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A Future Trend for Science Education: A Constructivism-Humanism Approach to Trans-Contextualisation

Jack Holbrook *, T. B. M. Chowdhury and Miia Rannikmäe

Centre for Science Education, University of Tartu, 51003 Tartu, Estonia; tapashib@ut.ee (T.B.M.C.); miia.rannikmae@ut.ee (M.R.)
* Correspondence: jack@ut.ee

Abstract: Today's society faces new challenges, especially related to sustainability, in which the role of science within society is becoming increasingly important. This study seeks to re-examine the focus of school science/STEM education in light of increasing societal challenges by introducing a trans-contextualisation component within science education so as to go beyond the classroom and seek to impact the societal setting. In so doing, this study, through a constructivism-humanism approach, develops a theoretical 4-phase model by adding a trans-contextualisation learning phase to a literature-supported 3-stage science education teaching model. This enhanced model is put forward to enable science education to play a stronger role in impacting societal development towards building an active informed citizenry, enabling society to reflect on potential ways to meet its needs in moving towards a sustainable future. The study seeks science educator views familiar with the 3-stage teaching approach on the enhanced 4-phase model in terms of its value, feasibility and potential constraints. Such views are shown to be positive and aligned with the generally supportive views of teachers identified in a prior study.

Keywords: trans-contextualisation; scientific literacy; 3-stage model; active informed citizenry; sustainable future; school science education; humanism

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1. Introduction

Scientific literacy, an envisaged goal for school science education [1], is expected to encompass the recognition and conceptualisation of the role of science in society. Nevertheless, school science still suffers from a lack of student interest [2], as well as poor student conceptualisation of core scientific ideas [3]. Furthermore, it has been claimed that an over-emphasis on conceptual scientific learning is "detaching" science learning from a focus on society concerns and, hence, it poorly prepares learners to relate to issues, such as the COVID-19 pandemic [4].

The challenge being faced, particularly evident during the COVID-19 pandemic, could be seen as two-fold. First, many people seemed to be sceptical about the role played by science, with respect to making science-influenced, responsible health-related decisions [5,6]. Additionally, second, there seemed to be a lack of ability, at both individual and collective levels, to reconcile such a science-influenced society dilemma [7,8]. This could be seen as raising the question as to whether promoting conceptually science-informed individuals is sufficient, or whether there is a further need to embrace a wider vision of science education, such as preparing a collective body of citizens who actively [9], scientifically [10] and collectively [4] participate in resolving encountered societal concerns.

A society-related vision of promoting citizens via school science was not seen as new. The Science, Technology and Society (STS) movement sought to place an emphasis on promoting students, through science education, as participating citizens within society [11,12]. Nevertheless, the STS movement was criticised for lacking a clearly defined structure, and for being more oriented towards science-bound problem-solving and less towards emphasising moral or ethical issues embedded within society [13]. While STS seemed to lack a theoretical underpinning to incorporate society aspects in science education, a later development including socio-scientific issues (SSI) emerged as a science educational construct, with principles influenced by philosophical, developmental and sociological components [14]. In fact, many research studies recommended incorporating SSI-based decision-making in the classroom, seeking to promote citizenship attributes, identified by different researchers as: "responsible citizenship" [15], "competent citizenship" [16], "environmental citizenship" [17], as well as "global citizenship" [18,19].

In promoting students to become responsible and competent citizens by being environmentally or globally informed, there seems to be a potential need for students to be able to move from a classroom collective decision-making environment, towards encompassing a wider community involvement outside the classroom [20,21]. Such a recognition is seen as promoting a shift from an individual or localised "social" view, towards establishing a wider community vision pertaining to a "societal" view. This has been referred to as a "trans-contextualisation" within science education [22].

The aim of this study is to explore the perceived value, endorsed by different stakeholders, of a shift towards the inclusion of an additional trans-contextualisation element in science learning, so as to enhance students' scientific literacy by including a stronger science learning role in promoting societal development.

The following research questions are put forward:

1. In what ways do different science education stakeholders perceive the value of incorporating a trans-contextual, societal focus within the teaching of science education?
2. What limits are seen as to the perceived feasibility and the perceived challenges with respect to implementing societal trans-contextualisation in science education?

2. Literature Review

2.1. Trends in Visions of Science Education

The OECD document "Education 2030: the future we want" in its shared vision indicates:

> *"In an era characterised by a new explosion of scientific knowledge and a growing array of complex societal problems, it is appropriate that curricula should continue to evolve, perhaps in radical ways"* [23] (p. 3).

In the past, the purpose of science teaching and learning has been more oriented to "produce citizens who understand science and are sympathetic to the work of scientists" [24]. There has also been an implied need for orienting school science towards "science for all", the latter being particularly recognised since the 1980s [25,26]. These two perceived directions for science learning seemingly align with two visions for the role of science education put forward by Roberts [27]. He advocates that vision I is seeing school science teaching as primarily preparing learners for science-related careers and, thus, emphasising students' science conceptual development. Vision II, on the other hand, places more emphasis on preparing learners for science-related social situations.

Nevertheless, a vision I versus a vision II division is not necessarily recognised as being clear-cut. In fact, Haglund and Hultén [28] have critiqued such a vision for leaving less room for perceiving science education playing a wider role in societal development. Various perceptions of vision III have been put forward, seeing this as:

- Promoting: a "pluralist" (collectivised) science education, as: "a legitimate future dimension in an expanded research agenda for scientific literacy, and it connects with theories of learning (and non-learning) predicated on knowing-in-action" [29];
- Initiating: "fuller and informed participation in the public debate about science, technology, society, and environment issues leading to justified decisions and sustainable solutions" [30];
- Emphasising: "philosophical values, politicization and critical global citizenship education" [31].

- Incorporating: a "transformative vision committed to participation and emancipation" [8].

Within visions I and II, simply contextualising science and reflecting on its multiple risks are seen as insufficient. Hence, vision III seeks to expand the scope of scientific literacy in promoting, both individually and collectively, an active societal engagement in resolving societal concerns.

2.2. From Science through Education to Education through Science

School curricula recognise that the discipline of science, or its sub-divisions, has an educational learning focus. However, less clear is whether to regard the teaching of science as a subject specific provision (i.e., science through education) or to emphasise the range of desired educational attributes through the teaching of science subjects (i.e., education through science). Table 1 gives a comparison of similarities and differences in reflecting between these two orientations [32] (p. 134).

Table 1. A comparison of similarities and differences in philosophical emphases between 'Science through Education' and the alternative 'Education through Science' approaches.

Science through Education	Education through Science
Learn fundamental science knowledge, concepts, theories and laws.	Learn the science knowledge and concepts important for understanding and handling socio-scientific issues within society.
Undertake the processes of science through inquiry learning as part of the development of learning to be a scientist.	Undertake investigatory scientific problem solving to better understand the science background related to socio-scientific issues within society.
Gain an appreciation of the nature of science from a scientist's point of view.	Gain an appreciation of the nature of science from a societal point of view.
Undertake practical work and appreciate the work of scientists.	Develop personal skills related to creativity, initiative, safe working, etc.
Develop positive attitudes towards science and scientists.	Develop positive attitudes towards science as a major factor in the development of society and scientific endeavours.
Acquire communicative skills related to oral, written and symbolic/tabular/ graphical formats as part of systematic science learning.	Acquire communicative skills related to oral, written and symbolic/tabular/graphical formats to better express scientific ideas in a social context.
Undertake decision-making in tackling scientific issues.	Undertake socio-scientific decision-making related to issues arising from society.
Apply the uses of science to society and appreciate ethical issues faced by scientists.	Develop social values related to becoming a responsible citizen and undertaking science-related careers.

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

The "education through science" approach can be seen as being in line with the visions of science education; not only limited to visions I and II, but also incorporating a vision III aligning with:

> *"sustainability, influencing choices with which we are confronted, requiring action at personal and societal levels"* [28] (p. 327).

Furthermore, the "education through science" approach seeks to meet the need for science education to play a wider role in empowering learners to actively and collectively engage in resolving scientifically embedded, social concerns. Such an approach aligns with the United Nations education policy envisaging the role of education as promoting democracy and human rights, enhancing global citizenship and tolerance, initiating civic engagement, and addressing sustainable development [33], as well as the OECD vision of promoting education aligned with social, economic and environmental considerations [23].

2.3. Theoretical Considerations within Science Education: From Solely Social Constructivism towards Constructivism-Humanism

Multiple science educators advocate a constructivist, in particular a social constructivist, approach to science teaching and learning [34–37]. Constructivism is considered advantageous, as students learn by constructing science conceptualisations influenced by prior experiences [14], often meaningfully stemming from a social, or cultural context [38,39]. Researchers also report that a constructivist approach has shown to be beneficial in promoting the active participation of students, thereby enhancing student motivation to learn science [40], as well as facilitating the promoting of conceptual learning [41], socio-scientific decision-making [42] and even encouraging students in pursuing science-related careers [43].

Nevertheless, although a social constructivist approach has been shown to successfully address students' active participation in constructing knowledge, researchers argue that such an approach lacks emphasis in enabling students' empowerment [44] in addressing societal concerns [45]. In addressing this gap, the humanism theory of learning emphasises the need to promote non-cognitive variables, such as the learners' perceived self-efficacy [46] and self-actualisation [47], with an aim to stimulate responsible, justice-oriented and democratic behaviour among learners [44].

A humanism orientation in promoting learning is seen as enabling science education to have a meaningful role in reflecting on society sustainability issues. This approach further supports argumentation on value-laden, social concerns [48] and in addressing society development. Within science education, the humanism addition places an emphasis on promoting socio-scientific decisions which lead to active and collective participation within society and, thus, a dialogue among citizens [49]. In particular, the humanism approach can be seen as a way of addressing social transformation via scientific literacy [50–52]. Such a focus is in line with vision III [28–31], plus an education through science approach [32].

3. Trans-Contextualisation in Science Education

Based on the science education trends presented in the literature, with respect to the visions (Section 2.1), approach (Section 2.2), and theories (Section 2.3), this study develops a model of a proposed 4-phase teaching approach towards promoting, through trans-contextualisation, an active informed citizenry [22].

The initial 3-stages of the model are based on the literature [53] and utilised in a European Commission project, named "Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science (PROFILES)" [54]. This study extends the 3-stage model, emphasising an education through science approach and a constructivism-humanism theory to add a 4th phase to the teaching–learning approach. This added 4th phase involves students' learning being extended beyond the classroom-based socio-scientific consensus decision-making by engaging students in

- Creatively developing relevant and meaningful action plans to address the socio-scientific concern at the society level;
- Based on an ethic, moral and responsible acceptance of the plans, to undertake persuasive actions, in a responsible and sustainable manner, to promote, democratically, a collective way forward for the well-being of citizens within society.

This phase is termed "trans-contextualisation" as illustrated in Figure 1, focusing on engaging students in a persuasive yet responsible manner in putting forward action-based approaches through applying their learning from the school to society [22].

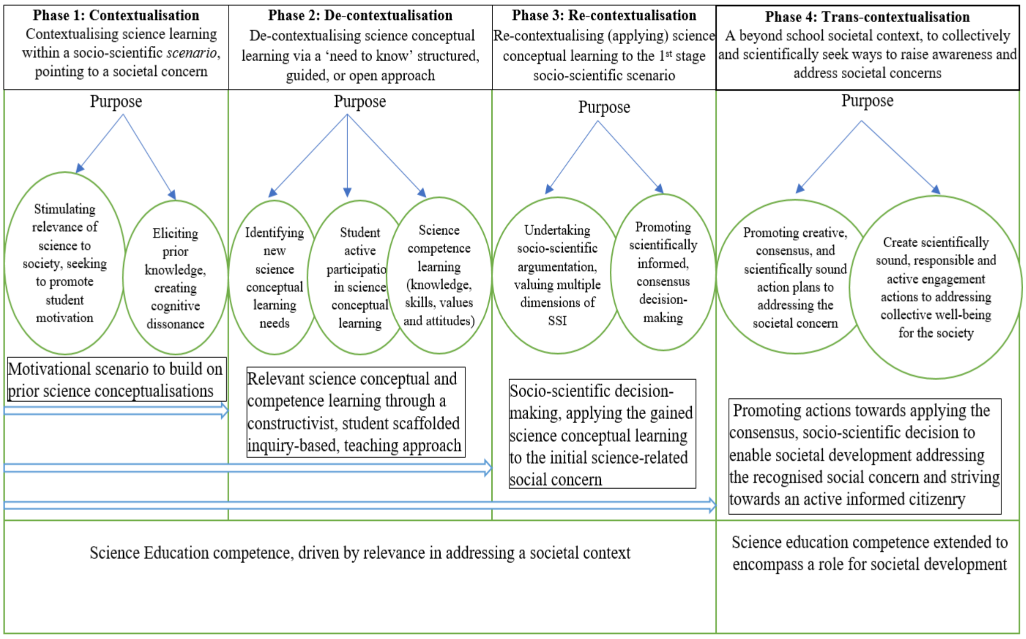

Figure 1. A 4-phase Constructivism-Humanism Approach to school science learning, seeking to develop an Active Informed Citizenry.

Based on this model, a study was conducted to identify teacher perceptions towards such a 4-phase approach [55]. The results indicated that participant teachers perceived the need for, but lacked, the preparation for putting into practice the transfer of student science learning beyond the school context towards addressing societal development.

4. Materials and Methods

The present study investigates science teacher educator, science curriculum developer and science education researcher views on the incorporation of the 4-phase model as a learning approach in science education. Their reactions are seen as important in establishing the need for the inclusion of trans-contextualisation within future science education curricula and teacher initial preparation and continuous professional development programmes, particularly in addressing sustainable development attributes and the promotion of an active informed citizenry. This study is undertaken by means of individual interviews.

4.1. Sample

A primary consideration for creating a small, but purposeful interview sample was their prior engagement with the 3-stage model through involvement in a European Union-funded PROFILES project (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) [54]. A convenient interview sample was selected from the five partnering countries of the project, i.e., Estonia, Ireland, Finland, Turkey and Israel. The male–female ratio of the sample was 3:2. The major science education involvement of the interviewees is given in column 1 in Table 2, and the rationale for participant selected is indicated in column 3 in Table 2.

Table 2. Profiles of interviewed participants.

Science Education Involvement	No. of Participants	Code	Rationale for Selecting Participants
Science teacher educator	1	TE	Undertaking profession development of secondary school science teachers to appreciate the value of the 3-stage model.
Science curriculum developer (CD)	2	CD1	Developing science curriculum content which sought to encompass the 3 stage model learning outcomes.
		CD2	Developing a science curriculum framework (based on learning theories/policies associated with the 3-stage model).
Science education researcher (SER)	2	SER1	Researching teacher professional development associated with relevance, science competence and socio-scientific issue-based teaching.
		SER2	Researching transversal skills via science teaching, involving teacher designed SSI-based scenarios.

4.2. Instrument

To undertake the semi-structured interviews, constructs were developed following a pre-structured guideline, as demonstrated in Table 3.

Table 3. Construction of the interviews.

Constructs	Description	Process	Sample Questions
1. Establishing participants' familiarity with the underlying 3-stage model.	Ascertaining participants' familiarity with the rationale behind each specific stage in the 3-stage model.	Each interview began by asking about their familiarity with the philosophy and approach for the 3-stage model. Specifically, participants were asked to recall the purpose, process and outcome of each stage.	1. How familiar are you with the rationale for introducing a science topic with a scenario (1st stage)? 2. In your perception, what was the key follow-up approach (stage 2)? 3. What was the purpose of the follow up to stage 3?
2. Identifying a potential need to go beyond the 3-stages, i.e., extend the model.	After the initial discussion, the interviews aimed to allow the interviewees to critique the 3-stage model and in particular their reaction to its limited scope for relating to actual societal development.	The interviewees were shown an example of stated outcomes from such a 3-stage model and asked whether they perceive attaining such outcomes as sufficiently exhaustive. Based on responses given, interviewees were asked to elaborate on whether there could ways whereby science education could play an extended society enhancing role.	1. Do you think consensus SSI decision-making within the classroom sufficiently addresses actual societal concerns? 2. Is there a need to reflect on ways for society to accept the decision? 3. (after a yes or no answer) Can you give a rationale for your answer, or can you explain your answer further?

Table 3. *Cont.*

Constructs	Description	Process	Sample Questions
3. Recognising the potential value of including an additional trans-contextual phase within science learning.	Assuming recognition of potential limitations of the 3-stage model, participants' reactions to a proposed additional phase, seeking to establish interviewee value of extending the SSI learning to include a 'from school to society component', labelled as a trans-contextual phase.	The interviewer proposed a 4th phase, explaining its meaning as involving students in putting forward ways to creatively transfer SSI outcome to impact on a beyond-classroom context, seeking to resolve a relevant societal concern. Interviewees were asked whether they perceived the value for the proposed addition (trans-contextualisation) to the familiar 3- stage model. Participants were further asked to justify their responses.	1. How do you react to a proposed 4th phase on the transference of science learning to a 'beyond the classroom action' phase? 2. (after introducing the trans-contextualisation concept)— In your opinion, is there added educational value in including such a 4th phase? 3. Do you perceive a rationale for adding the 4th phase feasible?
4. Determining the potential challenges in incorporating a trans-contextual phase within science teaching.	Interviewees were asked to reflect on the feasibility of adding a 4th phase, by focusing on possible ways to utilise the collectively resolved SSI actions to put forward creative actions for promoting meaningful societal developments within the community, drawing attention to possible challenges.	The participants were asked to comment on whether they perceive the implementation of a trans-contextual phase as feasible. In particular, participants were asked about challenges they perceive in incorporating an additional phase.	1. Do you feel it feasible for teachers to teach this 4th phase? 2. Do you see any concerns or major challenges in incorporating a trans-contextualisation phase? 3. If so, what challenges do you perceive with respect to implementing such a 4th phase?

4.3. Data Collection

Each of the five participants were interviewed separately via Zoom, and after seeking permission, the interviews were video recorded. Each interview typically lasted approximately 45 min.

4.4. Data Analysis

The recorded responses from each interviewee were transcribed for analysis and the data collected were inductively analysed, recognising that an inductive approach allowed the researcher to "focus on an individual's meaning" [56]. The data analysis process was conducted via analysing each transcript manually.

4.5. Validity and Reliability

Prior to use, the instrument was initially validated by two science education researchers with expertise on qualitative research methods and semi-structured interviews. Based on their suggestions, the initial "establishing familiarity of the 3-stage model" section (Table 3) was added to facilitate the interviews. In addition, two pilot interviews were undertaken to establish the validity of the instrument. Considering the responses from the pilot interviews confirmed that the instrument allowed the authors to obtain meaningful data based on the research questions; the instrument was considered valid.

The data interpretation procedure was generated by one of the authors and the interpretation reviewed independently by the other authors. In case of disagreement with respect to the interpretation, consensus by all authors was obtained via discussions. By this process, the final version of the interpretation was considered to be reliable and possible to replicate.

4.6. Ethical Considerations

The following four measures were undertaken to ensure ethical considerations.

(a) Trust: Prior to the data collection, the participants were sent separate emails, briefing them on the intention of the study and the intended topics of discussion during the interview.
(b) Consent: All the participants gave informed consent to the undertaking of the interview, recording of the interview, and anonymous reporting of the interview.
(c) Pseudonyms: All the participants were given pseudonyms to protect their identity.
(d) Secure storage: All data were stored in password-protected drives.

5. Results

5.1. Interviewees' Familiarity with the 3-Stage Model

All interviewees reported that they have been previously involved in guiding teachers in operationalising the 3-stage model within their respective country. To clarify their level of familiarity, interviewees were asked to recall specific activities based on their prior involvement, as indicated in Table 4.

Table 4. Interviewees' familiarity with the 3-stage model (√ = yes; x = no).

Interviewee	Familiar with the Philosophy of Introducing a Science-Related Societal Issue via a Scenario	Familiar with the Second Science Conceptualisation Stage Related to Inquiry-Based Science Education	Familiar with Resolving the Social Issue Arising from the Scenario, based on the Gained Science Conceptual Learning
TE	x	√	√
CD1	x	√	√
CD2	√	√	x
SER1	√	√	√
SER2	x	√	√

In the cases where interviewees reported that they were not able to immediately recall the purposes or processes, the interviewees were guided to recall possible examples so as to establish consensus understanding of the intentions of the contextualisation stage (an initial scenario), the de-contextualisation stage (promoting inquiry-based science learning), and the re-contextualisation (resolving the issue arising in the initial scenario, utilising meaningful conceptual science, alongside other social considerations, e.g., environmental, economic, social).

5.2. Interviewees Perceiving a Need for Science Learning to go beyond the 3 Stages

Interviewees' responses and an interpretation of the findings are given in Table 5.

Table 5. Interviewees' perception whether the 3-stage model for science teaching is sufficient for addressing science learning for societal development.

Interviewee	Overall Response	Justifications for the Response	Interpretation of the Finding
TE	Maybe	*I am not sure whether it is important to go beyond the 3 stages, because the model is used with students in the 15–16-year-old age group. The scenario, at the beginning, is to get students involved with the science topic. Then, the various inquiry-based activities involved, are very good for conceptualising the science. And if students are involved in the third stage, i.e., discussing the issue, then curriculum aims are met.* *But in the 4th stage, yes, I think it adds to the profiles . . . because we can actually see if the student is making the same decision when they go out of school*	Perceiving the learning, via the 3 stages, as meeting curriculum expectations and unsure of the need to actually engage with issues within the 'real' society.
CD1	No	*If students do not relate to an impact of their learning on the society (referring to the limitation of the 3-stage model), then there is no 'beyond' the classroom impact. However, for a further segregated learning phase, there is the need for a recognised focus on society change, bringing about a qualitative change in the teaching.*	Perceiving the need for enhancing the purpose of science education; this having implications for changes within the society.
CD2	No	*Student science learning needs to be in a social setting (referring to the 3-stages), but it cannot be isolated from actual society needs; there is a need to perceive science learning as being 'for the society'.*	Perceiving the need to prepare students via science learning to be involved in focusing on societal development.
SER1	Partly	*I partly agree because, maybe this (referring to the model) is lacking in actual student activities fully addressing the issue and thus not actually see that their learning can relate to an impact on the society. And a further stage can allow the taking of the resolution made, within the school situation, to appreciate how it can be made to relate to an out of school situation.* *But, in the 4th stage, yes. I think it adds to the profiles . . . because we can actually see if the student is making the same decision when they go reflect on the out-of-school situation.*	Perceiving a limitation within the 3-stage model with respect to enabling students to address and suggest ways to resolve societal concerns.
SER2	No	*'Firstly, we have to ask ourselves, what learning do we want students to achieve? Let's go back and ask ourselves, what do we want to achieve though science teaching. Is it just so students 'know' science? I don't think so. We need to think bigger and if consider whether there is a role of science for or within the society then the 3 stages are not enough.*	Perceiving the need to enhance the goal of science education, so that it reflects on implications for the society.

5.3. Interviewees Perceived Value in Incorporating Trans-Contextual Science Learning

Interviewee' responses on the perceived value (as amplified in Table 3) are presented in Table 6.

Table 6. An overview of interviewees' perceived value towards the incorporation of trans-contextualising science learning.

Interviewee	Response	Justification of Responses Put Forward by the Participants
TE	Yes	• Trans-contextualisation enables a shift from a more *'passive'* teaching–learning practice towards a student-centred teaching-learning practice. In line with that, the TE participant emphasised that the successful implementation of trans-contextualisation would; *"encompass a more contemporary vision of scientific literacy, with respect to promoting learners as 'concerned citizens who can educate the society when they focus on going beyond the classroom";* • Promote the learners as *"ambassadors"* of science and *"influencers"* in society towards resolving societal concerns with *"evidence-based scientific arguments"*; • Not only develop learners' cognitive knowledge (i.e., science conceptual learning), or psychomotor skills (i.e., science experimental skills), but also promote the affective domain (scientific attitude) towards perceiving the *"value of science learning"*; • Incorporate the most recent theoretical advancements in science education field, particularly *"it can build a bridge between the theories on how to teach science and how it can be implemented to aid the society"*.
CD1	Yes	• Promotes *"scientific competence"* (science conceptual knowledge/skills, socio-scientific values/attitudes) as opposed to *"reproducing scientific knowledge"* in order to *"tackle the societal problems related to equity, justice and democracy"* via *"an education through science" approach;* • Incorporates a vision of science education within the current international science education policies (i.e., UN, or OECD) towards promoting learners as *"responsible citizens"* seeking to attain *"sustainable development goals"*; • Promotes a network of *"not only students, but also local education authorities, school leaders, academic leaders, and community leaders, society in general, and also parental engagement"* to generate *"a platform for the students to initiate their scientific argument-based movements"*.
CD2	Yes	• Addresses the need to promote *"a democratic society" through enabling learners to implement their collective and consensus decisions towards addressing societal concerns via trans-contextualising science education from classroom to a societal environment;* • Involves learning theories, particularly social constructivism, to enable the learners to construct their science conceptualisations *"within a social setting"* in order to promote learners' active engagement in the learning process.
SER1	Yes	• Addresses the gap in current science education practice, which is not sufficiently reflecting *"how students can apply their socio-scientific decision-making in a real-life context"*; • Enables the learners to become *"actual decision makers"*, whereby their socio-scientific decision from the 3rd phase is seen as having *"an actual impact in society"*; • Envisages an *"ideal scenario where the students have the knowledge, skills and attitude to act within the society as informed and scientifically literate citizens and solve societal problems"*.
SER2	Yes	• Provides a sense of relevance and a reflection of science learning to society as perceived by the student, emphasising the need for the learners to " . . . *actually see that there is some effect of their science learning for society"*; • Allows the learners to actively resolve a societal concern via applying their science competence learning towards putting forward *"initiatives for families, society and communities related to how to deal with, for example, plastic waste"*; • Promotes learners' self-efficacy and ownership for *"smooth integration"* from the classroom to a societal context; from being a group of individual learners to becoming *"future citizens"*.

Table 6 indicates that the interviewees perceived a value for science education playing a role in societal development via trans-contextualising, thus enabling learning to extend from the classroom context to putting forward "beyond-school, societal development" approaches.

5.4. Interviewees' Perceived Feasibility and Challenges with Respect to Trans-Contextualising Science Learning

Interviewee responses to the perceived feasibility and potential challenges are reported in Table 7.

Table 7. Interviewees' perceived feasibility limits and challenges with respect to including trans-contextualisation in science education.

Interviewees	Feasibility Response	Justifications for the Response by the Interviewees	Interpretation
TE	Feasible, but there are challenges	*As I have seen, there are many teachers who haven't realised that teaching all those general competences are actually a task for every teacher.*	Teacher lack of familiarity with wider aims of science education.
		When they (students) are teenagers they are concerned about their own problems. Sometimes it is very difficult to find ways how to motivate them to express more general ideas and they are somehow not ready for that.	Perceived student lack of motivation towards resolving societal concerns.
		Sometimes teachers are saying, 'Oh I don't do all those role plays and 'argumentation'. I, maybe, am not good at it. I don't sometimes know how to do it. I need training-'	Teacher perceived lack of professional development.
CD1	Feasible, but there are challenges	*You can expect that there to be some resistance from the existing system, I am talking about the teachers, and even parents. It happens because they are used to a memorisation-based approach. So, it can take time to convince teachers to actually value and implement the 4th stage.*	Teacher resistance due to the dominance of a traditional teaching approach.
		There are challenges in evaluation by the teacher, or even management because the system, I think teachers are not ready for the assessing the 4th phase.	Perceived lack of ability to evaluate learning outcomes from a 4th phase.
CD2	Feasible, but there are challenges.	*The Estonian national curriculum points out the competences to promote in the curriculum and points out that teachers need to connect teaching with everyday life. But teachers have freedom; they can decide what to teach. And they may not choose to include the 4th phase in their teaching, because they may not feel it is important.*	Teacher perceived lack of value towards promoting trans-contextualisation.
		Teachers have to change the teaching approaches, otherwise it is challenging to implement this phase, you know … you cannot do it with lecture method-	Teacher preference to traditional teaching approach irrespective of society needs.
SER1	Feasible. There are challenges, but possible ways to mitigate against the challenges.	*In Finland there is a national matriculation exam which create huge pressure for the teachers and students, e.g., to read, to pass, to get good scores, this means teacher are very busy in this endeavour.* *But I think that there is not so much a time limit if teachers appreciate its value.*	Teacher perceived emphasis on external, content-oriented examination rather than valuing the educational gain.
		Although there are plenty of activities maybe the teachers are not familiar with the, or they think they are not relevant for science teaching. *However, there are new generations of teachers who are just very eager for their teaching at school, to have an impact in the society. And if they manage to conceptualise that which is necessary, then it is feasible.*	Teacher lack of familiarity, eagerness and perceived importance.

Table 7. *Cont.*

Interviewees	Feasibility Response	Justifications for the Response by the Interviewees	Interpretation
SER2	Feasible, but there are challenges.	*The teachers might not be willing to have such extra work, because they have other notions of the curriculum, e.g., a focus on conceptualisation of science topics.*	A perceived curricular content overload causing a teacher level challenge of limited instructional time.
		Teachers need to have the vision and receive training for such teaching.	Teacher perceived a lack of value towards promoting trans-contextualisation and professional development courses.

Table 7 indicates that the potential challenges with respect to trans-contextualising science teaching-learning for societal development can be categorised as;

(a) Teacher level (i.e., lack of familiarity, value, ability, and willingness);
(b) Curriculum level (i.e., content overload and emphasis on only science conceptual learning in external examinations), and
(c) Student level (i.e., perceived lack of student motivation to engage in resolving societal concerns, perceived lack of student ability to resolve societal concerns).

6. Discussion

This study seeks to establish the value, feasibility and challenges associated with extending a literature-elaborated, 4-phase model for the teaching of school science. In the 3-stage model [53], the focus is on triggering student motivation through a familiar society-related context, enabling students to appreciate the need to gain further conceptual science and then be able to make, through argumentation, consensus socio-scientific decisions. The proposed extension of the model focuses on incorporating an additional trans-contextual "school to society" learning phase. The additional phase seeks to bridge the gap between learning within the classroom towards realising, as well as operationalising, how this can potentially impact society, promoting an active informed citizenry [22].

In general, the individual interviewees agreed there was a need to relate socio-scientific consensus decisions, made in the science classroom, with the need to undertake a further societal step. Interviewees also indicated the need for students to identify approaches or pathways to relate classroom decisions more explicitly with society, thus seeking to stimulate society developments within the community, leading to the potential initiation of a citizenry movement [22]. There was also general agreement, but not necessarily in the degree of emphasis, for the need to promote "beyond cognitive" learning, seen within science education as particularly addressing humanism aspects in a social constructivist manner in the creation of potential pathways [44,46].

In line with the interviewees' responses, there is literature agreement that promoting socio-scientific decision-making within the classroom lacks the mechanism by which the learner can implement socio-scientific decisions in a real-world situation [20]. Furthermore, while from a motivational consideration, science conceptual learning and a meaningful socio-scientific decision-making component can be addressed within the classroom via SSI [42], there is support for addressing action, related to the societal concern, that requires a vision of science education going beyond the classroom context [36]. In addressing vision III through promoting science education to encompass sustainable development at a societal level, it is recognised that science learning needs to incorporate actions at both personal and societal levels [28–31]. Such a vision for societal development is identified as a means of addressing scientific literacy via the humanism theory [50,51].

In supporting the introduction of a 4th phase, seeking to bridge the "classroom–society" divide, interviewees indicated that this needed careful attention. All interviewees recognised the need for science education to address “the future we want” [23] and, in so doing, accepted there was a potential need to go beyond the 3-stage model and, hence, agreed with the need, as expressed in the literature, to prepare a collective body of citizens who are actively [9], scientifically [10] and collectively [4] able to participate in resolving encountered societal concerns.

The interviewees recognised the need to put more emphasis on the role of science education initiating civic engagement and focusing more on promoting a democratic approach to enhancing global citizenship. Added to this, the interviewees supported the extensive literature on SSI, seeing consensus making as an important contribution within science education for students’ future lives [40,41], and valued the desired purpose of education as serving a practical (utilitarian) role via science, i.e., education through science [32].

The interviewees recognised that science education needed to include argumentation on value-laden social concerns [48] and in addressing society development, the humanism addition placed an emphasis on promoting socio-scientific decisions through active and collective participation within society [49]. Thus, the interviewees recognised that the 4th phase further promoted a constructivism-humanism approach, in particular through promoting interaction within student-centred, science learning, whereby learners were expected to construct their learning to enable interactions within society [38,39], thus promoting self-actualisation [47].

The interviewees saw the value of the 4th phase in that learners could implement socio-scientific decisions in a real-world situation; thus, not simply addressing a societal issue as part of classroom learning but seeing this as being for the benefit of the whole of society [20]. They recognised that to stimulate action, related to a socio-scientific decision, required science education to go beyond the classroom context [36], seeking ways to promote societal engagement. Thus, the interviewees supported a potential need for trans-contextualising science learning from the classroom to society, enabling learners to put forward ways to creatively address societal concerns, thereby seeking to promote an active informed citizenry [55]. The interviewees saw the value of this phase as encouraging students to develop and potentially undertake constructive post-consensus action measures, seen as enabling students to:

- Actively and cooperatively participate in creative ideas for raising awareness of, and putting forward, meaningful approaches to execute the proposed resolutions;
- Impact, potentially at the societal level, by putting forward actions which raise awareness of the need to address scientifically embedded societal concerns;
- Implement consensus and justified SSI decisions, developed within the school setting, by seeking to persuade other citizens to undertake a collective responsible behaviour towards addressing specific societal concerns, based on sound scientific argumentation and for the betterment of society.

With an appropriate focus on societal concerns related to society issues, the interviewees saw the 4th phase as being able to provide a meaningful bridge in developing a sense of collectiveness, or “society” [4], as well as drawing attention to sustainability aspects, seen within society as environmental, economic and social [37] and the need to reconcile science-influenced, society dilemmas [23].

Nevertheless, the interviewees saw challenges by introducing a 4th phase. In particular, they mentioned the following seven limitations:

a. Teachers lacked familiarity with such wider aims of science education;
b. A perceived student lack of motivation towards resolving societal concerns;
c. Teacher perceived lack of professional development;
d. Teacher resistance due to the dominance of a traditional teaching approach;
e. A perceived lack of ability to evaluate learning outcomes from the 4th phase;
f. Teacher perceived lack of value towards promoting trans-contextualisation;
g. Teacher perceived emphasis on external content-oriented examination rather than valuing the educational gain.

Findings in the literature agree [42] and imply the potential need to provide teachers with "beyond classroom" SSI-related instructional training in line with the curriculum, which also includes appropriately designed teaching resources (i.e., SSI and follow-up teaching modules, relevant ICT-web-based content), assessment guidelines for beyond SSI-involved teaching, and other supporting resources (e.g., additional reports and assessment strategies).

7. Conclusions

The interviewees generally saw the value in incorporating a trans-contextual societal focus within the teaching of science education. They expressed its value in promoting educational attributes in the following ways:

(a) A more contemporary vision of scientific literacy, e.g., "concerned citizens who can educate society when focusing on going beyond the classroom, making an actual impact in society";
(b) Enhancing scientific competence so as to "tackle societal problems related to equity, justice and democracy" via "an education through science" approach;
(c) Engaging learners towards becoming "responsible citizens", seeking to attain "sustainable development goals";
(d) Creating a potential engagement network of "students, local education authorities, school leaders, academic leaders, community leaders, society in general and parents" to generate "a platform for the students to initiate a scientific (environmental) argument-based movement";
(e) Seeing individual learners visualising themselves as becoming "future citizens putting forward "initiatives for families, society and communities related to how to deal with, for example, plastic waste";
(f) Recognising learners as "ambassadors" of science education and "influencers" in society towards resolving societal concerns with "evidence-based scientific arguments";
(g) Addressing the gap in current science education practice, which is not sufficiently reflecting "how students can apply their socio-scientific decision-making in a real-life context".

Nevertheless, the participants questioned its feasibility from the perspective of:

(a) A perceived lack of appreciation for wider aims for science education and a perceived curricular content overload challenging the use of limited instructional time;
(b) A perceived student lack of motivation towards resolving societal concerns or a teacher lack of familiarity, preparedness and perceived importance;
(c) A teacher perceived lack of professional development and a lack of ability to evaluate learning outcomes from the 4th phase;
(d) A teacher not seeing the value of promoting trans-contextualisation.

Furthermore, the interviewees pointed out additional challenges in adding a 4th societal trans-contextual stage within science teaching. They saw challenges in:

- Not recognising the need to focus on society change;
- Not perceiving science learning as being "for society";
- Not seeing the need for science learning to impact society;
- The lack of availability of actual student activities addressing trans-contextualisation.

Limitations of the Study

Little attention was paid in the interviews to the science education role needed to:

- Support preparedness for life in the realities of a developing society;
- Develop student potential as individuals;
- Collectively learning meaningful and perceived-as-useful directions as a society;

Visualised as enabling students to succeed in a changing world.

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