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A Comparative Study of the Integration of Sustainability in the Lower Secondary Science Curriculum of Sweden and South Korea

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ABSTRACT

This research examines how sustainability is integrated in science curricula for Sweden and Korea. At this time, increasingly recurrent extreme weather events have wreaked havoc on people's lives and sustainability of the planet. Sustainability has become an important issue within the education field. Analysis of curriculum could offer an understanding of various social aspects, and science education has gradually incorporated social issues in its curriculum.

The analyses were guided by the basic content analysis of learning content in both curricula, and the interpretive content analysis in the light of four aspects of the curricula: presence of sustainability, views of the student, human-environment relationship and philosophical/theoretical underpinnings. The integration of sustainability in learning content of the curriculum was significantly higher in the Swedish science curriculum than the Korean one. As for sustainability presence, the Swedish curriculum adopted more explicit languages than the Korean curriculum. And both curricula viewed the student as an agentic individual with focusing on competencies for sustainability. With regard to human-environment relationship, the Swedish curriculum stated reciprocal relationships between human and nature, while the Korean curriculum showed a more anthropocentric view. Both curricula mainly embodied sociocultural and human-centered views of learning when it comes to philosophical and theoretical underpinnings. There is a need to consider a more sustainability integrated science curriculum framework with enough knowledge, descriptions of students as active agents, thought-provoking with regard to human-environment relationships, and the establishment of philosophical basis and theories underpinning sustainability.

Keywords: Sustainability, Science curriculum, Education for Sustainable Development (ESD), Sweden, South Korea, International comparative research

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Chapter 1. Introduction

1.1. The Background of the Study

In 2022, a series of extreme weather events occurred globally. In Europe, many countries suffered historical heat waves for months and broke records in various locations. These heat waves led to harsh droughts and an unexpected number of casualties, and moreover, are predicted to be the 'norm' in 2035, according to the forecast by the UK's Met Office Hadley Centre (Orie & Dewan, 2022). Meanwhile, Pakistan was hit by its worst floods this summer which reportedly killed thousands and caused an increase in diseases (Thomas, 2022). Also, California in the US was affected by numerous weather disasters such as storms, wildfires, heat waves and droughts which endangered life and caused infrastructure problems such as power grid emergencies (Bernstein, 2022). Korea was also no exception as Seoul was hit by torrential rain resulting in the worst flood in recorded history (M. Yoon, 2022). Extreme weather conditions are also revealed to give rise to physical changes to the earth, or even reverse environmental improvement by consistent human endeavor, hence putting our lives in peril. For instance, smoke from intense bushfires in Australia could contribute to the expansion of the ozone hole which has maintained a moderate level since the compulsory phasing-out of ozone-depleting chemicals in 1987 (Damany-Pearce et al., 2022).

Indeed, climate change has wreaked havoc on our living conditions and the cause is mainly due to human activities, which has been confirmed by science groups such as the Intergovernmental Panel on Climate Change of the UN (IPCC,

2021a). Furthermore, climate change makes our world increasingly unsustainable by not only posing irreversible negative impacts on ecosystems and biodiversity, but also disproportionately affecting the most vulnerable people (Nobre et al., 2016; Pörtner et al., 2022). Since the perception that climate change is caused by anthropogenic reasons possibly leading to catastrophe for humankind, diverse agents all over the world (e.g. the United Nations, governments) have grappled with this issue to come up with solutions to make our planet sustainable. To this, the idea of 'sustainable development (SD)' has been widely used in various contexts, since it was first institutionalized at the 1992 Earth Summit in Rio de Janeiro (The United Nations Conference on Environment and Development, UNCED) (Hopwood et al, 2005; Du Pisani, 2006). It is defined by the UN as: "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The United Nations [UN], n.d.-a, what is sustainable development? section. para.1). SD consists of three main pillars: economic growth, social progress and environmental sustainability. However, there have been critical voices that warn of the potential incompatibility of socio-economic development and environmental sustainability in pursuing sustainable development (e.g. International Council for Science and International Social Science Council, 2015). Indeed, there has been a conflict between socio-economic development and environmental sustainability for the last few decades (Jorgenson, 2010; Rich, 2014).

One of the main solutions is education, which is expected to play a critical role in achieving a sustainable society (WCED, 1987). In line with this, the concept of 'Education for Sustainable Development (ESD)' was presented in

2002, at the UN World Conference on Sustainable Development in Johannesburg, South Africa. Subsequently, the UN promoted UNDESD (UN Decade of Education for Sustainable Development) from 2005 to 2014 for the sake of integration of ESD in all educational sectors (Cebrián & Junyent., 2015). Even in SDGs (Sustainable Development Goals) introduced by the UN in 2015, education is considered one of the most influential means to achieve a sustainable planet.

However, South Korea ('Korea', hereinafter) is one of the notorious countries for its education fever. For instance, the availability of not only school districts but cram schools (or private educational institutions) in a certain area is a major factor in deciding house prices with 82% of elementary school students participating in private education in 2021 (Bae & Chung, 2013; Park & Lee, 2021; L. Yoon, 2022). The reputation of educational institutions mainly depends on how many students get accepted into prestigious universities. Not surprisingly, this fever has nothing to do with dissemination of sustainability through education at all, at least not here in Korea, although education is regarded as a main contributor to the sustainable future in the world as described above. To resolve this problematic phenomenon, there have been diverse efforts put on education reform so far. Nevertheless, the majority of teenagers are still struggling to get a good grade to enter good universities. Even if they notice the problems in society and are willing to take action, they are normally discouraged not to behave by surrounding adults. This is because any social actions by students tend to be seen as something at the expense of 'good grades', which is associated with good universities and subsequently, a stable and comfortable

future. However, Korean adolescents recognize climate change more seriously than adults, according to a survey (Choi, 2021). Moreover, another survey conducted by the National Environmental Education Center indicated that about one-third of students showed an intention to participate in school-striking in the future (National Environmental Education Center, 2021). Nevertheless, even school teachers don't have enough knowledge and interest when it comes to the integration of sustainability in their classes (Kang, 2019).

Amid deepening concerns about the climate crisis, levels of uncertainty about the future have increased. This uncertainty is associated with the survival of the planet and accordingly existential concerns and hopelessness (Ojala, 2012). Similarly, Sanson and Bellemo (2021) claimed that the climate crisis would pose threats not only on physical health but also on the mental well-being of young people. Obviously, young people are increasingly aware of the risks and have raised their voices on this issue, for example, by taking part in mass demonstrations called "School Strike for Climate" (Sanson et al., 2019; Lee et al., 2020; Han & Ahn, 2020). A Swedish 15-year-old environmental activist Greta Thunberg started this protest by skipping school on Friday and joining a global rally. They have demanded climate justice and that their governments be on track for a sustainable climate.

Since then, Swedish activist Greta Thunberg has become one of the most influential figures in climate change action. Taking this into account, people started to pay attention to environmental education in Sweden, as it is considered to contribute to building a generation of Greta Thunbergs (Givetash & Banic, 2020). Sweden, a small country with around 10 million inhabitants, together with

other Scandinavian countries Norway and Finland, is renowned for having a high level of social trust and a sound welfare system (Dahlen & Skirbekk, 2021). In addition to this, Sweden ranked first in the global sustainability index in 2020, conducted by a global non-profit environmental organization Earth.Org (Mulhern, 2020). As for education in Sweden, since a goal of an equivalent education was set as early as the 1990s, their education has successfully embraced the values of equity, diversity and equality (Johansson et al., 2007; Sundberg & Wahlström, 2012). Environmental education in Sweden is also impressive in that they have become a world leading nation in initiatives for ESD (Breiting & Wickenberg, 2010).

Meanwhile, science education has been encouraged to incorporate sociopolitical issues in its curriculum to meet needs and interests of young students (Hodson, 2003). Aside from the conventional knowledge-based learning, school science education has increasingly incorporated societal aspects since the emergence of the new teaching orientation called STS (Science - Technology - Sociology) (Mansour, 2009). In line with this, other approaches such as STSE (Science - Technology - Sociology - Environment) and SSI (Socio-scientific Issue), which all focus more on the action, have been introduced and developed (Hodson, 2010). In other words, science education has contributed to underpinning values and ethics in society, therefore benefiting the societies (Chowdhury, 2016). Reflecting on this trend, science education in some countries has already incorporated environmental implications in the curriculum as environmental issues are regarded as social problems which require better understanding of social context (Hoffstein et al., 2011; Grundmann, 2016). And it

is needless to say that those environmental issues are a main point in the concept of sustainability.

Sustainability has increasingly been promoted as an important issue within the education field. However, although Koreans are some of the most educated people in the world (Charlton, 2018), it is still doubtful that they could learn proper values and ethics to make an environmentally sustainable planet through school education. By contrast, Sweden is well-known for the progressive efforts toward sustainable society and its education integrated with sustainability. According to Cornbleth (2013), various aspects of society including the demographic, political, social, and economic trends have shaped curriculum in school. In other words, analysis of curriculum gives more understanding of the society. Also, comparative research is effective in identifying similarities and differences of examined targets (Brislin, 1976). Therefore, comparative analysis of the science curriculum of Korea and Sweden is conducted in this research, in order to find similarities and differences, and what elements have affected these findings.

1.2. Purpose of Study / Research Questions

The aim of this study is to comparatively analyze sustainability in the science curriculum of Sweden and Korea. The research questions to be answered can be listed as follows:

1. How is sustainability reflected quantitatively and qualitatively in Korea's and Sweden's national science curriculum?
2. What are the similarities and differences in how sustainability is reflected in the Korea's and Sweden's national science curriculum?

1.3. Significance of the Current Study

The particular significance of this study lies in the examination of how sustainability has been integrated and addressed in the science curriculum at lower secondary school. Although there have been several researches about the integration of sustainability in curriculum, the main focuses of studies have been higher education and Early Childhood Education for Sustainability (ECEfS). A few studies have specifically investigated science education for sustainability in secondary school. However, most of them suggested specific educational situations (e.g. in laboratory), or mainly described teachers' views on the subject. In addition, no study to date has examined the embedment of sustainability in the Swedish science curriculum, and only a few studies have investigated the integration of sustainability in the previous version of the Korean science curriculum. Jenkins (2007) claimed that it is urgent to change the science curriculum at lower secondary school in order to retain students' interests in science. Considering the trend of science education having engaged in social affairs, the embedment of sustainability in science education at lower secondary school seems to be appropriate. Hence, this research makes some important contributions to the implications for developing a science curriculum for a sustainable planet.

Chapter 2. Literature Review

This chapter involves a brief literature review on the following subjects to give more context to this thesis: Overview of integration of sustainability in education, followed by sustainability related curriculum and policies of Sweden and Korea; International Comparative Analysis of Curricula with its methods and trends. Literature on sustainability curriculum and policies in Sweden and Korea will be examined so as to give more understanding of socio-cultural backgrounds in terms of setting their curriculum with the perspective of sustainability. Given that this research is based on the international comparison on education, the introduction of general inquiry and challenges in this field needs to be provided to offer a proper framework in order for deeper understanding. Lastly, the framework, which will be used in the interpretive analysis of sustainability in curriculum**,** is investigated, in order to clarify how it was formed and has been used in relevant studies.

2.1. Integration of Sustainability in Education

As sustainability has increasingly gained a position as one of the main agendas that need to be imminently tackled worldwide, the education sector has incorporated sustainability within its system reflecting on the trend. This section includes a description about how sustainability has been incorporated into education, starting by finding its root in environmental education (EE). An explanation of education for sustainable development (ESD), which became a global movement later, was also presented. Since the concept of sustainability

and sustainable development were introduced in the UN system, ESD gradually grew to be one of the main agendas in the field, as education has been regarded to have a critical role in promoting sustainable development. Meanwhile, some criticisms and challenges over ESD exist**,** thus literature on how it has been criticized/challenged is provided. This review on criticisms would be meaningful, as ESD discourse has been integrated in formal education in terms of embedding sustainability. In the end, the future of sustainability education is going to be introduced. Throughout this research, sustainability education is used as an umbrella terminology encompassing related terminologies such as education for sustainability, education for sustainable development (ESD), environmental education (EE), environment and sustainability education (ESE), sustainability education, and any other forms of sustainability-oriented education.

2.1.1. Finding the Root of Sustainability

The concept of sustainability first emerged in the 1980s in the World Conservation Strategy (The International Union for Conservation of Nature [IUCN[, 1980), and was reinforced by the UN-sponsored World Commission on Environment and Development (WCED) report *Our Common Future*, also known as the Brundtland Report (WCED, 1987). According to the report, sustainability was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (The United Nations [UN], n.d.-b, para 2.), and sustainable development is a development that meets sustainability (UN, 2007).

Since the terms sustainability and sustainable development were adopted in this WCED report, there have been thousands of initiatives taken at local, national, and international levels to address various environmental challenges (Mebratu, 1998). However, Sauvé (1996) claimed that the principles of EE set in the historic Tbilisi Declaration (UNESCO-UNEP, 1978) includes the fundamental elements of sustainable development: the need to consider social aspects of the environment including economy, culture, politics, and so on; the stress on local, national, and global perspectives; the promotion of global cooperation, and so on. Hence, the history of EE needs to be examined here, so as to give more context in understanding of sustainability in education.

EE arose out of concerns with environmental degradation in the 1960s, mainly in the United Kingdom and the US (Palmer, 1998, p.3; Gough, 2013). Its profile continued to rise in the 1970s through conferences supported by key international institutions: The United Nations Conference on the Human Environment in Stockholm (1972); International Workshop on Environmental Education by the United Nations Educational, Scientific and Cultural Organization (UNESCO) / The United Nations Environmental Programme (UNEP) in Belgrade (1975); The First Intergovernmental Conference on Environmental Education in Tbilisi (1977) - which respectively resulted in the establishment of UNEP (Stockholm), The Belgrade Charter: the global framework for environmental education (Belgrade), and international consensus on development of environmental education policies (Tbilisi) (Palmer, 1998).

2.1.2. Emergence of Sustainability / Sustainable Development, and Education for Sustainable Development (ESD)

In line with a series of efforts described in chapter 2.1.1., the *World Conservation Strategy* was launched in 1980, as a major global initiative by IUCN, UNEP, and World Wildlife Fund (WWF). A milestone publication of *Our Common Future* (or the Brundtland Report) in 1987 contributed to considerable reinforcement and expansion of the essence of the *World Conservation Strategy*. In addition to the aforementioned fact that the concept of sustainability and sustainable development was endorsed in the report, education was demonstrated as a main point in the agenda: "The change in human attitude, in social values, and in aspirations that we call for depends on a vast campaign of education, debate and public participation" (WCED, 1987, pp. 8-9).

Since this demonstration was delivered through this historical report in 1987, the role of education to alleviate global issues has been frequently debated and examined (Hägglund & Samuelsson, 2009). Reflecting on this trend, education has retained the prestigious position for having a pivotal role in promoting sustainability in the UN's two consecutive development agenda which commenced in the 21st century: Millennium Development Goals (MDGs: spanning 2001-2015), and Sustainable Development Goals (SDGs: spanning 2015-2030) (Unterhalter, 2014; Mori Junior et al., 2019).

At a glance, the Brundtland Report seems to be the starting point for the concept of sustainability / sustainable development being incorporated in EE. However, despite their seemingly close relationships, sustainability had not been a part of the vocabularies of environmental education until the 1990s (Tilbury,

1995). It was officially 5 years later than the Brundtland Report, in the United Nations Conference on Environment and Development (UNCED) staged in Rio de Janeiro, or the Earth Summit in 1992, that environment and development education were recommended to be incorporated in the education sector. This summit was another monumental conference for the future of the planet, being attended by 120 heads of state and government, and delegates from over 170 countries. *Agenda 21* was the centerpiece of the conference and set out as a major action plan that all participating nations had to commit to save our planet (The United Nations [UN], 1992). A proposal regarding environment and development is made in chapter 36 that: "Governments should strive to update or prepare strategies aimed at integrating environment and development as a cross-cutting issue into education at all levels within the next three years" (UN, 1992, p. 321).

Education for sustainable development, or also known as ESD, is generally perceived to have been launched from *Agenda 21* adopted in the Earth Summit in 1992 (Jickling & Wals, 2008; Hopkins, 2012; Agbedahin, 2019). According to Hopkins and McKeown (2002), the initial ideas pertaining to ESD were included in Chapter 36 of *Agenda 21*, "Promoting Education, Public Awareness, and Training" (UN, 1992, p. 320). Hopkins and Mckewon also suggested three priorities and corresponding details of ESD captured in Chapter 36 of *Agenda 21*: (a) Improving basic education: Higher literacy rates and skilled work forces have more development options; (b) Reorienting existing education: To develop an education in order to guide and motivate people to live in a sustainable manner by learning appropriate knowledge, skill, perspectives, and values; (c) Public understanding, awareness, and training: All sectors including

business, industry, universities, governments, and so on are motivated to train leaders when it comes to environmental management and to give training to their employees

Additionally, sustainable development discourse as well as ESD evidently started to be preferred over EE from this point (Knap, 2000; Kopnina, 2012). The term ‘environmental education’ was only once used in the recommendation to further sustainability set forth by *Agenda 21* (Agbedahin, 2019). Correspondingly, ESD has been even partly regarded as an improved version of EE (Robottom, 2007; Jickling & Wals, 2008)

While UNESCO was appointed as a major agent to promote and expand ESD within the UN system, each nation that signed *Agenda 21* has been held responsible in embedding ESD in its educational initiatives based on the partnership with UNESCO. However, the concept of ESD is too broad and holistic to reflect on diverse worldviews on the planet (Hopkins & McKeown, 2002; Madsen, 2013). To this end, it needs to be adjusted to each local’s context, in order to design locally appropriate relevant curriculum.

2.1.3. UNDESD: Global Initiatives to Promote ESD

In 2002, the United Nations Decade of Education for Sustainable Development (UNDESD - spanning from 2005 to 2014) was declared in the United Nations General Assembly (UNGA). According to Tilbury and Mulà (2009), DESD is a global platform which offers a chance for each country’s education officials and practitioners to introduce a sustainable development discourse into their education system. By doing so, UNESCO, the lead agency to

promote the Decade, was aiming for higher public awareness in ESD initiatives (UNESCO, 2004).

As for its outcomes, Hopkins (2014) identified three significant aspects, including, increasing the importance of ESD by the engagement of ministers of education at the UNESCO World Conference in Bonn in 2009, the emergence of ESD as a component of quality education, and instilling ESD as a purpose of education. In other words, the UNDESD is evaluated to have played a crucial role in distributing the basic concept and framework of ESD in each country's formal education with progressive approval of its government.

However, there are several scholars who expressed a negative evaluation of the achievements from the Decade. For example, Huckle and Wals (2015) argued that in spite of the Decade's idealistic rationale, it ended up failing to lessen the impact of neoliberalism associated with individualization and financialization (Brodie, 2007; Davis & Walsh, 2017). They criticized the Decade in a regard that the Earth Charter, which was first adopted in the Earth Summit in 1992 and launched in 2002, remained too vague about how the advocated values such as 'universal responsibility', 'human solidarity', and 'humility regarding the human place in nature' could be disseminated in practical ways. This critical view on the DESD would be a segue into the next part that is about criticisms and challenges over ESD.

2.1.4. Criticisms and Challenges over ESD

Despite ESD gradually becoming a representative international movement to expand sustainability, there have been several concerns over the consolidated ESD discourse. For instance, Jickling and Wals (2008) pointed out that the concept of globalization in ESD could be regarded as a step toward advocating powerful international bodies such as the World Bank, the World Trade Organization (WTO), and UNESCO. In fact, the World Bank and WTO have been criticized for imposing a set of neoliberal economic policies along with the International Monetary Fund (IMF) (Peet, 2009; Siddiqui, 2012).

Here, neoliberalism is defined as a form of political economy that is only for restoring class power of the global economic elite (Harvey, 2005). Considering its focus on free market and free trade by liberating entrepreneurship, it is obvious that neoliberalism has elevated the markets and profits above all the aspects. In this regard, neoliberalism considers to export the cost of environmental degradation (Hursh & Henderson, 2011). Therefore, ESD could paradoxically exacerbate existential environmental problems in the end.

Another criticism was addressed by Kopnina (2014), noting that ESD has promoted economic development and its re-distribution as parts of great solutions to the current environmental degradation,however, which she claimed is paradoxical as those solutions could overshadow environmental problems. In other words, ESD has often contributed to a conflation of ecological sustainability and economic growth that allows neoliberal marketplace worldview (Selby & Kagawa, 2010; Bonnett, 2013; Kopnina & Meijers, 2014; Washington, 2018). She also argued that various interpretations on sustainable

development have confused students as well as teachers in terms of the integration of ESD in the classroom (Kopnina, 2014). In the same vein, she pointed out that even sustainable development goals (SDGs) are assuming the decoupling of economic growth with resource consumption, hence ending up cementing a currently dominating paradigm of sustainability-through-growth (Kopnina, 2020a).

2.1.5. The Future of Sustainability Education

Now it is undeniable that we are living through a precarious time in the history of the planet. Despite diverse endeavors to improve sustainability on the planet, it is considered to be inherently complex and complicated to achieve. In order to cope with these wicked problems, innovation competency needs to be dealt with in learning processes (Sterling, 2009). For example, instead of following business as usual trajectories such as the traditional economic growth model, drastically different approaches to the problem would be more effective. To this end, Sandri (2013) suggested 'creativity' as a fundamental factor that both teachers and learners have to be equipped with, in order to foster sustainability through education.

Wals et al. (2017) proposed a future of sustainability education as follows: "that connects people and empowers people to make change and to live meaningful, dignified and responsible lives" (p. 5). According to them, an ESD discourse failed to embrace multiple perspectives, hence post-human and new-materialist perspectives (Alaimo, 2012) need to be reflected when envisioning the future of sustainability education. Correspondingly, a transition

from the anthropocene to the ecocene, in which ecological violence and environmental injustice are alleviated with the collective wisdom and interrelations, is needed in the education field for the sake of achieving sustainability in the future (Alaimo, 2012; Wals et al., 2017).

2.2. Sustainability Curriculum and Policy in each Country

In this part, general educational initiatives and policies to promote sustainability in Sweden and Korea are going to be illustrated. Considering this research aims to examine lower secondary school curriculum, the focus of illustration is limited to the case of compulsory school as well as the general description. In order to provide a context for understanding them, each country's representative socio-cultural and political aspects are also identified first.

2.2.1. Sweden

2.2.1.1. Socio-cultural and Political Tendencies

According to relevant literature, Sweden has some unique socio-cultural and political tendencies, as follows. Sweden has built up a strong modern welfare state since the social reform started in the 1930s by the Social Democrats (Lundberg & Åmark, 2001). With respect to decision-making processes, Sweden has generally had a culture of consensus since the milestone Saltsjöbaden Agreement[1] in 1938 (Petersson, 1991). Sweden has been highly reputed for its emphasis on equal rights and individual freedom which affects economic and

[1] A Swedish labor market treaty signed between the Swedish Trade Union Confederation and the Swedish Employers Association on 20 December 1938, that became a model for other agreements ("Saltsjöbaden Agreement", 2022)

political decisions (Cars & West, 2015). In the early stage of industrial development, Sweden depended mainly on agriculture, mining, and forestry, and had a consistent cultural tradition of concern for nature, forest, the sea, and so on (Blomström & Kokko, 2007; Breiting & Wickenberg, 2010). In addition, outdoor activities and interest in nature have been considered the national identity (Sandell & Öhman, 2010; Gericke et al, 2020). Finally the Swedish school system was established in 1962 by the Swedish Parliament, with comprehensive, compulsory, and basic education for every child for 9 years.

General perception of Sweden as a prime model of the strong welfare state notwithstanding, there have been several signs of changes since the 1980s that dismantled socialist policies previously secured by ruling Social Democrats (Svensson, 2002). According to Svensson (2002), and Lindvall and Rothstein (2006), globalization and marketization in Sweden caused a shift in political power and the fall of the strong state. Instead, there have been growing demands for decentralization and individual choice. Blyth (2001) pointed out that the evolution of neo-liberal economic ideas has influenced the transformation of the Swedish model. In line with this, Mulinari and Neergaard (2010) claimed that neoliberal thoughts caused the transition towards a regime characterized by a neo-assimilationist and racialized social cohesion promotion. As a result, the pressure of neoliberalism has impacted even on the erosion of 'exceptional' citizenship in Sweden, which has been known as a model of tolerant, egalitarian, welfare state even for immigrants that account for around 20 percent of the population (Schierup & Ålund, 2011). However, in the wake of major challenges threatening humanity such as migration, climate change, and the Covid-19

pandemic, there have been discussions of implementing more regulatory governance in Sweden, apart from neoliberalism (Elander et al., 2022).

2.2.1.2. Integration of Sustainability in School Education

When it comes to sustainability education, Sweden has been one of the leading countries that have successfully integrated the global framework of ESD into the formal education system through curriculum, teaching methods, and so on (Breiting & Wickenberg, 2010; Cars & West, 2015). Besides, Sweden is the biggest donor country to UNESCO, which naturally includes policy support in ESD (The Ministry of Education and Research in Sweden, 2022). The Swedish government established the Swedish International Centre of Education for Sustainable Development (SWEDESD) in 2008, aiming for research and education on learning for sustainable development and global health. Also, eco-certified citizens, who are set up with essential knowledge and needed personhood for environmental problems, have been efficiently fabricated through the national curriculum in Sweden (Hillbur et al., 2016). Indeed, in the current Swedish National Curriculum for compulsory school (Lgr 11), sustainable development (SD) is clearly treated as one of fundamental values and overall goals (The Swedish National Agency for Education, 2018). The Ministry of Education and Research in Sweden (2021) also reported that "ESD is incorporated into regulations at all levels of the Swedish education system" (p. 2). Although the concept of SD is not contained as an independent subject in the Swedish school system, it is clearly incorporated in the description of all subjects in the curriculum (Boeve-de Pauw et al., 2015). Accordingly, teachers are

expected to incorporate sustainability themes in the classroom, hence, students are required to train their competence for the future.

2.2.2. South Korea

2.2.2.1. Socio-cultural and Political Tendencies

Korea has a relatively short modern history compared to that of Sweden. In fact, Korea is considered to have a remarkable industrial development success in world history (Cumings, 1984). It is needless to say, this rapid economic growth since the 1960s has contributed to rapid changes in social dynamics. Korea has generally developed a series of characteristics reflecting on this trend as seen in Table 2.1.

Table 2.1

Factors Impacting Economic Growth that also Influence Social Dynamics

Factor	Impact on social dynamics
Chaebol system	Economic development in Korea is based on the non-Western state-driven model (e.g. the national development strategies) with the *chaebol*[2] system (Murillo & Sung, 2013)
Divided Country	Since the Korean War, South Korea and North Korea have been separated for nearly seven decades
Focus on research and development innovations	Korea is one of the most innovative countries in the world with outstanding performance in the research and development (R&D) sector (Dayton, 2020). For instance, Korea topped the 2021 Bloomberg Innovation Index (Jamarisko et al., 2021)
Transition from authoritarian regime to democracy	There were democratization movements from 1980 through 1987, and Korea officially started the process of transition from authoritarian regime to new democracy with the revised constitution in 1987 (Lee & Moon, 1995; Im, 2004)

[2] A large industrial South Korean conglomerate run and controlled by an individual or family ("Chaebol", 2022)

Post-war development of education system	After the Korean War, the Korean education system started to be established after the U.S. system. Afterwards, elementary education for six years was mandated in the 1950s, and the compulsory education was extended by another three years (lower secondary) in 1985
Instability of global market on economy	Drive towards globalization by the government started in the 1990s. In the wake of the financial crisis in 1997, globalization was heavily implemented in Korea through exposure of Korea's economy to the global market (Cotton et al., 2000; Kim & Kim, 2003)
Growing generational divide	Intensifying generational conflict issues are quite prevalent in Korean society: generational power conflict; ideological conflict; cultural conflicts (e.g. economic growth with top priority vs consumerism, collectivism vs individualism) (Park, 2010)

Whereas some of these factors have led to compressed modernization of Korea, Korean society has suffered from several side effects, such as intergenerational conflict and education fever influenced by these abrupt social changes (Seth, 2002; Chung & Jung, 2014). Given that these factors have had an impact on the education system, it is helpful to provide more sociocultural context to understand the results presented in this study.

2.2.2.2. Integration of Sustainability in School Education

In terms of sustainability education, it is assumed that Korea has properly complied with initiatives of ESD by the UN (C. Kim, 2017). For example, the Presidency Commission on Sustainable Development (PCSD) was set up in 2000 (the commission was moved into a part of the ministry of environment later in 2010) in order to oversee sustainable development of the country. In line with this, in the wake of the promotion of UNDESD, the national promotion plan on

ESD was developed by PCSD in 2005 (Lee et al., 2005). Meanwhile, so-called 'Green Growth Education (GGE)' was promoted as a part of ESD by the government from 2008, and it has heavily influenced ESD trends in Korea (C. Kim, 2017). However, Yoo et al. (2013) pointed out that the GGE focuses on the harmony between economy and environment, whereas ESD is for the transition of the entire planet from economic, societal, and environmental perspective. After all, it might lead to a reduction in the meaning of sustainability education.

Kim et al. (2020) examined the integration of sustainability in the current national curriculum. According to them, with less emphasis on sustainability mainly being educated through cross-subjects rather than individual subjects, anthropocentric perspective is dominantly described. They suggested that inclusion of an ecological view would be needed for the sake of proper sustainability education.

Meanwhile, Oh et al. (2010) investigated the embedment of the concept of sustainable development in middle school science curriculum (2007 revised version). This study showed that the expression of 'sustainable development' was not adopted in the document, although some chapters included the sustainability related content. It was reported in the research that 'sustainable development' needs to be stated through the science curriculum, and appropriate content or learning programs with regard to sustainable development are required to be developed in order to cultivate core competency such as problem-solving and communication skills.

2.3. Comparative and International Education

This research is basically based on comparative and international education on two countries' curricula - Sweden and Korea. In this part, an overview and a general comparative inquiry used in the comparative and international education field are going to be introduced. Also, in order to help this research to have balanced perspectives, several challenges that comparative and international education have faced need to be reviewed. Hence, those challenges will be illustrated in the last paragraph.

2.3.1. Overview

To define international comparative research, Hantrais (2008), started with the widely accepted definition of comparative research, saying: “to describe studies of societies, countries, cultures, systems, institutions, social structures and change over time and space, when they are carried out with the intention of using the same research tools to compare systemically the manifestations of phenomena in more than one temporal or spatial sociocultural setting” (p. 2). In line with this, international comparative research needs individuals or groups to compare specific issues in two or more countries, she attached. Curriculum could be one of those issues in comparative research, and Crossley and Watson (2003) identified three benefits of comparative studies in curricula comparison: giving a better comprehension of the different curricula, clarifying similarities and differences, and improving global understanding of diverse cultures. Indeed, various stakeholders such as governments have attempted comparisons of

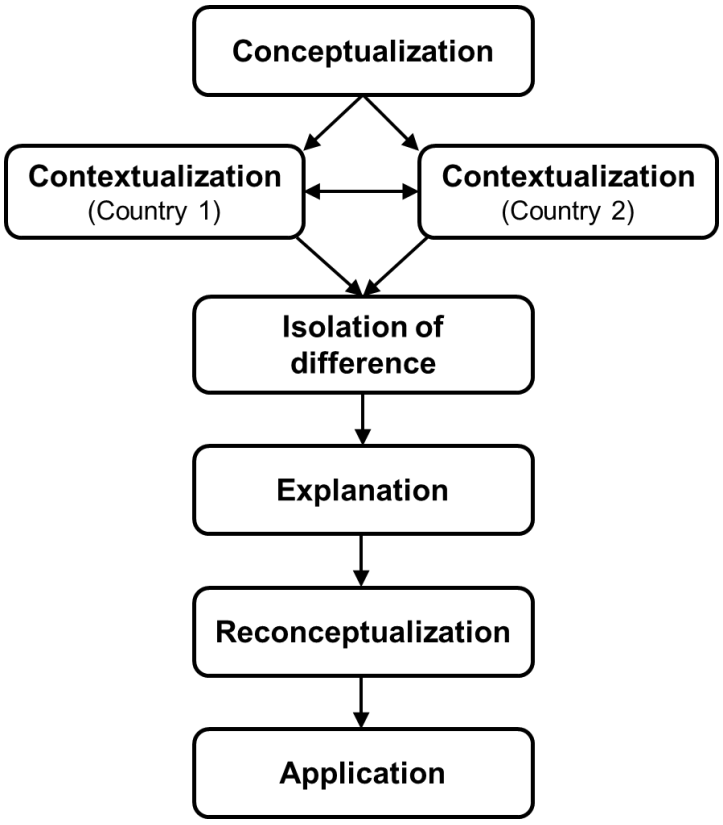
curricula so as to find new initiatives or strengthen global competitiveness (Adamson & Morris, 2014).

2.3.2. General Comparative Inquiry

Phillips and Schweisfurth (2014) developed a structure for comparative inquiry which reflects Bereday's (1967) concept of 'juxtaposition', meaning the process of establishing similarities and differences (See Figure 2.1).

Figure 2.1

Model for Comparative Inquiry



Note. Adapted from Phillips & Schweisfurth (2014)

In the first stage (*conceptualization*), the research questions are identified by neutralizing them from any specific context. The second stage (*contextualization*) includes a detailed illustration of educational phenomena (e.g. 'curricula' in this research) examined in the context of each country's culture, history, policy, religion, and so on. Bereday's (1965) concept of juxtaposition is very informative in this stage. The third stage (*Isolation of difference*) comprises an investigation of isolating differences through direct comparison based on the collected data. The fourth stage (*explanation*) involves explanation through the development of hypotheses that come from the previous stage. Lastly, the fifth (*reconceptualization*) and final stage (*application*) seeks the applicability or implications to other situations.

2.3.3. Difficulties and Challenges

One of the most generally acknowledged difficulties in comparative and international education is potentially biased interpretation (Crossley & Watson, 2003). According to them, researchers in the field need to be conscious about potential biases and preconceptions given that we are all conditioned by various aspects of the society we live in, including culture, upbringing, education, politics, our status, and so on. On the other hand, several studies pointed out biases on the direction or the result of the research might occur in accordance with research funding sources or political power (Crossley & Watson, 2003; Tan, 2015).

The impact of increased globalization is also often cited as a challenge of comparative and international education (Crossley, 2002). Here are some aspects of this challenge that he claimed. The first one is that research on the impact of globalization on the poorer, so-called South or nations needs to get more attention amid main focus having been upon either Western societies or newly industrialized East Asian countries in the field. For instance, Tikly (2007) pointed out that studies on low income countries generally lacked theoretical backgrounds and were often limited to illustrate the impact of economic globalization.

Another aspect of the challenge stemming from the impact of increased globalization is friction between local and global perspectives. There have been criticisms over the tendency to implement global but over-generalized solutions to local education problems (Crossley, 2002; Crossley & Watson, 2003). For example, Dyer (2001) reported the case of Rabaris[3] of India, who have been nomadic farmers for generations, so as to how international education movements such as *Education for All* (EFA) has complicated the lives of the local community. In the wake of the significant movement of EFA, the Indian government has promoted formal education to all their people. As a result, a new generation of Rabaris are turning back to their traditional nomadic lives and pursuing lives in town, although the Rabaris of India have maintained a skillful lifestyle on lands in an ecologically harmonious way. In order to generate new insights to address this issue, Torres et al. (2022) proposed the dialectic of the

[3] Rabari is an ethnic group from the Rajasthan also found in Gujarat Kutch region in India ("Rabari", 2022)

global and the local as a lens to practice a global-local interplay, insisting local effects of globalization also need to be prioritized in the research. In a similar vein, Bray (1999) suggested an approach to place the global and the local on a continuum between centralization (an internationalizing force) and decentralization (a localizing force). With this framework, both forces are able to play a complementary and competitive role to each counterpart, he assumed.

2.4. Framework for Interpretive Analysis of Sustainability in Curricula

To answer some part of the research questions, interpretive analysis of sustainability in two country's curricula with socio-cultural lens is practiced, as is going to be described in the next chapter. The research by Weldemariam et al. (2017) provides a template for interpretively analyzing the selected curricula. Their research compared five countries' (Australia, England, Norway, Sweden, and the USA) early years national curricula in the consideration of four aspects: presence of sustainability; view of child; human-environment relationship; and philosophical and theoretical underpinnings (See Table 2.2 to check details). Unlike their basic study by Ärlemalm-Hagsér and Davis (2014), they evoked both explicit and implicit concepts of sustainability whereas the previous research only focused on the explicit inclusion of sustainability in curriculum. Moreover, Weldemariam et al. (2017) added several new points of analyses such as human-environment entanglement and theoretical / philosophical underpinnings. By doing so, the researchers tried to expand their perspectives

beyond anthropocentrism and give implications for sustainability in curriculum. For instance, the concept of entanglement stands critical viewpoints toward anthropocentrism, implying an ontological requirement that finds inextricably intertwined relationships between nature and humans (Taylor, 2017).

Table 2.2

Four Themes to Critically Analyze Sustainability in Curriculum Adapted from Weldemariam et al.'s (2017) Framework

Theme	Description
Presence of Sustainability	- Both explicit and implicit manifestation of sustainability in curricula - Explicit language: sustainability - Implicit languages: environmental education, ecological approach, biodiversity, social diversity, recycling, and so on
View of the Child	- Children are situated as major stakeholders and actors in the effort towards a sustainable society - Additional focus on agency of more-than-human world and the intricate rationality between the two - Examination on curriculum "utterance" referring to the child
Human-Environment Relationships	- Interconnection between humans and the physical environment and culture - Entanglement rather than environmental stewardship - Examination on curriculum "utterance" referring to human-environment/nature-culture relationships
Philosophical and Theoretical Underpinnings	- Theoretical and philosophical assumptions are critical in shaping the worldview, the values, and the onto-epistemological underpinnings ingrained in curriculum - To reimagine our view on learning for sustainability and to get to know how the notion of sustainability is constructed

In this research, the above framework is used in the interpretive content analysis for the following reasons. First, it reflects on enduring critical perspectives on anthropocentrism which is considered to be one of main contributors to the current climate breakdown. Given that education for sustainable development (ESD) has been criticized for ending up cementing the current paradigm of sustainability-through-growth (Kopnina, 2020a), a critical approach needs to be adopted to grant balanced implications of integrating sustainability in curriculum. Second, several researchers such as Li et al. (2019) and Ohlsson et al. (2022) used this framework in their comparative studies about integration of sustainability in curriculum. Third, the result of the analysis by this framework can be easily recognized with a table or a continuum-based approach in the summarizing process.

Chapter 3. Methodology

With regard to the present study, it sought to comparatively analyze sustainability in compulsory school science curricula of Sweden and Korea. To this, the national curriculum documents of both countries were examined with proper frameworks. In this chapter, the methodologies used in this dissertation are presented. Firstly, the research design of the thesis is described together with a brief introduction of the methods used here. Secondly, main methodologies are illustrated in more detail with other example studies adopting these methodologies. Data analysis steps are presented followed by detailed information about data sources. In the last section, description of the process to secure reliability and validity is given.

3.1. Research Design and Overview

The intent of the present research was to examine the difference of how sustainability is integrated in the selected curriculum. The national curriculum of both countries were chosen and to be investigated - the first one is the Swedish Compulsory School Science Curriculum (revised in 2018) for grades 7th to 9th, and another one is the Korean National Science Curriculum for the Secondary Schools (revised in 2015). Based on a model for comparative inquiry suggested by Phillips and Schweisfurth (2014), two research questions were answered, and implications of this research were suggested (See Table 3.1).

Table 3.1

Comparative Inquiry Process Used for this Research

Process	Correspondence to this research
Conceptualization	Four research questions are formulated in the introduction part
Contextualization of each country	Answers to question 1 by establishing similarities and differences (juxtaposition)
Isolation of Difference	Answer to question 2 by describing similarities and differences between both curricula
Explanation	Described in conclusion part
Reconceptualization	Described in implications and needs for future studies
Application	

Two research questions framed the inquiry for this comparative analysis study.

1. How is sustainability reflected quantitatively and qualitatively in Sweden's and Korea's national science curriculum?
2. What are the similarities and differences in how sustainability is reflected in Sweden's and Korea's national science curriculum?

Given that answers to the research questions required direct analyses of curricula in light of sustainability, content analysis was an appropriate tool in this research. As the first question includes both quantitative and qualitative analysis of reflection of sustainability in the curriculum, a two part answer was needed - one was a frequency count (quantification), and another was a qualitative interpretation. Therefore, different branches of content analysis were adopted respectively. Analysis was conducted by applying rubrics, and the results were

shown in corresponding tables. More details about similarities and differences coming out of the results were illustrated in the following parts as an answer to the second research question. Additionally, several socio-cultural factors that have greatly informed the development of both societies are explained in the last chapter of the thesis by using relevant academic articles to give context for the differences between both curricula. Finally, implications for lower secondary school science education will be also suggested at the end of this thesis.

3.2. Content Analysis

Content analysis is a structural research method that is generally defined as a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use (Drisko & Maschi, 2016; Krippendorff, 2018). Tamir (1985) claimed that this strategy could contribute to the curriculum research and evaluation, and textbooks analysis, as the scope and the image of the subject can be acquired efficiently. Indeed, content analysis has been carried out in various studies to evaluate curricula of several subjects at a diverse level, in several countries (Kitila, 2009; Bjørnsrud & Nilsen, 2011; O'Donoghue et al., 2011; Bereczki, 2016). Also, a few studies attempted to assess sustainability in various documents such as relevant journals and business reports (Mallen et al., 2011; Landrum & Ohsowski, 2018). Meanwhile, there are three kinds of content analysis as a research methodology: Basic content analysis, interpretive content analysis and qualitative content analysis (Drisko & Maschi, 2016). Among them, basic and interpretive content analysis were employed in

this research. Basic content analysis is an approach using quantitative methods such as words/phrases counting to analyze data (Drisko & Maschi, 2016). Quantitative criteria for counting sustainability was used to help this research be more objective and transparent. On the other hand, interpretive content analysis goes beyond the quantification of explicit content. This approach focuses on summaries and interpretations generated by researchers rather than quantification, with enhancing transparency and systemization while objectivity is not necessarily assumed (Ahuvia, 2001; Drisko & Maschi, 2016). In the present research, this method was adopted in order to ensure consistency in how sustainability is described in both curricula.

3.3. Data Sources

In this chapter, detailed information about data sources is demonstrated. As previously stated, the national science curriculum documents of Sweden and Korea were used as the main sources. Throughout this chapter, structures of curriculum are illustrated with brief overall explanations of the school system and the national curriculum documents of two countries.

3.3.1. Swedish National Science Curriculum

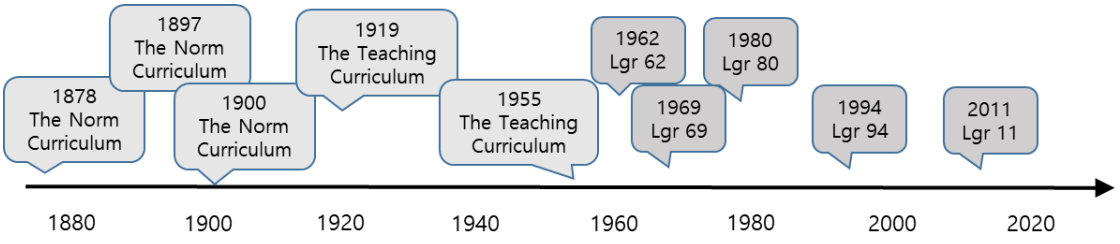
The Swedish Education Act mandates that children go to school for at least 10 years from the year they turn six. Swedish compulsory schooling consists of four stages: *förskoleklass* (‘preschool year’ or year 0), *lågstadiet*

(years 1–3), *mellanstadiet* (years 4–6) and *högstadiet* (years 7–9). According to relevant statistics, the enrollment rate of primary school age children in Sweden is 99.6% in 2015 and 99% for secondary complete rate in 2016 (Sweden Education Statistics, n.d.; The World Bank, 2020).

In Sweden, since the general curriculum was first established in 1878, there have been several revisions and changes including the introduction of the first national curriculum for compulsory school in 1962 (Lgr 62) (See Figure 3.1). The current curriculum (Lgr 11) was implemented in 2011 with the most recent revision applied in 2018 (the official document name: 'Curriculum for the compulsory school, preschool class and school-age educare 2011 (Revised 2018)') (The Swedish National Agency for Education, 2018). This newest version of the curriculum document was used in this thesis. As the English version of the official curriculum was also published by the authority, there was no need to translate from Swedish to English. (https://www.skolverket.se/download/18.31c292d516e7445866a218f/1576654682907/pdf3984.pdf)

Figure 3.1

Timetable of Changes in the Swedish National Curriculum



The curriculum document for compulsory school is mainly divided into three sections: fundamental values and tasks of the school, overall goals and guidelines, and syllabuses. Among them, the focus of the present research is on the syllabuses. Syllabuses are the most extensive part of the curriculum, which describe three parts: aim, core content and knowledge of all school subjects. The aim is for all grades of compulsory school, from one to nine. And the core contents are defined for every three school years: one-three, four-six, and seven-nine with four learning areas of '*the subject name* (e.g. *Chemistry*) in nature society', '*the subject name* and everyday life', '*the subject name* and world views', and '*the subject name*, its methods and ways of working'. Among these four learning areas of the core content in the Swedish curriculum, 'its methods and ways of working' was excluded in the basic content analysis, which is a part of answer to the first research question, as this does not describe the learning content itself (it is rather equivalent to 'instructional methods' of the Korean curriculum, which is described afterwards). The total number of core content of all science related subjects for the basic content analysis is 53. Lastly, knowledge requirements are presented for school years three, six, and nine.

In the curriculum from 2011 (Lgr 11), Swedish science education is separated into three subjects: Biology, Physics, and Chemistry. And all the students are required to take the same science courses. Hence, in the syllabuses part of the curriculum document, these three subjects were chosen for this study.

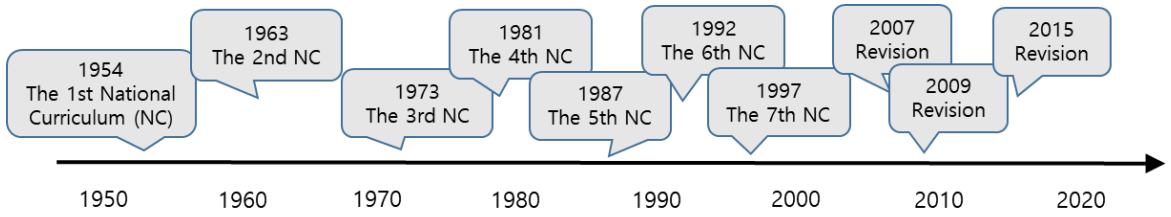
3.3.2. Korean National Science Curriculum

The Korean school education system operates on 6-3-3-4 basis, with six years of elementary school, three years of middle school, three years of high school, and four years of university. Among them, nine years of education including both elementary and middle school are compulsory. The primary school enrollment rate in Korea was 98.5% in 2015, and 96.7% for secondary completion rate in 2019 (Korea School Enrollment, n.d.; The World Bank, 2022).

In Korea, there have been nine main revisions and changes in the national curriculum since the first national curriculum was introduced in 1954 (See Figure 3.2). The current curriculum was introduced in 2015 (the 2015 Revision), and this newest version was used in this research (http://www.ncic.go.kr/mobile.dwn.ogf.inventoryList.do#). Considering the fact that the Ministry of Education in Korea does not offer the English version for the curriculum of each subject, it was necessary to translate targeted sentences to English for presentation in this thesis.

Figure 3.2

Timetable of Changes in the Korean National Curriculum



The official document of science curriculum includes three divisions: the common curriculum, the electives centered curriculum for common courses, and the electives centered curriculum for elective courses. Among them, the common curriculum contains content for learning in middle school (equivalent to grades seven to nine). Hence, corresponding parts in the common curriculum were targeted in this research. Curriculum documents of each subject, which correspond to the syllabuses in the Swedish curriculum in this research, describe four parts: characteristics, objectives, educational contents, and instructional methods/evaluation. Here, characteristics and objectives are described in the introduction section of each subject. Also, educational contents in the Korean science curriculum, which consists of 92 items for middle school, are regarded the same as the core contents of the Swedish curriculum in this study. Meanwhile, all the branches of science subjects are integrated under the name of 'integrated science', whereas biology, physics, and chemistry are independently described in the Swedish curriculum. The features of both curricula are briefly organized in Table 3.2.

Table 3.2

Descriptions of Data Sources

Data Sources	Descriptions
Swedish National Curriculum (Lgr 11)	- Implemented in 2011, and revised in 2018 - An official English version document - Science subjects: Biology, Physics and Chemistry - Focus on the Syllabuses - Three parts in syllabus of each subject: Aims, Core content, and Knowledge requirements - Core content for quantitative analysis: Biology 13, Physics 21, Chemistry 19 - 53 in total

Data Sources	Descriptions
Korean National Curriculum (2015 Revision)	- Implemented in 2015 - All branches of science related subjects are integrated into one subject named ‘common science’ - Focus on the middle school common science curriculum content - Four parts in selected curriculum: Characteristics, Objectives, Educational content, and Instructional methods/Evaluation - Educational content for quantitative analysis: 92 in total

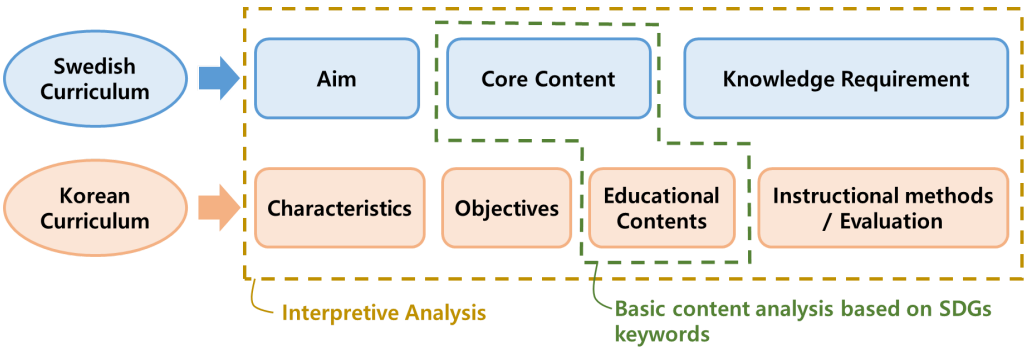
3.4. Data Analysis

In this research, both basic content analysis and interpretive content analysis were employed in order to answer the research questions efficiently. As for the basic content analysis, the rubric based on the process of finding keywords from the UN’s sustainable development goals (SDGs) served as a tool to assess sustainability in both curricula. As stated in the literature review, education in both countries has been generally influenced by the concept of ESD. In this regard, the ESD related concept of SDGs could be used in the analysis of sustainability in the curriculum. On the other hand, another rubric using the framework developed by Weldemariam et al. (2017) was adopted for a coding process to interpretively examine sustainability described in the curriculum.

More detailed information on which parts of the curriculum were chosen for each analysis is illustrated in Figure 3.3. Both core content from the Swedish curriculum and educational contents from the Korean curriculum were used in the basic content analysis, and all the targeted content in both curricula adopted in this research were to be interpreted with the relevant framework (interpretive content analysis).

Figure 3.3

Overview of Content Analysis in the Present Research



Subsequently, socio-cultural aspects which are considered to lead to differences from above analyses are going to be proposed in the final chapter. In the end, implications for science education will be suggested.

3.4.1. Rubric for the Basic Content Analysis

According to Fay et al. (2007), a rubric contains a set of categories which frame a series of evaluation criteria. To this end, main categories and criteria come from SDGs in this research to assess the frequency of the sustainability presence in core content (Sweden) / educational contents (Korea). SDGs were adopted by the United Nations in 2015, and are defined as “a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity” (UNDP, n.d, para.1). SDGs consist of 17 interconnected goals, and cover three dimensions of sustainable development: economy, society, and environment (UN, n.d.-a). In the basic content analysis, the frequency at which SDG-related content appears was quantified when targeted sentences include keywords of each sustainable development goal and explicitly represent

sustainability. As a reference to the search, keyword examples of 17 SDGs provided by the Sustainable Development Solutions Network (SDSN) are presented with descriptions of each goal in Table 3.3. While the keyword search approach helps discover critical information, it needs to be implemented carefully due to the potential of providing irrelevant information from multi-meaning words (Mori et al., 2019). In order to avoid this failure, the content for each targeted sentence including the SDGs keywords must be critically examined. For example, even if a certain sentence included a keyword, but if the meaning did not relate to the concept of sustainability, that sentence was not counted. Plus, if a certain keyword was represented in multiple goals (e.g. sustainability), it was necessary to comprehend the context of each sentence in order to help to make valid counts. Lastly, reliability and validity of the present research were established, which is going to be described in chapter 3.5.

Table 3.3

Descriptions and Keyword Examples of Sustainable Development Goals

Goal	Descriptions	Keyword Examples
1	End poverty in all its forms everywhere	Africa, Basic services, Class, Developing countries, Disadvantaged, End poverty, Environment, Equality, Extreme poverty, Poor, Poverty, Vulnerable
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Agricultural productivity, Crop, End hunger, Food security, Genetic diversity, Hunger, Nutrition, Poverty, Productivity, Stunting, Sustainable agriculture, Wasting
3	Ensure healthy lives and promote well-being for all at all ages	Affordable medicine, AIDS, Air pollution, Contraceptive use, Death rate, Family planning,

Goal	Descriptions	Keyword Examples
		Healthy, Improving mortality, Mental health, Reducing mortality, Sexual health, Vaccines
4	Ensure inclusive and equitable education and promote lifelong learning opportunities for all	Access to education, Basic literacy, Education, Gender equality, Global citizenship, International cooperation, Literacy, Universal education
5	Achieve gender equality and empower all women and girls	Discrimination, Equal opportunities, Feminism, Gender, Human rights, Violence, Women
6	Ensure availability and sustainable management of water and sanitation for all	Accessible water, Drought, Ecosystem protection, Floods, Hydro power, Irrigation, Recycled water, Rivers, Sanitation, Wastewater, Water
7	Ensure access to affordable, reliable, sustainable, and modern energy for all	Battery, Carbon, Clean energy, Climate goal, Coal, Electricity, Emissions, Energy efficiency, Fossil-fuel, Greenhouse gas, Renewable energy, Solar power, Wind power
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Banking, Economic growth, Enterprises, Global trade, Innovation, Stable jobs, Sustainable consumption, Sustainable economic growth, Work opportunities
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Clean technologies, Electrical power, Industrialization, Infrastructure, Sanitation, Technology, Water resources
10	Reduce inequality within and among countries	Age, Culture, Disabilities, Discrimination, Equal opportunity, Equity, Indigenous, Poverty, Social protection
11	Make cities and human settlements inclusive, safe, resilient and sustainable development	Adaptation, Air pollution, Climate change, Disaster management, Housing, Pollution, Population, Resilient, Resource efficiency, Transport, Waste, Water
12	Ensure sustainable consumption and production pattern	Capitalism, Consumption, Energy consumption, Food supply, Food waste, Natural resources, Recycling, Sustainable, Waste, Water pollution
13	Take urgent action to combat climate change and its impact	Average global temperature, Carbon dioxide, Climate, Ecosystems, Emissions, Global warming, Greenhouse gas, Natural disaster,

Goal	Descriptions	Keyword Examples
		Pollution
14	Conserve and sustainable use the oceans, seas and marine resources for sustainable development	Biodiversity, Coastal ecosystem, Ecosystem management, Fishing, Marine, Ocean, Water resources
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Animals, Biodiversity, Deforestation, Drought, Ecosystems, Forest, Land conservation, Land degradation, Poverty, Reforestation, Soil, Species, Tree
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Abuse, Conflicts, Corruption, Discrimination, Education, Equity, Exploitation, Freedom, Human rights, Inclusion, Justice, Peace, Sexual abuse
17	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	Civil society partnerships, Global partnership, International cooperation, International supports, Knowledge sharing, Poverty eradication, Technology cooperation agreements

The United Nations (UN). (n.d.-c). *The 17 Goals*. https://sdgs.un.org/goals

Sustainable Development Solution Network (SDSN). (n.d.). *Compiled Keywords for SDG Mapping*. https://ap-unsdsn.org/wp-content/uploads/2017/04/Compiled-Keywords-for-SDG-Mapping_Final_17-05-10.xlsx

Given that every sentence did not include the same sustainability level, it seemed to be reasonable to measure the level of sustainability presence within the targeted sentences. Here, three levels of presence were considered - low, medium, and high. Scales were determined depending on how importantly the sentences are describing sustainability.

An example of rubric for basic content analysis which takes into consideration every element described in this chapter is shown in Table 3.4. Examples of analysis using this rubric are indicated in Table 3.5.

Table 3.4

Example of Rubric for Basic Content Analysis

Core content / Educational contents	SDG number	Scale		
		1=Low presence	2=Medium presence	3=High presence

Table 3.5

Examples of Basic Content Analysis of the Present Research

Core content / Educational contents	SDG number	Scale		
		1=Low presence	2=Medium presence	3=High presence
Impact of people on **nature**, locally and globally. Opportunities for **consumers** and citizens of society to contribute to **sustainable development**.	12			O
Models in physics to describe and explain the earth's radiation balance, the **greenhouse effect** and **climate change**. (p.180)	7		O	

As presented in the above examples of the analysis, the words (or phrases) that presented sustainability were bolded and underlined. Also, selected sentences corresponded to the SDG numbers according to their content. Lastly, a standard was applied to measure presence as follows: if more than 80% of content within the sentence presents sustainability, the scale was 3 (High presence); if the percentage was 30-80%, the scale was 2 (Medium presence); if the percentage was less than 30%, the scale was 1 (Low presence).

The reflection on sustainability was calculated and presented in percentages (%). The formula adopted here is illustrated as follows:

Reflection rates on sustainability (%)

= Sum of presence scale / (total number of the content X 3)

For example, if there are four learning content with high presence, one content with medium presence, and two content with low presence, out of total 20 learning content, the reflection rate is calculated as follows: (4 X 3 + 1 X 2 + 2 X 1) / (20 X 3) = 26.7 %.

3.4.2. Rubric for the Interpretive Content Analysis

Based on the literature review, a framework developed by Weldemariam et al. (2017) was used for the interpretive content analysis. All the sentences in targeted parts of both curricula were investigated in the light of four themes: presence of sustainability; view of child; human-environment relationship; and philosophical and theoretical underpinnings. Among the above four aspects, 'view of child' was converted to 'view of student', given that this research is targeting curricula for lower secondary students. The description of 'view of student' remained almost the same as that of 'view of child' displayed in Table 2.2, with substitutions of 'the child' or 'children' with 'the student' or 'students' in it.

Hence, the new description of 'view of student' is as follows: Students are situated as major stakeholders and actors in the effort towards a sustainable society. There is additional focus on the agency of a more-than-human world and the intricate rationality between the two. And finally, an examination on curriculum "utterances", meaning any time there is reference to the student. An example rubric for interpretive content analysis was made using these four aspects, and presented in Table 3.6.

Table 3.6

Example of Rubric for Interpretive Content Analysis

Aspects	Content description	Interpretation

3.5. Reliability and Validity

Reliability indicates the consistency of the result in each test, and validity means the degree to which a scale accurately measures what it is expected to measure (Fitzner, 2007; Bannigan & Watson, 2009). In the present research, reliability was established by inter-rater agreement (IRA), and validity was ensured by the content validity. IRA indicates the degree to which multiple evaluators using the identical rating scale give the same rating to the same objective (Graham et al., 2012). Here, two experts (one in science education, and one in environmental education) and the researcher of this study joined as raters in the process of IRA. The raters were given the chosen sentences with corresponding SDG numbers, a list of 17 SDGs and the following 169 targets, and the keyword list. They were required to rate the level of sustainability presence according to the applied standard that is stated in chapter 3. 4. 1. In case of disagreement on the rating, the online meeting was held in order to share raters' opinion and reach agreement.

Content validity regards whether a scale has covered the relevant or excluded irrelevant items when it comes to its content (Sireci, 1998; Bannigan & Watson, 2009). A critical review by experts for completeness and clarity is done to establish content validity, and at least five experts in relevant fields are useful to estimate validity (Yaghmaie, 2003; Bannigan & Watson, 2009). Hence, five

experts were invited - two from science education and three from environmental education.

In the basic content analysis, content validity was estimated for selected sentences about whether they are relevant to sustainability or not, and experts were also asked to indicate whether they agree with the determination of the number of the SDGs of those sentences. Subsequently, IRA was practiced as described in this chapter. The percentage of absolute agreement in this procedure is 76.4%, which met the level considered to demonstrate a justifiable level of agreement (75-90%) (Hartmann, 1977; Stemler, 2004). In the interpretive content analysis, the experts were requested to assess if the targeted sentences adequately corresponded to one of four aspects in the framework.

Chapter 4. Results and Discussions

In this chapter, the results of the content analyses practiced in this research are displayed with the discussion of each result. An answering process to the first research question is twofold: a frequency count and interpretation. In the first part, the frequency of the sustainability presence will be illustrated through the result of the basic content analysis. In the second part, the interpretation of how sustainability is integrated in both curricula will be described through the interpretive content analysis. In both parts, the discussion will be followed in order to clarify similarities and differences, which is the answer to the second research question.

4.1. Basic Content Analysis of Sustainability in Both Curricula

The result of quantification in both curricula through the basic content analysis is shown in Table 4.1. The sustainability indicating keywords in selected sentences are highlighted with underline and bold in the table. Subsequently, the frequency of each goal integrated in the sentences from both curricula is illustrated in Figure 4.1. Additionally, proportions of each goal (upon reflecting on presence scales) ingrained in the targeted parts of each country's curriculum are displayed in Figure 4.2, respectively.

Table 4.1

Result of Basic Content Analysis

Country	Core content (Sweden) / Educational contents (Korea)	SDG number	Presence Scale (Low-1, Med-2, High-3)
Sweden	Impact of people on **nature**, locally and globally. Opportunities for **consumers** and citizens of society to contribute to **sustainable development**. (p.169)	12	3
	Biological diversity, and factors threatening and favoring this. Public discussions on **biological diversity**, such as in the relationship between forestry and hunting. (p.169)	15	3
	Local **ecosystems** and how they can be studied from an **ecological perspective**. Relationships between populations and **resources** available in **ecosystems**. The local **ecosystems** in comparison with regional or global **ecosystems**. (p.169)	15	3
	How **physical and mental health** is affected by sleep, diet, exercise, social relationships and addictive substances. Common **diseases** and how they can be prevented and treated. Viruses, bacteria, infection and the spread of infections. Antibiotics and resistant bacteria. (p.170)	3	3
	Human sexuality and reproduction, and also questions concerning identity, **gender equality**, relationships, love and responsibility. Methods for preventing **sexually transferable diseases** and unwanted pregnancy at individual and global levels, and from a historical perspective. (p.170)	5	3
	Energy flows from the sun through nature and society. Some ways of storing **energy**. Different types of **energy** quality, and their advantages and disadvantages in relation to the **environment**. (p.180)	7	1
	Models in physics to describe and explain the earth's radiation balance, the **greenhouse effect** and **climate change**. (p.180)	7	2
	Supply and **use of energy** historically and currently, as well as possibilities and limitations in the **future**. (p.180)	12	2

Country	Core content (Sweden) / Educational contents (Korea)	SDG number	Presence Scale (Low-1, Med-2, High-3)
Sweden	People's use of **energy** and **natural resources**, locally and globally, as well as what this means in terms of **sustainable development**. (p.191)	12	3
	Chemical processes in the manufacture and **recycling** of metals, paper and plastics. Life-cycle analysis of some common products. (p.191)	12	3
	Processes for purifying **drinking water** and **waste water**, locally and globally. (p.192)	6	3
	Common chemicals in the home and in society, such as cleaning products, cosmetics, paints and fuels, and how they affect **health** and the **environment**. (p.192)	12	2
Korea	Students can understand the need for **biodiversity** conservation, and investigate and present examples of activities to maintain **biodiversity**. (p.59)	15	3
	The distribution and use cases of **seawater**, freshwater, and glaciers in the hydrosphere can be investigated, and the value of **water** as a **resource** can be discussed. (p.72)	6	2
	Data related to **disasters** can be investigated. Causes and damages of **disasters** can be scientifically analyzed. (p.74)	13	3
	Understand the layered structure of the atmosphere and explain the **greenhouse effect** and **global warming** in terms of radiative equilibrium. (p.76)	7	1

Note. All the core content of Sweden in the table is quoted from *Curriculum for the Compulsory School, Preschool Class and School-age Educare* (The Swedish National Agency for Education, 2018), and all the education contents of Korea is quoted from *Science Curriculum (2015 Revision)* (Ministry of Education, 2015) and translated by the researcher.

Figure 4.1

Frequency of each Sustainable Development Goal Presented in Both Curricula

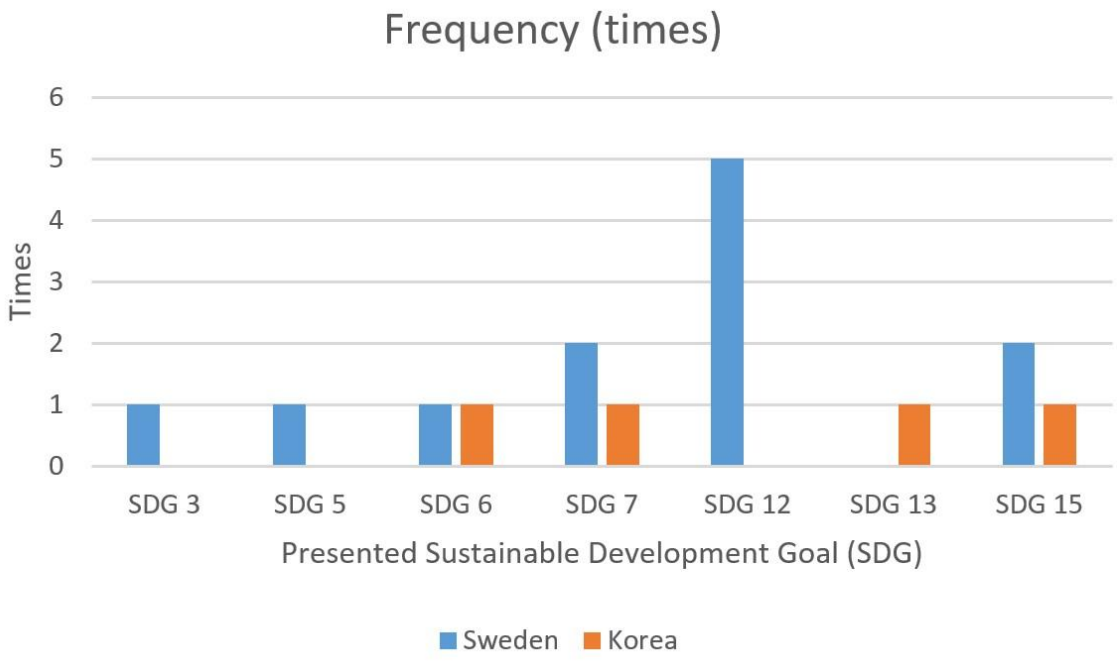
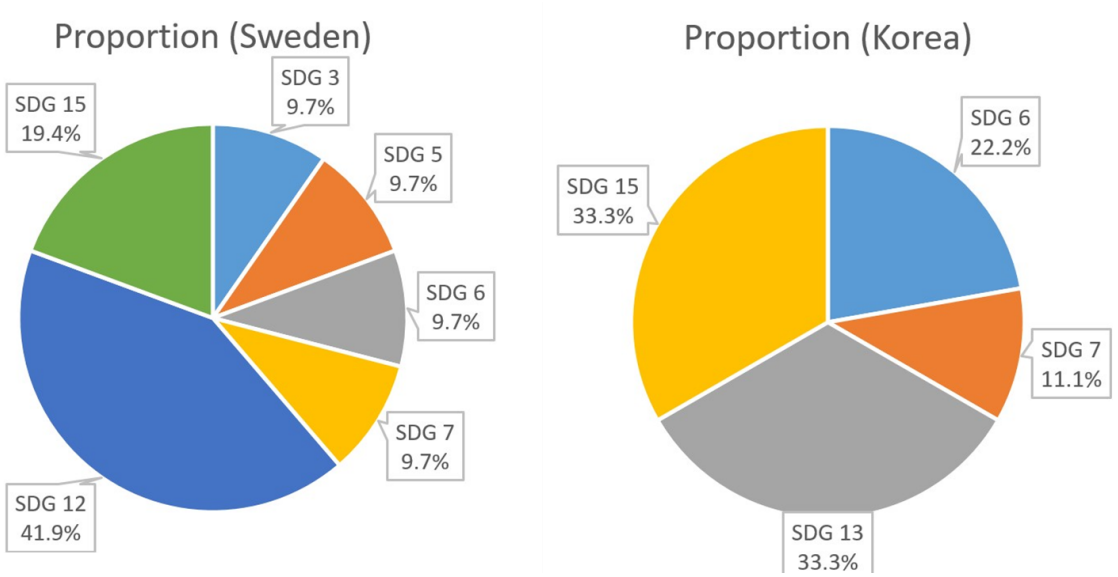


Figure 4.2

Proportions of each Sustainable Development Goal Presented in Both Curricula



In the Swedish curriculum, 12 out of 52 total targeted core content integrated sustainability to various extents. Among them, SDG 12 (Ensure sustainable consumption and production patterns) stands out as the most frequent, appearing 5 times, and the largest proportion of 41.9% based on the sustainability presence scale. SDG 15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss) also shows significant figures with 2 times appearance and accounting for 19.4% of the sustainability presence.

Meanwhile, only 4 out of 92 total educational contents in the Korean curriculum turned out to embed sustainability. None of the SDGs are significant in the selected sentences, and SDG 6, 7, 13, 15 are included once, respectively. Also, proportions by the goal don't show any remarkable trend.

The reflection rates (%) to the entire targeted sentences on sustainability upon applying presence scales of both countries are 19.9% in Sweden, and 3.3% in Korea. The rates are shown in Table 4.2 with the simple number of sentences embedding sustainability.

Table 4.2

Reflection Rates on Sustainability upon Applying Presence Scales

Sweden		Korea	
Count	Rates upon applying presence scales	Count	Rates upon applying presence scales
12 / 52	19.9 %	4 / 92	3.3 %

From the basic content analysis in this research, two differences significantly turned out. First, the sustainability reflection rate of Sweden is more than 6 times higher than that of Korea. Even though there is no absolute standard about enough integration of sustainability in the curriculum, the Korean science curriculum doesn't seem to incorporate sustainability properly.

The second difference found in the basic content analysis is that the SDG 12 is remarkable in terms of embedding sustainability in the Swedish curriculum, whereas it is not dealt with in the Korean curriculum. Goal 12 is to 'Ensure sustainable consumption and production patterns' (UN, n.d.-d, para.1). Goal 12 includes eight targets (Targets 12.1 - 12.8) and three targets with regard to means of implementation (12.a - 12.c). All the targets and corresponding core content of the Swedish curriculum are portrayed in Table 4.3.

Table 4.3

SDG 12 Targets and Corresponding Core Content of the Swedish Curriculum

Targets	Corresponding Core content
12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.	None
12.2 By 2030, achieve the sustainable management and efficient use of natural resources.	Supply and use of energy historically and currently, as well as possibilities and limitations in the future. (p.180)
	People's use of energy and natural resources, locally and globally, as well as what this means in terms of sustainable development. (p.191)
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along	None

Targets	Corresponding Core content
production and supply chains, including post-harvest losses.	
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their lifecycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.	Common chemicals in the home and in society, such as cleaning products, cosmetics, paints and fuels, and how they affect health and the environment. (p.192)
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.	Chemical processes in the manufacture and recycling of metals, paper and plastics. Life-cycle analysis of some common products. (p.191)
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.	None
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.	None
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.	Impact of people on nature, locally and globally. Opportunities for consumers and citizens of society to contribute to sustainable development. (p.169)
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.	None
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.	None
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.	None

Note. All the core content of Sweden in the table is quoted from *Curriculum for the Compulsory School, Preschool Class and School-age Educare* (The Swedish National Agency for Education, 2018).

4.2. Interpretive Content Analysis of Sustainability in Both Curricula

An overview of the findings from the interpretive content analysis is presented in Table 4.4. Also, all the excerpts that indicate each theme (presence of sustainability, view of the student, human-environment relationship, and philosophical/theoretical underpinnings) from both examined curriculum documents are shown in Appendix 1.

4.2.1. Presence of Sustainability

Sweden addresses sustainability in a more explicit way. With sustainability being expressed in sustainable development, the Swedish science curriculum (The Swedish National Agency for Education, 2018) states: "Knowledge of nature and people provides people with tools to shape their own wellbeing, and also contribute to sustainable development" (p.166). In addition, the curriculum notes the need for "Opportunities for consumers and citizens of society to contribute to sustainable development" (p.169). The curriculum also stresses local perspectives as well as global ones, by using the terms locally and globally several times (example, p.169, p. 191, and p.192). Local perspectives need to be included, as the language of the SDGs often only implies what is acceptable from international perspectives (Schleicher et al., 2017).

Table 4.4

Overview of Findings on the Four Aspects of the Framework for the Interpretive Content Analysis

Country	Curricula aspects			
	Sustainability presence	View of the student	Human-environment relationship	Philosophical/ theoretical underpinning
Sweden	Explicit: Knowledge of science contributes to sustainable development; Contribution to sustainable development as consumers and citizens. Emphasis on both local and global perspectives. Sustainability topics: biological diversity, ecological perspectives, health, sustainable consumption, gender equality, sexuality, recycling, waste, climate change, resources, chemicals, and the environment	Encouraging to consider contentious situations. Emphasized competencies: systemic and critical thinking, interpersonal competency through discussion, values-thinking, problem-solving competency	Stressing an ecological perspective. Debate over natural resource use and ecological sustainability Relationship between people and resources in ecosystem Biological relationship among human body, nature, and society Dealing with environmental technology	Focus on critical thinking, social discussions and arguments - sociocultural approach and anthropocentric ways of learning. Ecological perspective: considering interrelation between population and nature.
Korea	Not explicit. Addressing biodiversity, water, disaster prevention, and global warming Aiming to cultivate democratic citizenship	Being democratic citizens. More focus on knowledge Considering both local and international cases Emphasized competencies: interpersonal competency, integrated problem-solving competency	Mainly anthropocentric view: use the nature as a resource, science as a tool for convenience	Socio-cultural: mainly focused on cognitive processes, learning through discussion - anthropocentric way of learning. Objectification and positivism of science: to solve problems through science

As sustainability is not explicitly addressed in the Korean science curriculum, there is a need to consider implicit integration of sustainability. As an aim in science education, the curriculum states: “Recognize the mutual relationship between science, technology and society, and develop knowledge as a democratic citizen based on this” (Ministry of Education, 2015, p.4). A democratic community is essential in achieving sustainable development, as sustainable development requires participatory actions of civil societies (Warburton, 2013).

It is noted that biological diversity, ecological perspectives, health, sustainable consumption, gender equality, recycling, waste management, and environment are addressed as sustainability topics. Likewise, biodiversity, water as a resource, and disaster prevention are dealt with in the Korean science curriculum to support sustainability.

4.2.2. View of the student

While the widely accepted practice of evaluating students’ sustainability does not seem to exist (Waltner et al., 2019), several competencies that students need as active agents to improve sustainability of the planet. These include “collaboration, integrated problem-solving competency, interpersonal competency, futures-thinking, values-thinking, critical thinking, self-awareness, anticipatory thinking, systems-thinking, and strategic-thinking” (Wiek et al., 2011, p. 205; Guerra et al., 2022, p. 1). However, research about how curriculum documents contribute to the role of students in relation to sustainability and their competencies is still in its infancy (Weldemariam et al., 2017). Despite

unclarified effects of curriculum documents, both curricula illustrated different portrayals of students which may influence on students' participatory attitudes in relation to sustainability.

In the Swedish curriculum framework, students are encouraged to consider and discuss contentious situations such as gender equality. This can be seen as socioscientific issues (SSI), which are dominantly regarded as sustainability related issues (Klosterman et al., 2012). Discussions on controversial issues have increasingly become important in this approach (Colucci-Gray et al., 2006). Besides, much of the content aims to enhance students' competencies in relatively explicit ways: critical thinking, systemic thinking, problem-solving competency, and interpersonal competency.

In the Korean curriculum, student agency is mainly described as a cognitive process in order to understand scientific knowledge, rather than competencies with regard to sustainability. However, it is still noted that some competencies are presented in the curriculum, such as interpersonal competency, and integrated problem-solving competency.

4.2.3. Human-Environment Relationship

The most significant difference between both curricula in terms of human-environment relationship is that ecological perspectives including relationships between human and nature, and ecological sustainability are mentioned in the Swedish curriculum (The Swedish National Agency for Education, 2018) as follows:

> ... its models and theories to describe and explain biological relationships in the human body, nature and society (p.167); Local ecosystems and how they can be studied from an ecological perspective and relationships between populations and resources available in ecosystems (p.169); Pupils can talk about and discuss issues related to health, natural resource use and ecological sustainability, and differentiate … (p.175).

Given Sweden's traditional concern for nature and interest in outdoor activities as described in chapter 2.2.1.1, the embedment of ecology-related notions seems consistent in their context. However, Naess (2017) proposed a distinction between 'shallow' and 'deep' ecology movements. According to him, 'shallow ecology movement' means "fight against pollution and resource depletion" with the central objective of "the health and affluence of people in the developed countries" (p. 115). In contrast, 'deep ecology movement' endorses 'biospheric egalitarianism', which recognizes intrinsic value in the environment and considers concern about justice for the environment (Naess, 2017; Kopnina, 2020b). Naess also claimed that deep ecology supports the 'relational, total-field image', rejecting the image of man-in-environment (p. 115). Although several statements seem to be close to shallow ecology (e.g. 'use of resources', 'environmental technology'), deep ecology is also emphasized in the Swedish curriculum. In other words, the Swedish science curriculum seems to integrate both deep and shallow ecology, whereas ESD has been criticized for its exclusion of the deep ecology perspective (Kopnina, 2014).

In the Korean curriculum (Ministry of Education, 2015), anthropocentric perspectives are observed from some statements as follows: '... the value of water as a resource…' (p.72); 'To consider methods to use science to make our lives more convenient' (p.84). As discussed in chapter 4.1, science has been a major influence for the nation's economic development. Roles of science and technology are integrated in the distinctive idea of development in Korea (S. H. Kim, 2017). Moreover, Lee (2019) asserted that industrialization and modernization in Korea were put forward for over four decades after the Korean war, based on strong statism and anti-communism which were almost religious beliefs in Korean society. Lee claimed that this did not allow any environment or ecology related issues to be top agenda of the nation. The seemingly prevalent embedment of the human-centered and technocentric worldview in the Korean science curriculum can be explained in these contexts.

4.2.4. Philosophical / Theoretical Underpinnings

Littledyke and Manolas (2010) claimed that the post-positivist position in understanding science is crucial to education for sustainability, given that probability needs to prioritize rather than certainty in describing sustainability issues. According to Fox (2008), post-positivism recognizes the interpretation of the world to construct knowledge, and in the philosophy of science derived from a critique of positivism which views the measurement of phenomena as central to the understanding.

As indicated in Table 4.4, both curricula are based on socio-cultural approach through discussion (Sweden and Korea) or cognitive processes (Korea).

In other words, anthropocentric ways of learning are mainly shown in the targeted curricula. Meanwhile, objectification and positivism of science are also shown in the Korean curriculum as follows: "... all students to understand the concept of science and to develop scientific knowledge to solve individual and social problems scientifically and creatively by cultivating scientific inquiry skills and attitudes" (Ministry of Education, 2015, p.3). Also, despite the dominant socio-cultural approaches, ecological perspectives are partially integrated in the Swedish curriculum. This might be helpful in engaging students in sustainability issues with, probably world views beyond the human.

Chapter 5. Conclusions and Implications

This research has illustrated the differences and similarities between the science curriculum of Sweden and Korea for lower secondary school (grades 7 to 9) in terms of the integration of sustainability. To this end, how many core content / educational contents integrate sustainability were measured by basic content analysis using relevant keywords from the SDGs. Subsequently, how sustainability was stated was portrayed in the light of four aspects for interpretive content analysis. The findings provide valuable insights for integrating the concept of sustainability in the science curriculum.

In this chapter, answers to research questions are briefly illustrated with a concluding description. Some interpretations of research results and future research suggestions will be added. Afterwards, implications for the science curriculum in terms of integration of sustainability will be suggested in the second part. Lastly, limitations of this study are going to be illustrated in terms of a composition of science related subjects and characteristics of targeted sentences of both curricula.

5.1. Conclusions

The present research adopted basic content analysis and interpretive content analysis approaches in order to answer two research questions. The first research question sought to identify both quantitatively and qualitatively how sustainability is reflected in Korea's and Sweden's national science curriculum. The second question was conducted to discover similarities and differences of

how sustainability is integrated in both targeted curricula. In this part, the first main finding is suggested corresponding to the first question, and then the second finding is described to answer the second question. Additionally, socio-cultural backgrounds for giving more contexts of the results, and an unexpected finding for further research are also illustrated.

The first main finding of the present study is that reflection on sustainability in the Swedish curriculum is more significant than the Korean curriculum. As for a reflection on sustainability in core content / educational contents, the percentage of the Swedish science curriculum was more than 6 times higher than its counterpart. Moreover, the number of sustainability integrated sentences of the Swedish science curriculum which were used for the interpretive content analysis, was significantly higher than that of the Korean science curriculum despite a smaller volume of the Swedish one. This could be explained by how science is seen, and the expected role of science in the context of each country. According to Eurobarometer, which is a collection of cross-country public opinion surveys conducted regularly on behalf of the EU Institutions since 1974, Sweden is one of the most optimistic and confident EU countries about science and technology towards societal challenges such as climate change (Garrison, 2014). In a similar vein, their secondary science teachers and students have optimistic views about science and technology being a critical part in societal development (Oscarsson et al., 2009). Moreover, Sweden generally has a high level of consensus prevailing in every aspect of society, and within the process of reaching consensus, science seems to play an important role. For example, in the early phase of Covid-19, Sweden followed the

exceptional strategy that is almost equivalent to ‘herd immunity’ instead of societal shutdowns used in many other countries, with almost all facilities including restaurants, schools opened (Jung et al., 2020; Orlowski & Goldsmith, 2020). Brusselaers et al. (2022) suggested that the Public Health Agency that labeled advice from national scientists mainly contributed to implementation of this strategy as extreme positions. Obviously, a high level of approval of science in considering societal issues is heavily interconnected to science curriculum in Sweden. As described in chapter 2, Sweden is one of the top countries when it comes to promoting sustainability in their society. Hence, sustainability has become a remarkable national agenda, therefore, sustainability can be said to have been progressively integrated in science education. On the other hand, science education in Korea has a tradition of focusing on scientific information and knowledge (Son, 2016). She pointed out that although the concept of social responsibilities such as sustainability are successfully ingrained in the general statements of the national curriculum, each subject’s curriculum has failed to incorporate them. In order to explain this tendency, it is notable that Korea seems to have regarded science education as one of the main tools for the sake of economic development of the country. Cho (2013) claimed that science education in Korea is essential for the nation’s economic growth and development, as well as cultivation of scientific knowledge. Moreover, the Korean government started to promote science education for the talented in the 1980s, as the economic strategies of Korea shifted from labor-intensive industries to innovative fields such as semiconductors (Jung & Mah, 2014). This perspective towards science education can be seen as a reasonable background of why knowledge and

information has been stressed rather than social responsibilities including the pursuit of sustainability. More generally, this also could be deeply connected to how education has played a role in the rapid economic growth of Korea. Education is one of the most important driving forces in the economic development of modern Korean society (Levent & Zeynep, 2014). In one study, the contribution of education in economic growth of Korea from 1975 to 2004 was estimated around 40%, and secondary education accounts for 87% (Jang, 2007). This suggests that secondary education in Korea has focused on its efficiency mainly for economic growth, and science education is not exceptional.

Also, there was an unanticipated finding in the basic content analysis, which would be connected to a future research suggestion. Among some SDGs integrated in the Swedish curriculum, the most frequently included goal was Goal 12, which focuses on "a driving force of the global economy" - consumption and production (UN, n.d.-d. para.1). SDG 12 is generally evaluated to incorporate the concept of sustainable consumption and production (SCP) (Bengtsson et al., 2018; Gasper et al., 2019). The roles of SCP in the discourse of sustainable development are as follows: one of "overarching objectives of, and essential requirements for, sustainable development" (UN, 2003, p.2); environmental protection and poverty reduction (Akenji & Bengtsson, 2014). However, several criticisms have been made by a few researchers. Bengtsson et al. (2018) found that two dominant points simultaneously exist in SCP, which are *efficiency*, and *systemic*. According to these researchers, *efficiency* refers to an emphasis on encouraging more efficient production methods and products, while *systemic* focuses on overall amounts of consumption, related institutional and social

changes, and distributional issues. Here, an approach of efficiency has been criticized that it is not likely to lead to sustainability as it lacks a restructuring of the current socio-economic arrangement, which is regarded to be essential to enhance sustainability. In a similar vein, Dermody et al. (2021) claimed that SDG 12 is vulnerable in an underlying assumption of Goal 12 is the agreement and support of the status quo, including the neo-liberal free market, and the importance of protecting the wealth and power of political elites. These criticisms suggest that it needs to be conscious to incorporate the ideas of SDG 12 in the curriculum. Although the science curriculum needs to integrate the concept of sustainability, a heavy emphasis on SDG 12 could be criticized for the potential contribution to the current problematic societal structures. Meanwhile, several authors have criticized ESD for less considering 'environment', and still presuming growth and consumption, which are main contributors to the current climate crisis, would perpetuate (Kopnina, 2012; Stein et al., 2022). Considering a starting point of this research was concern about climate crisis (or environmental issues), the integration of many characteristics of Goal 12 might be arguable in this regard, despite a high presence of sustainability in the curriculum. Accordingly, the embedment of sustainability needs to be increased, and to contain balanced views which are not biased towards anthropocentric or neo-liberal frameworks. As the methodology adopted in this research was content analysis, making a research question for addressing this subject was limited. Therefore, I suppose that further research is needed to consider the unexpected finding of integrating many SDG 12 elements in the curriculum with critical perspectives over ESD.

Another main finding of the present study is that there are several differences as well as similarities in both curricula when it comes to four curricula aspects as follows. With regard to the ‘presence of sustainability’, the framework from Sweden included more explicit sustainability language, whereas the languages from Korea were implicit. As for ‘view of the student’, amid both curricula considering the student as an agentic individual, the Swedish curriculum emphasized more competencies for sustainability. Still, becoming democratic citizens was mentioned in the Korean curriculum, which is regarded as influential in the promotion of sustainability. Regarding ‘human-environment relationship’, the Swedish curriculum expressed reciprocity between human and nature by implementing the vocabulary of ‘ecology’. As for ‘philosophical/theoretical underpinnings’, both curricula basically embodied a sociocultural and human-centered view of learning.

5.2. Implications

Findings of the present study should be considered when planning the new science curriculum from now on in order to enhance the effective embedment of sustainability. As implications for both science curricula in applying sustainability are shown below.

First, enough knowledge about sustainability needs to be included in the school curriculum in order to raise students’ awareness of how to sustain the environment. Indeed, climate change related knowledge influences public perceptions toward climate change risk, thus the knowledge is a prerequisite for influencing future consumer behavior (Tobler et al., 2012; Shi et al., 2016). As of

now, ESD seems one of the most influential frameworks for this. Several countries have expended considerable effort into incorporating values or principles of sustainable development in their education system since the beginning of the UNDESD in 2005 (Gough, 2011; Cars & West, 2015; Nagata, 2017). However, criticisms over ESD as described in chapter 2 have to be taken into consideration given that more frequent and intensifying extreme weather events from the climate crisis are expected to wreak havoc on the entire aspects of our societies.

Second, students have to be described as active agents in promoting sustainability in the science curriculum. In many countries, students have been traditionally expected to be passive in the classroom. For example, Korean students tend to be comfortable receiving information from teachers rather than thinking critically to solve problems, influenced by the Confucian tradition (DeWaelsche, 2015). However, various competencies such as critical thinking, values-thinking and interpersonal competency need to be ascribed to active students to improve sustainability of the planet, as demonstrated in chapter 4. Moreover, intergenerational equity is one of the core concepts of sustainability, which is generally expressed as the planet for future generation (Golub et al., 2013). Indeed, the issue of intergenerational injustice in climate change is a common view of participants of School Strike for Climate started in 2018 (Lee et al., 2022). Given that curriculum reflects social trends, the science curriculum has to contribute to help students to be equipped with competencies to become active agents in achieving sustainability.

Third, the science curriculum has to be designed to provoke students into thinking about the relationships between humans and the environment. In fact, the environment tends to be underestimated in the discourse of sustainable development, as it singles out economic growth as a part of solution, which might have exacerbated the current environmental problems (Kopnina, 2012). In line with this, misguided human-centered anthropocentric attitudes are generally considered to contribute to environmental degradation (Kopnina et al., 2018; Bassey, 2020). Sustainability related education programs have to promote connectedness to nature to enhance the understanding of positive human-nature relationships (Liefländer et al., 2013).

Lastly, the philosophical basis and theories underpinning sustainability should be embedded within the science curriculum. Obviously, the underpinnings need to contribute to the development of balanced views towards sustainability. They also involve building the concept of sustainability constructively built into learners' perceptions and this also needs to be better linked to the understanding of sustainability. However, there is evidence that even teachers lack understanding of sustainability as it is an abstract, flexible and complex concept (Carew & Mitchell, 2006; Birdsall, 2014). In line with this, it is obvious that learners have a bigger difficulty in knowing what sustainability means for them. Establishing the philosophical basis and theories underpinning sustainability through science education would enable not only students but also teachers to build a conceptual framework of knowledge about sustainability. Weldemariam et al. (2017) argued that worldviews and values are decisively determined aligning with theories and philosophical assumptions. They described how

students, who are prepared to encounter contingent matters such as sustainability, are directly influenced by students' understanding of the underpinnings. Correspondingly, learning more and differently could lead to reimagining our perspective on sustainability (Malone et al., 2017).

5.3. Limitations of Study

In Korea, there are four science related subjects including biology, physics, chemistry, and earth science, whereas only three subjects of biology, physics, and chemistry exist in the Swedish curriculum as science subjects. Generally speaking, the Earth system is explored in earth science, therefore earth science is considered to be essential in understanding central environmental issues (Vasconcelos & Orion, 2021). In the Swedish curriculum, instead of having earth science as an individual subject, geography contains earth science related content, and that subject was not targeted in this research. Hence, there is a limitation in deciding identical target subjects for the comparison, and sustainability related topics in geography of the Swedish curriculum was excluded.

There are also differences in characteristics of targeted sentences stated in both curricula. As this research is based on a comparative study, it needs to have consistent quality and similar quantity of targeted data. Nevertheless, considerable differences appeared in both quality and quantity in the research. When it comes to investigating the embedment of sustainability in core content / educational contents, the number of sentences in the Korean science curriculum were too low, which hinders a meaningful comparison of two curricula.

Moreover, descriptions of the Korean one tended to be more scientifically specific, whilst sentences in the Swedish one seemed to be more general. For these reasons, exact comparisons of both curricula were limited to some extent.

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Appendix

Appendix 1

Coding Results of the Interpretive Content Analysis

Country	Aspects	Content description	Interpretation
Sweden	Presence of Sustainability	Knowledge of biology is of great importance for society in such diverse areas as health, natural resource use and the environment. (p.166)	Knowledge of science contributing to sustainable development(SD)
		Knowledge of nature and people provides people with tools to shape their own wellbeing, and also contribute to sustainable development. (p.166)	
		Opportunities for consumers and citizens of society to contribute to sustainable development. (p.169)	Contribution to SD as citizens and consumers
		Biological diversity, and factors threatening and favoring this. Public discussions on biological diversity, such as in the relationship between forestry and hunting. (p.169)	Biological diversity as a sustainability topic
		How physical and mental health is affected by sleep, diet, exercise, social relationships and addictive substances. (p.170)	Health as a sustainability topic
		Common chemicals in the home and in society, such as cleaning products, cosmetics, paints and fuels, and how they affect health and the environment. (p.192)	Influence of chemicals on health and the environment, as a sustainability topic
		Knowledge of energy and matter provide people with the tools to contribute to sustainable development. (p.177)	Knowledge for sustainable development
		Models in physics to describe and explain the earth's radiation balance, the greenhouse effect and climate change. (p.178)	Climate change as a sustainability topic
		People's use of energy and natural resources, locally and globally, as well as what this means in terms of sustainable development. (p.191)	Use of resources as a sustainability topic

Appendix 1. Continued

Country	Aspects	Content description	Interpretation
Sweden	Presence of Sustainability	Processes for purifying drinking water and waste water, locally and globally. (p.192)	Water as a sustainability topic Considering local/global perspectives
		Human sexuality and reproduction, and also questions concerning identity, gender equality, relationships, love and responsibility. Methods for preventing sexually transferable diseases and unwanted pregnancy at individual and global levels, and from a historical perspective. (p.170)	Sexuality and gender equality as sustainability topics
			Considering contentious issues
	View of the Student	Through teaching, pupils should be given the opportunity to ask questions about nature and Man based on their own experiences and current events. (p.166)	Critical thinking
		teaching should contribute to pupils developing their critical thinking over their own results, the arguments of others and different sources of information. (p.166)	
		As part of these systematic studies, pupils should be given opportunities, through practical investigative work, to develop skills in the use of both digital tools and other equipment. Pupils should be given opportunities to look for answers by using different types of sources. (p.166)	Systemic thinking
		As a result, pupils should be given the pre-conditions to manage practical, ethical and aesthetic situations involving health, use of natural resources and ecological sustainability. (p.166)	Problem-solving competency Considering contentious situations
		Critical examination of sources of information and arguments encountered by pupils in different sources and social discussions related to biology, in both digital and other media. (p.170)	Interpersonal competency through discussion
	Human-environment Relationship	Pupils can talk about and discuss issues related to health, natural resource use and ecological sustainability, and differentiate facts from values, and formulate their views with well developed explanations and describe some of the possible consequences. (p.175)	Ecological sustainability

Appendix 1. Continued

Country	Aspects	Content description	Interpretation
Sweden	Human-environment Relationship	Teaching in biology should essentially give pupils the opportunities to develop their ability to use knowledge of biology to examine information, communicate and take a view on questions concerning health, natural resource use and ecological sustainability, and use concepts of biology, its models and theories to describe and explain biological relationships in the human body, nature and society. (p.167)	Focus on biological relationships between human, nature, and society
		Pupils study the impact of different factors on ecosystems and populations and describe complex ecological relationships and explain and make generalisations concerning the flow of energy and ecocycles. (p.175)	Need to study ecological relationships, and the energy flow in ecosystem
		Knowledge of chemistry is of great importance for society in such diverse areas as health, economy in use of resources, development of materials and environmental technology. (p.188)	Dealing with environmental technology
		Local ecosystems and how they can be studied from an ecological perspective. Relationships between populations and resources available in ecosystems. The local ecosystems in comparison with regional or global ecosystems. (p.169)	Emphasis on relationships between human and resources in ecosystems from ecological perspectives
			Focus on interrelation between nature and human from ecological perspectives
	Philosophical/ Theoretical Underpinnings	Critical examination of sources of information and arguments encountered by pupils in different sources and social discussions related to biology, in both digital and other media. (p.170)	Critical thinking and human interaction through arguments and discussion: Socio-cultural approach, anthropocentric ways of learning
		Pupils can talk about and discuss issues related to health, natural resource use and ecological sustainability, and differentiate facts from values, and formulate their views with well developed explanations and describe some of the possible consequences. (p.175)	
Korea	Presence of Sustainability	Recognize the mutual relationship between science, technology and society, and develop knowledge as a democratic citizen based on this. (p.3)	Democratic citizenship as a sustainability topic

Appendix 1. Continued

Country	Aspects	Content description	Interpretation
Korea	Presence of Sustainability	To understand the importance and necessity of biodiversity by understanding the meaning of biodiversity and examining examples of activities to maintain biodiversity. (p.59)	Biodiversity as a sustainability topic
		For the investigation of activities to maintain biodiversity, internet searches or relevant books can be used, and the research is divided into social, national, and international activity cases. (p.60)	Considering both local and international cases
		Data related to disasters can be investigated. Causes and damages of disasters can be scientifically analyzed. (p.74)	Disasters as a sustainability topic
		Understand the layered structure of the atmosphere and explain the greenhouse effect and global warming in terms of radiative equilibrium. (p.76)	Global warming as a sustainability topic
		The distribution and use cases of seawater, freshwater, and glaciers in the hydrosphere can be investigated, and the value of water as a resource can be discussed. (p.72)	Water as a sustainability topic
			Interpersonal competency through discussion
	View of the Student	'Science' is a subject for all students to understand the concept of science and develop scientific knowledge to solve individual and social problems scientifically and creatively by cultivating scientific inquiry skills and attitudes. (p.3)	Integrated problem-solving competency
		In 'Science', students learn scientific knowledge and methods of inquiry in a fun way through situations related to daily experiences, cultivate scientific knowledge, recognize the correct mutual relationship between science and society, and grow into desirable democratic citizens. (p.3)	Being democratic citizens
		In 'Science', various inquiry-oriented learning is made possible. In addition, through integrated understanding of basic concepts and exploratory experiences, science and core competencies such as scientific thinking ability, scientific inquiry ability, scientific problem solving ability, scientific communication ability, scientific participation and lifelong learning ability are cultivated. (p.3)	Integrated problem-solving competency

Appendix 1. Continued

Country	Aspects	Content description	Interpretation
Korea	Human-environment Relationship	To consider methods to use science to make our lives more convenient, and to discuss its usefulness. (p.84)	Anthropocentric view: use science for convenient life
		The distribution and use cases of seawater, freshwater, and glaciers in the hydrosphere can be investigated, and the value of water as a resource can be discussed. (p.72)	Anthropocentric view: water as a 'resource'
			Learning through discussion: anthropocentric way of learning
	Philosophical/ Theoretical Underpinnings	'Science' is a subject for all students to understand the concept of science and develop scientific knowledge to solve individual and social problems scientifically and creatively by cultivating scientific inquiry skills and attitudes. (p.3)	Cognitive processes: socio-cultural and anthropocentric way of learning Objectification and positivism of science: to solve problems through science

Note. All the core content of Sweden in the table is quoted from *Curriculum for the Compulsory School, Preschool Class and School-age Educare* (The Swedish National Agency for Education, 2018), and all the education contents of Korea is quoted from *Science Curriculum (2015 Revision)* (Ministry of Education, 2015) and translated by the researcher.