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LINKING SCIENTIFIC CONCEPTS WITH STUDENTS' PERSONAL DAILY LIVES: USING THE METAPHYSICAL MEANING OF SCIENTIFIC CONCEPTS

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Abstract. *The declining interest in science learning, along with students' perception that science is irrelevant to their daily lives, has been identified as a significant issue. This research aimed to help students connect abstract scientific concepts with their personal and everyday experiences. To achieve this, the research utilized the metaphysical principles implied by scientific concepts, a component of Kuhn's paradigm. To replace the abstract term 'metaphysical meanings', the term 'Meaning of Life implied by Scientific Concepts' (MLS) was introduced to make these metaphysical principles more accessible and comprehensible for students. Using MLS, activity sheets were developed and implemented with 57 lower-secondary students. The results showed that students could effectively identify real-life examples of the presented MLS, the number of students who successfully generated MLS increased with additional class sessions, and the content of the MLS expressed by the students was thoughtful and meaningful. Post-activity interviews indicated that students found this approach interesting and helpful for understanding concepts, and teachers were impressed by the quality of the students' work, expressing a desire to implement this approach in their classes. It is concluded that using MLS to connect abstract scientific concepts with students' everyday lives is both feasible and applicable in school science.*

Keywords: *Metaphysical Principle, Scientific Concepts, Everyday Context, Kuhn's Paradigm*

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Introduction

Many science educators have advocated for integrating everyday contexts into science instruction. This approach not only facilitates students' comprehension of scientific concepts (Baker & Millar, 1999; Bennett et al., 2007; Karsli & Patan, 2016; Lubben et al., 1996) but also enhances their problem-solving skills (Fortus et al., 2005; Yu et al., 2015), stimulates interest and motivation in science learning (Lubben et al., 1996; Sekarini & Arty, 2019; Slovinsky et al., 2021), improves attitudes toward science (Bennett et al., 2007; Majid & Rohaeti, 2018), and cultivates a good sense of citizenship in future society (Feinstein, 2009)

However, empirical research has shown that many students lack proficiency in connecting scientific knowledge with real-world situations (Irish & Kang, 2018). For example, in research within a contextualized science curriculum that utilized daily experiences, Campbell and Lubben (2000) found that over half of the participating secondary school students could not link the scientific content to the socio-economic dimensions of everyday contexts. Furthermore, approximately two-thirds could not adeptly employ scientific principles to solve practical problems. Similar findings were reported by Chu et al. (2012), who used a diagnostic tool designed by Yeo and Zadnik (2001) to assess students' understanding of thermal concepts in real-life situations. They observed that 50% to 75% of students in grades 10 to 12 responded inaccurately.

Although students recognize the connection between science and everyday life, their perceptions are often limited to its technological applications, such as cars, electrical appliances, architecture, and space rockets, instead of more personal aspects of their daily lives, including habits, friendships, family dynamics, and school experiences. This narrow view can lead students who are preparing for non-scientific and non-engineering fields to regard science as irrelevant to their learning (Park & Song, 2009). Park and Song (2009) found that approximately 50% of surveyed lower- and higher-secondary students expressed that learning science was unnecessary.

Korean students exhibit distinct traits in the context of science education, with Korean lower-secondary students consistently securing top posi-

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tions in the cognitive domain of the Trends in International Mathematics and Science Study (TIMSS) since 1995. However, their standings in the affective domain, which includes measures of confidence and interest in science, have remained below the international average (TIMSS & PIRLS International Study Center, 2024). Research within Korea has also shown a decline in students' positive perceptions of science classes as they progress from elementary to high school (e.g., Kim et al., 2006). Beyond Korea, this decreased interest in science is a global issue, particularly evident in many Western European countries. For example, van Griethuijsen et al. (2015) reported that only 22.5% to 29.6% of primary and secondary school students in the Netherlands (n=1,239) and the UK (n=1,618) favored science or mathematics over other subjects. Similarly, Steidtmann et al. (2022) noted a decline in interest in physics among 3,577 lower-secondary students in Western Germany as they progressed from grade 5 to grade 7.

The cultivation of a heightened interest in science is increasingly recognized as a pivotal objective in science education (Harackiewicz et al., 2016). The present research seeks to address the challenge of meeting this objective by emphasizing the integration of scientific concepts with students' everyday experiences. This approach is founded on the assumption that students will more likely see science as relevant and meaningful by grasping the direct relationships between scientific knowledge and daily life (Kervinen et al., 2020). Consequently, this perceived relevance is expected to increase students' active engagement in science learning (Giamellaro et al., 2022), thereby reducing science avoidance (Aniashi Sylvester et al., 2019; Avraamidou & Osborne, 2009).

However, as previously noted, many approaches have predominantly focused on the technological applications of science within everyday contexts, often neglecting or overlooking the direct connection to students' personal lives. Therefore, this research focuses on the daily experiences of students rather than the technical or engineering applications of science for two reasons. First, engaging with technical applications requires not only scientific knowledge but also an understanding of the applications themselves. In contrast, focusing on daily experience only requires scientific knowledge. Therefore, this approach aims to reduce the cognitive load involved in linking scientific concepts to everyday contexts. Second, fostering connections between science and students' personal lives is expected to directly enhance their motivation to learn and maintain interest in the science subject. That is, this orientation towards the personal and experiential aspects of science in everyday contexts aims to promote a more intrinsic engagement in science among students.

However, a fundamental question remains about the necessity of such connections for effective science learning. A promising answer to address these issues may be found in Thomas Kuhn's concept of the paradigm provides a promising solution to these issues. Kuhn posited that a paradigm serves both as a standard and a model for learners to follow and learn from (Kuhn, 1970, pp. 10–11). According to Chalmers, scientific paradigms include five critical components: concepts, applications, experiments, methods of inquiry, and metaphysical principles (Chalmers, 1982, p. 91). Our research specifically focuses on introducing metaphysical principles into science education.

Metaphysical principles form the foundational framework of scientific conceptual systems, shaping the view of nature or the world these systems imply. The scope of these principles is inherently comprehensive. However, applying metaphysical principles to individual scientific concepts is also feasible because the scale of the paradigm can be tailored to smaller conceptual units (Knill, 1991, pp. 62–63; Kung, 1989a, pp. 9–10; Orman, 2016, p. 50). Moreover, metaphysical principles extend beyond the natural world, encompassing human and societal dimensions (Knill, 1991, p. 52; Lincoln, 1985, p. 25; Ogawa, 1995, p. 587). Therefore, metaphysical principles can also be represented in the context of human society.

Based on this theoretical framework, this research adopts the assumption that metaphysical principles can be applied to smaller scientific concepts taught in science class and expressed in the context of human society, particularly in relation to students' personal daily lives. Consequently, this research assumes that introducing metaphysical principles into science learning is justified and that employing this approach can help students connect scientific concepts to their personal daily lives. However, this approach is based on novel premises that have not been previously explored. Consequently, this research basically aimed to examine the applicability and feasibility of this approach in the science learning of lower-secondary students.

Theoretical Background

Metaphysical Principles Necessary for Science Learning

Knill (1991, p. 52) noted that the term 'paradigm' originates from the Greek word 'paradigma', meaning 'model'. Similarly, Kuhn, in his seminal work 'The Structure of Scientific Revolutions' (Kuhn, 1970, p. 10), argued that paradigms serve as models providing a coherent tradition in scientific research. Kuhn further explained that normal

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science, which is guided by a prevailing paradigm, informs 'scientists about entities that nature has or does not have and how those entities behave' (Kuhn, 1970, p. 109). Within this framework of normal science, researchers have engaged in debates and conducted studies to refine and expand fundamental concepts and theories in their field (Rouse, 2002, p. 2). Individuals aspiring to become scientists are trained and practice within the confines of the prevailing paradigm, adhering to its prescribed methodologies and directions. Therefore, secondary school science education must also operate within this paradigmatic framework to prepare students to join and contribute to the scientific community (Kuhn, 1970, p. 11).

Defining the nature of the scientific paradigm is challenging; however, in his seminal work 'What is This Thing Called Science?', Chalmers (1982) described that a paradigm can be comprehensively understood through its five key components: core laws and assumptions, standard application of core laws, experimental apparatus and technologies that connect core laws with the real world, general methodological prescriptions, and general and metaphysical principles (Chalmers, 1982, p. 91). Considering that students need to learn science within a paradigmatic framework, it logically follows that the final component – metaphysical principles – also needs to be integrated into science education.

Role of Metaphysical Principles in Learning Science

What role can metaphysical principles play if they are introduced into the secondary science curriculum? Metaphysics is intrinsically linked to science, as it provides a fundamental perspective on nature and the world that is deeply embedded in the universal concepts of science. Thus, metaphysical principles play a crucial role in the acquisition of scientific knowledge. For example, De Regt and Dieks (2005) showed how a metaphysical worldview can significantly contribute to scientific understanding as follows:

> Consider an individual who adheres to the metaphysical belief of 'corpuscularism', interpreting all natural phenomena as results of direct interactions by particulate matters. Then (s)he would naturally accept Huygens' explanation of wave phenomena, which posits that waves are propagated through the action of a medium. Conversely, this person would likely reject Newton's law of gravity, which posits that forces can act at a distance, implying that objects can interact without any physical medium generating this interaction (summarised from De Regt & Dieks, 2005, pp. 160–161)

Cobern (2000) highlighted that scientific knowledge is fundamentally grounded in various presuppositions that reflect specific worldviews or metaphysical commitments, indicating that beliefs and scientific knowledge are interconnected. Consequently, he advocated for a science education approach that encompasses not only scientific knowledge but also its underlying nature and meanings, that is, metaphysical principles. Similarly, Bunge (2000) underscored the intersection between science and philosophy, arguing that incorporating metaphysical principles into science education can deepen understanding of abstract concepts like energy, which, although commonly and routinely used, do not directly correlate with observable reality.

Hewson (1981, pp. 393–394) argued that the metaphysical commitments held by science students were crucial for constructing new concepts and revising misconceptions. Additionally, many science educators have asserted that when learning modern physics – such as relativity and quantum mechanics – that diverge from classical paradigms, the introduction of new metaphysical principles is essential (Greca & Freire Jr., 2013).

Small-scale Metaphysical Principles

Kung (1989a, pp. 9–10) proposed that paradigms could be viewed as models, categorizable into macro, meso, and micro levels. Specifically, the macro paradigm encompasses the dominant worldview of a whole era (Kung, 1989b, p. 214). Within this framework, the scientific community shares a common and universal perspective and agrees on criteria considered most significant. Additionally, Kung elaborated that this overarching macro paradigm includes various meso and micro paradigms, the latter of which are employed to solve detailed problems at a more localized scale (as cited in Arjun, 1998, p. 21).

Other researchers have noted that paradigms can be categorized into broad (large-scale) and narrow (small-scale) forms. For example, Knill (1991) acknowledged that overarching paradigms comprise smaller constituent paradigms. Orman (2016) indicated that Kuhn viewed the paradigm as comprehensive aggregates of problems, methods, theoretical principles, and metaphysical assumptions. He further described the small-scale paradigm specifically as follows: 'The (small scale) paradigm is in this sense, just an example, a single phenomenon, a singu-

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larity' (Orman, 2016, p. 50). Similarly, Kindi (2013, p. 93) noted that Kuhn used the term 'paradigm' in both a narrow and a broad sense.

This delineation implies that small-scale paradigms, which focus on individual concepts or phenomena, coexist with large-scale paradigms. As previously mentioned, these paradigms are composed of metaphysical principles and core concepts. Consequently, the differentiation in paradigm scales suggests that these concepts and metaphysical principles can also be categorized into large, medium, and small scales. Therefore, this research specifically focuses on a single, small-scale concept taught in schools, as well as the corresponding smaller-scale metaphysical principles implied by this specific concept. An illustrative example of this perspective is provided below.

Macro scientific concept: *Newton's mechanics theory*
Macro metaphysical principle: *The physical universe has no empty space and is like a giant clock that acts in the form of all forces pushing out (Chalmers, 1999, p. 109).*
Micro scientific concept: *Law of action and reaction (Newton's third law)*
Micro metaphysical principle: *The interactions between objects are inherently bi-directional, not uni-directional.*

Metaphysical Principles and Human Society

Kallio-Tamminen (2004, p. 297) argued that while Descartes clearly demarcated the human mind from non-human entities in the natural sciences, this distinction breaks down in modern physics, especially in quantum theory. Kallio-Tamminen (2004, p. 298) further discussed Bohr's assertion that, unlike classical physics which regarded humans as mere passive observers of nature, modern physics views them as active participants. This shift in perspective is exemplified by the Heisenberg's uncertainty principle, which posits that the very act of observation by the observer inevitably affects the physical attributes of the observed object, such as its position, momentum, energy, and time.

This concept underscores the profound interconnectedness between observers and the external world, challenging traditional notions of objective observation. In other words, nature does not exist independently of humans and society but rather is intertwined with them. Consequently, this research accepts the view that the metaphysical principles implied by scientific concepts extend beyond nature itself and represent a worldview that encompasses the natural environment, humanity, and society.

This perspective is also supported by the works of Lincoln (1985), Ogawa (1995), and Knill (1991). Specifically, Lincoln (1985, p. 25) stated that paradigms are more than just models or patterns and reflect human's fundamental beliefs and assumptions about the world. Similarly, Knill (1991, p. 52) noted that although Western paradigms have historically separated humans and nature, there is a shift towards a new paradigm that integrates social and ecological values. Furthermore, Ogawa (1995, p. 587) introduced Takeuchi's (1979) definition of 'worldview' as 'the metaphysical systematic hypothesis about the universe, as a whole, in which human and nature are involved'. Consequently, Ogawa argued that science can adopt and represent a variety of worldviews, reflecting the different cultural backgrounds and the individuals who belong to those backgrounds.

Based on the preceding discussions, this research assumes that metaphysical principles implied by scientific knowledge can be expressed in the everyday lives of students. This assumption posits a tangible intersection between abstract scientific concepts and the concrete realities that students experience. An illustrative example of this assumption is provided below:

Scientific concept: *Law of universal gravitation*
Metaphysical principle: *Objects can interact with each other without direct action by medium*
Metaphysical principle expressed as the student's personal daily life: *You can sense your friend's difficult situation without him or her expressing it explicitly.*

This research introduced the terminology, 'meaning of life implied by scientific concepts (MLS)', instead of 'metaphysical principles' for two primary reasons. First, the new terminology simplifies complex philosophical language, thereby making it more accessible to younger learners. Second, new terminology emphasizes the relevance of scientific concepts to everyday life; that is, it highlights that the meaning of scientific concepts can be expressed as the students' personal experiences in everyday life.

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Research Purpose

To evaluate the applicability and feasibility of a novel approach of this research, the specific research objectives are as follows:

1) Develop and implement activity sheets to help students connect scientific concepts to their personal daily lives using metaphysical principles.
2) Assess whether students comprehend and accept the metaphysical principles implied by scientific concepts and if they can articulate these principles through both written and visual representations.
3) Conduct interviews with students and teachers to evaluate the applicability and appropriateness of integrating this innovative approach into science education.

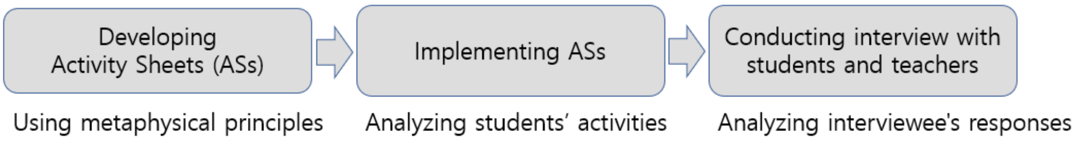
This research primarily focuses on helping students recognize the relevance of abstract scientific concepts to their personal daily experiences. However, it does not explore the effects of these activities on students' interest in science or their understanding of scientific concepts.

Research Methodology

General Background

The objective of this research is to facilitate students' recognition that abstract scientific concepts are fundamentally connected to their personal daily experiences through the application of MLS. The MLS is metaphysical principles expressed in terms of students' personalities, interests, relationships, school life, and other daily activities. To meet this objective, activity sheets (ASs) suitable for regular lower-secondary science classes were developed and implemented. Students' completed sheets were then analyzed to determine if they could effectively comprehend and internalize the MLS concept. Furthermore, the research assessed students' ability to express MLS creatively and in detail using written and visual formats. Following the activities, interviews were conducted with students and science teachers to evaluate the strengths and weaknesses of the activities and the feasibility of integrating them into general science classes. Figure 1 outlines the research process.

Figure 1
Overall Process of Research



Participants

This research was conducted over one year with two 9th-grade classes at a lower-secondary school in a metropolitan city in South Korea. One class consisted of 27 male students, and the other comprised 30 female students. These students engaged in study activities during their regular science classes, which followed the national science curriculum. Informed consent was obtained from all 57 student participants before beginning the activities.

Thirty student participants, including males and females, were randomly selected for interviews. Three to four students were interviewed at the end of each class session in which the activity was implemented, and all had given their consent to be interviewed beforehand. Following the completion of all activities, interviews were conducted with four science teachers who consented to participate. The interviewees consisted of one male and three female teachers. Two specialized in physics, one in chemistry, and one in biology. They had an average of 17.5 years of teaching experience, ranging from 13 to 25 years. All student and teacher interviewees provided informed consent before being interviewed.

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Activity Sheets (ASs)

The ASs consisted of two types: AS-A and AS-B. The purpose of AS-A was to acquaint students with the MLS. This process involved three steps: First, the teacher introduced an MLS, and the students provided personal examples that related to it. Next, they evaluated whether the first activity effectively connected the scientific concepts to their everyday experiences. In the final step, students selected a scientific concept from what they had learned in general science class and created their own MLS for that concept.

AS-A was implemented in four classes, with each activity lasting approximately 20 minutes during a regular science class. Table 1 illustrates the framework of AS-A as used in the first class. The scientific concept, MLS and students' activity of the first step of each AS-A implementation are concisely summarized in Table 2. The contents of the second and third steps are identical across all classes.

Table 1
Summary of AS-A's Structure Applied in the First Class

Step	Contents	
1	Scientific concept [Conductor and insulator]	Conductors have a lot of free electrons, allowing the flow of electric current, while insulators have no free electrons, preventing the flow of current. Conductors and insulators are used differently based on their respective properties.
	MLS	A strength can become a weakness, and a weakness can turn into a strength.
	Activity	List two of your strengths and weaknesses, respectively. Then, explain how to change your weaknesses into strengths.
2	Likert-scale question	Do you think it is appropriate to link scientific concepts with your daily life in the first step activity?
3	Activity	Select a scientific concept from what you've learned and articulate its corresponding MLS.

Table 2
Scientific Concept and MLS Provided by Teacher in the First Step of AS-A

Class	**Scientific concept**	MLS & Activity
1	Conductor and insulator	(MLS) A strength can become a weakness, and a weakness can turn into a strength. (Activity) List two of your strengths and weaknesses, respectively. Then, explain how to change your weaknesses into strengths.
2	Series and parallel connection of resistors	(MLS) Different outcomes can be produced depending on how they are utilized. (Activity) Write down daily examples resulting in different outcomes with the same condition depending on how you use them.
3	Electric current and magnetic field	(MLS) Phenomena that seem unrelated may actually be interconnected. (Activity) Write daily examples that seemed unrelated but turned out to be connected to you.
4	Electromagnetic induction (Lenz' Law)	(MLS) Nature also tends to resist change. (Activity) Write down my efforts to change habits that are difficult for me to change.

AS-B expanded the third step of AS-A; that is, it was specifically designed to allow students to express the MLS in a more detailed and creative manner. In this activity, students independently chose a scientific concept and initially generated their own MLS for their chosen concept. This MLS was then further refined and elaborated using various formats, including poems, diaries, and mixed media involving text and visuals. AS-B was conducted in three classes, with each activity being conducted after the completion of a designated unit in the general science curriculum and lasting approximately two hours.

Interviews

Interviews with students were conducted in an unstructured format to allow for free expression of their opinions. The main focus of these interviews was to obtain students' overall perceptions of the activities, which might

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have been unfamiliar to them, and to discuss any difficulties they encountered or benefits they received from the activities. Each student interview lasted approximately 10 minutes.

For the teacher interviews, the purpose and content of the activities were introduced first. Then, the activity sheets completed by students were reviewed. These interviews were also unstructured, allowing teachers to openly discuss their thoughts. Key questions addressed their agreement with the objectives of the activities, perceptions of their strengths and weaknesses, and the feasibility of integrating these activities into their regular science teaching. Each teacher interview lasted approximately 20 minutes.

Data Collection and Analysis

The primary data for this research were collected from student responses on two types of activity sheets – AS-A and AS-B – as well as from interviews with students and teachers. The 57 student participants each completed AS-As in four separate classes. Therefore, a total of 228 AS-As were collected. However, some activity sheets that were left blank or were incompletely filled out were excluded from the analysis.

AS-A consists of three distinct steps, and the students' responses for each step were analyzed. In the first step, the focus of the analysis was on how effectively students represent their daily experiences as examples of the MLS provided by the teacher. In the second step, students assessed the appropriateness of linking the scientific concept to the MLS in the first step using a Likert scale. The average responses were then calculated and further categorized by class and gender. For the third step, the appropriateness of students' MLS representations was scrutinized based on the common attributes between the scientific concepts and the students' daily lives. The evaluation criteria used for this analysis are outlined in Table 3. Additionally, in the third step, the characteristics of the MLS content generated by the students were analyzed to assess the relevance and quality of their responses.

Table 3
Criteria for Determining the Appropriateness of MLS Generated by Students

Type		Criteria	Example of MLS
A		MLS is described based on common attributes between scientific concepts and students' personal daily lives.	(For electromagnetic induction) Just like a magnet moving in a coil creates electricity, if you keep trying and don't give up, your efforts will eventually lead to success*.
B	B1	MLS is described as an intuitive feeling without connection presented by Type A.	(For apparent/absolute magnitude of a star) Do I have to be number one to get recognition?
	B2	MLS is described as a technological application in everyday life.	(For electromagnetic induction) Electric generators can make electricity by electromagnetic induction.
C		MLS is described as unclear.	(For aurora) The starlight that you see when you hit your head is similar to that of an aurora.
D		Misconceptions are included.	When the same electric poles rub, the opposite electric poles are generated, …

Note. * This is MLS about scientific concept in parenthesis.

AS-B was implemented three times with 57 students, resulting in a total of 171 activity sheets collected for analysis. In this activity, students selected scientific concepts and elaborated detailed and creative representations of the MLS, utilizing formats such as poems and diaries, including both text and visuals. The analysis of these activities in AS-B used the same evaluative criteria as those outlined in Table 3.

The initial analysis of student activities in AS-B, as well as the third step of AS-A, was conducted by the first author of this research. The initial analysis was further refined and finalized after a series of discussions with an expert panel, which included one professor and three to four science teachers who were graduate students. Interviews with students and teachers were systematically categorized and analyzed based on response characteristics.

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Research Results

Students' Activities in AS-A

Since AS-A consists of three distinct steps, student activities were analyzed separately for each step. In these steps, students 1) provided examples of the MLS as introduced by the teacher, 2) assessed the appropriateness of the relationship between the scientific concept and the MLS provided in the first step, and 3) generated MLSs for the chosen scientific concepts.

The First Step of AS-A

In the first step of AS-A, as detailed in Table 1, students were asked to present daily examples of the MLS, which varied significantly across different classes. That is, according to Table 4, the proportion of students who effectively presented these examples ranged from 26.7% to 96.7%, depending on the specific MLS content. On average, 64.0% of students were assessed as having adequately provided examples. The data also highlights a gender disparity in performance, with female students outperforming male students – 72.5% compared to 54.6%, respectively.

Table 4
The Number of Students Who Performed the First Step of AS-A Appropriately (N = 57)

Gender	Class				Average
	1	2	3	4	
Male (*n* = 27)	14 (51.9)*	11 (40.7)	11 (40.7)	23 (85.2)	14.8 (54.6)
Female (*n* = 30)	26 (86.7)	8 (26.7)	24 (80.0)	29 (96.7)	21.8 (72.5)
Sum	40 (70.2)	19 (33.3)	35 (61.4)	52 (91.2)	36.5 (64.0)

Note. * The number in the parenthesis is the percentage calculated by 14 / 27 * 100

Analysis of the examples provided by the students, as detailed in Table 5, shows that they frequently selected topics closely related to their personal experiences, including aspects like personality, appearance, time, learning, and human relationships. This finding suggests that the students had a solid understanding of the intended purpose of the activity.

Table 5
The Contents of the MLS Examples Presented by the Students

Class	MLS	Topic of example
1	A strength can become a weakness, and a weakness can turn into a strength.	Personality (29), Appearance (13), Behavior (11), Ability (4), Others (2)
	(ex.) Personality: I'm very impatient, but this can motivate me to work quickly.	
2	Different outcomes can be produced depending on how they are utilized.	Time (8), Person (4), Object (3), Money (2), Physical condition (1), Others (1)
	(ex.) Time: Everyone is given the same amount of time, but the future they will experience varies depending on how they spend it (time).	
3	Phenomena that seem unrelated may actually be interconnected.	Object (10), Human relationship (8), Learning (7), Behavior (3), Money (2), Game(1), Others(5)
	(ex.) Object: I thought using my cell phone for a long time would not be related to my eye health, but it turned out that my eyes got worse because of cell phone use.	
4	Nature also tends to resist change	Habit (37), Personality (11), Language (3), Others (11)
	(ex.) Habit: It is hard to fix the habit of biting nails.	

Note. The numbers in the parentheses indicate the number of responses, and the sum of responses is different from the total number of students who performed appropriately in Table 4 because one student might have done more than two activities.

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The Second Step of AS-A

In the second step of AS-A, students assessed the appropriateness of the relationship between the scientific concept and the MLS as presented in the first step. Students rated appropriateness on a five-point Likert scale, with -2 indicating inappropriateness and +2 indicating appropriateness. According to Table 6, students generally thought the relationship was appropriate, with an average response of 1.05 for male and 1.00 for female students, with little variation across classes (0.83 to 1.36). In addition, only an average of 3.9 students per class (6.8%) rated the relationship as inappropriate.

This finding indicates that students comprehensively understood and accepted the link between scientific concepts and MLSs. This inference is further supported by the reasons students described for their responses. That is, students positively answered that the connections were appropriate because they found the scientific concept easy to understand (20.0%), agreed with the MLS (36.1%), therefore, viewed the relationship between the two as acceptable (37.8%).

Table 6

Students' Assessment of the Relationship Between Scientific Concept and MLS (N = 57)

Class	Male (*n* = 27)		Female (*n* = 30)	
	No. of response (%)	Average of Likert response	No. of response (%)	Average of Likert response
1	20 (74.1)	1.10	25 (83.3)	0.84
2	24 (88.9)	0.83	28 (93.3)	1.00
3	25 (92.6)	1.36	29 (96.7)	1.03
4	24 (88.9)	1.22	29 (96.7)	1.14
Average	23.3 (86.3)	1.05	27.8 (92.7)	1.00

The Third Step of AS-A.

In the third step of AS-A, students were asked to create their own MLSs. They could either choose a scientific concept learned in class or use one recommended by their science teacher. According to criteria outlined in Table 3, MLSs represented based on common attributes between a scientific concept and the students' personal daily lives were categorized as 'A'. Within this category, 'A1' denoted MLSs for the concepts chosen by students themselves, while 'A2' referred to those for the teacher-suggested concepts (Table 7).

According to Table 7, 32.5% of students successfully generated appropriate MLSs. While this success rate might initially appear insufficient, a positive trend is observed across the sessions: the proportion of students creating appropriate MLSs increases from 8.7% in the first class to 47.4% by the fourth class.

Table 7

Number of Students Who Generated Appropriate MSLs (N = 57)

Class	Male (*n* = 27)		Female (*n* = 30)		Sum		
	A1	A2	A1	A2	A1	A2	Sum (%)
1	3	0	2	0	5	0	5 (8.7)
2	9	0	10	0	19	0	19 (33.3)
3	7	0	16	0	23	0	23 (40.4)
4	10	2	6	9	16	11	27 (47.4)
Sum	31		43		74		
No. of average students per each class	7.8* (28.9)**		10.5 (35.0)		18.5 (32.5)		

Note. * This number is calculated by (sum of students) / (no. of class) = 31 / 4 = 7.8.
** The number in the parenthesis is the percentage calculated by 7.8 / 57 (the total no. of students) * 100 (%)

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The results in Table 7 indicate that students' ability to generate appropriate MLSs improved with repeated practice. This observation is further supported by the data in Table 8, which reveals that, for the four class sessions, only 3.5% of students consistently generated an appropriate MLS in every session. However, 70.2% of students could produce an appropriate MLS at least once during these four sessions. This trend suggests that repeated exposure and practice can enhance students' capability to effectively create MLSs.

Table 8

The Number of Students Who Generated MSL During Four Classes (N = 57)

Type	No. of students (%)
Generating appropriate MSL only once during four classes	17 (29.8)
Generating appropriate MSL twice during four classes	14 (24.6)
Generating appropriate MSL three times during four classes	7 (12.3)
Generating appropriate MSL each time (four times) during four classes	2 (3.5)
Sum	40 (70.2)

An additional notable finding from the third step of AS-A is the serious and meaningful nature of the MLS content generated by the students. As categorized in Table 9, these examples reflect more than just the engineering applications of science; they demonstrate deep connections between scientific concepts and their daily thoughts and experiences. Although not every student reached this level of insight, the examples in Table 9 stand out for their meaningfulness and relevance, particularly considering that the students were in lower-secondary school.

Table 9

Examples of Content of MLS Generated by Students in the Third Step of AS-A

Category	**Scientific content**	MLS
Human Relationship	If you rub the (plastic) stick with fur, the stick is charged with (-) by the electrons convey.	When two people are together, one person's characteristics are transmitted to the other.
	The absolute magnitude of the star may be smaller, even if the apparent magnitude is larger.	To compare two people, you must look at them under the same conditions. Do not compare carelessly.
Friendship /Family	The magnetic field around the wire becomes stronger as it gets closer and weaker as it gets farther away.	Friendship and love become stronger when people get closer, and weaker when people get farther away.
	The planets include Mercury, Venus, Earth, Mars, Jupiter, and so on.	My family includes me and my mom, dad, and younger brother.
Cooperation /Help /Control	Increasing the current in the bulb brightens the bulb.	If you give me a lot of support, I can perform better.
	Electrons do not speed up because of resistance.	Resistance (from a teacher or friend) is needed to control us properly because if we try to do something too quickly, we may lose control.
Effort	Electric energy is voltagecurrenttime.	I will achieve my dream by taking the three things of effort, conviction, and practice.
	Electromagnetic induction (Lenz's Law)	It is difficult to change. So we have to make an effort to change.
Personality /Self-esteem	The direction of the magnetic field changes depending on the direction of the electric current.	Depending on the situation, what I have to do can vary. Let's not stick to only principles.
	Electricity does not flow even if only one is not connected.	Korea cannot be complete without me. Thus, I am a precious being.
Surrounding Environment	The direction of the magnetic field can be found with your right hand.	Even a difficult problem can be easily solved if you look for solutions.
	The magnetic field increases when the electric power becomes strong.	In a race, if the opponent runs fast, I run fast, too.

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Category	**Scientific content**	MLS
Others	Voltage is the ability to flow electric current.	Like voltage, laugh is the ability to make people happy.
	The brightness of the sun belongs to the dark star.	The sun that I thought was the brightest is not so bright. It is like a frog in a well.

Students' Activities in AS-B

In AS-B, students were asked to select scientific concepts from their science textbooks and creatively articulate MLS using detailed formats like diaries or poems, enhanced with textual and visual elements. Each student completed this activity on three separate occasions. According to Table 10, an average of 61.4% of students successfully expressed appropriate MLSs, showing a significant improvement from the 32.5% success rate observed in the third step of AS-A (Table 7). This marked enhancement reinforces the previous interpretation that the ability to appropriately express MLS can be increased through repeated engagement in these activities.

Table 10
Number of Students Representing MLS Appropriately in Each Implementation (N = 57)

Gender	Implementation			Sum	Average (%)
	First (%)	Second (%)	Third (%)		
Male (*n* = 27)	16 (59.3)	15 (55.6)	10 (37.0)	41	13.7 (50.7)
Female (*n* = 30)	17 (56.7)	26 (86.7)	21 (70.0)	64	21.3 (71.1)
Sum	33 (57.9)	41 (71.9)	31 (54.4)	105	35.0 (61.4)

Table 11 shows examples of the MLS content created by students across three different implementations of AS-B. Figure 2 provides actual examples of the students' activities related to these examples. Figure 2 is provided due to the particularly interesting and meaningful nature of the students' activities, which are deemed significant enough to highlight their thoughtful and meaningful engagements.

Table 11
Examples of Content of MLS Generated by Students in AS-B

Implementation	No.	**Scientific concept**	MLS
First	Ex.1	Solar system	Just as different planets form one solar system, we are one.
	Ex.2	Attraction between opposite poles of magnets	Let's accept each other even if they are different, as if the opposite poles pull each other.
Second	Ex.3	Constellation	Just as stars that make up a single constellation have their own characteristics, we look normal, but each of us has our own characteristics.
	Ex.4	The phase of the moon	Just as the moon doesn't really change its shape, how something looks may not be the only truth.
Third	Ex.5	Physical change	The mind does not change even if appearance changes.
	Ex.6	Interphase in the cell division	Just as cell division occurs after a long period of interphase (similar to cicadas), we must work hard for a long time for future changes.

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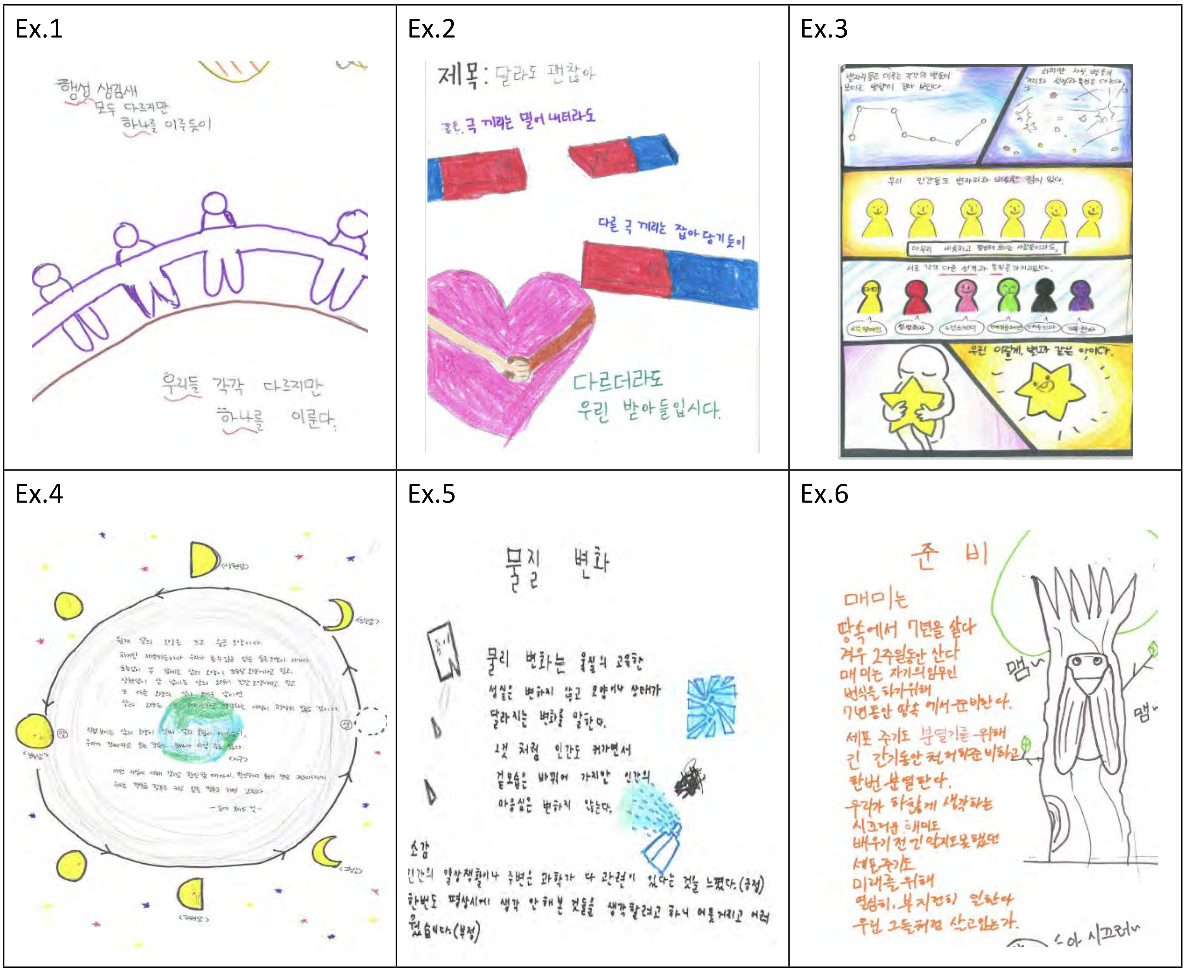
Figure 2

Examples of Students' Activities Performed in AS-B



Interview Results

Interviews with Students

Table 12 presents the results of the unstructured interviews conducted with all 30 participants. Over half (56.7%) of the interviewees commented on their interest in the activity, describing it as fascinating. Only 6.7% of students reported that the activity was not interesting. Initially, the researcher was concerned that the philosophical aspect of the activity might be challenging for lower-secondary students. However, these positive responses were very encouraging.

Although the efficacy of this activity was not validated through experimental research methods, a significant majority of students (93%) voluntarily reported finding it beneficial in various ways. Specifically, 50.0% of the students mentioned enhanced conceptual understanding, and 36.7% appreciated its role in facilitating personal reflections. The activity also encouraged peer communication, with about one-third of the participants (36.7%) providing positive feedback on this interactive approach. Consequently, according to the voluntary responses obtained through unstructured interviews, the incidence of negative feedback among students was notably low.

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Table 12
Students Responses in the Interview (N = 30)

Category	Subcategory	Examples of Responses
Interest (30; 100)*	Interesting (17; 56.7)	'It was interesting to know that something in my life that seemed completely unrelated to science had something to do with it'. 'I feel like I'm going to find the essence of science because it starts in a philosophical sense'.
	Neutral (11; 36.7)	'It is so-so'.
	No-interesting (2; 6.7)	'I don't know why (I did this)'.
Help (28; 93.3)	For understating concepts (15; 50.0)	'If I understand the concept of science, I only know it, but if I think about the meaning of it in my daily life, I will go deeper and deeper'.
	For reflecting life (11; 36.7)	'Originally, I didn't have any idea about life, but when I connected it with the concept of science, I felt something about life'.
	For enhancing thinking ability (2; 6.7)	'It makes me think a lot. Instead of memorizing it for a test, it gave me wisdom
	Others (4; 13.3)	'It is difficult'.
Activity (12; 40.0)	Communicating (11; 36.7)	'Even if I can't think of it at first, I can think of it when I listen to my friends'.
	Other (1; 3.3)	'It's better to do it alone'.

Note. * The numbers in parentheses indicate the number of students and its percentages, respectively.

Interviews with Science Teachers

Teachers were encouraged to freely express diverse opinions. As a result, their responses could be categorized into five distinct types. The first type involved science teachers acknowledging the 'beneficial aspects' of the activities. Specifically, they highlighted how the activities effectively enhanced students' thinking abilities and engaged an active and wider range of student participation. Examples of actual responses that exemplify this category are provided below:

'Connecting science with life seems to have much more merit'.
'I think this is the best activity to practice and develop students' thinking skills'.
'It makes students think a lot when they see it'.
'This is an activity that students can do in their own way, so I think all students can participate regardless of their achievement level'.

As the second type of response, teachers noted that the activities might pose 'difficulty' for students, particularly due to the challenges commonly faced in writing or engaging in critical thinking. Specific responses included, 'I think it would be harder to write a poem itself than to understand the difficult aspects of scientific elements' and 'First of all, they hate to think'.

The third type of response emphasized the need for 'practice' to effectively execute these activities. Teachers suggested that a sustained and gradual approach would be beneficial. The teachers' responses included, 'I think if students do it step by step, steadily for about a year, it will have a good effect and help them' and 'A lot of practice is necessary when they start'.

The fourth type of response from the teachers was an expression of surprise at the high quality of the students' activities, which they evaluated as 'very good'. Teachers were impressed by the students' outcomes, as reflected in the following statements: 'I think they're better than I thought. If I ask my students to do this in my class, I wonder if they can perform like this'; 'I think the students who received an A grade (Table 3) did pretty well'.

The fifth type of response revealed that teachers were willing to implement these activities in their classes, provided they had adequate support. Their comments included, 'I think it would be worth doing it if a guide was provided' and 'It's completely different from simply conveying scientific knowledge, so I want to try it'.

In summary, teachers showed a strong interest in adopting this novel and meaningful approach, motivated by the impressive quality of the students' work. However, they emphasized the need for practical guidance and sufficient time for gradual practice to ensure more effective implementation.

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Discussion

There have been suggestions and efforts to introduce and apply the philosophy of science, including metaphysics, to science learning (e.g., Matthews, 1994). For example, Sherratt (1982) mentioned that the use of the philosophy of science in science learning has a benefit of demonstrating the humanistic and cultural aspects of science. And Russli (2016), criticizing the conventional physics learning for focusing primarily on content and systematic inquiry-driven technical aspects, emphasized the importance of introducing metaphysics in physics learning to help students be aware of the meaning of life.

However, it is not easy to find studies that have directly introduced metaphysics into the process of science learning. For example, Galili & Hazen (2001) pointed out that, despite the emphasis on the importance of the philosophy of science, there were very few cases implemented in actual school teaching. Therefore, at the outset of this research, a significant challenge anticipated was the difficulty of integrating metaphysical principles into lower-secondary students' science learning. That is, there was concern that, even after grasping new scientific concepts, students might struggle to express the metaphysical meanings implied by these concepts using their everyday experiences.

However, as a result of actual application, the students accepted MLS well and evaluated the relationship between the scientific concept and their daily life as appropriate. In particular, in the task of having students express MSL directly, the proportion of students who appropriately presented MLSs increased, as the class was repeated. That is, with repetition across four sessions, the proportion of students who appropriately presented MLSs increased to approximately 50%. Moreover, around 70% of the students managed to present an appropriate MLS at least once during these sessions. And when enabling students to generate MLSs through enriched formats such as poems, diaries, and drawings, approximately 60% of the students appropriately and meaningfully expressed MLSs. Especially, it was evaluated that the contents of the students' MLSs were very meaningful and thoughtful, even though they were lower-secondary students. Therefore, we could conclude that when teachers effectively communicate scientific concepts along with their MLSs, students not only understand but also embrace the metaphysical meanings implied.

Moreover, the contents of the student-generated MSL included topics such as human relationships, family or friendship, personal effort, and cooperation with friends, which means that students' thinking about MLS was deeply rooted in their direct experiences. This can be evaluated to be a different result from previous efforts to link science to engineering and technological applications (e.g., Cajas, 1999; Sevian et al., 2018) or social and environmental issues (e.g., King & Henderson, 2018; Roth & Lee, 2004). In addition, considering the reports that students have difficulty in connecting science to everyday situations in previous studies (e.g., Campbell & Lubben, 2000; Chu et al., 2012; Irish & Kang, 2018), this result can be a good and effective strategy to solve this difficulty.

Directly linking science to students' personal everyday lives is expected to shift their perception from viewing science as irrelevant – something only necessary for future science-related careers – to seeing it as meaningful. Consequently, students began to naturally appreciate the reasons for learning science, fostering increased motivation and interest in science study. This approach is, therefore, expected to significantly enhance students' engagement and enthusiasm for learning science. In fact, 57% of the students interviewed spontaneously described the activities as interesting. This response is particularly significant considering that the interviews did not explicitly prompt students to evaluate the activity's interest level; rather, students were encouraged to freely express their thoughts about the activities. Additionally, 50% of students independently reported that the activity helped them understand scientific concepts, supporting the expectation that this research approach can facilitate conceptual learning. This result supports prior research stressing that metaphysics' understanding of scientific concepts can be beneficial to student learning itself (e.g., Bunge, 2000; Cobern, 2000; De Regt & Dieks, 2005).

Although this research did not systematically verify whether the approach effectively enhanced student motivation and interest, active participation in science learning, or conceptual understanding, some indicative evidence of these positive effects emerged in post-activity interviews with students.

Conclusions and Implications

This research aimed to demonstrate that abstract scientific concepts could be effectively linked with students' personal and everyday experiences by appropriately utilizing the characteristics of Kuhn's paradigms. Paradigms serve as standards and models that science students are expected to follow and learn from. Given that metaphysical principles are one of the major components of these paradigms, integrating them into science education is both justifiable and beneficial. These principles encompass not only the natural world but also human and societal domains, and they are also applicable even to the meanings of single, small-scale concepts that students learn in

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ordinary science classes. This research was built on this perspective and asked students to articulate the metaphysical meanings implied by the scientific concepts using their day-to-day experiences.

The results indicated that when teachers presented MLSs, many students could effectively find examples from their everyday experiences and deemed the relationship between the scientific concepts and the MLSs appropriate. Additionally, in activities where students selected scientific concepts and articulated MLSs for these concepts, the number of students who produced appropriate MLSs increased with repeated practice. Furthermore, students engaged thoughtfully and meaningfully in the activities that encouraged a richer representation of MLS through writing and drawing. This level of engagement was so impressive that other teachers who reviewed the students' work expressed admiration for the depth and quality of the students' activities.

Interviews with students revealed that they spontaneously found this approach both interesting and helpful for understanding scientific concepts and reflecting on their personal lives. Teachers, in their interviews, described the approach as innovative and meaningful. They were particularly impressed by the quality of the students' activities. However, they also noted that more detailed guidance and sufficient practice time could enhance the effectiveness of this approach.

As a result, this novel approach is proven to be somewhat applicable, even for junior high school students. However, further investigation is needed to identify the specific conditions that would enhance the effectiveness of this approach. Additionally, further research is essential to determine whether this approach can positively impact students' interest in science, deepen their conceptual understanding, and help them prepare for future careers in science-related fields.

Declaration of Interest

The authors declare no competing interest.

References

Aniashi, S. O., Okaba, L. A., Anake, E. U., & Akomaye, M. U. (2019). Classroom science with everyday life: A means for improving performance in sciences and national development in Nigeria. *International Journal of Science and Technology Educational Research, 10*(3), 25–29. https://doi.org/10.5897/IJSTER2019.0457

Arjun, P. (1998). An evaluation of the proposed new curricula for schools in relation to Kuhn's conception of paradigms and paradigm shifts. *South African Journal of Higher Education, 12*(1), 20–26.

Avraamidou, L., & Osborne, J. (2009). The role of narrative in communicating science. *International Journal of Science Education*, *31*(12), 1683–1707. https://doi.org/10.1080/09500690802380695

Baker, V., & Millar, R. (1999). Students' reasoning about chemical reactions: What changes occur during a context-based post-16 chemistry course? *International Journal of Science Education, 21*(6), 645–665. https://doi.org/10.1080/095006999290499

Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context- based and STS approaches to science teaching. *Science Education*, *91*(3), 347–370. https://doi.org/10.1002/sce.20186

Bunge, M. (2000). Energy: Between physics and metaphysics. *Science & Education, 9*(5), 459–463. https://doi.org/10.1023/A:1008784424048

Cajas, F. (1999). Public understanding of science: using technology to enhance school science in everyday life. *International Journal of Science Education*, *21*(7), 765–773. https://doi.org/10.1080/095006999290426

Campbell, B., & Lubben, F. (2000). Learning science through contexts: Helping pupils make sense of everyday situations. *International Journal of Science Education*, *22*(3), 239–252. https://doi.org/10.1080/095006900289859

Chalmers, A. (1982). *What is this thing called science?* (3rd ed.). Open University Press.

Chu, H. E., Treagust, D. F., Yeo, S., & Zadnik, M. (2012). Evaluation of students' understanding of thermal concepts in everyday contexts. *International Journal of Science Education*, *34*(10), 1509–1534. https://doi.org/10.1080/09500693.2012.657714

Cobern, W. W. (2000). The nature of science and the role of knowledge and belief. *Science & Education, 9*, 219–246. https://doi.org/10.1023/A:1008747309880

De Regt, H. W., & Dieks, D. (2005). A contextual approach to scientific understanding. *Synthese, 144*, 137–170. https://doi.org/10.1007/s11229-005-5000-4

Feinstein, N. (2009). Why teaching 'everyday science' makes sense. *Phi Delta Kappan*, *90*(10), 762–766. https://doi.org/10.1177/003172170909001017

Fortus, D., Krajcik, J., Dershimer, R. C., Marx, R. W., & Mamlok-Naaman, R. (2005). Design-based science and real-world problem-solving. *International Journal of Science Education, 27*(7), 855–879. https://doi.org/10.1080/09500690500038165

Galili, I., & Hazan, A. (2001). Experts' views on using history and philosophy of science in the practice of physics instruction. *Science & Education*, *10*, 345-367. https://doi.org/10.1023/A:1011209131446

https://doi.org/10.33225/jbse/24.23.882

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Giamellaro, M., L'Heureux, K., Buxton, C., Beaudry, M. C., Ayotte-Beaudet, J. P., & Alajmi, T. (2022). Learning to teach science from a contextualised stance. In J. A. Luft & G. M. Jones (Eds.), *Handbook of Research on Science Teacher Education* (pp. 439–451). Routledge.

Greca, I. M., & Freire Jr, O. (2013). Meeting the challenge: quantum physics in introductory physics courses. In M. R. Matthews (Ed.), *International handbook of research in history, philosophy and science teaching* (pp. 183–209). Springer Netherlands.

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights from the Behavioral and Brain Sciences, 3*(2), 220–227. https://doi.org/10.1177/ 2372732216655542

Hewson, P. W. (1981). A conceptual change approach to learning science. *European Journal of Science Education, 3*(4), 383–396. https://doi.org/10.1080/0140528810304004

Irish, T., & Kang, N. H. (2018). Connecting classroom science with everyday life: Teachers' attempts and students' insights. *International Journal of Science and Mathematics Education*, *16*, 1227–1245. https://doi.org/10.1007/s10763-017-9836-0

Kallio-Tamminen, T. (2004). Quantum metaphysics: The role of human beings within the paradigms of classical and quantum physics [Doctoral dissertation]. Finland: University of Helsinki.

Karsli, F., & Patan, K. K. (2016). Effects of the context-based approach on students' conceptual understanding: "The umbra, the solar eclipse and the lunar eclipse." *Journal of Baltic Science Education*, *15*(2), 246–260. https://doi.org/10.33225/jbse/16.15.246

Kervinen, A., Roth, W. M., Juuti, K., & Uitto, A. (2020). The resurgence of everyday experiences in school science learning activities. *Cultural Studies of Science Education*, *15*(4), 1019–1045. https://doi.org/10.1007/s11422-019-09968-1

Kim, S. -D., Lee, S. -G., & Choi, S. -B. (2006). Research on the students' interest in science subjects. *Journal of the Korean Society of Earth Science Education, 3*(3). 191–197.

Kindi, V. (2013). Kuhn's paradigms. In V. Kindi & T. Arabatzis (Eds.), *Kuhn's The Structure of Scientific Revolutions Revisited* (pp. 91–111). Routledge.

King, D., & Henderson, S. (2018). Context-based learning in the middle years: achieving resonance between the real-world field and environmental science concepts. *International Journal of Science Education*, *40*(10), 1221-1238. https://doi.org/10.1080/09500693.2018.1470352

Knill. G. (1991). Towards the green paradigm. *South African Geographical Journal, 73*(2), 52–59. https://doi.org/10.1080/03736245.1991.9713549

Kuhn, T. S. (1970). *The structure of scientific revolutions* (2nd ed.). The University of Chicago Press.

Kung. H. (1989a). Paradigm change in theology. A proposal for discussion. In H. Kung & O. Tracy (Eds.), *Paradigm change in theology* (pp. 3–33). T & T Clark.

Kung. H. (1989b). What does a change in paradigm mean? In H. Kung & O. Tracy (Eds.), *Paradigm change in theology* (pp. 212–219). T & T Clark.

Lincoln, Y. S. (ed.) (1985). *Organisational theory and inquiry: the paradigm revolution*. Sage Publications.

Lubben, F., Campbell, B. and Dlamini, B. (1996). Contextualising science teaching in Swaziland: some student reactions. *International Journal of Science Education, 18*(3), 311–320. https://doi.org/10.1080/0950069960180304

Majid, A. N., & Rohaeti, E. (2018). The effect of context-based chemistry learning on student achievement and attitude. *American Journal of Educational Research*, *6*(6), 836–839. https://doi.org/10.12691/education-6-6-37

Matthews, M. (1994). *Science teaching: The role of history and philosophy of science*, Routledge.

Ogawa, M. (1995). Science education in a multi-science perspective. *Science Education, 79*, 583–593. https://doi.org/10.1002/sce.3730790507

Orman, T. F. (2016). "Paradigm" as a central concept in Thomas Kuhn's thought. *International Journal of Humanities and Social Science, 6*(10), 47–52. https://api.semanticscholar.org/CorpusID:19261112

Park, D., & Song, J. (2009). When do science lessons appeal to students? - Secondary school students' views on the value of school science and the appealing aspects of science lessons to students. *Journal of the Korean Association for Science Education*, *29*(6), 593–610.

Roth, W.-M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education*, *88*, 263–291. https://doi.org/10.1002/sce.10113

Rouse, J. (2003). Kuhn's philosophy of scientific practice. In T. Nickles (ed.), *Thomas Kuhn* (pp. 101–121). Cambridge University Press.

Rusli, A. (2016). Science awareness and science literacy through the basic physics course: Physics with a bit of metaphysics?. *Journal of Physics: Conference Series*, *739*(1), Article 012012. https://doi.org/10.1088/1742-6596/739/1/012012

Sekarini, R. P., & Arty, I. S. (2019). Contextual-based science outdoor learning to improve student curiosity. *Journal of Physics: Conference Series*, *1233*(1), 012103. https://doi.org/10.1088/1742-6596/1233/1/012103

Sevian, H., Dori, Y. J., & Parchmann, I. (2018). How does STEM context-based learning work: What we know and what we still do not know. *International Journal of Science Education*, *40*(10), 1095-1107. https://doi.org/10.1080/09500693.2018.1470346

Sherratt, W. (1982). History of science in the science curriculum: A historical perspective part I: Early interest and roles advocated. *School Science Review*, *64*, 225–236.

Slovinsky, E., Kapanadze, M., & Bolte, C. (2021). The effect of a socio-scientific context-based science teaching program on motivational aspects of the learning environment. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(8), em1992. https://doi.org/10.29333/ejmste/11070

Steidtmann, L., Kleickmann, T., & Steffensky, M. (2022). Declining interest in science in lower secondary school classes: quasi-experimental and longitudinal evidence on the role of teaching and teaching quality. *Journal of Research in Science Teaching, 60*(1), 164-195. https://doi.org/10.1002/tea.21794

Takeuchi, K. (1979). *Kindai gorishugi no hikarito kage* [Light & shade of modern rationalism]. Shinyosha.

https://doi.org/10.33225/jbse/24.23.882

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

TIMMS & PIRLS International Study Center. (2024). TIMSS: Trends in International Mathematics and Science Study. https://timssandpirls.bc.edu/timss-landing.html

van Griethuijsen, R. A., van Eijck, M. W., Haste, H., Den Brok, P. J., Skinner, N. C., Mansour, N., Gencer, A. S., ... & BouJaoude, S. (2015). Global patterns in students' views of science and interest in science. *Research in Science Education*, *45*, 581–603. https://doi.org/10.1007/s11165-014-9438-6

Yeo, S., & Zadnik, M. (2001). Introductory thermal concept evaluation: Assessing students' understanding. *The Physics Teacher, 39*, 496–504. https://doi.org/10.1119/1.1424603

Yu, K. C., Fan, S. C., & Lin, K. Y. (2015). Enhancing students' problem-solving skills through context based learning. *International Journal of Science and Mathematics Education*, *13*, 1377–1401. https://doi.org/10.1007/s10763-014-9567-4

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