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Demonstrating Didactic Models for ESD and Bildung in School Education

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Abstract

Objective of the article: The aim of this article is to synthesise the findings of relevant research articles and to demonstrate several “didactic models” of education for sustainable development (ESD) in school education.

Research method: The method of narrative literature review was used to identify didactic models for ESD in school education.

A short description of the context of the presented issue: The term *didactic* refers to the professional scholarship of teaching. In recent decades, the need to develop didactic models that would support school teaching and to allow for this adjustment in new teaching contexts has been addressed. Research has shown that school subject teachers work differently with ESD. It demands holism and pluralism, which requires embracing multiple stakeholders and communities, and a multi-disciplinary approach. Shedding light on achieving sustainability with its holist and pluralist features, this article analyses relevant research articles and demonstrates several “didactic models” for ESD in school education.

Conclusions and recommendations: I propose socioscientific issues-based teaching and learning (SSI-TL) as a useful didactic model for ESD and argue for the need to embrace didactic models like SSI-TL in teacher professional

development for both pre- and in-service teachers. The article explicitly considers the value of applying Communities of Practice as a theory to guide educational practices and research on education for sustainability in school science. The implications of applying the didactic models presented in the article are relevant not only for ESD, but also for students' development of *Bildung* to become reflective and responsible citizens.

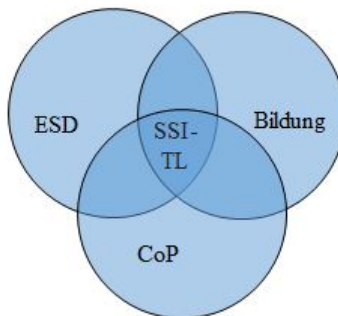
Keywords: didactic model, socioscientific issue-based teaching and learning, education for sustainable development (ESD), school science, *Bildung*, teacher professional development

Introduction

Globally, education for sustainable development (ESD) has increasingly been recognised since the Decade of Education for Sustainable Development (DESD) from 2005 to 2014; teachers' crucial role in ESD to ensure the sustainability of our world has also been addressed (Bourn et al., 2017; Montebon, 2018; UNESCO, 2014, 2020). In line with ESD, there are ongoing discussions about how to integrate ESD into science education programmes and science teacher education to grow responsible citizens for a sustainable future (e.g. Feldman & Nation, 2015; Stratton et al., 2015). It has been suggested that school education in the 21st century should embrace a broader perspective in order to prepare citizens to understand the various components of sustainability – including social, environmental and economic aspects – and to enable them to make social, political and environmental decisions for themselves and their communities (Feldman & Nation, 2015). All the above-mentioned ESD and 21st-century science education initiatives are embraced in Hodson's (2003) notion of "critical scientific literacy" (CSL) or Vision III of scientific literacy, which discusses scientific engagement and sociopolitical action (Sjöström & Eilks, 2021). Based on the importance and complexity of ESD, the need to develop didactic models has been recognised (Dudas et al., 2023; Herranen et al., 2021) so as to allow for the implementation of teaching

designs and analyses in new teaching contexts for sustainability. However, the existing didactic models have their limitations. Thus, the aim of this article is to synthesise the findings of relevant research articles as the basis for demonstrating several didactic models for ESD in school science. In particular, the didactic models which embrace multiple stakeholders and communities and follow a multi-disciplinary approach have been addressed by UNESCO (2014, 2020). This paper further proposes using Communities of Practice (CoP; Wenger, 1998) as a theory to guide ESD educational practices and research in science education. I identify and delineate several didactic models at various school levels, from preschool to upper secondary, and I discuss how CoP can be used to guide educational practice and research in school science for ESD. The implications of the article are relevant not only for the sustainability of the world, but also for students' development of *Bildung*, a well-established philosophical/spiritual tradition in continental Europe which addresses the need to develop citizens to take reflective and responsible action in and with society in multiple dimensions (Herranen et al., 2021, p. 2). A framework for socioscientific issues teaching and learning (SSI-TL) that incorporates futures thinking as an ESD didactic model with CoP and *Bildung* is delineated in Figure 1.

Figure 1. The SSI-TL framework presented in this paper



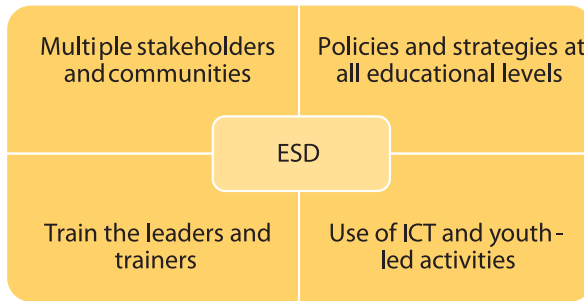
The roadmap for ESD implementation after DESD

Synthesising the findings in the relevant literature, I found what the UNESCO (2014) Global Action Programme since the DESD has suggested as a roadmap to serve as the ESD beacon for science education. The Global Action Programme proposes five priority action areas, including “transforming learning and training environments by integrating sustainability principles into education and training settings”, “building capacities of educators and trainers to more effectively deliver ESD”, “accelerating sustainable solutions at local level by scaling up multi-stakeholder ESD networks”, “advancing policy” and “empowering and mobilizing youth” (p. 15). Teaching strategies are part of teacher professional development (Shuman, 1986, 1987), so there is no doubt that teachers need to learn teaching strategies for ESD. How these five priority action areas are embraced in school education becomes important for the future direction of ESD and *Bildung*, and it is important to provide didactic models with concrete examples of practice.

Embracing these five priority action areas, four guiding principles (Figure 2) have been recognised for the development of educational practices and research on ESD with the questions of what, why and how.

1. Multiple stakeholders and communities: increasing multi-stakeholder networks in local communities to accelerate sustainable solutions at the local level and expanding multi-stakeholder networks in national and international communities
2. Policies and strategies at all educational levels: integrating ESD into policy at all levels, from school to higher education, as well as organisations and national policies and strategies
3. Train the leaders and trainers: equipping leaders, educators and trainers with the necessary knowledge, skills, attitudes and values of ESD via training programmes
4. The use of ICT and youth-led activities: empowering and mobilising youth via information and communication technology (ICT) and more youth-led ESD activities

Figure 2. The four guiding principles for ESD practices and research



To what degree has school education embraced these four principles for ESD since 2015 and the DESD? Since the UN Conference on the Human Environment in Stockholm in 1972, sustainable development has been strongly linked to environmental education (Cars & West, 2015). Since 1990, social aspects of sustainable development, such as human rights, multi-culturalism and gender equity, have emerged (Tanaka, 2017). But how have the social aspects of ESD been presented in school education to date? Based on the four principles (Figure 2), two types of didactic models (theme-based and SSI-based) were identified for ESD.

"It is important to know what has been done after DESD, which is from 2005-2014", so I write " after DESD since 2015".

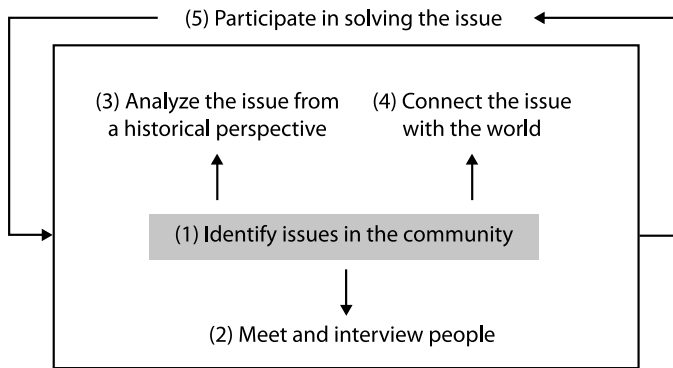
Theme-based didactic models

Perusal of the literature revealed that most school science was linked to environmental education and subjects related to the natural sciences. This resonates with the way that sustainable development was discussed in the past, with a strong focus on environmental education (Cars & West, 2015; Tanaka, 2017). However, some teaching approaches which embrace a multi-disciplinary approach were found.

In the Japanese context, Tanaka (2017) mentions the Development Education Association and Resource Center's (DEAR) primary education

curricula for ESD from 2000 and 2010. The DEAR curriculum 2000 focused on teaching global issues and participatory learning (like photo language and role-play) via “12 thematic curricula: food, culture, environment, trade, literacy, refugees, international cooperation, foreign people in Japan, etc.” (Tanaka, 2017, p. 23). Later, the DEAR curriculum of 2010 was proposed to focus on local issues and their relationship to global issues (Figure 3).

Figure 3. The DEAR ESD Curriculum of 2010 (Tanaka, 2017, p. 24)



In a Chinese kindergarten with a science education profile in Hongqiao (Wong et al., 2019), an action research model (with two cycles of planning, action, observation and reflection) was adopted to implement ESD with 10 teachers. The objectives of ESD for children – covering the three domains of environment, economy and sociocultural issues – were applied (see Table 1). Taking children’s life experiences into account, they found that “garbage”, “water” and “recycling” (linked to the environment and economy domains) were easy for them to implement in ESD, since the themes fit within “traditional science education”, whereas the social justice and sociocultural domains were new and required additional teacher training (Wong et al., 2019). Visual representations like videos were used to stimulate children’s participation in ESD activities, but it was found that the participating teachers struggled to match their teaching strategies with ESD objectives and children’s development while implementing ESD in kindergarten (Wong et al., 2019).

Table 1. The Objectives in Wong et al.’s Action Research Study (2019, p. 502)

Domain	Objective
Environment	To be familiar with the surrounding environment and having knowledge of relevant resources in the environment. To know that some resources are recyclable and it is important to protect natural resources. To know not to do things that may affect others’ quality of life now or in the future. To be able to support the sustainable development of the environment.
Economy	To understand that the production, use, and discarding of goods and services can be reduced. To understand the impact of public facilities on people’s lives. To practice lifestyles and distribute concepts that support sustainable consumption during educational activities or in daily life.
Social-cultural	To understand local and other cultures. To be able to enjoy different cultures. To be able to make friends with children from different places, enjoy participating in activities, and experience the joy of living together.

From the above-mentioned two examples of theme-based teaching strategies, themes covering all three pillars (ecology, economy and sociology) of ESD were developed and applied in primary schools and preschools. However, it took longer to implement all the themes, which tackle only one pillar at a time and are not integrated. The issues requiring more research are how children react to the themes and whether children’s ESD concept remains unintegrated. Teachers also found it challenging to devise themes to match ESD from their own experiences and children’s development. Connecting multiple stakeholders and communities as well as ICT and youth-led activities proved tricky at the preschool level. These issues require further resolution through teacher training.

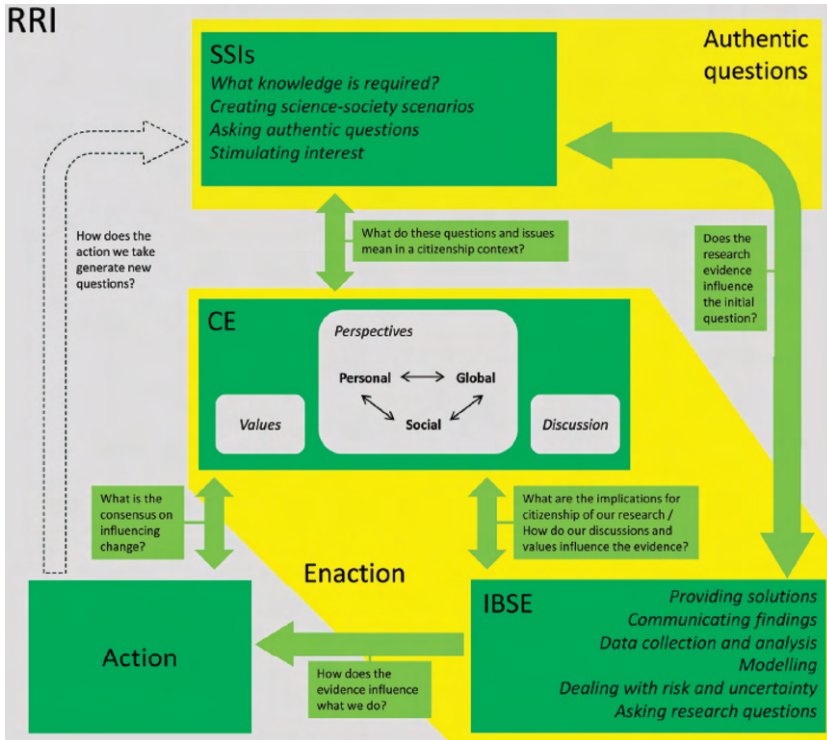
SSI-based didactic models

Controversial issues concerning the complex interrelationship between science, technology and society are termed socioscientific issues (SSI; Patronis et al., 1999; Zeidler et al., 2002). Examples of SSI can be found in the topics of climate change, consumption, nuclear power as an energy resource and several issues related to the COVID-19 pandemic, such as the

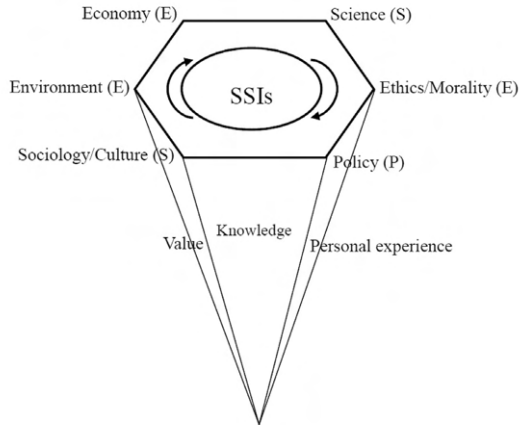
use of quarantine and face masks. Over the past 30 years, SSI-related educational research has become one of the main trends in the field of science education, and many researchers have appreciated the significance of SSI, emphasising the need to design issue-based curricula as part of the school science canon (Chang Rundgren & Rundgren, 2010; Chang Rundgren, 2011; Driver et al., 2000) and for ESD (Levrini et al., 2021). However, just as some teachers were found to be positive about, but ill-prepared to integrate ESD into science lessons, some were also found to be positive about, but ill-prepared for SSI-based teaching (Amos & Levinson, 2019; Rundgren & Chang Rundgren, 2018), even though SSI-based teaching has been embraced within ESD internationally (Amos & Levinson, 2019; Eilks, 2015).

Socioscientific inquiry-based learning (SSIBL) was developed in one EU FP7 project, PARRISE (2014–2017), with 18 partners in 11 European countries. More recently, it has been demonstrated how SSIBL could be engaged with students learning the 2030 Sustainable Development Goals embracing responsible research and innovation (RRI), inquiry-based science education (IBSE), citizenship education (CE), and SSIs (Amos & Levinson, 2019). *Ask–Find Out–Act* is the basis for the teaching and learning sequence of SSIBL (Figure 4). School science teacher training with SSIBL was the focus in the PARRISE project, and the link between SSIBL and curriculum has been used to motivate teachers' engagement in SSIBL workshops (Amos & Levinson, 2019; Rundgren & Chang Rundgren, 2018). However, how SSIBL can contribute to ESD was not explicitly addressed in the PARRISE project, and teachers' understanding of ESD was not explored. While reflecting on the four guiding principles for ESD educational practices and research (Figure 2) since the DESD, multi-stakeholder networks in communities and solutions at the local community level and youth-led activities were not as clearly addressed in SSIBL as they had been in the previously mentioned theme-based model in China (Wong et al., 2019) and Japan (Tanaka, 2017). Even though personal, social, global and stage-of-action perspectives were present, it was challenging to make the link with communities and to have students put their solutions into practice due to time constraints and teachers' limited SSIBL teaching experience (Rundgren & Chang Rundgren, 2018).

Figure 4. The Detailed SSIBL Model (Amos & Levinson, 2019, p. 31)

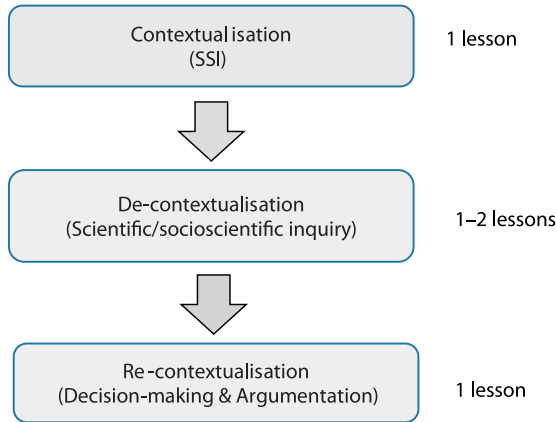


Like SSI-TL, the SEE-SEP model, which was developed in 2010, aimed at teaching and learning SSI and SSI-based argumentation (Chang Rundgren & Rundgren, 2010; Chang Rundgren, 2011). The SEE-SEP model not only stresses the holistic view of SSI, but also gets people to look at SSI separately via the different subject areas of science, economy, ethics/morality, social culture, environment and policy (SEE-SEP) and includes individuals' knowledge, values and experiences (Chang Rundgren & Rundgren, 2010; see Figure 5).

Figure 5. The SEE-SEP Model (Chang Rundgren & Rundgren, 2010, p. 11)

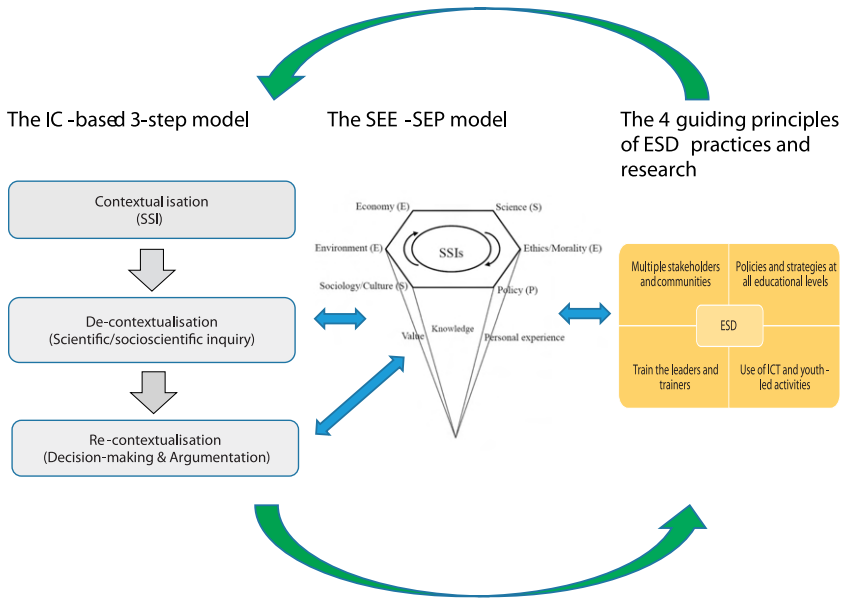
In the PARRISE project, the SEE-SEP model was combined with the SSIBL framework for teacher training (Rundgren & Chang Rundgren, 2018). Instead of the *Ask–Find Out–Act* model used by Amos and Levinson (2019), it used an inquiry- and context-based (IC-based) three-step model developed in another EU FP7 project, PROFILES (Walan & Chang Rundgren, 2015). As shown in Figure 6, the IC-based three-step model includes the stages of contextualisation (introducing SSI), de-contextualisation (conducting scientific or socioscientific inquiry) and re-contextualisation (making decisions and argumentation). This teaching activity can be structured as a minimal three-hour activity in a school lesson or a longer one-month course – or even a one-term programme. The IC-based three-step model is feasible in a teaching and learning context (Rundgren et al., 2014; Walan & Chang Rundgren, 2015).

Figure 6. The IC-Based Three-Step Model



In my opinion, the second step of de-contextualisation provides many possibilities for inquiry concerning ESD’s three pillars (social, ecological and economical) and the four guiding principles of ESD practices and research (see Figure 2). For example, teachers can use the SEE-SEP model to enable students to find multi-disciplinary, multi-stakeholder and multi-community solutions (based on the SEE-SEP model’s six subject areas of science, economy, ethics/morality, social culture, environment and policy; see Figure 5) by searching the internet and interviewing local, national and international stakeholders. It is certainly possible to apply ICT in this step, for example, by using Zoom or Skype for interviews or searching for viewpoints via social media. Then, in the step of re-contextualisation, ICT, youth-led activities, policy and strategy aspects can be engaged in decisions and solutions, feeding back into Step 1 of the SSI context (Figure 7). Much depends on the available time and how teachers design the SSL-TL activities. The use of the SEE-SEP model has proved feasible in primary through upper secondary school levels and in teacher training workshops (Cebesoy & Chang Rundgren, 2023; Rundgren & Chang Rundgren, 2018). However, more research is needed at the preschool level and in teacher professional development programmes.

Figure 7. The Integrated Teaching Model for ESD



The theory of Communities of Practice for ESD

Communities of Practice (Wenger, 1998) has been recommended by Sadler (2004) as an appropriate theory for science education in the context of SSI. Here, I advance the use of CoP for ESD through key CoP concepts such as participation and reification, boundary (brokers and boundary object) and locality (local community and global society) (Wenger, 1998). A large quantitative survey of teachers’ teaching practices for ESD (Borg et al., 2012) showed that upper secondary teachers in subject areas such as the physical sciences, social sciences and languages have different teaching strategies for ESD. It was also found in a later qualitative study that science teachers engaged with environmental science-related issues (use of energy, ecology, toxic substances and recycling), while social science and language teachers engaged with issues such as human rights and population, and environmental issues like climate change and recycling (Sund & Gericke, 2020). The same phenomenon was revealed in

preschool teachers (Wong et al., 2019) and primary school teachers (Ak-sland & Chang Rundgren, 2020). Teachers also embraced ESD differently, depending on the subjects they taught: science teachers tended to be more lecture-based, while social science and language teachers used media and ICT more often (Sund & Gericke, 2020). Social science and language teachers' practices were more in line with a holistic view of ESD, suggesting the need for cross-curricula teaching, which could help teachers bridge the divides between school subjects and broker connections by introducing "elements of one practice into another" (Wenger, 1998, p. 105). In addition to the concept of broker as a type of connection, there is boundary object, which includes "artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnection" (Wenger, 1998, p. 105). Here, SSI-TL is regarded as the context for different boundary objects. For example, in the SEE-SEP model (Figure 5), knowledge, values and experiences are seen as important boundary objects that can connect local and international communities as well as diverse school subject "communities". This seems to satisfy the approach of 3M for ESD by involving multi-stakeholder networks, multi-disciplinary approaches and multiple communities (Figure 2). Wenger (1998) also developed the notion of locality, pointing out that "the history of modern times involves a transition from local communities to global societies We can develop new ways of participating in the global, but we do not engage with it" (p. 131). This is also an important notion for embracing the concept of creative entrepreneurship for ESD via SSI-TL, even though we might not be able to directly engage with the global context during SSI-TL activities.

Conclusion and discussions

The literature review revealed that what school science teachers find most challenging is integrating ESD into their lessons (Montebon, 2018; Wong et al., 2019). Environment-related themes and activities were generally embraced by both pre-service and in-service science teachers

in their teaching practice (Aksland & Chang Rundgren, in press; Montebon, 2018; Wong et al., 2019). The environmental domain was most prevalent in pre-service teachers' understanding, while human rights and equity were less often mentioned (Montebon, 2018). It was furthermore found that people's attitudes towards ESD were also influenced by culture (Montebon, 2018). One misconception about sustainability was that it is only about the environment and recycling (Aksland & Chang Rundgren, 2020; Montebon, 2018). Teachers' understanding of sustainability varied according to the subjects they taught. Science teachers were found to have a stronger awareness of environmental sustainability than social studies and primary school teachers, who generally had stronger awareness of economic and sustainability issues (Atmaca & Kiray, 2020). The holistic understanding and teaching strategies of ESD need to be delivered through teacher training programmes (Aksland & Chang Rundgren, 2020; Cebesoy & Chang Rundgren, 2023; Montebon, 2018; Rundgren & Chang Rundgren, 2018), particularly via the SSI-TL model (Cebesoy & Chang Rundgren, 2023; Rundgren & Chang Rundgren, 2018). Regarding the SSI-TL model, I argue that the IC-based three-step model in combination with the SEE-SEP discussion in the second and the third steps is vital and a suitable didactic model for ESD and *Bildung* to embrace all four guiding principles for ESD practices and research in school education.

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