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“Safety” and “integration”: examining the introduction of disaster into the science curriculum in South Korea

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ABSTRACT
The diversifying impacts of global disasters such as climate change and COVID-19 call for systematic consideration of how disasters can be addressed in different school subjects. In this paper, we discuss how the relationship between disaster and science education has been codified and framed in South Korea through an analysis of national curriculum and policy documents in the 2010s, a period marked by several human-caused disasters with lingering social impacts. A genealogical reading of policy documents reveals how disaster emerged as a curricular theme at the intersection of two policy discourses: the discourse of safety and the discourse of integration. Further analysis of the documents points to three tensions about science education that underlay this process, as disaster, a non-traditional topic, was introduced into the science curriculum. Our findings provide insights into the tensions and conflicting ideas about what should be learned in school science. We contend that a stronger theoretical and empirical base is needed when introducing new curriculum topics such as disaster into the curriculum. More effort is needed to justify the new topic against the existing aims and structures of school subjects, to consider the unique social and political context, and to bridge the gap between curriculum policy and classroom practice.

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1. Introduction

The enduring question of “what should be taught in schools” has been central to educators throughout the history of schooling. With the establishment of science as a school subject, the corollary question of “what should be taught in school *science*” has been and continues to be a subject of considerable interest and the intense debate around the science curriculum (Jenkins, 2019). These two questions, each pertaining to the purpose of schooling and that of teaching science, have mutually shaped each other to produce science curricula that meet the needs of society at different times. In recent years, forecasting and accommodating the future needs of society have arisen as a key direction for science curriculum reform (OECD, 2020a). Various curricular themes other than the content knowledge of science have been proposed and then introduced into formal curricula, such as critical thinking (Siegel, 1989), argumentation (Erduran & Jiménez-Aleixandre, 2007), socioscientific issues (Zeidler et al., 2005) and integrated STEM (Bybee, 2013) in order to accommodate both enduring and emerging societal needs. Countries are keen to reform

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their science curriculum promptly and adopt these new educational goals so that their pupils do not fall behind in the globalized society (Lingard & McGregor, 2014; Tan, 2012).

A relatively recent issue concerns how the science curriculum should respond to the pressing societal and environmental challenges (Wals et al., 2014), and particularly to disasters. The 2010s saw a rapid global increase in the risk of various disasters from natural and human triggers, such as the 2011 Fukushima nuclear disaster in Japan, Australian bushfires in 2019–2020, and the COVID-19 pandemic, to name a few, which have called for urgent responses from the education sector. These recent and ongoing crises have led people to view disasters as tangible threats with immediate and direct impacts on our individual and social lives. In various fields of social sciences, the study of disasters is rapidly emerging in response to these local and global disasters (Dietrich & Knowles, 2020; Dowty & Allen, 2011), with a broad aim of building disaster resilience at the individual and societal levels. However, in science education, interest have been mainly focused on individual disasters (e.g. COVID-19, the Fukushima nuclear disaster, Hurricane Katrina, Flint water crisis) or subcategories of disasters (e.g. chemical accidents, infectious diseases, earthquakes, hurricanes), rather than considering disaster as a category of sociotechnical events and examining its relationship with science education. The lack of attention to disaster as a curricular theme has led to a lack of systematic consideration with regard to how the scientific and social studies of disasters may intersect, or conflict, with the aims of science education (Park, 2020).

An encouraging sign, however, is that disaster-related themes are beginning to appear in curriculum and assessment guidelines. For example, the PISA 2025 Science Framework include "agency in the Anthropocene" as a component and expects young people to "work individually and with others across a range of scales, from local and global, to understand and address complex challenges that face all beings in our communities" (OECD, 2022, p. 49). A recent report from Stanford University on the role of science education in an age of misinformation highlights that many of the issues facing people today require the ability to evaluate science-related information (Osborne et al., 2022). The "current issues" that the report's authors used include COVID-19, climate change and extreme weather events, wildfires, and floods, all of which are examples of disasters. These recent frameworks suggest that various local and global challenges of the present day are inherently connected to disasters and that educators should address these needs in the curriculum.

Meanwhile, the increasing focus on these issues in the science curriculum raises questions about their relationship to (science) curriculum. How should we decide what to include and what not to include in the science curriculum, especially when the curriculum is already overloaded in many education systems? (OECD, 2020b). One possible argument would be that topics such as disaster provide useful contexts for learning science and should therefore be a part of the science curriculum, which has intuitive appeal. However, this argument can be challenged by proponents of knowledge-based curriculum. Young (2008) distinguishes between context-dependent knowledge and context-independent knowledge. Context-dependent knowledge relates to common-sense, practical knowledge that enables individuals "cope in the world that he or she is a part of" (pp. 14–15) and can be acquired unconsciously through everyday experiences. In contrast, context-independent knowledge includes generalized disciplinary knowledge that exceeds particular, everyday cases. Young refers to the latter type of knowledge as "powerful knowledge" that schooling and curriculum should allow all students to access. He stresses that the context-dependent, everyday knowledge that students bring to the classroom should be a concern of teachers' pedagogy (as a useful tool for facilitating the learning of powerful knowledge) rather than that of curriculum design.

According to this knowledge-centered view of curriculum, the curriculum should be organized around subjects such as science and the disciplinary concepts and their relationships, to empower learners to view the world as more than a set of experiences. It is also argued that the curriculum "should exclude the everyday knowledge of students" (Young et al., 2014, p. 94), but instead "be based on a break with experience" (p. 88). If we accept this approach to curriculum, then teaching about disasters, despite its relevance to students' lives, should be left to teachers in their pedagogical practice rather than to curriculum designers, unless the aim is to teach about disaster as a subject in its own right. Alternatively, if we view everyday and sensory experiences as integral to learning theoretical concepts in science (Wrigley, 2018), the urgency and relevance of disasters in the world and the social demands associated with them can provide a strong rationale for its inclusion in the science curriculum. We will illustrate later how these different views of the science curriculum were manifested as disaster-related learning goals were introduced in Korea.

The aim of this paper is to document and analyze how questions about the purpose and scope of the science curriculum unfolded in the recent history of curriculum reform in South Korea between 2009 and 2022, particularly in the context of introducing disaster into the science curriculum. Using a historical and discursive approach to studying curriculum policy, we trace how major disaster events in Korea in the 2010s instigated a social need to emphasize disaster safety in education, which influenced the subsequent development of the national science curriculum and science education standards. A close examination of the curriculum and policy documents suggests that the unprecedented emphasis on disasters in the recent 2015 national curriculum, triggered by a catastrophic transport disaster, was not without struggles and objections, particularly regarding how disaster might intersect with the traditional goals of science education. Using the South Korean case, this study aims to consider how some old and new questions about the science curriculum can manifest themselves in curriculum decision making, which can have significance beyond national boundaries. Our inquiry was guided by three interconnected questions: How is disaster presented in recent science curricula and science education policy in Korea? What were the discourses that shaped the introduction of disasters into the curriculum in Korea? And what implications for curriculum policy can be drawn for teaching about disasters in science education?

2. Disasters and science education

The relevance of science learning to individuals' lives has increased with various global and local emergencies over the past decade. Humans are living under increasing threats from natural and human-made hazards, many of which are produced and intensified by modern science and technology (Beck, 1992; Christensen & Fensham, 2012) and require science and engineering knowledge to address. In the wake of recent global crises caused by major disasters such as climate change, there have been calls for action against the increasing risks of disasters (Bencze et al., 2020; Ripple et al., 2017). These disasters point to the need to understand the close interaction of science, technology and society in the unfolding of disasters in order to develop effective approaches to teaching about disasters at different stages of education. In other words, effective education about disaster is needed to equip students with knowledge of the nature of disasters and their relationship to science and technology. It is crucial for citizens to understand not only the various hazards around them but also the social conditions that shape disaster risk and vulnerability (Kelman, 2020). An informed understanding of disasters has been suggested to be vital to promoting education for social justice (Preston, 2012). As such, it is not difficult to identify potential links between disaster-related themes and the broader democratic goals of science education, such as sociopolitical activism (Tolbert & Bazzul, 2017), social justice (Barton, 2003), and engineering ethics (Amir & Juraku, 2014; Ko et al., 2023).

Within science education research, studies have been focused on case studies of disasters such as the severe acute respiratory syndrome (Wong et al., 2008, 2009), the Taiwan earthquake (Tsai, 2001), the Chernobyl (Cross et al., 2000; Lijnse et al., 1990; Wilson, 2013) and Fukushima (Neumann, 2014; Neumann & Hopf, 2013a, 2013b) nuclear disasters, and the Flint water crisis (Davis & Schaeffer, 2019). The COVID-19 pandemic has also precipitated research exploring its relevance to science education (Archila et al., 2021; García-Carmona, 2021; Ha et al., 2022; Herman et al., 2022; Saribas & Çetinkaya, 2021; Stapleton & Meier, 2022). A broad range of issues have been explored in relation to these disasters, such as socioscientific reasoning, environmental justice, worldviews, and risk perception. Different research traditions, including socioscientific issues education (Sadler & Zeidler, 2003), environmental and health education (Heuckmann & Krüger, 2022; Williams et al., 2017), and risk education (Christensen & Fensham, 2012; Kolstø, 2006; Pietrocola et al., 2021; Schenk et al., 2019), have informed these studies.

Scarce in the current literature, however, is a consideration of how these individual, seemingly disparate disasters can be understood holistically in the context of science education through the lens of disaster studies. That is, there is a lack of "thinking across disasters" (Fortun & Morgan, 2015) from a science education perspective. For example, few COVID-19 studies in science education refer to studies on the SARS epidemic that came out about a decade earlier (Wong et al., 2008, 2009). In recent years, initial efforts have been made to theorize disasters in the context of science education. Oyao et al. (2015) proposed a competence-based framework for studying the science behind natural hazards and disaster risk reduction, learning about the impacts of disasters, enhancing disaster preparedness, promoting cross-functional skills (e.g. creativity and innovation, futures thinking and risk-based decision making), cultivating dispositions (e.g. adaptability, leadership and self-direction), and linking learning to action for resilience and sustainability. Whilst their study was focused on natural disasters, Park (2020) drew on science and technology studies (STS) to consider the relationship between science education and disasters triggered by natural or human causes. He illustrated how students can learn about the nature of science and technology through the study of disaster cases, and also argued that an approach based on STS can help students better anticipate, analyze and respond to disasters.

In the present study, we take a view based on STS, where disasters are defined as "failures of diverse, nested systems, producing injurious outcomes that cannot be straightforwardly confined in time or space, nor adequately addressed with standard operating procedures and established modes of thought" (Fortun et al., 2016, p. 1004). We believe that the STS approach to disasters in science education has at least three advantages. First, STS focuses on the role of science and technology not only in the *reduction* of disaster risks but also in the *production* of them in modern societies (Beck, 1992). This focus resonates with the recent emphasis on teaching the nature of science and technology (Lederman et al., 2002; Waight & Abd-El-Khalick, 2012) and STSE education (Bencze, 2017) where the focus has shifted from ready-made science to science-in-the-making (Latour, 1987). Second, it views science and technology as equals rather than separate enterprises by introducing the concept of "technoscience," which enables us to consider natural and technological in a holistic way rather than as dichotomous categories (Kelman, 2020). Finally, with its focus on the social, political, and cultural dimensions of science and technology, STS creates opportunities to address critical issues such as disaster justice and inequalities in the context of science education (Davis & Schaeffer, 2019). STS also allows for the consideration of disasters as a socioscientific issue that requires, and lends itself to, recognizing the inherent complexity of the issue, valuing multiple perspectives, engaging in inquiry, and applying skepticism when presented with potentially biased information, and recognizing the affordances and limitations of science in addressing the issue (Sadler & Zeidler, 2009). In turn, the STS conceptualization of disasters can help to shed light on the gaps in the current policy.

3. The context of science curriculum making in South Korea

Science education in South Korea is centralized, and all students in public and private schools study science according to the national curriculum. The national curriculum is regularly reviewed and revised every five to seven years, which is a relatively short cycle compared to other countries (OECD, 2020b). The national curriculum has also been fast to incorporate social and political agendas that are present at the time of curriculum review and revision (Choi et al., 2011; So, 2020). In the meantime, the process of curriculum development in South Korea is hierarchical, with policymakers and general education scholars developing the general curriculum framework (the "general section"), after which subject experts develop individual programs of study based on the general section

(So, 2020). As such, frequent revisions and responsiveness to emerging societal needs are defining features of science curriculum policy in Korea.

At the same time, however, there is a strong resistance in South Korea to increasing the curriculum content by inserting new topics. Over the past two decades, the government has made sustained efforts to reduce students' workload by constantly reducing the content of the science curriculum (Jang, 2020, MOE, 2015a; So & Kang, 2014), and as a result, a number of content areas in the science curriculum have been removed from the primary and secondary curriculum in recent reforms (Ministry of Education. (MOE, 2009, 2015b). The emphasis on a "lighter" curriculum was in part motivated by the government's decades-long battle to reduce household expenditures on private tutoring (Kim, 2016) and to lower students' academic stress and increase life satisfaction (Rees & Dinisman, 2015). The 2015 science curriculum contains only 80% of the content and attainment standards compared to its predecessor to "optimize" the learning load (KOFAC, 2015). In the implementation guide for the national curriculum, MOE demands that "... the contents reduced or removed from the 2009 national curriculum should not be considered in the subject curriculum and assessment plan [at schools] and otherwise it would constitute a breach of relevant education legislation (Korea Institute of Curriculum and Evaluation (KICE, 2021, p. 70). In short, early adaptation to societal needs and reduction of curriculum content are two opposing forces that drive the curriculum reforms in Korea, which influenced the introduction of new curriculum content positively or negatively.

4. Conceptual framework for understanding policy change

In analyzing disaster-related science curriculum policies, we view curriculum policy as "ideological and political artifacts which have been constructed within a particular historical and political context" (Gale, 1999, p. 399). At the same time, we consider policy not as a fully linear, rational process but as a product of "the interaction of values, interests and resources guided through institutions and mediated through politics" (Davis et al., 1993, p. 15) that reflects and reinforces power and ideologies (Fairclough, 2009) in the curriculum. Specifically, our analysis is based on Bowe et al'.s (1992) characterization of policy making in education. Policy discourses are initiated in the *context of influence*, where interested parties negotiate the purpose of the policy and the meaning of key concepts. This is followed by the *context of policy text production*. Articulated in the language of the common good, policy texts represent policy in various forms of documents. These texts can include not only primary documents such as the national curriculum and science standards, but also secondary documents that were produced before and after the legislation. Bowe et al. (1992) underscore that individual texts may not be internally coherent and that the texts themselves are the outcome of struggle and compromise. Once produced, policy texts are then implemented in the third context, the *context of practice*, where the policy is subject to reinterpretation and recreation by practitioners.

Our analysis began with an examination of the context of policy text production, with the aim of uncovering the struggles, clashes and tensions that underlay the recent introduction of disasters in the Korean science curriculum policy. The examination of the documents then allowed us to identify several contexts of influence, characterized by two dominant discourses that shaped the production of the curriculum. Our focus on policy text analysis means that it can offer limited information on the context of practice, but towards the end of the paper we will address some nascent evidence relating to teacher practice and classroom implementation to provide insights into how and to what extent the policy might influence teacher practice and, subsequently, pupils' understanding of and attitude towards disasters.

5. Analytical procedures

This paper first traces how disaster was introduced to science curriculum policy in Korea, focusing on the period from 2009 to 2022. This time period reflects the two major curriculum reforms that took place in 2015 and 2022, respectively, and the changes that have been made since the previous major curriculum reform in 2009. The primary data for our analysis included the national curricula (the general section and the science section), science education standards (Table 1), and a range of artifacts produced during the development, implementation and evaluation of these curriculum documents. These artifacts included reports of research conducted as part of the curriculum development process, and records of public hearings, expert panel meetings, symposia, and press releases related to the curriculum reforms. In addition to the science curriculum documents, policy documents on disaster risk reduction and disaster safety were also included for analysis to understand the context in which the discourses on disasters found their way into the science curriculum.

Using thematic analysis (Braun & Clarke, 2006), we first read and reread the texts, asking what happened and why, which led to the initial coding of the documents. Recognizing that there is "a terrifying multitude of possible answers to any 'why' question" in qualitative analysis (Miles & Huberman, 1994), we sought to discover as many potential causal chains as possible, both within and across documents. Where the influence of one document on another was apparent (e.g. by explicit references between documents), we took note of such relationships, and these notes were then aggregated and organized chronologically to understand the process of policy change, which was then discussed among the four authors. It was often necessary to link the disaster-related policies to external contexts of culture, society and curriculum change, which is inevitable given that texts can only be fully understood in relation to other texts and social relations rather than in isolation from them (Fairclough, 2010). This process led to the identification of two dominant discourses that shaped the introduction of disasters from the complex policy landscape: the discourse of safety and that of integration (Section 5).

Once we gained an initial, chronological insight into "what happened and why" around these two discourses, we then delved into the less obvious part of the analysis—the clashes, tensions and negotiations between competing interests of actors, inconsistencies and potential problems within the curriculum policy regarding the introduction of disaster. Feedback on curriculum drafts from stakeholders, expert reviews, and survey studies recorded in the policy documents served as useful resources for understanding these issues. We used a flexible approach to coding to uncover these issues from the documents, using both inductive and theory-driven codes. The latter group of codes were derived from both disaster theory (e.g. preparedness, safety, risk) and curriculum theory (e.g. curriculum integration, teacher enactment). The codes were then grouped into categories, and an iterative, multi-round discussion between the three authors led to the identification of themes within and across documents (Braun & Clarke, 2006).

6. Policy discourses that shaped the introduction of disaster in the science curriculum

6.1. The rise of "safety" after the Sewol Ferry disaster

Levin (2008) uses Edelman's concept of "condensation symbols" to describe why certain events serve as triggers for curriculum debates and reforms. Condensation symbols are small events "which become highly symbolic as they seem to embody, or condense, a range of beliefs and values in a particular case" (p. 19). In South Korea, there was one particular disaster that gave prominence to "safety" as a condensation symbol in Korean society. This was the Sewol Ferry disaster that occurred on April 16, 2014, which claimed the lives of 304 passengers including students and teachers from a high school, on their way to Jeju Island for a school field trip. The deadliest maritime accident in the country in four decades, the disaster provoked intense reflection and further action on the disaster management system as well as many other aspects of Korean society such as law, security, politics, social policy, and education (Jang, 2020; Park, 2020, 2022; Shin & Hyun, 2022). From a policy point of view, the Sewol disaster served as a "focusing event" that stimulated the emergence of safety as a policy problem (Kingdon, 1984; Pierce et al., 2017) in such a manner that the launch of Sputnik in the late 1950s triggered education reforms in the United States (Neal et al., 2008).

This social response to the Sewol disaster soon created a 'discourse of safety' in curriculum making, reflecting a strong and urgent social and political need for the new national curriculum to incorporate the safety agenda. New policies focusing on disaster safety were introduced throughout the education sector. A number of guidelines were announced to increase disaster preparedness and resilience through education. The MOE published *A Comprehensive Response for Safety in the Education Sector* (MOE, 2014a), followed by *Seven Domains for Safety Education in Schools* (MOE, 2015b). The government also commissioned and published *A Survey Study on the Needs of Schools, Nation, and Society*, which identified disaster safety education as a priority area for education, with an explicit reference to the Sewol disaster (MOE, 2014). Capitalizing on these efforts and the heightened public interest in disasters after Sewol, the Advisory Board for National Curriculum Revision recommended that each school subject introduce a new unit and also strengthen the links between existing curriculum topics and disasters to support disaster safety education (MOE, 2015b). In response to this recommendation, a new subject called "Safe Life" was created for the first and second grades, and safety-related units were created in several subjects for the third to twelfth-grade curriculum. The most visible of these new initiatives was a new unit called 'Disasters and Safety' in the eighth-grade science curriculum (see Section 7.1 for more information). These new units and subjects were part of the MOE's attempt to highlight safety education at all levels of education in a developmentally appropriate manner (MOE, 2014).

Besides the national curriculum reform, the Sewol disaster also influenced other science education policy reforms in the country. Just before the Sewol disaster and concomitant with the development of the 2015 national curriculum, the MOE and the Korea Foundation for the Advancement of Science & Creativity (KOFAC) had jointly initiated a five-year project from 2014 to 2019 to develop science education standards for the next generation, which would be comparable to the *Next Generation Science Standards* in the USA. The project culminated in the publication of the *Korean Science Education Standards* (KSES) which set out science learning standards for the 12 years of compulsory education (MOE & Korea Foundation for the Advancement of Science and Creativity. (KOFAC, 2019). The influence of the safety discourse on the production of the KSES is most discernible from the 84 references to "safety" and 30 references to "disaster" (compare this with "physics," which appears 29 times). The following statement from the KSES illustrates how "safe life" and "safe society" were used to justify the inclusion of disaster in the science curriculum:

> Managing risks to achieve a safe life and society is a prerequisite to meeting the basic needs of people to live healthy and happy lives, and it is a fundamental element of the "quality of life" that our society pursues today . . . Safety education to prevent and manage these accidents and risks is important in the education for scientific literacy . . . [Students] need to know the causes of disasters, methods of prevention and response and how to take action. This includes, for example, the causes of and solutions to natural disasters such as typhoons, earthquakes, floods, and infectious diseases. (MOE & Korea Foundation for the Advancement of Science and Creativity. (KOFAC), 2019, p. 52)

As such, the KSES placed disaster-related knowledge and competences within the broader goals of scientific literacy and safety education, and disaster prevention and management skills of individuals were presented as a component of safety education. In summary, it can be said that the emphasis on disaster safety after 2014 started as an urgent societal need, which gave rise to a curriculum policy that subsequently shaped the science curriculum. This process demonstrates how a subject-general curriculum discourse instigated by a tragic social event can be imposed on the reform of individual subject curricula such as the science curriculum.

6.2. The drive for "integration" of the sciences

While the analysis of relevant documents points to the discourse of safety that emerged after the Sewol disaster as the main impetus, there was another discourse on the integration of school subjects—in line with the ongoing interest in curriculum integration in Korea and internationally (Drake, 2010; Kang, 2019)—that played a role in the introduction of disaster. At the outset of its planning, the 2015 national curriculum was envisioned as an integrated curriculum for all students that would replace the old two-track high school education system divided into the humanities stream and the science stream (MOE, 2014b), which was viewed as ineffective for individuals and society and thus to be phased out (Son, 2014).

The science curriculum in Korea is traditionally divided into four science subjects (physics, chemistry, biology, and earth science), and most secondary science teachers are qualified in one of these subjects. In particular, earth science in Korea is a wide-ranging subject that encompasses astronomy, oceanography, geology, atmospheric science, and some aspects of environmental science (MOE, 2015a). The solid status of earth science as a quarter of the Korean science curriculum is contrary to those in many other education systems where elements of earth science are covered in other subjects such as physics and geography (Greco & Almberg, 2016). Until the mid-2010s, issues related to safety and disaster received little attention in the Korean science curriculum. In the quadripartite structure of school science, most natural disaster-related issues—earthquakes, typhoons, floods and droughts, and climate change—were covered in the earth science curriculum rather than in the other three science subjects (MOE, 2015a). These were described predominantly as natural phenomena, and disasters caused by non-natural and human-made hazards were not explicitly included in the science curriculum. In this way, disasters were presented within the disciplinary structure of earth science (or its subdisciplines such as meteorology and geology).

The possibility of addressing disaster beyond the subject of earth science was expressed principally in terms of safety education as a cross-curricular theme. In the documents predating the curriculum revision in 2015, in the (subject-)general section of the national curriculum, some initial signs of safety and disaster education were present, mainly in the form of cross-subject curriculum goals. The general section of the 2009 national curriculum introduced 39 cross-subject learning themes that included "safety education" and "safety and disaster preparation" (MOE, 2009), which were later merged into "safety and health education" in the 2015 national curriculum (MOE, 2015a). Although the intention of the curriculum developers was that cross-subject objectives should be taught in all subject areas, in practice, there was little emphasis on safety and disaster in the science curriculum, or any other specific subjects. In addition, concerns were raised by practitioners that too many cross-subject goals were present in the curriculum and therefore could not be effectively incorporated into instruction (MOE, 2014).

The meaning of integrated curriculum has been debated in international science education research and policy (Drake & Burns, 2004; UNESCO, 1990). During the making of the 2015 national curriculum, the idea of integrated curriculum was interpreted to include both integration between science and other subjects and integration between the four science subjects. While the former type of integration was of more interest to the developers of the general section of the national curriculum, within the science curriculum, the integration of the four sciences was seen as an immediate and contentious issue. An expert panel was formed to examine possible ways to incorporate physics, chemistry, biology, and earth science within science subjects (Kwon & Ahn, 2012; Son, 2014), resulting in a suggestion to establish several integrated units associated with the four scientific domains in the middle school science curriculum. In line with the overall curricular emphasis on safety education, "Disasters and Safety" was introduced as a new stand-alone unit to integrate four sciences (Section 7.1).

7. Three tensions underlying the introduction of disasters

7.1. Tensions about the relationship between science and disaster

In the process of policy making, many concepts that were previously taken as obvious and unambiguous are questioned, contested and contested. It is thus important to understand what meanings are attached to key concepts in a certain policy by policy actors (Bacchi, 2009). In relation to the focus of this study, it is important to consider how the recent policies have situated "disaster" in relation to science education. The "Disasters and Safety" unit in the 2015 national curriculum presented two standards related to disasters: first, "to collect information on examples of disasters and analyze their causes and impacts *scientifically,"* and second, "to respond to disasters using *scientific* principles." (MOE, 2015a, p. 74, italics added) In both standards, the connection between disasters and science is made explicit in order to justify the place of disaster in science learning. The curriculum then specifically demands that students investigate cases of disasters such as chemical spills, the spread of infectious diseases, meteorological disasters, earthquakes, volcanoes, and transportation accidents (MOE, 2015a). Given that the motivation came primarily from the Sewol Ferry disaster, a maritime transport accident, it appears reasonable that the curriculum includes a fair range of disasters triggered by both natural and technological hazards, which can be seen as an improvement over the traditional focus on the former in the science (mostly earth science) curriculum.

Furthermore, these standards strongly suggest that science is seen as a tool for understanding and dealing with disasters. Viewed from the distinction between the hazard-centerd and STS perspectives on disasters that we discussed earlier, the national curriculum might be seen as adopting a narrow characterization of disasters in the science curriculum, which has resulted in missing out on potential opportunities to address and discuss with students the dynamic interaction of science, technology and society in the context of disasters. For example, the curriculum does not address the fact that scientific and technological advances can create new sources of disaster risk, as illustrated by examples such as nuclear and chemical accidents. Although the curriculum made some links between science and disasters, there was a strong tendency to represent the problem as one of assuring "safety" from disasters. This suggests that the unit focuses on understanding the important role science and engineering can play in making life safer, without understanding the nature of science and technology in both creating and reducing disaster risks (Beck, 1992). The absence of the social, cultural and ethical implications of disasters, which could have illuminated the relevance of science to society, reinforces this sense of missed opportunity.

Table 1. Key policy documents related to disaster and science education, published 2009–2015.

Year	Document	Author
Science curriculum documents		
2009	National Curriculum: Science	MOE
2015	Final report of a study on developing the draft science curriculum	KOFAC
2015a	National Curriculum: Science	MOE
2019	Development of Korean science education standards for next generation	MOE & KOFAC
2019	Scientific literacy for all Koreans: Korean science education standards for the next generation	MOE, MSICT & KOFAC
2019	Developing performance expectations, school implementation strategies, evaluation indicators of the Korean science education standards for the next generation	MOE & KOFAC
2020	A study on the implementation of the 2015 National Science Curriculum	MOE & KOFAC
Disaster & safety documents		
2014b	Research on the restructuring of the science curriculum integrating the humanities and science tracks	MOE
2014c	A survey study on the needs of schools, nation and society	MOE
2014	Background research for improvement of the General Section of the National Curriculum	MOE & Daegu Metropolitan Office of Education
2014a	A comprehensive response for safety in the education sector	MOE
2015b	Seven domains for safety education in schools	MOE

Table 2. Examples of disaster-related learning goals presented in recent science curriculum documents.

Domain	Disaster-related goals in science curriculum documents
Content knowledge and procedural knowledge	Understand the scientific causes of disasters . . . and understand the importance of science in ensuring information security and ethics and bridging the information divide in the intelligent information society (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 73). Explain the causes of climate change in terms of natural and anthropogenic factors. [12ES1 04–04] (MOE, 2015a) Differentiate between infectious and non-infectious diseases, and understand the characteristics of pathogens that cause infectious diseases in relation to infection or prevention. [12BS1 03–05] (MOE, 2015b) Investigate data related to disaster cases and scientifically analyze the causes and damages. [9S 16–01] (MOE, 2015a)
Relevance to life	Understand the scientific causes of disasters, the impact of disasters on daily life, and know how to respond to various disasters to live a safe life (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 73). Recognize the importance of the social management of disasters and propose scientific measures for disaster response (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 73). Explore accidents related to collisions in everyday life and evaluate the effectiveness of safety devices using impact and momentum. [10IS 03–02] (MOE, 2015b)
Participation and action-taking	. . . participate in disaster prevention and response. For example, this includes the causes of and responses to natural disasters such as typhoons, earthquakes, floodings as well as infectious diseases (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 52) Participate in educational programs focused on the causes of accidents and measures for prevention and response. (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 52) Discuss the environmental, social and economic impacts of climate change caused by human activities and how to solve climate change problems scientifically [12ES1 04–04] (MOE, 2015a) Evaluate the pros and cons of nuclear power generation, solar power generation, and wind power generation and improvement measures from the perspective of solving global environmental problems caused by climate change. [10IS 09–04] (MOE, 2015a)

7.2. Tensions between "understanding" and "surviving" disasters

The lack of agreement on the relationship between science and disaster leads to the question of what the disaster-related learning goals should be in the science curriculum. This relates back to the fundamental question of why disasters need to be addressed in the science curriculum, and in turn what the purpose of school science is. In our analysis, these goals were presented incoherently in the textbooks, and there were also inconsistencies between the national curriculum, science education standards, and assessment frameworks. The disaster-related curriculum goals presented in Table 2 can illustrate this point. A broad range of goals, denoted by verbs such as "understand," "know," "differentiate," "participate," and "evaluate," are presented in relation to disasters, and learners are also expected to contribute to safe society at the individual and social level from their knowledge of disasters (MOE, Ministry of Science and ICT & KOFAC, 2019, p. 73), although how learner's knowledge of disasters can translate into a contribution to safety is not explicated.

Whilst these documents covered various goals about disasters in relation to science education, some documents were focused exclusively on the "survival" and "safety" aspect of disaster education. The following is a list of assessment criteria recommended by the KOFAC for disaster-related learning goals in the KSES (MOE & Korea Foundation for the Advancement of Science and Creativity. (KOFAC, 2019).

- Participate in safety education for everyday life
- Participate in safety education for inquiry activities
- Participate in safety education for disasters
- Participate in safety education for intelligent information society
- Propose a safety education program for individuals based on science
- Use scientific measures to reduce risk in everyday life
- Use scientific measures to reduce risk during inquiry activities such as laboratory work

- Use scientific measures to reduce the risk of disasters
- Use scientific measures to reduce the risk in intelligent information society

If we compare this list with the learning goals presented in Table 2, it can be seen that the assessment criteria are addressing only part of the learning goals (participating in disaster-related activities and taking action). Students' knowledge and understanding of disaster concepts, and the role of science and engineering in dealing with disasters are missing from these assessment criteria. In summary, there are inconsistencies and a lack of agreement across the curriculum documents regarding "understanding" and "surviving" disasters, and the cognitive and functional learning goals about disasters.

Although such inconsistency and incoherence in policy texts is not uncommon (Bowe et al., 1992), they can cause problems in policy implementation, particularly when the aim is to introduce new topics such as disaster. This points to the problematic discrepancy between curriculum policy intentions and policy actions. In part, this may be due to the fact that disaster has been introduced for "symbolic" reasons (Blackmore & Lauder, 2005) without sufficiently considering its practical consequences such as learning goals and pedagogical approaches. Although an empirical investigation of policy implementation is beyond the scope of this study, some insights can be drawn from the initial evidence that is currently available. In a study on the implementation of the 2015 national curriculum, MOE and KOFAC (2020) have found that teachers spent relatively little time on the new disaster unit in 8th-grade science due to a lack of knowledge and experience. Some teachers mentioned that they used the new disaster unit to address COVID-19, which was rapidly spreading at the time. One teacher also mentioned that relating the disaster unit to earthquakes, volcanoes and weather events would be a useful way to teach about disasters "scientifically." These responses suggest that science teachers need a stronger link between disaster and "science" to justify teaching about disasters in their classrooms.

7.3. Tensions between disciplinarity and integration

We discussed earlier that integration of subjects was one of the two main rationales for the introduction of disasters into the science curriculum. The discourse of integration can be observed frequently in the documents produced in the development of the science curriculum and standards. Depending on how different curriculum actors evaluated the relevance of disasters to science education, questions were raised as to whether disaster is a suitable topic to be taught in science rather than other school subjects. During the making of the 2015 national science curriculum and the KSES, conflicting views were expressed on which subject should be responsible for teaching disasters. One expert panel member and high school science teacher commented that science as a subject needs to address various cross-subject competencies including disaster safety, referring to physics topics such as momentum, radioactivity and buoyancy that could be related to disasters. Another panel member, a curriculum expert, suggested broadening the scope of science education to encompass various social issues:

> . . . To what extent and how should global and local socioscientific issues such as the environment, disasters, food, water, energy, health and safety be included in the integrated science curriculum? . . . I suggest that the science curriculum should be broadened to include humanistic imagination, social capacities as related to the content of science. This would mean reverting to a system of knowledge before specialisation; we might see that it's time for science to address issues such as values and social responsibility. In that sense, science education should address cross-subject topics such as the environment, disasters, food, water, energy, health and safety. (A curriculum studies professor)

A similar argument for an extended conception of science education was expressed by another panel member, but this time with an explicit focus on integration:

> "Scientific literacy" as the aim of science education can be cultivated by studying any science subject, and it's easier to cultivate it when science is studied holistically. By studying science in an integrated manner, students can deal with social issues based on scientific thinking and scientific attitudes. It would also allow for improving the systematic thinking, logical decision-making, and problem-solving skills. (A science education professor)

By emphasizing the cross-subject skills that learners need to cope in a changing world, these comments resonate with the critiques of knowledge and subject-based curriculum (Alderson, 2020; White, 2018) As seen in the second comment, the inclusion of disaster in the science curriculum can be justified based on its contribution to critical scientific literacy as the aim of science education (Park, 2020), rather than its place in the structure of the parent discipline (i.e. academic science). In this view, there can be as much value in teaching about disaster as in teaching about electromagnetism and stoichiometry.

Some actors, however, dissented from this view on the role and scope of science education. In particular, there was criticism of how disaster-related themes entered KSES. As discussed earlier, the KSES conceives scientific literacy broadly and accordingly highlights the social relevance of science, and it is in this context that disaster-related topics were addressed in the standards. In the expert feedback on the draft of the KSES, some reviewers (mostly science teacher educators at universities) disagreed with the scientific literacy it envisioned as well as the rationale for including disasters. One reviewer commented that some aspects of the "participation and action" dimension should be addressed in the ethics classes rather than in science, and that the terms in the KSES need to be "intrinsic to science" (MOE & KOFAC, 2019). The emphasis on disasters was also criticized, as exemplified by the following comment:

> Regarding "contributing to sustainable society," what would be the scientific and sociocultural contributions to it? If one learns science, does it influence sustainability in a sociocultural way? This should be addressed in humanities and social studies subjects [rather than science] . . . For disaster safety, it's sufficient to address it in practical arts education [rather than science]. *It doesn't fit with science*. (Italics added)

These conflicting attitudes demonstrate how the inclusion of disaster in the science curriculum can be supported or contested on the basis of more fundamental ideas about what science as a school subject should entail. On the one hand, we can see an emphasis on intercultural skills needed to address challenging global issues, which calls for an expanded notion of scientific literacy. On the other hand, some actors emphasized the identity of school science distinct from other school subjects such as humanities, social studies and practical arts. This contrast can be interpreted in terms of different approaches to subject matter in curriculum—subject matter as disciplinary knowledge and subject matter as practical and experiential knowledge that is not confined within disciplinary boundaries (Deng & Luke, 2008).

The tension between disciplinarity and interdisciplinary knowledge has also been observed in the context of curriculum implementation. A study by the MOE and KOFAC (2019) on the implementation of the 2015 national curriculum has found that science teachers tended to spend minimal time teaching the new "Disasters and Safety" unit. One of the reasons for this was that the teachers did not view the unit as a "scientific" one due to the lack of disciplinary knowledge, that is, knowledge of physics, chemistry, biology and earth science. Instead, they viewed the unit as a collection of interesting topics to discuss with students "in spare time" after covering all the disciplinary knowledge had been covered. Such a response from teachers implies that science teachers viewed disaster as pertaining to learners' everyday experiences rather than to scientific disciplines, and therefore as an issue of pedagogy rather than a curriculum issue.

8. Implications for curriculum policy

In this study, we have illustrated how the discourses around safety and integration gave rise to the introduction of disaster as a curricular theme in science education in Korea, creating tensions and contradictions around the possible ways disaster might be justified in the science curriculum. Given the increasing emphasis on environmental and sustainability topics in science education globally (Wals et al., 2014), as well as the broader efforts to incorporate disaster risk reduction into formal education (Shiwaku & Fernandez, 2011; United Nations Office for Disaster Risk Reduction [UNDRR] & Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector [GADRRRE], 2017), the Korean experience can provide insights for other education systems looking to undertake similar initiatives. Our study also shows how "old" dichotomies about curriculum between, for example, disciplines and integration, and cognitive and functional goals, manifest in a specific policy context of curriculum reform. As such, our work responds to the call by curriculum scholars for enquiry into how the subject matter for school subjects are selected (Deng, 2009).

In light of the recent debates on knowledge-based curriculum (White, 2018; Young & Muller, 2013), the South Korean case highlights the different views held by curriculum actors about the identity and aims of science as a school subject, and the extent to which the science curriculum should address subject-general and cross-subject curriculum goals. On the one hand, the introduction of disaster emerged in harmony with the global emphasis on environmental and socially relevant issues (OECD, 2022; Osborne et al., 2022) that are important for learners as responsible citizens. On the other hand, disaster preparedness and safety have a much stronger link to learners' everyday experiences than the disciplinary structure of science, which transcends experience. In the knowledge-based views of curriculum, reforming the science curriculum to enhance safety can be seen as an "instrumentalist" (Young et al., 2014, p. 90) approach to curriculum, similar to using the curriculum to promote human well-being or to stimulate economic growth. In what follows, we discuss some implications of the study's findings for curriculum policy. Although our focus has been on the science curriculum, these implications may be useful in understanding the context and process of introducing new curriculum topics into other school subjects.

First, for effective implementation of curriculum policy, it is essential that curriculum makers consider how the new content such as disaster can be aligned with the existing and accepted aims of science education. This is particularly important in cases where the reform itself was driven by external societal needs rather than intrinsic needs within science education, as was the case in South Korea. Neither safety nor integration were initiated by the needs of science education intrinsically; rather, they were the result of broader social agendas being "imported" into the science curriculum, requiring new justification on the part of science educators. The resistance of some stakeholders to the KSES on the grounds that disaster-related goals were not "about science" illustrates this point. For some curriculum reviewers and teachers, disaster was considered unsuitable as a topic in the science curriculum due to the lack of connection to the parent discipline (science in this case). The study provides an example of resistance to high-relevance cross-subject curriculum topics when there is little consensus within the community about the aims and scope of science as a school subject.

Establishing stronger connections between the aims of science education and that of teaching about disasters (Park, 2020) will be crucial to justifying the place of disasters in the science curriculum. A comprehensive conceptualization of disasters based on STS and the inseparability of science and society (Fortun & Frickel, 2013; Knowles, 2014) could help curriculum makers develop a robust justification for including disasters in the science curriculum. In this sense, our findings offer useful insights that can be extended to other curriculum topics introduced to the curriculum in response to emerging societal needs in different national contexts, especially given the growing global attention to disaster-related issues in curriculum and assessment guidelines (OECD, 2022; Osborne et al., 2022).

Second, the analysis also points to the need to consider the sociohistorical and sociopolitical contexts in which science curriculum policy is shaped and enacted, for a nuanced understanding of science education policymaking. By articulating the link between the broader social context such as the Sewol disaster and curriculum change, our study extends the discussion about the sociopolitical construction of science curricula initiated by earlier works (Banner et al., 2012; DeBoer, 1991; Ryder & Banner, 2011; Yao & Guo, 2018). This approach enables interpreting curriculum reforms as governments' response to pressing policy problems in society and the needs of the public (Levin, 2008). It still remains an open question, though, to what extent social and political agendas should be allowed to motivate and drive science curriculum reforms, as illustrated by an education professor's comment during a public hearing for the 2015 national curriculum:

> The core problem is not that safety is not part of the subject curricula but that we are not doing the safety education contents that are already existing. Is it right, from the curriculum point of view, we create a new subject or introduce a certain topic to the curriculum every time a new social issue emerges? (An education policy professor)

Finally, notwithstanding this study's focus on policy text production rather than policy implementation and practice, implications can be drawn for reducing the gap between curriculum policy and teacher practice when introducing new themes such as disaster into the science curriculum, or any other subject curriculum. Some sources of teacher resistance to addressing disasters were consistent with previous studies (Park et al., in review). In addition, the inconsistencies identified within and across curriculum documents and guidelines suggest that there was a general lack of consideration of pedagogy and assessment which are crucial for teacher implementation. Given the controversial, uncertain and sensitive nature of disasters (Hand & Levinson, 2012), support to reduce teacher resistance and practical barriers is essential for the successful implementation of the curriculum. Underlying these difficulties is the absence of a clear justification for disasters in the science curriculum, which we discussed earlier. We assert that research efforts to establish solid theoretical and empirical basis for including new topics such as disasters in the curriculum will be instrumental in reducing the gap between policy and practice.

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