

RESEARCH ARTICLE

A Comparison of School Science Curricula of Indonesia, Vietnam, and Thailand

R. Ahmad Zaky El Islami,^{1,5*} Song Xue,² Indah Juwita Sari,³ Le Hai My Ngan,⁴ Vipavadee Khwaengmake,⁵ Samia Khan,⁶ Nguyen Van Bien,⁷ Chatree Faikhamta,⁵ Nguyen Thi To Khuyen,⁸ and Thaursean Prasoplarb⁵

^{1,3}Universitas Sultan Ageng Tirtayasa, Serang, Indonesia

²University of Dundee, Dundee, United Kingdom

⁴Ho Chi Minh City University of Education, Ho Chi Minh, Vietnam

⁵Kasetsart University, Bangkok, Thailand

⁶University of British Columbia, Vancouver, Canada

⁷Hanoi National University of Education, Hanoi, Vietnam

⁸National Taiwan Normal University, Taipei, Taiwan

*zakyislami@untirta.ac.id

Abstract: This study aimed to investigate the science curricula of Indonesia, Vietnam, and Thailand. This study was undertaken to compare science curricula and determine which scientists' current practices, such as hypothesizing, are represented in science curricula. A cross-case analysis was carried out using the junior science curriculum (ages 12–14) of these countries. The analysis revealed similarities in the science curriculum, including that the purpose of the science curriculum is to develop scientific literacy. The junior secondary science curriculum content tends to consist of biology, physics, chemistry, and earth and space sciences. Students are prescribed no more than 10 hours/week, and each science curriculum displays processes commonly associated with scientific experimentation and, to a lesser degree, modeling. Student-centered learning and inquiry are promoted as the main approaches in the science curriculum, and learning outcomes are assessed by teachers using exam-based and non-exam methods both as a formative and summative assessment. The analysis uncovered key differences. One example of key differences is the purposes of the science curriculum. Indonesia includes spiritual attitude and making decisions in daily life. Vietnam includes awareness of natural science. Thailand includes nationalism, life skills, and creativity. Integrated science is included only in Indonesia's curriculum. It was found that Indonesian students have more time to learn science than other countries, followed by Vietnamese and Thai students. Vietnam's curriculum clearly includes practices involving judgment about data, revision of ideas, and constructing explanations. Indonesia promotes a scientific approach. Vietnam promotes the scientific method, whereas Thailand promotes the scientific method and scientific inquiry as to their main pedagogical approaches. Finally, Indonesia and Thailand have large-scale assessments at the national level for graduation requirements on science subjects. However, there is no apparent national science examination in Vietnam at the junior level. These ostensible alignments suggest that science curriculum development is increasingly global and that there is evidence of unified representations of practices associated with science. The study will be of significance to science educators, government ministries, and international bodies of education who seek to develop science curricula.

Keywords: science curriculum, comparative research, practice, Indonesia, Vietnam, Thailand

Recently, Indonesia, Vietnam, and Thailand have renewed and refreshed their science curricula in an attempt to improve the quality of science education. Our research team investigated how this goal is realized by examining their stated intentions, alignment with practice, and content coverage in science. All countries have implemented the latest versions of their new science curricula, and all countries have documented challenges with regard to the design of the science curricula.

Curriculum Theory

We chose in this study to examine the entire science curricula to offer a baseline during times of renewal and influence by global policy organizations. As mentioned, we also examined practices within the science curriculum to assess how science is portrayed in these curricula. Curriculum research is a complex field of study (Pugach et al., 2020). As such, definitions of curriculum vary within curriculum studies. For example, Egan (1978) suggested that curriculum is the study of any and all educational phenomena. Pinar (2013) followed the Latin derivation of the word and explained that curriculum means a course to run or a race course. He also focused on the runner or whoever comes into contact with the curriculum. Priestley (2011) noted that the curriculum is more than just a product. It is a process and includes questions about what we do, how, and why. For this study, the notion that curriculum suggests how and what is important to study and for whom and that a curriculum is remade across multiple sites of activity was adopted. In processual terms, curricular development might further be construed as a relational process of meaning-making experiences by agentive social actors in intersecting contexts (Priestley & Philippou, 2020).

In terms of the meanings associated with a curriculum, Taba (1962) stated that a curriculum usually contains a statement of aims and specific objectives, content, teaching priorities, and an outcome evaluation. These components of the curriculum by Taba (1962), in line with Sand et al. (1960), identified four curriculum components: (a) the objectives, (b) types and quality of learning opportunities, (c) organizing threads and patterns of organization, and (d) evaluation procedures. However, since this time, Glatthorn et al. (2005) divided the curriculum components into curricular

policies, fields of study, programs of study, courses of study, units of study, and lessons. Additionally, Chu (2012) adopted seven curricular emphases in science from Roberts (1998) to include everyday applications; structure of science; science, technology, and decisions (STS; science, technology, and society); scientific skill development; correct explanations; self as explainer (personal explanation); and solid foundations. Based on the previous frameworks of curriculum components, curriculum emphases, and definition of curriculum, the framework employed to address the research question suggests agentive actors make meaning from the curricula that is embedded with purposes, content, learning activities, teaching strategies, and evaluations. These five components can be used to make meaning about the practices of scientists promoted in the science curricula of Indonesia, Vietnam, and Thailand.

In terms of science curricula, according to Deng (2007), school subjects are different from, yet dialectically related to, the academic disciplines such as the discipline of science. Allied with a discipline-precedes-subject position is one that construes the academic discipline and the school subject as fundamentally continuous. Whereas teachers admittedly deal with relatively simple facts, concepts, and principles in classroom situations, they nonetheless teach the same domain-specific facts, concepts, and principles held by the disciplinary expert. It could be argued that knowledge of disciplinary facts, concepts, and principles (Young & Muller 2013) also pertains to knowledge of powerful epistemic practices in the sciences. These practices emanate from science disciplines (Eilks & Hofstein, 2017) and include, for example, the use of analogy and simulation. Thus, the notion of practice within the science curriculum invokes a dialectic among experts to promote a kind of literacy about practices in the sciences that can be used to help solve problems (Dillon, 2009; Shen, 1975).

Comparative Curriculum Research

Although national curriculum documents are very much about the nation, Lingard (2021) contends that national curriculum-making is more or less an expression of and response to globalization. Comparative curriculum research becomes important in order to begin to locate and assert these global expressions. Comparative curriculum research is not new, but the suggestion that we make in this paper that potential alignments portend a global narrative might

be. For example, Vulliamy et al. (1997) studied teacher identity and curriculum change by using a comparative case-study analysis from small schools in England and Finland reported on the processes of curriculum change in primary schools. The authors reported that the current policies of the two countries are moving in opposite directions, with Finland dismantling its long-standing subject-based national curriculum and encouraging school-based curricula incorporating integrated topic work (Vulliamy et al., 1997; Webb & Vulliamy, 1999). A curricula comparison was conducted between Vietnam and Australia by Phan et al. (2018). Phan et al. (2018) studied students' experience of participating in curriculum internationalization in Vietnam and Australia. In another comparative curriculum study, Voogt and Roblin (2012) compared 21st-century competency frameworks among eight nations. They noted commonalities amongst the frameworks. However, they also raised that the connections between core subjects and 21st-century competencies should be clearly identified. Based on the literature, noteworthy previous comparative studies have been conducted to compare curricula (including in the area of science). However, comparisons tend not to be focused on the disciplines. We contend that studies comparing renewed science curricula will be beneficial to assess a new composite of practice in this subject area.

Previous comparative science education studies in ASEAN countries have been conducted, although not entirely in the area of K-12 science education. For example, in Thailand, studies by Nuangchalerm and El Islami (2018a, 2018b), El Islami et al. (2018), and El Islami and Nuangchalerm (2020) compared Indonesian and Thai pre-service science teachers on scientific literacy and each domain of scientific literacy. However, these previous studies only examined the content of science, the science process, the context of science, and the scientific literacy of Indonesian and Thai pre-service science teachers. A comparative study on the curriculum of science education programs in the teacher education program has, however, been conducted by Vibulphol et al. (2015). Vibulphol et al. (2015) studied teacher education programs in two universities in Finland and Thailand. They reported the characteristics of the elementary and secondary school teacher education programs in the selected universities and discussed the roles and significance of 21st-century skills. Vibulphol et al. (2015) found that Thai science education programs focused more

on course comprehension, but the Finnish curriculum had a more comprehensive educational view because, they argued, the policies and approaches to teacher education were different. However, an exploration of the school science curricula of Thailand and Finland used in this previous study was not the main focus of the study. Mnguni et al. (2020) compared Indonesian science teachers' and South African science teachers' curriculum ideologies. The results indicated that most teachers in both countries generally preferred what was termed a student-centered curriculum ideology for school science. This previous study found that there are local context-specific factors that inform the preferred ideologies of teachers. This previous study is important in the implementation and curriculum reforms as Roehrig et al. (2007) stated that the implementation of the curriculum was strongly influenced by the teachers' beliefs about teaching and learning as well as the presence of a supportive network at their school site. A previous study on the school science curriculum conducted by Michie (2017) compared the Indonesian and Australian curricula while focusing particularly on the science curriculum in junior high school. The author found similarities in the citizenship aims, content, key ideas, skills, and assessment strategies of both countries' science curricula. The analysis noted the level of detail of both countries' science curricula, the use of competency frameworks in one curriculum and not the other, similar themes or big ideas, and varying topic emphases. Their country comparisons also raised similar implementation issues to extend the exploration of the science curriculum in other countries would support dialogue about the substantive area, in this case, promotion of practices.

It has been asserted that curricular renewal has the potential for influencing teachers' teaching and students' learning in science (DeBoer, 2000; Powell & Anderson, 2002; Roehrig et al., 2007; Harty, 1993). Although, there is substantive comparative curricular research that can offer positive pathways to impact educational systems (Roblin et al., 2017). Given this contention, future examinations of curricula would benefit from a deeper examination of Eastern and Indigenous practices associated with science. Comparative science curriculum research that aims with the context would be further beneficial. Finally, there are almost no studies that offer a comparison of science education curricula in terms of practices. A study that included practices, even an initial one

such as this, would be beneficial in that it tends to avoid an over-emphasis on non-domain specific 21st-century skills or content areas of interest to dominant international or national organizations.

Purpose of the Present Study

This study is timely as the research team sought to hone in on various elements of science curricula, including the engagement in practices associated with scientific work. Practices are significant because they represent how scientists generate new knowledge and are embedded in all contemporary science curricula. The research question guiding the study was how curricula can be compared and how current practices of scientists are represented in recently renewed science curricula.

One of the focuses of this comparative case study is on “scientific practice.” Practices associated with science are a component of science curricula that arguably makes it unique from other subject areas and is one of the most challenging aspects of curriculum development in science education. It is assumed that a study including scientific practices will help illustrate differences among curricula more than if the comparison was confined to aims, content-based topics, or assessment alone. Practices in this study are considered to be an array of human activities (Cetina et al., 2005) that, in accounts of the sciences, reflect publicly known ways of generating knowledge about science and solving problems. Such practices include, for example, reasoning about models, analyzing and interpreting visual data, engaging in argument from evidence, and offering justifications. Practices have played a central role in the reconceptualization of recent science curricula (Duschl & Bismarck, 2016). In addition, curriculum research on practices can play a further valuable role in assessing how science is portrayed, locating new lines of inquiry into how practices are to be taken up among practitioners and relationships among practices, 21st-century skills, and competency-based curricula.

Method

This study follows an interpretive research paradigm where meanings derived from the analysis were negotiated and taken as shared among researchers who were engaged in making or enacting the curricula

in various teaching and teacher education contexts within their respective countries. A case study was considered appropriate for the research. Case studies are a trans-paradigmatic and transdisciplinary heuristic that involves the careful delineation of the phenomena for which evidence is being collected (event, concept, program, process, etc.). Case studies enable researchers to circumscribe the unit of analysis (i.e., the main entity for which data is being collected; VanWynsberghe & Khan, 2007) where the unit of analysis comes into sharper focus as the research progresses. The unit of analysis at the outset of the present study was the science curriculum. After the curricular analysis, this unit will come into a sharper focus.

The use of comparative case studies allows the research team to provide rich pictures of “instances in action.” This is important to the research because it makes triangulation possible within and across cases (Stake, 2006). Comparative case study research also can advance theory by identifying the “class” to which an “instance” belongs (Guba & Lincoln, 1981), generating new typologies (George & Bennett, 2005), and constructing working hypotheses (cf. Flyvbjerg, 2001; Kenny & Grotelueschen, 1984). In this study, the authors undertook comparative case studies of the curriculum to generate working hypotheses and translatable concepts about the science curriculum (Stake, 2006).

We performed a cross-case analysis comparative analysis with each country representing a case for comparison. A cross-case analysis was considered appropriate for the aims of the research in that: (a) there may be common curricular themes that are emphasized or underutilized across cases and may yield differential outcomes and (b) an analysis of different curricula can be suggestive of hypotheses that point to underlying themes in terms of the main dimensions of a science curriculum (Khan & Van Wynsberghe, 2008). We will remain sensitive throughout the cross-case analysis to methodological issues of comparing highly different curricula and contexts and issues pertaining to the comparison of curricula from the global south with those from the north.

Although comparing multiple case studies holds great potential to inform theory in the field of systems thinking, Rueschemeyer (2003) cautioned that the researcher must “increase the number of cross-case comparisons without losing the advantage of close familiarity with the complexity of cases”

(p. 323). Our stance and the stance of others (Khan & VanWynsberghe, 2008) is that it is possible to learn from both the uniqueness and modality of a case. Wherever possible, all data will be converged to support conceptual connections among scientific practices, science curricula, national policies, and outcomes.

Diagrams of relationships will be developed as an early conjecture, and new information will be used to elaborate or remove aspects of the diagram. In this way, rival hypotheses were successively eliminated because of their lack of empirical consistency. Using the diagrams and associated anomalies will help criticize and revise the initial hypotheses.. Comparative research has the potential to produce translatable outcomes that can impact stakeholders in other countries. For this reason, a cross-case analysis was further considered appropriate as (a) there may be common responses to a policy that are emphasized or under-utilized across cases and yield differential outcomes and (b) as part of a field study, analyses of different curricula can be highly suggestive of hypotheses that point to the development of science education that is occurring in these countries.

Context of Comparative Case Studies

For this comparative analysis, three countries have been purposively and conveniently selected. All three countries have recently renewed and refreshed their science curricula. Indonesia has a revised curriculum that has been implemented since 2013, with revisions occurring as recently as 2017 (Indonesian Ministry of Education and Culture, 2017). Vietnam published a new science curriculum in 2018 and officially launched it in 2020 (Vietnamese Ministerium of Education and Training [MOET], 2018). Thailand also renewed its science curriculum in 2017 (Thai Ministry of Education, 2017). The global south countries have unique school science curricula emerging from social, economic, and political factors within each country. However, Indonesia, Vietnam, and Thailand are all members of an economic block belonging to the Association of Southeast Asian Nations (ASEAN), which has a formal website at <https://asean.org/asean/asean-member-states/>. ASEAN countries have committed to involving “STEM Education” in their national curriculum. Although, Indonesia has not yet announced it explicitly in its national curriculum (Hasani et al., 2021).

In terms of political systems, Thailand has a devolved political system that is a constitutional monarchy. Indonesia follows a democratic system and is a republic with the President as head of state. Vietnam is a socialist republic. In terms of economic ranking, according to the International Monetary Fund (IMF), in 2019, the GDP per capita (PPP) in each country can be seen in Table 1. It shows the GDP of each country based on publicly available statistics reports (International Monetary Fund, 2019). The human development report of each country is reported in Table 2 (United Nations Development Programme, 2018). This human development report was published by the United Nations Development Program in 2016 and represented a global ranking.

Table 1

GDP Per Capita (PPP) Ranking of Indonesia, Vietnam, and Thailand in 2019

| Countries | Rank |
|-----------|------|
| Thailand | 73 |
| Indonesia | 101 |
| Vietnam | 128 |

Table 2

Human Development Ranking of Indonesia, Vietnam, and Thailand in 2016

| Countries | Rank |
|-----------|------|
| Thailand | 83 |
| Indonesia | 116 |
| Vietnam | 116 |

In terms of government responsibilities for curriculum development, Indonesia has a Ministry of Education and Culture (<https://kemdikbud.go.id>). Vietnam has a centralized Ministry of Education known as the Vietnamese Ministerium of Education and Training (MOET; <http://moet.gov.vn/>). Thailand has a ministry of education known as the Ministry of Education (MOE; <http://en.moe.go.th/enMoe2017/>).

In Indonesia, science is taught as a subject beginning in 4th grade, whereas science concepts are integrated into other subjects in Grades 1-3 (Indonesian Ministry of Education and Culture, 2017). In contrast, in Thailand and Vietnam, science is taught in the first grade at elementary school as a separate science subject

(Institute for Promotion of Teaching Science and Technology [IPST], 2008; Thai Ministry of Education, 2017; Vietnamese MOET, 2018). By junior high school or ages 12–14 years, all countries in this study teach science as a separate subject. Thus, we begin to investigate the similarity and differences in curricula among these three science curricula at this level. In senior secondary school, students are taught Chemistry, Biology, and Physics subjects at the approximate ages of 15–18 years.

Even though all countries have different local policies and mandates, they participate in international bodies that support education (e.g., Organisation for Economic Co-operation and Development [OECD]) and may be influenced by potential policy drivers such as Programme for International Student Assessment (PISA) from these organizations (OECD, 2018). This influence permits an investigation of similarities in curricula that arise from increasingly global systems of education in science. For example, the PISA results regarding 15 years old's science literacy are different among these three countries (OECD, 2001; OECD, 2004; OECD, 2007; OECD, 2010; OECD, 2014; OECD, 2018). This is shown in the 2015 results in Figure 1, where science was the primary area being assessed (OECD, 2018).

PISA aims to examine scientific practices in their assessment of scientific literacy. They have been examining results since 2000 (OECD, 2001). The newest PISA scientific literacy scores in 2015 of Indonesian and Thai students have been below the OECD average, whereas Vietnamese students have tended to be amongst the top nations in the OECD (2018). For PISA 2018, Vietnamese students did not participate in the scientific literacy PISA survey (OECD, 2019a). ASEAN science curricula aim to promote 21st-century practices. This analysis could help examine the global policy drivers that are part of the environment for change in science and how these three participating countries in PISA have emerged to frame their curricula in their latest renewals (Operti et al., 2018).

Comparison Indicators

The present study investigates the similarities and differences between Indonesia, Vietnam, and Thailand's science curricula for Grades 7–9 or the approximate ages of 12–14. The aspects of the curriculum being investigated are based on the authors' framework, including:

1. The purpose of science subjects in junior high school consists of aims, goals, and objectives.

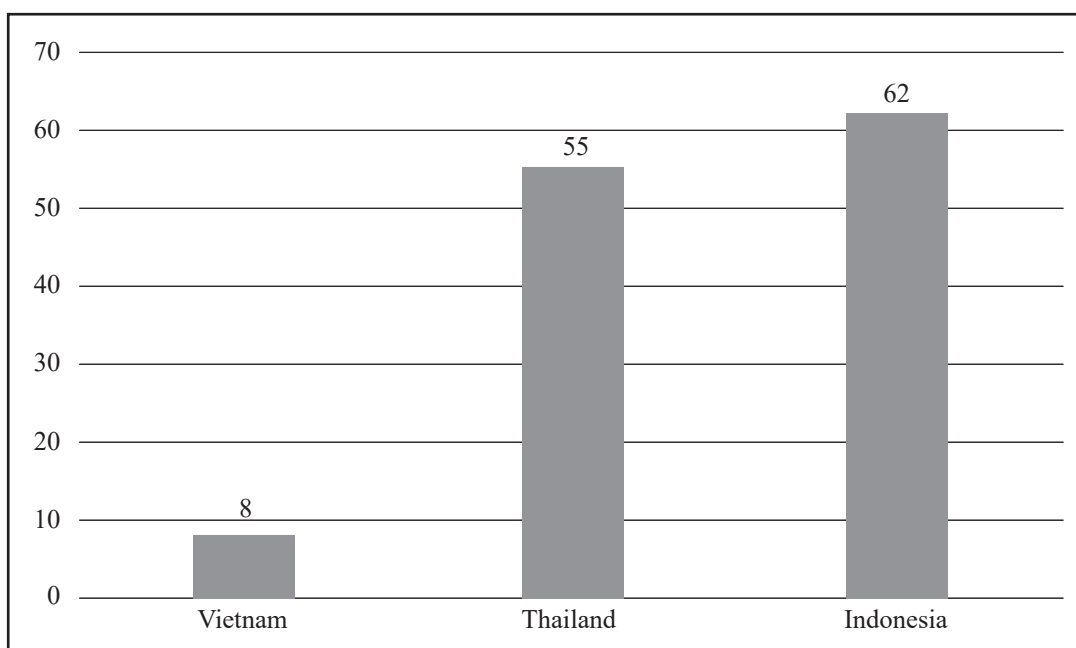


Figure 1. PISA 2015 Ranking on Students' Scientific Literacy of Indonesia, Vietnam, and Thailand

2. Science curriculum content in junior high school.
3. Learning experiences consist of time for science subjects to implement the school science curriculum and significant scientific practices in the curriculum.
4. Teaching strategies, which consist of the main approaches to teaching, are promoted in the science curriculum.
5. The evaluation consists of a content assessment and type of assessment.

An instrument was developed to compare the components of each countries' science curriculum and included categories (purpose of the science curriculum in junior high school, science curriculum content in junior high school, learning experiences, teaching strategy, and evaluation). To develop the instrument, initially, all authors from each country were asked to present their country profile of science education in June 2019. They then conducted online meetings every two weeks to discuss emerging differences and similarities in the science curricula comparison for the three countries. During the online meetings, all authors were asked to fill out the instrument with the initial categories above and discuss the findings. They noted similarities and differences until a consensus was reached on both the categories and the codes. The instrument and the codes that were developed can be seen in Table 3.

Indonesia

In reference to the coding in Table 3, the following statements were coded from the Indonesian Ministry of Education and Culture for the seventh until ninth grades or approximately 12–14 years of age: “A science subject at junior high school level applies integrated science learning activities on scientific practices including observing, asking, experimenting, associating, and communicating” (Indonesian Ministry of Education and Culture, 2017, pp. 5–6). According to our codes document, the first sentence, “observing, asking, experimenting, associating, and communicating,” would be coded as the main approaches to teaching promoted in the Science curriculum.

Vietnam

In reference to the coding Table 3, the following statements were coded from the Vietnam Ministry

of Education for the seventh until ninth grades or approximately 12–14 years of age: “Training skills to detect and solve problems in practice using a variety of methods such as practical teaching, problem-based teaching, project-based teaching, experiential teaching, discovery, and differentiation” (Vietnamese Moet, 2018, p. 87. According to our codes, the first sentence, “Training skills and differentiation” was coded as the main approaches to teaching promoted in the Science curriculum.

Thailand

In reference to the coding Table 3, the following statements were coded from the Thailand Ministry of Education for the seventh until ninth fourth grades or approximately 12–14 years of age: “Educational outcomes are assessed by qualitative and quantitative forms through formative assessment, educational summative assessments at the institution, and large-scale assessments at the national and local levels and international assessment” (Thai Ministry of Education, 2017, p. 7). According to this curriculum document, the first sentence, “Educational outcome.... and international assessment,” was coded as a type of assessment.

Data Analysis

Document analysis was undertaken to examine each curricular document. This was followed by a cross-case analysis to compare the science curricula. There are several examples of document analysis occurring among individual and multiple case studies. For example, Bertram (2019) conducted a content analysis of the history curricula of Rwanda and South Africa. Bertram (2019) employed three criteria for what constitutes “powerful knowledge” and examined each curriculum for the presence of these criteria. Curricular topics were compared in a table. The table was drawn upon to extrapolate and infer instances of powerful knowledge. In a second example, Day and Billmeyer (2018) performed a textually oriented discourse analysis of the Scottish and Swedish Science curricula. First, the relevant science curriculum documents relating to the Scottish Broad General Education phase and the Swedish Compulsory phase of the science curriculum were identified and shared. All documents were read and analyzed in English, with the Swedish curricular documents having been published in English and cross-checked with the

Table 3*The Instrument Categories and Codes to Compare the Curricula*

| Categories | Code Words | Researcher Coding Questions |
|---|--|--|
| Purpose of the science curriculum in junior high school | Aims, goals, and objectives | What are the aims, goals, and objectives of the science curriculum at the junior high school? What are the science concepts in the 7th grade? What are the science concepts in the 8th grade? |
| Content of science curriculum in junior high school | School science curriculum content | What are the science concepts in the 9th grade? How many pages are in the school science curriculum document? How many basic competencies/indicators are in the 7th grade? How many basic competencies/indicators are in the 8th grade? How many basic competencies/indicators are in the 9th grade? |
| Practices | Scientific practices in the curriculum | What are the scientific practices in the curriculum? |
| Learning experiences | Time of science subject for implementing the school science curriculum | How many hours of science are taught per week? How many hours of science are taught per year? |
| Teaching strategies | Main approaches to teaching promoted in the Science curriculum | What is the main approach to teaching promoted in the Science curriculum? |
| Evaluation | Content assessment Type of assessment | What is assessed in the science learning? How to assess the students' achievement in science learning? |

Swedish version for translational issues. Second, the authors read, identified, and analyzed the science documents to assess how these documents orient the science curricula. Third, the authors identified the common and contrasting features of each countries' science curriculum to establish the extent to which each curriculum attended to the orienting vision for the curriculum. Fourth, the texts were analyzed to establish the dominant voice projected by each curriculum document (i.e., that of the policymaker, the teacher, the student).

The OECD performed an analysis of the Netherlands' curricular renewal efforts using a first of its kind curriculum content mapping (CCM) set of analytic tools to allow countries to compare and contrast curricular competencies with others for peer learning as well as to do a reality check on how much their policy intentions are articulated explicitly (OECD, n.d.). In this analysis,

learning areas somewhat synonymous with traditional subjects were mapped onto the Netherlands' curricula by experts from the Netherlands and the OECD. The expert group generated "heat maps" for each of the learning areas to show the content mapping. Each heat map also contained 28 competencies from the OECD. Heat map levels were ascertained and consisted of determining the extent to which competency was embedded within the learning area. In their analysis, all 28 of the OECD's CCM competencies were identified to varying degrees in and across the proposed learning areas for the Netherlands curriculum. Bar charts and tables were produced, including comparative analyses of major themes from the OECD, the Netherlands curriculum, and the curriculum of other participating countries (Voogt & Robblin, 2012).

In terms of the present study, we collected data from national curricular documents and used Table 3

as an analytic instrument with five key components of the science curriculum framework. The data analysis consisted of reviewing the documents and cross-checking with the instrument. Each country performed its own analyses, and the research teams engaged in a dialogue to debrief and arrive at a consensus on their coding according to this instrument. The lead author of this paper then conducted a cross-case analysis by building a larger comparative table. The lead author asked questions and explored emerging findings with each country leads. To build trustworthiness, these findings were iteratively presented at global research meetings online, and the information was cross-checked again for reliability by each member state in the analysis. In terms of coding, the lead author of the study invited each country to code its own curriculum among the categories that were set out. Each country was also invited to verify the coding and the counts through regular presentations of the findings as they emerged. Each country also member-checked the counts and codes prior to publication. The analysis of the three curricula was subsequently used to respond to the research question, “How and to what extent are the current practices of scientists represented in the science curricula of Indonesia, Vietnam, and Thailand?”

Results

The overall goal of the research was to provide a marker for how science is portrayed in the science curricula at this point in time. To accomplish this, the aims, content, practices, teaching strategies, and assessment of three science curricula were examined. Each of these curricula has emerged in the context of global economic drivers. The drivers arguably include, to varying degrees, membership, participation in and consultation by the OECD (c.f. PISA assessment), World Economic Forum, World Bank (c.f. 21st century skills; 4th Industrial Revolution ASEAN), and returns to competency-based education cited in many curricula (Khan & Krell, 2019).

Cross-Case Analysis of Science Curricula

The Purposes of Science Curricula

To investigate the comparison of the purposes of science curricula in junior high schools in these three

countries, we first investigated the aims, goals, and objectives of each country’s curriculum. The cross-case analysis is shown in Table 4. The aims in this study are defined as general purposes at the highest level, the goals in this study are defined as purposes at the grade level, and the objectives in this study are defined as statements that refer to measurable student outcomes (Noddings, 2007).

The Science Curriculum Content

To further investigate the similarities and differences of the science curricula, we divided science into four common fields: biology, physics, chemistry, and earth and space sciences (OECD, 2019b). These common areas were compared in terms of content offerings. The science curriculum content in seventh grade in Indonesia is divided into five fields of science: integrated science, biology, physics, chemistry, and earth and space sciences. Integrated science means that the concept is an integrated manner of physics, chemistry, and biology. However, the science curriculum content in eighth grade in Indonesia is divided into three fields of science: biology, chemistry, and physics. Additionally, the science curriculum content in ninth grade in Indonesia is divided into five fields of science: integrated science, biology, physics, chemistry, and earth and space sciences. These fields include content that is available in Table 5 (Indonesian Ministry of Education and Culture, 2017, p. 11).

The science curriculum content in seventh grade in Vietnam is divided into three fields of science: biology, chemistry, and physics. However, the science curriculum content in eighth and ninth grades in Vietnam is divided into four areas of science: biology, chemistry, physics, and earth and space sciences. These fields include content that is available in Table 5 (Vietnamese MOET, 2018, pp. 8–22).

The science curriculum content in Grades 7–8 in Thailand is divided into four fields of science: biology, physics, chemistry, and earth and space sciences. However, the science curriculum content in ninth grade in Thailand is divided into three fields of science: biology, physics, and earth and space sciences. These fields include content that is available in Table 8 (Thai Ministry of Education, 2017). Table 5 compares the content of the science curricula for each country.

Table 4*Aims, Goals, and Objectives of the Science Curricula of Indonesia, Vietnam, and Thailand*

| Code | Indonesia | Vietnam | Thailand |
|-------------|---|---|--|
| Aims | The aims of the Indonesian science curriculum are to promote science attitudes, an understanding of integrated science, application of natural science concepts and ethics to daily life, problem-solving, decision-making in life based on scientific and ethical principles, human problem-solving, and an understanding of the impact of technological developments on human life (Indonesian Ministry of Education and Culture, 2017, p. 4) | The Vietnamese science curriculum aims are to enhance natural science awareness, understanding of science, and scientific knowledge and skills learned in daily life (Vietnamese MOET, 2018, p. 5) | The aims of Thailand's science curriculum are to promote the understanding of scientific concepts in science (e.g., biological science, physical science, earth and space sciences); the nature of science, such as the scope and limitations of science; skills in researching and inventing science and technology; five important skills (analytical thinking, creative thinking, critical thinking, collaborative thinking, and problem-solving skills); awareness of the relationship between science, technology, human beings, and the environment; the application of scientific knowledge and understanding to society; and the science-minded person with morality, ethics, and values in using creative science and technology (Faikhamta & Ladachart, 2016; Thai Ministry of Education, 2017). |
| Goals | Indonesia's science curriculum focuses on building competencies, including spiritual attitude competence, social attitude competence, knowledge competence, and skills competence (Indonesian Ministry of Education and Culture, 2017). | The goals of Vietnam's science curriculum focus on the development of a "natural scientific competence" with three components: natural science awareness, understanding of science, and application of scientific knowledge and skills learned for daily life (Vietnamese MOET, 2018). | The goals of Thailand's science curriculum are to enrich communication ability, thinking ability, problem-solving ability, the ability to use life skills, and the ability to use technology. Additionally, in Thailand, the curriculum focuses on developing learners with desirable characteristics to be able to live happily with other people in society as a Thai citizen and world citizen, as follows: the love of the King and the nation, honesty, discipline, seek to learn sufficient living, commitment to work, love being Thai and have a public mind (Thai Ministry of Education, 2017; Office of the National Education Commission, 1999). |
| Objectives | The objectives of Indonesia's science curriculum focus on cognitive, affective, and psychomotor skills (Indonesian Ministry of Education and Culture, 2017, p. 7). | The objectives of Vietnam's science curriculum focused on students' awareness and ability to study and apply the content of natural science education, which is based on a combination of scientific topics, including substance and transformation of substances, living things, energy, and transformation, Earth, and sky. Topics are arranged mainly in a linear fashion, with a certain degree of concentric structure and a number of interdisciplinary and integrated topics to form general principles about the natural world (Vietnamese MOET, 2018 p.8). | The objectives of Thailand's science curriculum focus on the ability of students to learn science which focuses on linking knowledge with processes, having important skills in researching and creating knowledge using a process, suitable for class with biological sciences, physical science, Earth and Space science, technology design and technology, and computational science (Thai Ministry of Education, 2017). |

Table 5*Science Curriculum Content of Three Countries at Grades 7–9*

| Grade | Science Fields | Science Curriculum Content |
|---|--------------------------|---|
| Indonesia science curriculum in seventh grade | Integrated Science | – Science object and observation |
| | Biology | – Classification of organisms – The system of organization in life – Biological interactions |
| | Physics | – Energy |
| | Chemistry | – Elements, compounds, and mixtures |
| | Earth and space sciences | – The layers of the Earth and natural disasters – The solar system |
| Indonesia science curriculum in eighth grade | Biology | – Structure and function of plant tissues – Digestive systems – Blood circulatory systems – Respiratory systems – Excretory systems |
| | Physics | – Motion and style – Work and simple machines – Frame and muscle – The pressure of a substance – Vibrations, waves, and sound – Light |
| | Chemistry | – Additive and addictive substances |
| Indonesia science curriculum in ninth grade | Integrated Science | – Technology and environmentally friendly |
| | Biology | – Reproduction – Plant and animal breeding – Inheritance – Biotechnology |
| | Physics | – Force – Sound – Light – Magnet |
| | Chemistry | – Atom – A chemical element – Molecule – Summary of the periodic table of chemical elements – Diverse living world |
| | Earth and space sciences | – Soil |
| Vietnam science curriculum in seventh grade | Biology | – Metabolism and energy metabolism in organisms – Induction in organisms – Growth and development in organisms – Reproduction in organisms – The organism is a unified body |
| | Physics | – Force – Sound – Light – Magnet |
| | Chemistry | – Atom – A chemical element – Molecule – Summary of the periodic table of chemical elements – Diverse living world |

Table 5 continue....

| Grade | Science Fields | Science Curriculum Content |
|--|--------------------------|--|
| Vietnam science curriculum in eighth grade | Biology | <ul style="list-style-type: none"> – Human body biology organs – Organ system in the human body |
| | Physics | <ul style="list-style-type: none"> – Force – Specific gravity and pressure – Energy and life |
| | Chemistry | <ul style="list-style-type: none"> – Chemical reaction – Reaction rate and catalyst – Acid – Base – pH – Oxide – Salt – Chemical fertilizers |
| | Earth and space sciences | <ul style="list-style-type: none"> – Biosphere and biome on Earth |
| Vietnam science curriculum in ninth grade | Biology | <ul style="list-style-type: none"> – Genetic phenomenon – Evolution |
| | Physics | <ul style="list-style-type: none"> – Light – Electricity – Magnet |
| | Chemistry | <ul style="list-style-type: none"> – Properties of materials – Electricity – Magnetism |
| | Earth and space sciences | <ul style="list-style-type: none"> – Exploiting resources from the Earth’s crust – Summary of “Chemistry of Earth’s crust” |
| Thailand science curriculum in seventh grade | Biology | <ul style="list-style-type: none"> – The unit of life and plant life – The system of organization in life – Bio interactions |
| | Physics | <ul style="list-style-type: none"> – Force and movement – Work and energy – Substances in daily life |
| | Chemistry | <ul style="list-style-type: none"> – Solution |
| | Earth and space sciences | <ul style="list-style-type: none"> – Atmosphere |
| Thailand science curriculum in eighth grade | Biology | <ul style="list-style-type: none"> – Animal life – The human body |
| | Physics | <ul style="list-style-type: none"> – Substances and changes – Light |
| | Chemistry | <ul style="list-style-type: none"> – Elements and compounds |
| | Earth and space sciences | <ul style="list-style-type: none"> – World and change |
| Thailand science curriculum in ninth grade | Biology | <ul style="list-style-type: none"> – Life and environment – Ecology – Genetics |
| | Physics | <ul style="list-style-type: none"> – Diversity of life – Properties of electricity – Basic electronics |
| | Earth and space sciences | <ul style="list-style-type: none"> – The Universe |

The Schooling Experience and Scientific Practices Required

In Indonesia, students learn science for about 200 hours/year, divided into 5 hours/week (Indonesian Ministry of Education and Culture, 2017, pp.11–31). Students must learn science for about 140 hours/year in Vietnam, divided into 4 hours/week (Vietnamese Moet, 2018). In Thailand, students must learn science for about 120-140 hours/year, divided into 3–5 hours for fundamental sciences and 3–5 hours additionally for an advanced science program (Thai Ministry of Education, 2017). It appears that among the three countries, science subjects are learned by students no more than 10 hours per week and no more than 200 hours per year. We can extrapolate this time to the Grades 7–9 science curricula. The difference, however, appears to be that Indonesian students in Grades 7–9 have more time to learn science than in other countries, followed closely by Vietnamese and Thai students of the same grade cohort.

Scientific practices are learned during science education (Berland et al., 2016). Numerous studies indicate that engagement in scientific practices can not only promote students' understanding of scientific knowledge and scientific processes (e.g., Chen & Klahr, 1999; Ford & Forman, 2006; Kuhn et al., 2008) but also contribute to improved literacy and ability in science (Erduran et al., 2004; McNeill et al., 2006; Sampson et al., 2011; Songer & Gotwals, 2012). The practices associated with science, as stated in the Indonesian school science curriculum, include making observations, asking questions, experimenting or investigating using controlled variables, using ICT, and communicating (Indonesian Ministry of Education and Culture, 2017, p.5). The scientific approach is considered to be an approach that promotes these practices in no particular order (Ibrohim et al., 2019). The Indonesian science curriculum for Grades 7–9 also discusses modeling.

The stated practices in the Vietnamese science curriculum include suggesting issues, asking questions for problems, and analyzing the context to propose problems. The practices mentioned in this curriculum also include making judgments and building hypotheses, analyzing problems to make judgments, developing and stating hypotheses, developing a logical framework of steps to find out, selecting the appropriate method (observation, experimentation, investigation, interview, retrospective data), preparing

a plan to explore, implementing the plan, collecting and storing data from the results of the review, experimenting and investigating, evaluating results based on analysis, processing data by simple statistical parameters, comparing results with hypotheses, constructing explanations, and drawing conclusions and adjusting when necessary (Vietnamese MOET, 2018). Vietnam encourages inquiry learning to reflect scientific practice (Thao-Do & Yuenyong, 2017).

The scientific practices reported in the Thai school science curriculum include the development of scientific methods: questioning, hypothesizing, experimenting, collecting data, measuring and analyzing data, and drawing conclusions and reporting on them. Integrated into this curriculum are learning mathematical models, mentioned in the vocabulary portion of the curriculum but not in any indicators (Thai Ministry of Education, 2017). Thailand's curriculum aims to be relevant to students' real-life experiences. Science process skills have been highly emphasized, particularly in structured inquiry, whereby students are trained to do science projects using laboratory experiments. They learn the process and steps of doing science with a common intention that they practice their science process skills while conducting their experiments (Tornee et al., 2017).

The Main Approaches to Teaching Promoted in the Grades 7-9 Science Curriculum

In Indonesia, a scientific approach is taught as the main approach to teaching that is promoted in the science curriculum. Their scientific approach consists of five main activities; observing, asking, experimenting, associating, and communicating. These five activities can be arranged for any instructions and can be used by teachers based on needs in the learning process (Indonesian Ministry of Education and Culture, 2017, pp. 5–6). This approach can be included in a discovery learning context (In'am & Hajar, 2017).

In Vietnam, the main approaches to teaching promoted in the science curriculum appear to be training skills to detect and solve problems in practice using a variety of methods such as practical teaching, problem-based teaching, project-based teaching, experiential teaching, discovery, and differentiation or those methods can be stated as the scientific method (Vietnamese MOET, 2018). Local scientific learning material (including natural phenomena related to the

material, reviews, sample questions and answers, exercises, and evaluation questions) have contributed to positive outcomes for students (Priyanto et al., 2017).

In Thailand, the main approaches to teaching stated in the science curriculum are scientific methods and scientific inquiry (Thai Ministry of Education, 2017). Thailand has also adopted socio-scientific issues-based instruction as a pedagogical approach in their elementary through high school science curricula to support the growth of research (Office of the National Education Commission, 2003).

The Evaluation Mechanisms

In Indonesia, three components are assessed by teachers: knowledge, skills, and attitudes (Indonesian Ministry of Education and Culture, 2017, pp. 4–5). Knowledge is a cognitive ability that contains verbal knowledge, knowledge organization, and metacognitive strategies (Tabun et al., 2019; Kraiger et al., 1993). Skill refers to a psychomotor ability, such as the ability to perform a task without conscious monitoring and with other tasks (Tabun et al., 2019; Kraiger et al., 1993). Attitude involves affect, self-efficacy, and perception about the ability to perform, goal setting, and motivation (Tabun et al., 2019; Kraiger et al., 1993).

In Vietnam, students are assessed by teachers in various forms, such as participation observation by the teacher, assigned tasks and homework (short study), sub-unit tests, and summative assessments of each unit (Vietnamese MOET, 2018). Based on Young Lives primary and secondary school surveys in 2011–2013 in Vietnam, cognitive tests such as Maths and reading comprehension at the primary level were administered to students at the beginning and the end of the school year. Additionally, psychosocial measures for students and teachers relating to academic self-concept and motivation, for example, were included at the end of the year (Iyer & Moore, 2017).

In Thailand, the objective of evaluating educational outcomes is to provide accurate, timely, and valuable information about the level of eligibility (requirements required) of the program and to gauge student progress to guide learning activities, adjust teaching, management, and program development activities. The scope of the assessment is the entire content and requirements of the science curriculum. Assessment is based on evidence of the process of training, learning,

and products in the learning process of students. Educational outcomes are assessed in qualitative and quantitative forms through formative assessment, educational summative assessments at the institution, and large-scale assessments at the national, local levels, and international assessments (Thai Ministry of Education, 2017)). Tablet-based assessment is one of the applications for primary school levels in Thailand as an evaluation method. Tablet-based assessments were successfully evaluated and used at primary schools in Thailand and gave an improvement in students' learning skills and behavioral outcomes (Nang & Harfield, 2018).

Discussion

Based on Table 4, in comparing the aims, all countries aim to develop knowledge, skills, attitudes, and science literacy for use in their daily lives. All countries have aims related to scientific literacy. It appears that these three countries describe scientific literacy in the aims without mentioning the term of scientific literacy explicitly. For example, there are references to daily life and society in all countries. Thailand's aims also include creativity. For example, Thailand's science curriculum promotes using creativity to innovate in science and technology (Thai Ministry of Education, 2017). In contrast to Vietnam and Thailand, Indonesia aims to understand science in an integrated manner (as integrated science) (Indonesian Ministry of Education and Culture, 2017, p. 5). Integrated science is a science learning approach that connects fields of science and their knowledge and application in their daily lives into a single unit of discussion. Integrated science aims to increase the efficiency and effectiveness of learning, increase interest and motivation, and some basic competencies can be achieved at once (Indonesian Department of Education, 2006).

Based on Table 4, in comparison, all countries have goals to develop knowledge, skills, and attitudes associated with science. Unlike other countries, however, the attitudinal goals of Indonesia's science curriculum are to build a spiritual attitude competence and a social attitude competence (Indonesian Ministry of Education and Culture, 2017, p. 4). Finally, and in contrast to the other curricula, Thailand very clearly positions its science curriculum as one that

helps to develop life skills, advance technology, and nationalism (Thai Ministry of Education, 2017).

Based on Table 4, all countries have objectives to develop knowledge, skills, and attitudes in science. In contrast to Indonesia and Vietnam, Thailand's objectives include a mandate to develop computational science within science education.

Based on the description of aims, goals, and objectives, we conclude that the purpose of the science curriculum of Indonesia, Vietnam, and Thailand bears some similarities and notable differences. The similarities between the three countries are in the purposes of the science curriculum to develop scientific literacy. The differences between the three countries can be shown that, in Indonesia, addressing the spiritual attitude is one purpose of the science curriculum (Indonesian Ministry of Education and Culture, 2017, pp. 4–5). It means that, by learning science, students should improve their faith in God (Indonesian Ministry of Education and Culture, 2017). Another purpose is to address the understanding of science in an integrated manner (Indonesian Ministry of Education and Culture, 2017, pp. 4–5). It means that students should understand science as integrated science through physics, chemistry, and biology (Indonesian Ministry of Education and Culture, 2017, p.6).

In Vietnam, the new science curriculum focuses primarily on competency, in which students must have a transfer from the awareness of natural science to the application of science to daily problems. The ability to transfer this knowledge is indicative of an acquired competency and an important purpose of the science curriculum (Vietnamese MOET, 2018). In Thailand, the science curriculum addresses nationalism and life skills (Thai Ministry of Education, 2017). It means that Thai students should improve their nationalism in the Kingdom of Thailand and have good life skills after learning science. Another notable difference is that, for the Thailand curriculum, the text is very clear about developing computer science knowledge and skills in a science subject and includes creativity in their purpose. Indonesia includes making decisions in daily life using science as well. Computer science for junior high school students focuses on developing computational thinking as skills and knowledge needed to become successful young generation students in sciences and engineering (Bargury, 2012).

Based on the description of the science curriculum content in Table 5, we can conclude that the similarities

across the three countries are that the curricula consist of several main fields of science: biology, physics, chemistry, and earth and space sciences. The difference is that Indonesia has integrated science (Indonesian Ministry of Education and Culture, 2017, p. 5). Wei (2009) stated that the international tendency towards an integrated science curriculum is recognized as integrating four traditional subjects (biology, chemistry, geography, and physics) into a new course in junior high school with the purpose of solving the long-term problem of students' overburdening schoolwork and encouraging student initiative.

The similarities between the three countries regarding students' learning experiences are that science is no more than 10 hours per week and no more than 200 hours per year and that there are common scientific practices in all science curricula investigated. Our analysis suggests that the common practices are weighted towards the planning and carrying out of experiments. These practices include "experimenting," collecting data, analyzing data, and reporting on this data using representations. Although there is some evidence of modeling, it is not prevalent. Less common are creating investigations or suggesting issues (Vietnam), asking for explanations (Vietnam), making judgments (Vietnam), data storage (Vietnam), working with ICT (Indonesia), using statistics (Vietnam), adjusting conclusions (Vietnam), and using mathematical models (Thailand). Although Indonesian students appear to have more time to learn science than other countries, other countries have additional practices associated with science.

All three countries appear to promote acting like scientists to learn science. The differences in the three countries' curricula appear to be that Indonesia uses a "scientific approach," Vietnam uses practical teaching, problem-based teaching, project-based teaching, and experiential teaching, whereas Thailand uses the scientific method and scientific inquiry.

In comparison in terms of assessment, the similarities among the three countries are the evaluation of the same types of learning outcomes such as knowledge, attitude, and skills. Indonesia and Thailand have large-scale assessments for science at the national level. However, there is no national examination in Vietnam. In Indonesia, as of 2021, the national science examination as a requirement to graduate will be removed. In Indonesia, students are assessed using an attitude observation sheet and supported by self-

assessment and peer-assessment. To assess students' knowledge in Indonesia, written and verbal tests and assignments are predominantly used. To assess the students' skills, performance tests, product, project, and portfolio methods are used (Indonesian Ministry of Education and Culture, 2017, pp. 13–14). In Vietnam, the form of assessments consists of homework questions, objective tests, essays, reports, verbal Q & A such as interviews, and observations such as visual observations of experiments, discussion groups, field studies, and projects to apply knowledge into practice (Vietnamese MOET, 2018). In Thailand, evaluation forms, observation forms, paper tests, and online tests are used. Some programs practice and assess their students by using existing standardized tests or aptitude tests, for example, PISA, TIMSS, O-NET, or higher-level tests (Thai Ministry of Education, 2017). All three countries showed evidence in their science curricula of a broad range of assessments, including objective tests and additional measures such as observation sheets and interview guidelines.

Conclusion

Predominantly, the purpose of science education in all three countries is to develop scientific literacy. The differences in terms of the aims of the science curricula are notable. In Indonesia, the curriculum also promotes a spiritual attitude among students and the understanding of science in an integrated manner. In Vietnam, a key difference in their science curriculum includes promoting awareness of integrated natural science as one of the important purposes of the science curriculum. The uniqueness of Thailand's science curriculum is that the purpose of science education is to address nationalism and foster "life skills" such as problem-solving and critical thinking. Moreover, Thailand is very clear in developing knowledge and skills pertaining to computer science with the subject of science. Thailand's curriculum also includes creativity in science. Additionally, In Indonesia's curriculum, science education also supports making decisions in daily life.

The similarity between the three countries regarding science curriculum content includes biology, physics, chemistry, and earth and space sciences. The similarities between the three countries regarding students' learning experiences are that students learn science

no more than 10 hours per week and no more than 200 hours per year. Indonesian students have more time to learn science than other countries, followed by Vietnamese students and Thai students. During this time, not only is content taught, but scientific practices are key in every science curriculum. Additionally, the Thai science curriculum integrates scientific practice with mathematical modelings such as equations or formulas.

Next Generation Science Standards (2013) released eight practices of science that are essential for all students to learn and describe, including asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations, engaging in argument from evidence, and obtaining, evaluating and communicating information. All curricula employ student-centered learning and inquiry as a central approach to teaching science. Indonesia uses what they term as a scientific approach. Vietnam uses practical teaching, problem-based teaching, project-based teaching, and experiential teaching (this can also be stated as the scientific method). Thailand uses what they refer to as the scientific method and scientific inquiry. Assessment of science occurs in all three curricula using test and non-test measures of assessment such as interview guidelines and observation sheets. The differences between the three countries are that Indonesia and Thailand have large-scale assessments at the national level to assess science subjects as a requirement for graduation. However, the national examination in Indonesia will cease in 2021.

This cross-case analysis provides several broad but significant comparisons of renewed science curricula at this critical time when countries are implementing plans to promote STEM and participating in global organizations. Each country has renewed its curricula in the context of global policy drivers that promote practices associated with the doing of science and applications of science in assessment situations. Although each country has notable differences, overall, there appears to be a greater commonality in the areas of the purposes and aims of science education, the learning and assessment experiences promoted, and the practices considered as representative of the scientific endeavor.

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Declaration of Ownership

This report is our original work.

Conflict of Interest

None.

Ethical Clearance

This study was approved by our institution.

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