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A Qualitative Content Analysis of the Grade 4 Learning Modules and Lesson Plan on Energy based on the Three-Dimensional Learning Model

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Abstract: Online learning platforms and resources created by the Indonesian Ministry of Education, Culture, Research, and Technology were a blessing in disguise out of the unprecedented school closure caused by the Covid-19 pandemic. These learning resources are yet to be examined to ensure their usability and their role in improving the quality of learning in science classes. This study analyzed the learning modules and a sample lesson plan from the Teachers Learn Teachers Share platforms based on the three-dimensional learning framework. It examined to what extent is the 3-dimensional learning framework incorporated into the grade 4 learning modules and lesson plan on Energy. The methodology for analyzing the sufficiency of disciplinary crosscutting concepts, scientific practices, and core ideas applied here will enrich the Science, Technology, Engineering, and Mathematics (STEM) based education corpus of knowledge. Findings show that the disciplinary core ideas dimension is the most sufficiently covered of all three dimensions while the practices dimension is only partially covered as some of the points are mostly inferred, and the crosscutting concepts dimension still shows much room for improvement. Primary school teachers and schools' curriculum development units should enrich the learning modules by expanding the discussions on the module coverage with crosscutting concepts.

Keywords: *Energy, learning modules, lesson plan, science, three-dimensional learning.*

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Introduction

In science learning, students do not acquire science facts or ideas only, but they should also engage in practices to develop a scientific temper and build abstract concepts across disciplinary boundaries. Now that the pandemic is over, the lessons learned during remote learning should drive educators to balance those three expectations to improve the quality of learning in science education. Hence, this study aims to investigate the alignment within the written physical science curriculum at the operational level. Specifically, this study reviews the Grade 4 science learning modules and the lesson plan based on the three-dimensional learning model (3D learning model) (Anderson, 2011).

Indonesia has attempted a range of educational reforms over the past twenty years to prepare its young people to acquire science literacy and live as contributing citizens in the twenty-first century. Unfortunately, recent international assessments reported the low performance of Indonesian students in the last two decades. In Programme for International Student Assessment (PISA) 2022, Indonesia ranked 71 in Reading, ranked 70 in Mathematics, and 67 in science out of 81 (Organisation for Economic Co-operation and Development [OECD], 2023). The Country Note from PISA 2022 reveals that around 34% of students in Indonesia achieved Level 2 or higher in science compared to the OECD average of 76%. PISA's Level 2 definition means these students can explain basic scientific phenomena and evaluate the validity of a conclusion based on the data. However, only 0.1% of Indonesian students achieved high levels of performance in science, specifically at Level 5 or 6, which falls below the OECD average of 7% (OECD, 2023). These students can creatively and autonomously apply their science knowledge to various situations, including unfamiliar ones. This finding shows the prevalent inequality issue in Indonesian education. The recent pandemic has further served as a magnifying glass exposing the inequality in providing quality education for all students. Students from privileged

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backgrounds can access high-quality learning resources from anywhere in the world, while those from disadvantaged backgrounds lack access to adequate resources. The provision of online learning platforms and resources by the Indonesian Ministry aims to close the gap.

However, the concern about the low performance in science has brought to light a study of learning profiles in developing countries (Pritchett & Beatty, 2015). The study argues that curriculum mismatch has led to a lack of coherence with learning goals and asks why there is so little learning in spite of the increasing number of schooling years. Pritchett and Beatty Pritchett and Beatty (2015) contend that "paradoxically, there is greater learning potential if curricula and teachers slow down" (p. 276). Their argument for the re-centering of the curricula and teaching leaves a gap that this study aims to fill. What does slowing down the curriculum entail? It is important to ensure that the learning resources meet the learning attainment standards. Within this context, this study then embarked on a content analysis approach to examine the quality of the online learning resources.

We focus on using the 3D learning framework to look into the grade 4 learning modules and lesson plans on energy provided as online learning resources by the Indonesian Ministry. Houseal (2015) states that in the 3D learning model, the use of energy and matter materials aims to enable students to understand the subject matter easily within the limitations of the existing ecosystem. In the primary school curriculum in Indonesia, energy and matter materials are included in the 4th grade, so this study only observed data from the 4th grade. Grade 4 is chosen because it is deemed to be a critical year for STEM education as it is the starting year of the latter grades of primary school when students develop their problem-solving abilities and future interest in STEM fields. Early exposure to integrated STEM curricula is crucial in fostering a positive learning experience and preparing students for further education in STEM at the secondary level (Hudson et al., 2015; Radloff, 2015).

To examine how the reform agenda is translated into the science curriculum at the primary school level, this study investigates the alignment within the written physical science curriculum at the operational level. Specifically, this study reviews the Grade 4 science learning modules and the lesson plan based on the 3D learning model (Anderson, 2011).

Literature Review

In 2012, the National Research Council (NRC) published a document titled A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council [NRC], 2012), that NRC intended the document as a starting step to build a new K-12 science education standard. This Framework consists of three interwoven and overlapped threads: Disciplinary Core Ideas (DCI), Scientific Practices (SP), and Crosscutting Concepts (CC), which should be the foundation of science learning in K-12 education. According to this Framework, students should learn the core ideas (consisting of essential concepts in sciences) through practices (engaging of scientific and technological skills integrated with knowledge) across CC (consisting of transferrable ideas across various disciplines).

One may notice that the Framework missed mathematical and digital literacies. Still, this does not mean the writers ignored those two literacies; indeed, the writers stated that those two literacies, together with reading literacy, were highly important for the students' future life and career. Therefore, they should be in separate documents, and the standards for these literacies have been available.

This study uses the above Framework, now popularly known as the 3D learning model, to examine a lesson unit in Indonesia's 2021 Grade 4 learning resources. This study methodology closely follows the research method (Houseal, 2015; Kaldaras et al., 2021). By scrutinizing the learning modules, this study identified the core ideas, practices, and crosscutting concepts present and not present. Then, this study examined a sample lesson plan using the same 3D learning model. By combining those two examinations, this study proposes suggestions at practical and policy levels. The following Figure 1 describes the steps in this study.

Figure 1. Steps to Perform Identification

Figure 1 represents the steps on identifying the potential insufficient core ideas, crosscutting concepts, and practices by applying 3D learning model. In 1985, the American Association for the Advancement of Science (AAAS) proposed an initiative for the future of education in science, mathematics, and technology that every student should experience to be literate in those three disciplines. This initiative, popularly called Project 2061, translated the vision of the future into Benchmarks for Science Literacy (AAAS, 1993), listing a set of essential goals for 2nd, 5th, 8th, and 12th graders in science learning. In subsequent discussions, the document will be identified as benchmarks. Interestingly, the learning goals in benchmarks were expressed in three parts: the nature of science, math, and technology, the common themes, habits of mind using cross-disciplinary thinking. In addition, the Benchmarks' construct and the notions selected in this document are parallel to several contemporary education ideas as reiterated in the books *Understanding by Design* (Wiggins & McTighe, 2005) and habits of mind (Costa & Kallick, 2000). In particular, the common themes in benchmarks, namely systems, models, constancy and change, and scale, are what *Understanding by Design* coined as big ideas.

Then, in 2012, drawing from the AAAS's documents (Benchmarks and Atlas of Science Literacy) and National Academies' document (National Science Education Standards), NRC published the document A Framework for K-12 Science Education: core ideas, crosscutting concepts, and practices (NRC, 2012). This NRC's document will be identified as the Framework in subsequent discussions. NRC stresses the students' engagement in practices that may motivate them to study science and engineering. This conceptual Framework details the fundamental components of science learning and groups them into three dimensions: DCI, CC, and SP (See Figure 2). In this study, the DCI are only those under the physical sciences.

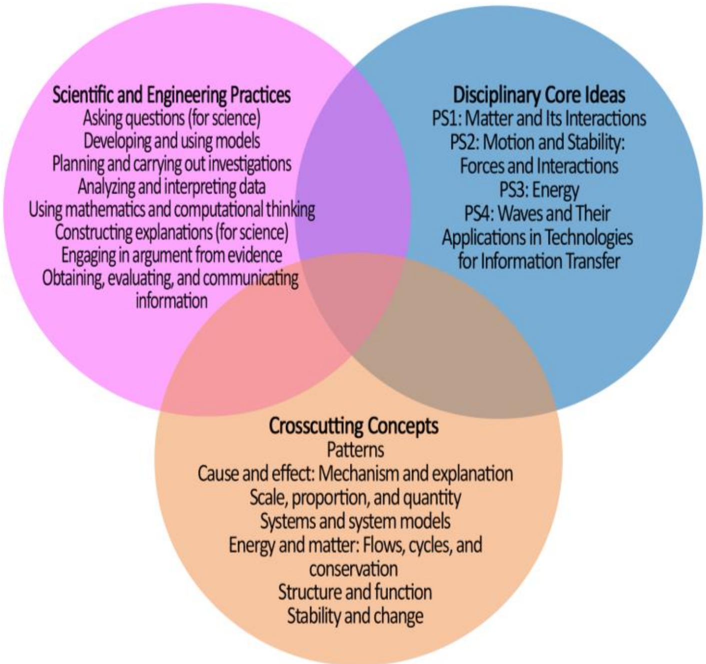

Figure 2. The Venn Diagram Representation of the 3D Learning Model

Figure 2 above shows a Venn diagram of the 3D learning model applied in the physical sciences. In Dimension 1, there are four major fields: the physical sciences, the life sciences, the earth and space sciences, and engineering, technology, and science applications. The field of physical sciences covers four core ideas, where each core idea has sub-ideas (Houseal, 2015).

In Dimension 2, the *Framework* lists the scientists' investigative behaviors and practices when modeling and creating theories of the universe and the engineers' constructive behaviors when designing and building systems. The *Framework* includes eight scientific and engineering practices, which can be seen in Figure 2 (Houseal, 2015).

Since this analysis focuses on physical sciences, points 1 and 6 above will be restricted to "Asking questions" and "Constructing explanations," respectively. It needs to be noted here, first, that the "inquiry" behaviors are not solely for pedagogical reasons, but they are also important in themselves. Every student should develop the inquiry practice for preparing them to function effectively in the present science-and-technology-enriched life. Second, the choice to use the word practice instead of skill because NRC wants to stress the involvement of knowledge in this process.

Young children can be introduced to all eight practices to varying degrees, allowing their exposure to these practices and their ability to utilize them to develop gradually as they grow. The Next Generation Science Standards (NGSS) specifies the skills and competencies students are anticipated to gain by the conclusion of each grade range (K–2, 3–5, 6–8, and 9–12) in order to enhance each of the practices. As this study analyzes Grade 4 module, to guide our data analysis, below is the list of practices to be developed for the fourth graders within the 3-5 grade band (NRC, 2013).

In Dimension 3, the *Framework* lists the crosscutting concepts that play fundamental roles across science and engineering. In other words, the crosscutting concepts are not disciplinary dependent; indeed, these concepts challenge the traditional disciplines' boundaries and invite various fields to collaborate. Moreover, entering the third decade of the 21st century and experiencing the COVID-19 pandemics, we are increasingly convinced of the need to nurture cross-disciplinary literacy now more than ever. The *Framework* enlists seven crosscutting concepts which can be seen in Figure 2 (Houseal, 2015).

Drawing from the above 3D learning descriptions, we analyze the learning modules and a sample lesson plan. The learning modules and lesson plans are examined in accordance with the 3D learning model. Firstly, there is the DCI which consist of definitions of energy, conservation of energy and energy transfer, relationship between energy and forces, and energy in chemical processes and everyday life. The second one is SP which consists of asking questions and defining problems, planning and carrying out investigations, and constructing explanations and designing solutions. The third is CC, comprising energy and matter, the influence of science, engineering, and technology on society and the natural world, and science is a human endeavor.

In summary, the 3D-learning model systematized into the three-dimensional structure above guides us in scrutinizing whether the present digital learning modules sufficiently provide opportunities for the students to improve their DCI, hone their scientific practice skills, and strengthen their CC in a means to develop a deeper understanding of the human role in the universe. Hence, this analysis is necessary to ensure that students with limited face-to-face teacher-student interaction not only know scientific facts but are also on a path to becoming mature human beings skillful in SP and playing significant parts in the betterment of the world and their local surroundings.

Furthermore, analyzing the online learning modules and lesson plans is deemed important in light of the recent pandemic situation which revealed a disparity in providing every student a quality education in Indonesia. While students from underprivileged circumstances might not have access to sufficient resources, those from rich ones can obtain top-notch learning materials from anywhere in the world (Gozali et al., 2023; Lie et al., 2020, 2023). The Indonesian Ministry's provision of online learning platforms and resources was intended to reduce the disparity. As the learning platforms and resources are still available for educators after the reopening of schools, it is necessary to analyze the quality of those learning materials.

In brief, the study was conducted to address the concern about curricular mismatch. The claim that an overly accelerated curriculum in low-performing countries is the culprit (Pritchett & Beatty, 2015) should not hurriedly be followed by reducing the coverage of the curriculum before analyzing its depth.

Methodology

Research Design

This study uses the three-dimensional (3D) learning model to examine a lesson unit in Indonesia's 2021 Grade 4 learning resources. This study methodology closely follows the research method (Houseal, 2015). By scrutinizing the learning modules, this study identified the core ideas, practices, and crosscutting concepts present and not present. Then, this study examined a sample lesson plan using the same 3D learning model. By combining those two examinations, this study proposes suggestions at practical and policy levels. Figure 2 describes the conceptual model that details the fundamental components of science learning and groups them into three dimensions: Crosscutting Concepts, Practices, and DCI.

Data Source and Unit of Analysis

The data sources in this study were grade 4 learning modules and a sampled lesson plan. Grade 4 learning modules can be downloaded from *Berani Belajar* (Dare to Learn) website, specifically designed to respond to the remote learning mode instigated by the Covid-19 pandemic (Dare to Learn, 2022).

Each grade level consists of nine learning themes. The learning themes in grade 4 cover 1) my environment, 2) food security, 3) body system, 4) communication media, 5) means of transportation, 6) the nature of Indonesia, 7) energy in life, 8) diversity in Indonesia, and 9) solar system. This study focused on theme 7, comprising four sub-themes: energy in our life, fossil fuel, alternative energy, and energy saving. Each sub-theme consists of student, parent, and teacher modules. The content analysis was conducted on the student and teacher modules.

It is compelling to note that theme 7 corresponds with the sustainable development goal 7 affordable and clean energy (Department of Economic and Social Affairs Sustainable Development, 2023). We chose to focus on Energy because access to affordable, reliable, and sustainable energy for all citizens is still a prevalent issue in many regions in Indonesia. Furthermore, this issue has severe implications for the other goals. The lack of access to reliable electricity in some disadvantaged areas, for instance, has become a stumbling block to ensuring quality education for all (goal 4), particularly so during the Covid-19 pandemic.

The sample lesson plan was downloaded from Teachers Learn Teachers Share (Ministry of Education and Culture, 2021). This website was built by the Indonesian Ministry of Education and Culture as a forum for teachers to learn and share to support the *Merdeka Belajar* (freedom to learn) agenda before the Covid-19 pandemic. As of 24 October 2021, the website has over 1 million users and is linked to official teachers' professional development platforms. The lesson plan on energy for grade 4 semester 2 was uploaded by *Bagas Akbar Maulana* on 18 June 2020 and showed the highest count (5109) of the downloaded material. Maulana taught in a state primary school, SDN 2 Karang Tengah Mata, and submitted this lesson plan to the Open University. The content analysis based on the 3D learning framework was conducted on this lesson plan.

The unit of analysis on the learning modules and the lesson plan is phrases or sentences denoting learning outcomes, scopes and sequences of materials, and learning activities. The learning modules and the lesson plan were written in the Indonesian language. The researchers translated the data taken from these documents into English.

Data Collection and Analysis

The three researchers collected and analyzed the data from the learning modules and the sampled lesson plan based on the Next Generation Science Standards (NGSS) 3D learning framework, as summarized in the attachment. Based on the content analysis conducted in this study, the researchers examine the alignment match between the curricular goals in the learning resources and the lesson plans with respect to all three aspects: DCI, SP, and crosscutting concepts.

Phrases and sentences filled in the inferred and explicitly stated columns were analyzed and presented in the findings section. The researchers divided the tasks of reviewing and analyzing the data from the learning modules and the sampled lesson plan. When there was disagreement among the three researchers, the researchers conducted a second round of review and reanalyzed to reach a consensus.

This study did not involve any human subjects, and therefore, the researchers did not request any consent. Furthermore, this study did not breach any confidentiality code as the learning modules and a sampled lesson plan analyzed in this study can be freely accessed by the public from an Indonesian Ministry of Education and Culture website (https://ayoguruberbagi.kemdikbud.go.id/).

Findings/Results

By studying the grade-4 learning modules (471: energy in our life, 472: fossil fuel, 473: alternative energy, and 474: energy saving) and the sample lesson plan based on the 3d learning model, we present the findings grouped in three dimensions: DCI in the physical science (namely, energy), SP, and crosscutting concepts. since this study focuses on energy in grade 4, the analysis uses the PS3 in the next-generation science standards (NRC, 2013). In each dimension, findings on the learning modules are presented first, followed by those from the sample lesson plan.

Disciplinary Core Ideas (DCI)

Our analysis of the four modules in energy found four areas in this first dimension of physical sciences: (a) definition of energy; (b) conservation of energy and energy transfer; (c) relationship between energy and forces; (d) energy in chemical processes and everyday life.

PS3.A: Definitions of Energy

All four modules invest in presenting the definitions of energy. The first module (471), energy in our life, sets definitions of potential and kinetic energy (p. 7), lists kinds of energy: chemical, heat, mechanical, solar, electricity, nuclear (pp. 29-32), and offers examples of energy in everyday life (pp. 31-32). The second module (472) discusses types of fossil fuel, namely oil, gas, coal (p. 7), electricity usage at home (p. 14-15), Watt-hour as a measurement in electricity usage (p. 16-19), and renewable and non-renewable energy (p. 21-23). As the name "Alternative Energy" suggests, the third module (473) reiterates Biomass (biogas, biofuel), Wind, and Water Current (p. 6). In addition, this module covers renewable energy (p. 7) and discusses the advantages and disadvantages of each alternative energy (p. 20-22). The last module (474) reaches the more concrete energy level by presenting several kinds of fuel for cooking (p. 61-62) and data on the types of energy used in the world (p. 80).

The sample lesson plan sets as its learning outcomes: understanding various forms of energy and its uses in everyday life and describing sound energy in our surroundings and its characteristics. This lesson plan goes beyond the four modules. It addresses the movement of sound and sets as its indicators and scope of material: explaining sound reflection, sound propagation, and sound absorption.

PS3.B: Conservation of Energy and Energy Transfer

In this second point, all four modules discuss energy conservation and energy transfer. The first module (471) reveals the transfer of energy from solar energy to electricity, such as lighting electric bulbs (p. 34), irreversible energy conversion (p. 51), the conversion of movement to sound (p. 64), and the conversion of energy (p. 68). The second module (472) takes a contextual setting of energy conversion in iron (p. 13) through a discussion of energy conversion in Indonesia, from coal, heat, steam, and turbine to electricity (p. 16). The third module (473), the Alternative Energy module, introduces energy conversion from wind power and water current to electricity (p. 8). In contrast, the last module (474) introduces energy-saving and gives examples of wasting energy, such as leaving unused electrical appliances (p. 17-18).

The learning objectives stated in the lesson plan aim to enable students to explain that sound can transmit from its source to other places through media or other objects and to describe sound transfer and things that can absorb sound.

PS3.C: Relationship between Energy and Forces

Only the first module attempts to point out the relationship between energy and forces in the Food as a Source of Energy (p. 15-19). The other three modules do not cover this area. The lesson plan covers sound reflection, transmission, and absorption but does not include the relationship between sound transmission and energy transfer.

PS3.D: Energy in Chemical Processes and Everyday Life

This domain relates to the everyday application of energy. The term "produce energy" typically denotes the process of transforming stored energy into a usable form for practical purposes. The first module includes energy conversion in a flashlight (p. 30) and chemical processes in baking (p. 51). The other three modules do not reach this practical application of energy.

The lesson plan does not explicitly include the practical use of sound transmission and energy transfer, although some assessment items mention concrete examples of sound propagation.

Scientific Practices (SP)

In some literature, SP belongs to the first dimension, but here we place it under the second dimension to make the study focus on the disciplinary scope. SP aim to build students' habits of inquiry and scientific investigation. The use of the term "practices" instead of a word like "skills" is employed to stress that involvement in scientific inquiry demands not just the proficiency but also the specific knowledge associated with each particular practice. In reference to the grade band of 3-5 set by NGSS, three essential practices for fourth graders are planning and carrying out investigations, constructing explanations and designing solutions asking questions, and defining problems.

Asking Questions and Defining Problems

Fourth-graders should hone their scientific skills to ask questions and define problems by building on their previous K–2 experiences. These skills are essential practices in a science class to teach students to investigate and predict reasonable outcomes based on patterns such as cause and effect relationships.

Of the four modules, the second module, Fossil Fuel, attempts to get students to ask questions in the statement "To ask adults how we can save fossil fuel (p. 8)." Unfortunately, this statement is not followed by learning tasks that would lead students to define problems of fossil fuel. The question does not trigger learners' curiosity to investigate cause-and-effect relationships in fossil fuel issues.

The lesson plan outlines using a cooperative learning method of STAD (Student Teams Achievement Divisions) (Slavin, 2011). The learning activities detail fourteen steps of what students should do in their team learning activities and collaborate in their teams. Searching for information and sharing knowledge with team members should increase students' exercises in asking questions and defining problems.

Planning and Carrying Out Investigations

Module 2 (energy in our life) and module 3 (alternative energy) lead fourth graders to plan and carry out experiments to test the phenomenon's variables and design solutions. Module 2 assigns students to investigate potential and kinetic energy using marbles or balls (pp. 9-10), and in module 4, students make a toy windmill model (pp. 56-57). Through these experiments, students' observations will guide them in acquiring data, which can serve as the foundation for either explaining a phenomenon or evaluating a design solution.

The lesson plan assigns team members to complete worksheets, but it does not explicitly specify what kinds of investigations they should do. While the learning modules offer experiments in energy movement, the lesson plan relies mainly on teachers' and students' explanations. The attached assessment contains some items on sound energy that could enhance students' understanding through SP but instead are formatted in multiple-choice and short answer types.

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions by fourth graders are included in three of the four modules. In light of grave concerns for fossil fuels, the second module lists tasks that are expected to understand the importance of fossils for the planet earth. The module explicitly assigns students to:

1. Explain how fossil fuel was formed (p. 7)
2. Explain why fossil fuel is not renewable (p. 7-8)
3. Explain what will happen if fossil fuel is gone (p. 8)

4. Analyzing and determining specific energy as renewable or non-renewable, and explaining the reasoning (p. 23)
5. Explain why fossil fuel usage causes global warming (p. 34-37)
6. Analyze, compare, and explain which strategy can save energy more (p. 68)

The third module gets students to inquire why alternative energy, in some cases, is considered renewable energy (p. 9), and the fourth module encourages students to ponder why and how we should save energy (p. 26).

The utilization of practices related to designing solutions and constructing explanations is anticipated to encourage students to employ evidence, including observations, measurements, the application of scientific concepts, and patterns, to address real-world problems. Engaging students in such practices should enable them to form a habit of scientific inquiry and prepare them to solve energy-related issues. The lesson plan gives a detailed list of learning activities that include students explaining the topic to their team members. Unfortunately, it does not specify how they can use evidence to construct explanations and design solutions to problems.

There are three essential practices constructing explanations and designing solutions, planning and carrying out investigations, and defining problems and asking questions that relevant practices in the earth science section related to energy (NRC, 2013).

Communicating Information, Evaluating, and Obtaining

Students should engage in the practices of gathering, assessing, and sharing information from trustworthy sources, such as books and other reliable media, to elucidate the phenomena outlined in the Earth Science section (4-ESS3-1). This is essential for them to describe how energy and fuels originate from natural resources and how their utilization impacts the environment. Regrettably, the four modules and the lesson plan do not incorporate these practices for students.

Designing Solutions and Constructing Explanations

The practices of formulating explanations and devising solutions by utilizing evidence that identifies variables for describing and forecasting phenomena involve generating and contrasting various solutions to a problem based on how effectively they adhere to the design solution's criteria and constraints (4-ESS3-2). Unfortunately, unlike the preceding practices, this particular approach is not included in the lesson plan and modules.

Crosscutting Concepts

The ultimate dimension is designed to fulfill the requirement of incorporating both disciplinary content and the concepts and methodologies that transcend various scientific fields. These crosscutting ideas are applicable throughout all branches of science and challenge students to perceive the interplay between science and society.

Energy and Matter

To enhance students' understanding that energy can be transferred in various ways and between objects, the first module covers energy flow in an ecosystem (p. 18-19), energy conversion in a stove and our body (p. 41), and energy conversion in an iron and others (p. 43). The third module presents systems that can conserve energy in a certain form to another, mostly electricity (p. 27-30, 32-35).

The lesson plan covers sound energy and movement. The learning outcomes of understanding various forms of energy and their uses in everyday life and describing sound energy in our surroundings and its characteristics are not elaborated further in the learning activities. Perhaps, these points are assumed to be covered in the teacher's explanation.

The Natural World and Technology on Society, Engineering, and Influence of Science

The second module attempts to establish connections between the physical science of energy and technology with society and the natural world by discussing the following current issues:

- The fossil fuel usage that causes global warming (p. 34-35)
- The oil pollution in the sea threatening marine life (p. 47-48)
- The fossil fuel consumption and ozone destruction (p. 68-69)
- Gas consumption and distance traveled (p. 31-32)
- Energy consumption of TV set for a certain amount of duration time (p. 40)
- Energy consumption of electric bulbs (p. 52)

When exploring the option of alternative energy, the third module discusses air pollution caused by car emissions (p. 45-46) and offers the idea that biofuel may reduce air pollution (p. 45-47). On a similar note, the last module warns that smoke from industry and cars using fossil fuel causes air pollution (p. 39) and suggests that humans consider using plants to reduce air pollution (p. 54-55) to help save the ecosystem. It further recommends certain plants such as rain trees to help absorb air pollution to play an essential role in the ecosystem (p. 42). This module also attempts to teach how to calculate the cost of fuel consumption (pp. 47-48). Some items in the assessment attached to the lesson plan do address real-world problems related to sound energy. However, they do not seem to foster analytical and synthetical thinking levels required to lead students to find connections to current issues in society.

Science Is a Human Endeavor

All in all, the four modules attempt to engage the students to experience that science is a human endeavor and knowledge of science is essential. Through knowledge and skills, human beings should know what to do best to conserve energy and protect the natural environment from further destruction. The cultivation of this knowledge and skills is best nurtured within the school system.

Other than the Student Teams Achievement Division (STAD) activities that engage students in collaborative learning, the lesson plan does not explicitly prescribe how students can acquire the knowledge and skills pertaining to sound energy to foster their love for science as a human endeavor to solve real-world problems.

The results and discussion should be presented together in a clear and concise manner. In the discussion section, focus on highlighting the practical implications of the research findings rather than restating the results. Combining the results and discussion within the same section is recommended to reduce the need for lengthy quotations. Tables or graphs should illustrate distinct results. It is crucial that the data analysis results are trustworthy in addressing the research questions. When citing references in the discussion, avoid duplicating references already mentioned in the introduction. Additionally, include comparisons with findings from previous studies.

Discussion

Our analysis results reveal that the grade 4 learning modules and sample lesson plan indicate some points in the three dimensions of crosscutting concepts, SP, and DCI. A few other points are not explicitly stated or non-existent. This leaves some room for improvement in developing future learning modules and lesson plans.

The first dimension, DCI, seems to be covered more comprehensively in the four modules and the lesson plan, particularly on energy definition and conservation of energy and energy transfer. The other two points (the connection between energy and forces, as well as the role of energy in chemical processes and daily activities) are not explicitly and expansively stated. Not all knowledge can be obtained in school, and not all science content ideas can be covered in the curriculum. Rapidly developing technology can provide fast information to students, and thus, they have to be guided to search for information themselves and filter the correct and incorrect information. The important role of science in everyday life can help students in reasoning so that students are accustomed to thinking critically. This brings us to the next dimension.

The second dimension emphasizes that classroom processes should engage students in doing science, requiring skills and knowledge specific to each practice. In reference to the grade band of 3-5 set by NGSS, three essential practices for fourth graders are designing solutions and constructing explanations, carrying out investigations and planning, defining problems, and asking questions.

It is found that the four modules clearly encourage students to apply mathematics in scientific activities and experience working with various math representations. Nevertheless, the modules should more systematically lead the students to apply and exercise their computational thinking skills. The students can explore simple, relevant tasks through their computational thinking perspectives. Furthermore, all modules, except the first one, explicitly ask students to construct explanations of various situations. In this part, the modules succeed in demonstrating how students can develop their communication and language skills through science learning and vice versa. This integrated learning experience is precious and beneficial to the students during the pandemics for learning opportunities are scarce. One simple improvement that can be made by enriching learning opportunities to ask questions. The modules do instruct students to ask adults on several occasions, but the questions they are expected to ask have been explicitly prepared in the modules. Hence, the learning modules fail to seize the students' opportunity to learn to formulate their own investigative questions. Knowledge begins with a question. Therefore, the experience of formulating and posing questions is essential for students' future studies and lives. On a brighter note, students have a valuable opportunity to build and use toy windmill physical models to do experiments in module 473, but unfortunately, there are no other similar opportunities in other modules. Equally, modules 472 and 474 implicitly ask students to study data represented in tables and diagrams, but their opportunities to collect and study the collected data should be more frequent. primary school students should experience a proper scientific investigation process on simple concepts. Finally, instead of providing the information, the modules need to provide more opportunities for the students to search for information themselves and communicate the findings.

While questioning practices are yet to be strengthened in the modules, the lesson plan relies on a cooperative learning method of STAD (Slavin, 2011) to provide exercises for students to ask questions and define problems. As Wiggins and McTighe propose, teachers and students need to develop their abilities to formulate essential questions to reach comprehensive facets of understanding (Wiggins & McTighe, 2005). While the learning modules offer experiments in energy movement, the lesson plan, including the attached assessment, relies mainly on teachers' explanations and students' understanding of those explanations. The strengths of the modules and the lesson plan analyzed in this study can serve as professional capital for teachers to design and deliver learning processes that engage students in developing SP. On the other hand, the missing practices in the modules and lesson plan entail that teachers are expected to demonstrate pedagogical content knowledge and competencies to facilitate the cultivation of practices. In other words, the shortcomings of the documents leave necessary room for teachers to develop their own capacity to fill in the void.

This last dimension, crosscutting concepts, aims to extend students to go beyond the disciplinary boundary and observe the interconnectedness between sciences and society. These learning opportunities prepare students to face and solve real-life problems. The modules implicitly offer discourses on cause and effect concepts, but the teachers should create more opportunities for students to learn the cause and effect patterns. Whenever an opportunity comes up, teachers can trigger the cause and effect idea to the students through media and methods, such as drawing cause and effect diagrams. All module--except the second one clearly provides opportunities for the students to build a system perspective in their minds, and we know that system thinking is essential in this modern life. However, the modules are short on finding the systems' elements, the structure, and their functions. The purpose of the system is also important and should be present in the discourse.

Correspondingly, some CC are not elaborated in detail in the learning activities in the lesson plan. By the same token, this void creates potential opportunities for teachers to expand the content coverage as well as delve into the depth of students' critical thinking. Through engaging lessons, teachers foster their love for science as a human endeavor to solve real-world problems.

Analysis of the three dimensions in science learning on the modules and lesson plan on energy has brought up some insights. in summary, of all the three dimensions, the DCI dimension is the most sufficiently covered, while the practices dimension is only partially covered as some of the points are mostly inferred. On the other hand, CC dimension still shows much room for improvement. The rapid and continuous growth of scientific knowledge makes it impractical to comprehensively delve into every disciplinary concept in the primary school curriculum. Consequently, in light of the abundance of easily accessible information today, a critical objective of science education is not to impart "all the facts," but rather to provide students with a foundational level of knowledge and essential skills. This equips them to independently gather, evaluate, and interpret information as they progress. Additionally, the crosscutting concept dimension plays a vital role by unifying the three dimensions and encouraging students to establish connections between the fundamental concepts related to Energy across various fields of study and educational levels. This empowers them to assess and choose trustworthy sources of scientific knowledge and prepares them for ongoing development in the years ahead, shaping them into not only scholars of science but also future problem solvers who utilize scientific approaches.

In summary, the findings in this study may lead us to new theoretical endeavors in researching the depth of the scientific practice skill, and CC included in the previous generation textbooks and learning modules. On the practical side, we may analyze the balance of teacher preparation on the three aspects of science education using the 3D learning model and NGSS.

Conclusion

The pandemic crisis has exposed very fundamental issues in the education system in Indonesia as it does in many other parts of the world. The virus outbreak hit Indonesia only five months after the new Indonesian Ministry of Education and Culture was inaugurated and three months after the launching of the *freedom to learn* reform agenda. The unprecedented school closure and the lack of readiness for online learning mode in the majority of schools all over Indonesia were handled with agile actions to set up online learning platforms and resources. The online modules are available for download by the public in response to the pandemic crisis as well as in support of the *freedom to learn* reform. As a matter of fact, the crisis has expedited the reform agenda. The findings of this study highlight two merits of the online learning resources represented by the grade 4 modules and the sample lesson plan.

First, these 2021 learning modules were developed and made accessible to the public in such a short period of time to respond to the pandemic situation that the efforts promptly met the needs of the education stakeholders, particularly students, teachers, and parents. But now that the pandemic has been contained and schools have returned to face-to-face meetings, these learning resources can still be accessed at teachers' disposal.

Second, in line with the nature of the learning-from-home mode at the primary school level, the learning resources include the student module, teacher module, and parent module. The study did not analyze the parent modules in detail and yet we found that the parent modules cover practices more than disciplinary core ideas and crosscutting concepts. Recurring practices in the parent modules are planning and writing investigation reports, comparing two things, translating data from tables, observing graphs, creating infographics, making conclusions, and writing a reflection. Crosscutting concepts include changed shapes of cooked food, side effects of fossil fuel, windmill model, and energy saving. The investment in practices and crosscutting concepts in the parent module suits learning-from-home mode as it involves parents in facilitating hands-on learning experiences for their children.

Finally, the sample lesson plan also includes a self-reflection sheet for teachers prompting them to self-evaluate and reflect on their lesson delivery, including apperception, material coverage, learning media, teaching methods and techniques, and students' attainment. Reflection and reflective practice (RP) have now become popularly used in teacher education and development programs worldwide. For instance, in a study conducted by Miles and colleagues in 1993, they examined initial teacher education programs in England and Wales, and they discovered that more than 70% of these courses incorporated elements related to reflection, reflective practice, and reflective inquiry (Miles et al., 1993). Considering the vast knowledge base in reflective practice, the five prompts in the reflection sheet attached to the lesson plan still seem rudimentary, but it is a good starting point to embark teachers in the habit of reflective practices.

Recommendations

This study recommends a few points of improvement. First, the disciplinary core ideas dimension on energy is adequately covered. However, learning resources still need to elaborate more on the other two dimensions. The resources must explicitly state the scientific practices and crosscutting concepts equipped with some operational guidelines. The modules should include appendices on current issues related to the themes to enrich the crosscutting concepts. The online resources with these appendices are easy to update as necessities regularly arise.

Second, the module's lesson plan implicitly covers the dimensions of scientific practices and crosscutting concepts in the 3-D learning framework. Highly competent and experienced teachers may develop the learning materials and activities in engaging classroom processes exercising the two dimensions, but less capable teachers would need more guidance and assistance in the teacher modules. Similarly, many parents will need operational guidance in exposing the two essential dimensions in the modules.

Third, to top off those two points of recommendation, the online learning platform can be further complemented with interactive forums for the different stakeholders' groups: students, teachers, and parents, where they can share their best practices. The teacher and parent forums may be further investigated in future research as the pandemic disruption has shifted the locus of learning and compelled learners to be more autonomous.

Finally, the recommendation for further research, namely the 3-D science learning analysis model can be implemented in other themes and classes. Just as this pandemic crisis has exposed some fundamental issues in the education system, the same crisis has also sparked and expedited innovation in online education, particularly in science education at the primary level, and created fresh opportunities to reimagine the science curriculum. Adequate coverage of disciplinary ideas with ample opportunities to form a habit of scientific inquiry and sufficient exposure to crosscutting concepts will further facilitate students on their journey to become life-long science learners and responsible citizens to contribute effectively to modern life.

Limitations

Some of the limitations of this study include (1) examining a lesson unit in Indonesia's 2021 grade 4 learning resources, (2) the data sources in this study were grade 4 learning modules and a sampled lesson plan on energy, (3) using 3D learning framework. The methodology for analyzing the sufficiency of DCI, SP, and CC applied here will enrich the STEM-based education corpus of knowledge.

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Conflict of Interest

The authors state that they have no conflicts of interest regarding the study's design, data collection, data analysis, data interpretation, manuscript preparation, or the decision to publish the results.

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Authorship Contribution Statement

Lestari: Drafting manuscript, data acquisition, data analysis / interpretation, technical or material support, writing. Pranoto: Concept and design, Editing/reviewing, writing. Lie: Editing/reviewing, writing, final approval.

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