered to provide possibilities to have the intended learning outcomes as previously described.

To apply the curriculum design reported in this paper to the practice of primary science education in Vietnamese culture, the role of teachers is crucial, as they are considered to be the most influential factors in educational change (Duffee and Aikenhead 1992). Many studies show that teachers' actions in classrooms are largely determined by their knowledge and beliefs about teaching and learning (Loughran, Mulhall, and Berry 2004). Teachers frequently do not implement curriculum materials that contradict their ideas about content and how this content should be taught (Cotton 2006). Therefore, the application of this design in the Vietnamese culture requires a teacher professional development program.

A program of teacher professional development should help Vietnamese teachers to give shape to their learning of content knowledge of science (i.e. knowledge of air pressure, plant roots, and CO_2 reactions) and pedagogical knowledge about perspectives that are new to them. The design can only address current curriculum problems when Vietnamese teachers accept the new approach. Without the teachers' acceptance and without the necessary changes in the practice of science teaching, the application of the design leads to the state of *a new vase, and old wine [bình mới rượu cũ].* There is a need for the evaluation of the design in a next step of research. Providing a concrete design (formal curriculum), this study is the first stage in contributing to the development of a knowledge base for the synthesis of elements of social constructivism and Confucian heritage culture for the design of an appropriate curriculum for primary school science in Vietnam.

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