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Scientific Holism: A Synoptic ("Two-Eyed Seeing") Approach to Science Transfer in Education for Sustainable Development, Tested with Pre-Service Teachers

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Abstract: This paper presents a synoptic ("Two-Eyed Seeing") approach to science transfer in Education for Sustainable Development (ESD), based on an ontological framework inspired by two related concepts from Western philosophy (Sellars' synoptic view) and indigenous wisdom (Two-Eyed Seeing). It was tested and further developed in a participatory research process with first year student science teachers. The results show that this model can support a balanced approach between a scientific and a holistic perspective at each stage of the teaching process—preparation, implementation and assessment—and help to integrate sustainability issues consistently into science lessons. In the course of the research process, the model has developed into a viable educational tool that distinguishes between a person-oriented lifeworld image and a things-oriented scientific image and guides the systematic transfer between the two images. It promotes students' reasoning and scientific practice as well as their identity formation and community interaction, two equally important issues in ESD of today. The pre-service teachers were careful to close the loop, as they put it, between the two images. They saw health and environmental issues as particularly helpful in realising scientific holism. The pre-service teachers interpreted the role of the teacher as a facilitator or mediator between the two images rather than as an expert and advocate of a one-sided scientific image of the world. The model may be of general interest to teachers and researchers who design, implement, evaluate and investigate ESD activities. The potential use of the scientific holism framework and the synoptic ("Two-Eyed Seeing") tool for science transfer in public and political sustainability discourse is also discussed.

Keywords: education for sustainable development; health education; science education; science transfer; two-eyed seeing

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1. Introduction

1.1. The COVID-19 Pandemic: A Crossroads for Science and Sustainability

The COVID-19 pandemic was a major socio-scientific issue in which scientific and social aspects were intimately intertwined. Given the socio-scientific character of many sustainable development (SD) issues, there is an urgent need for science education and science communication approaches that empower scientifically literate citizens to make socially informed decisions based on appropriate scientific information. From this point of view, the COVID-19 pandemic was a worldwide test of citizens' scientific literacy and of the political role of science in society [1].

1.2. Rethinking Scientific Governance: Beyond Deficit Thinking

We cannot say that this test has been passed without problems. The pandemic highlighted what has been pointed out in the public understanding of science discourse for more than 20 years, namely that traditional science communication strategies, which are often one-sided and expert-oriented, are not sufficient to scope a wider audience. Such approaches, known as deficit thinking, are based on the idea that the public's lack of scientific literacy is the core problem for good decision-making [2].

The pandemic has reinforced this thinking [3]. Paradoxically, despite ongoing efforts at public engagement, public discourse has been affected by a subtle, top-down dynamic of scientism [4] that has generated scepticism [5] and sometimes even rejection of science [6], This is also known as the backfire effect [7], and it is suggested that we need to be more imaginative in presenting alternative models of scientific governance and fostering a culture of experimentation [8].

Bogner [9] points out that contemporary political discourse, as the pandemic and other SD challenges such as climate change show, is increasingly dominated by struggles for scientific legitimacy. In this way, political discourse is dominated by battles over expertise and knowledge rather than considering emotions, feelings and values. He calls this the epistemisation of politics. Building on Bogner's observations, Zeyer [10] has suggested that this current societal trend can also be attributed to the way science has been taught in the past. Schools and school science may have inadvertently encouraged scientism, although science education researchers have warned of the dangers of an unquestioned reverence for science [11,12]. The pandemic emphasises the need for innovative models for the governance of science that resonate in both education and public discourse [13].

1.3. Bridging Views: Scientific Holism, a Synoptic ("Two-Eyed Seeing") Approach in Education for Sustainable Development

This paper evaluates the concept of scientific holism, a Western philosophy-based approach to science transfer in Education for Sustainable Development (ESD) as a possible guiding framework for science-based and value-sensible discourse on sustainable development in schools and in the public sphere. In general, this perspective promotes a holistic yet scientifically grounded approach to socio-scientific issues and avoids both unbridled faith in science and pure esotericism.

ESD is conceived as "a key element of the 2030 Agenda for Sustainable Development. Its aims form one of the targets of the Sustainable Development Goal on education and it is considered a driver for the achievements of all 17 SDGs" [14]. The ESERA (European Science Education Research Association) special interest group Science | Environment | Health is concerned with the role of science education in ESD. It particularly wants to promote the mutual benefit between the three educational fields of science education, environmental education and health education [15]. The paper is situated within these research activities.

Scientific holism is reminiscent of Two-Eyed Seeing as it was conceptualised by Canadian Indigenous Elders Albert and Murdena Marshall [16]. "Two-Eyed Seeing" (TES) was originally intended to bring together Indigenous knowledge and Western scientific knowledge. Although some believe that its application should remain in this original context, others see its potential for broader educational and policy integration (see below Section 2.2). In this article, the label TES as a tool for scientific holism is used—with all due respect to its origins—not only because it is a catchy formula that defines the common core of a variety of approaches, but also because this wants to signify a kinship that is important in the context. If the Western connotation of the tool should be emphasized, the term synoptic transfer approach is used.

From an ESD perspective, the new approach is mainly motivated by the socio-scientific nature of most SD issues. In the context of health and the environment, a balance between a holistic and a scientific perspective has been identified as particularly important. From the perspective of science education research there is some more evidence in favor of the here presented approach. First of all, including socio-scientific issues [17,18] is a widely accepted goal of civic science education [1], science for everyday life [19] and humanistic science education [20]. Moreover, the model certainly also has intrinsic didactic strengths because it simultaneously addresses person-oriented and thing-oriented learners and integrates both empathic and systematic aspects into science lessons. It has been shown that this can promote the motivation of all pupils, especially many girls, for science lessons [21]. Finally, the approach combines two important contemporary topics in science education research, Argumentation and Scientific Practices, and Identities and Discourse Analysis, as they were identified by Odden et al. [22] in an encompassing trend analysis for sience education research. In the present article, these aspects will not be discussed extensively. Nevertheless, they can open a wide research field for TES in science education.

2. Background of the Synoptic Transfer Approach ("Two-Eyed Seeing")

2.1. Sellars' Stereoscopic View

The framework of Scientific holism [23] is based on Wilfrid Sellars' ontological approach of the stereoscopic or synoptic view, as it has recently been further elaborated by Esfeld [24]. Sellars [25] postulated that we see the world with two different eyes, a scientific and a holistic eye, and that these eyes produce two equally important but ontologically different images. He referred to the constant transfer back and forth between these images as stereoscopic view or synoptic view. In analogy to the biological version of stereoscopic vision, humans must superimpose the two images to, as Sellars writes, know one's way around.

Sellars basic suggestion is that the two images of the world differ not on an epistemic level, but in their primitive ontology, i.e., in the elementary building blocks from which they are constructed. The scientific image consists of things, entities that are characterised by their position in relation to other things. In the final instance, the things in the scientific image are made up of theoretically positioned, imperceptible point particles or matter in motion [24].

The other image, which Sellars calls the manifest image, consists of persons. In this conception, persons are the ontological building blocks of communities and are at the same time characterised by their membership in this community. Unlike point particles, which form atomistic systems of things, communities are formed holistically from persons, i.e., they are only persons qua forming a community with other persons and vice versa. Humans in particular are sentient persons with freedom of belief, will and action. In principle, however, in the manifest image everything else is conceived in analogy to persons, although there are different degrees of similarity to persons—e.g., cats are more similar to persons than trees, etc., and the similarity to persons fades in inorganic matter, although it never completely disappears [24]. This can only be understood insofar as these entities are conceived as parts of a community, i.e., in terms of a social holism approach.

2.2. Indigenous Two-Eyed Seeing

There seems to be an important kinship between the Sellarsian approach to stereoscopic view and Two-Eyed Seeing, which was originally introduced to the academic community by Canadian Indigenous researchers Elder Albert and Murdena Marshall to describe the process of bringing together the strengths of Indigenous and Western knowledge for the benefit of all [26]. TES has been used successfully in Canadian science education [27] and maths education [28].

Tow-Eyed Seeing is not a unique framework. In a careful review of the application of the two-eyes principle in healthcare, Roher and colleagues [26] conclude:

"It is interesting to note that scholars tend to interpret Two-Eyed Seeing in different and sometimes contradictory ways [...]; a number of terms have been used to characterise Two-Eyed Seeing, including theoretical framework, concept, methodology and guiding principle. Each of these terms has very different meanings and has implications for the application of the guiding principle in research studies" (p. 7/22).

The authors translate "Etuaptmumk", the Indigenous term for TES, as "the gift of multiple perspectives". They claim that this translation is important to fully understand the guiding principle of TES and to "extend it beyond Indigenous and non-Indigenous perspectives" (p. 7/22). They conclude that this flexibility is one of the strengths of TES, allowing "the guiding principles to contribute to different projects in different and customised ways" (p. 3/22).

An interesting version of TES is called the 'TES approach with epistemic insight' [29], which refers to the inclusion of the context of knowledge and the ways of understanding that knowledge. It points out that sharing knowledge and understanding each other is a collaborative process on equal terms that requires what has been called the C4-R4 philosophy. C4 stands for Co-learning, Co-designing, Co-creating and Co-sharing, while R4 means good Relationships based on Respect, Responsibility and Reciprocity, as the bedrocks of an eye-level process [30]. C4-R4 has been developed to guide TES between Western science and Indigenous Wisdom. This article argues that it can be extended to Scientific Holism and the continuous and systematic transfer between the scientific image and any (including Western) manifest images.

2.3. A First (Ontological) Framework of Scientific Holism

In order to develop a first and preliminary framework for scientific holism in ESD, the basic Sellarsian concept of the two ontologically complementary images was merged with the indigenous TES approach with epistemic insight. Translated into Sellarsian terminology, this means that there must be a constant transfer (switching of eyes) between the manifest and the scientific image of the world. The crucial question is how to make the transfer between the two images without reducing one to the other, and in a manner that respects the integrity and value of both images. We called the transfer from the manifest image to the scientific image reductionist or atomistic, and the transfer from the scientific image to the manifest image holistic (Figure 1).

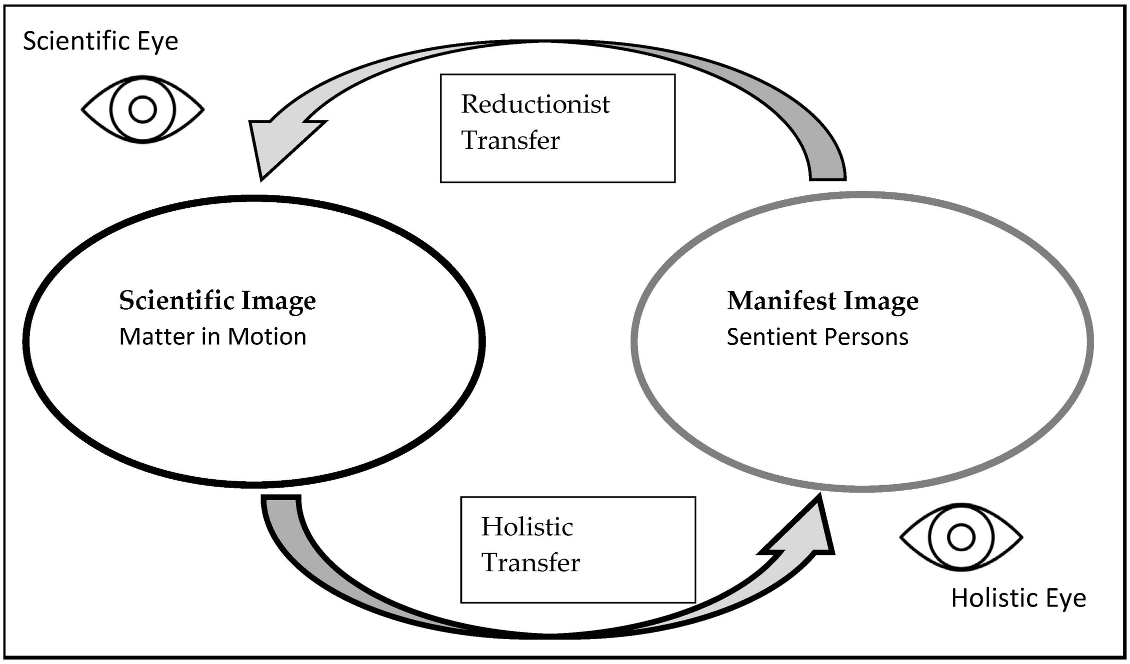

Figure 1. An ontological framework of Scientific Holism and Two-Eyed Seeing [23].

Figure 1 depicts the tool of TES in the Scientific Holism framework. It involves a continuous and systematic transfer between the two images. It aims to utilise the two different ontological perspectives of the two images to perform a synoptic transfer, i.e., a transfer that involves, at any time both perspectives, while one of them is always the scientific image. In principle, the loops of Figure 1 can occur in different sequences and without restriction. Although they appear so, they are not hermeneutic because the two images are considered as two equally comprehensive truths about the world. Note that there can be a variety of manifest images (depending on the people and communities who are involved), but always also the scientific image, which is seen, with due caution, as one image, for example in terms of the family resemblance approach [31]. We call this approach scientific holism.

3. Method

3.1. Participatory Action Research

This paper, starting from the ontological model of the stereoscopic view (Figure 1), takes the first steps towards the goal of developing a heuristic for TES in science education—that is, a tool for science teachers to prepare, guide, and evaluate action in science classrooms. It seemed appropriate, therefore, to involve the stakeholders of a future didactics of TES—pre-service teachers—at the very beginning of their studies, when they had no knowledge of existing science teaching practices and no theoretical underpinning for their first steps towards professionalization. It was expected that with their help, this research would be able to gradually transform a theoretically motivated model into a heuristic that science teachers could use in their daily practice.

Furthermore, it seemed appropriate in this constellation to use participatory action research. There was hope and promise that this type of research would not only provide conceptual refinement and theoretical progress for the researcher, but at the same time, and independent of research success, provide pre-service teachers with an opportunity for embodied reflection on science teaching, their role as science teachers, and their identity as future science teachers.

The basic idea of action research in education is that it is conducted in practice with the collaborative involvement of relevant stakeholders (i.e., researchers and teachers) and is designed to build on and contribute to both educational research and practice [32]. It aims to facilitate a shift from teacher-centered to student-centered teaching [33] and involves participants in conducting research on their own practice to improve teaching and learning, practices, and programs [34]. Importantly, the researcher is also a participant in the activities (ibid.).

A whole spectrum of types of action research can be found in the literature., between the two poles of technical (also called "knowledge-generating") action research, in which an external researcher aims to test a specific construct based on a particular theoretical framework [33], and teacher-centered action research, in which science teachers identify their problems of practice and are involved in all aspects of action research [32].

The distinction between these perspectives is not always sharp, and many action research projects in science education are not static with respect to the above modes (ibid.). This research can be located between these two poles, an approach often referred to as interactive, practical or participatory action research [33]. In science education, participatory action research strengthens the relationship between science (as perceived by students) and learners' everyday environments, and it provides a strong impetus for incorporating social science, environmental, health, and political perspectives into science teaching units [35].

3.2. Setting

The study was part of an introductory course for science pre-service teachers at a university of teacher education. In this course, students worked in groups to prepare short teaching sequences called miniatures. They performed these miniatures with their peers as their students. In what follows, we refer to the pre-service teachers who performed the miniatures as teachers and the pre-service teachers who were the students as students. The researcher who taught the course is referred to as the instructor. Miniatures are a type of microteaching that combines actual teaching with guided preparation and assessment sequences. We have always used them to introduce and reinforce important didactic principles such as the concept of didactic reconstruction. This year, for the first time, TES was used as a basic heuristic for this intervention, i.e., it was used for the preparation, implementation, and evaluation of the miniatures.

There were three courses with 20 to 25 participants each. Each course began with an introductory session in which the course schedule was presented and an introduction to the concept of TES was given. Then the students chose working groups of two or three and a topic for their miniature, and for the remainder of the session they began preparing their presentations, assisted by the instructor of the course.

The chosen topics had to be interdisciplinary (biology and physics) and were limited to three areas: Blood and blood pressure, Hearing and acoustics and Musculoskeletal system and mechanics. Within these three areas, students could pursue their own ideas. More about the chosen topics can be found below in the Results section.

After the introductory session, each group presented their miniature by teaching their classmates during the following weeks of the course. Each presentation lasted at least 20 min but could be longer depending on the intentions of the teachers and the activities of their students. No miniature lasted longer than 40 min.

Each presentation was followed by a plenary discussion in which the participants analyzed their observations during the presentation, what they appreciated and criticized during the session, how they would improve certain parts, etc., etc. This phase was followed by a final intervention by the instructor, who added his own observations and linked them and the previous discussion to the heuristic of the TES and to the relevant literature of science education research. Throughout these activities, the initial heuristic was discussed, evaluated, and refined in constant collaboration with all students involved. Course assessment included each student's active participation in a miniature, in the general activities of the course, and in the submission of a final written summary and reflection by each group on their own miniature.

3.3. Data Collection

Over the course of 12 weeks, all available data were collected. This included participatory observation of the instructor, his protocols, the allocation of documents of students teaching, and the final reflections submitted by the students [36]:

In participatory, open, direct observation, the observer participates as much as possible in the life and activities of a group under study in order to gain an insider's perspective, or at least to understand it. In this project, the instructor had to play a dual role: He was a participant with corresponding functions in the field and at the same time an observer. This can also lead to an overload, as this role means participation and distance at the same time. This conflict was easiest to manage during the presentation of the miniature, where the students acted on their own responsibility and the instructor deliberately retreated to the status of a distanced observer. In the evaluation phase, different levels of participation in the field had to be negotiated against the background of the specific situation. Full participation was required in the final phase of each miniature when the instructor provided direct feedback. However, this had to be carefully reflected upon at each stage. Being as active as possible was not always conducive to the research goal, as there was a risk that participant engagement in the case would become so great that the research would be compromised.

Protocols were used to record courses of action and to "log" behaviors, decisions, etc especially in relation to TES and shaping the design of the heuristic. After each session, the instructor reread the notes, rearranged them, added additional comments and reflections, and commented on the parts where he was directly involved and could not take notes. These notes were considered a type of "tracking" or diary notes. Depending on the purpose and goal, these notes were written in varying degrees of detail. They ranged from verbatim transcripts of negotiations and discussions to notes about important decisions or retrospective reminiscences. They were created using Microsoft OneNote, which allowed a combination of typed and handwritten notes.

It was decided not to use video or tape recordings. While they would have allowed for a more accurate and detailed representation of the process, they were felt to be too disruptive to the natural flow of the lesson and the different perspectives on the actions.

The document collection included actual documents such as work materials used during class, photos of experiments, and PowerPoint slides presented by the teachers. Important documents were also the summaries and reflections on their own miniature that each group had to submit at the end of the course.

An example of this procedure is shown in Figure 2. Here the instructor began the activity by drawing two circles to initiate a picture in the manner of Figure 1. He then drew a red symbolic heart to symbolise the role of the heart in the manifest image. He instructed the students to improvise and draw how they would see the heart in the scientific image. After some hesitation, the students became very active. They filled the circle on the right with drawings representing the scientific image of the heart. Inside the circle, some of the students involved drew a biological picture of the heart, with a left heart, a right heart, an aorta and a vena cava. Outside the circle was a picture of a pump with valves (representing a physical access to the heart).

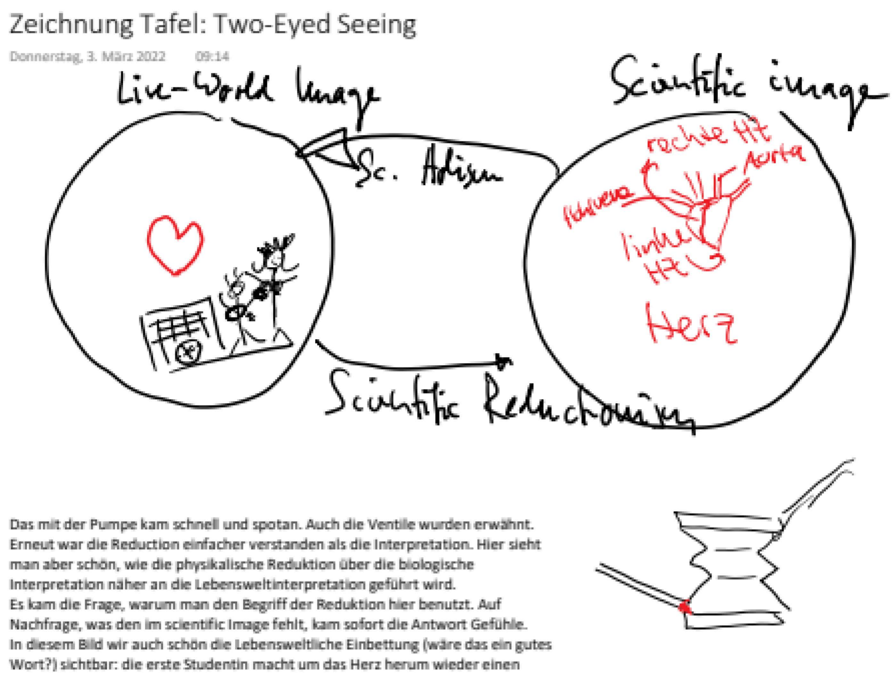

Figure 2. Screen representation of the Two-Eyed Seeing heuristic translation of the German text see below).

After this, the students were much more uncertain about how to get back to the manifest image. They asked what 'manifest' was supposed to mean, and at this point the instructor explained that it was about embedding the scientific aspects in the lifeworld. After this explanation, one student suddenly started drawing two children playing sport (with their hearts in the centre of their bodies) and a football in a goal.

Note that the two world images are exchanged, compared to Figure 1, which is an expression of the fact that the instructor was doing this activity for the first time. He noted (German text in Figure 2):

> *"The matter of the pump came up quickly and spontaneously. The valves were also mentioned. Again, the reduction was easier to understand than the interpretation. But this is a good example of how the physical reduction leads to the biological interpretation, which is closer to the lifeworld interpretation. The question was asked why the term reduction is used here. When asked what was missing in the scientific picture, the answer came immediately: feelings. In this picture we also see the lifeworld embedding (would that be a good word?): The first student draws a person around the heart (but very small). The next student then adds a goal and a soccer ball to the small person, as well as a heart rate monitor. The third student adds another person to take the pulse."*

This is an example of data collection that illustrates many features of the collected data: the picture of the students' drawings, the notes taken after the lesson and the impact on the evolving course. From then on, the term lifeworld image was used instead of manifest image.

3.4. Ethical Consent

All students were informed about the research project at the beginning of the activities and gave their consent for their materials to be used in the research activities.

3.5. Data Analysis

For the analysis of the data, we used the method of qualitative content analysis [37]. We adopted an interpretive approach. This approach allows researchers to view social action and human activity as text. Human action can then be viewed as a collection of symbols that express layers of meaning. Observational data can thus be transcribed into written text for analysis.

In the first stage of content analysis, we began with the research question. In our case, we were interested in how Figure 1 of the stereoscopic view could be implemented in our students' development, practice, and evaluation of miniatures, and how it could be improved or refined to facilitate this process. In this way, the labels in Figure 1 directly provided the analytic categories for analyzing the various data blocks.

Once the categories of analysis were established, the next step was to review the data to note additional relevant themes and category labels (grounded categories) for sorting the data (axial coding).

After establishing the analytic (top-down) and grounded (bottom-up) categories, explicit definitions or coding rules were developed for each category (either analytic or grounded). This criterion was either simply a specific statement about a particular sentence or word, or it included inferential levels. The data were then sorted according to these criteria for selection into different categories. This strategy was used to identify and explain thematic patterns. This process was conducted using MAXQDA 2022 software.

4. Results

4.1. Overview of the Miniatures

67 students took part in the module. 29 were female and 38 were male. Their average age was 24 years. Most of these students (54) had completed their secondary school education with a final examination, the Matura, and had then gone straight into teacher training at the University of Teacher Education. Their teaching experience was limited to an initial teaching placement at an external school. Seven of the students had completed another degree programme before entering teacher training, four had previously worked in another non-academic profession and two had previously been primary school teachers.

The 67 students were divided into three parallel courses, two with 24 students and one with 19 students. The courses each lasted 12 weeks and were structured in the same way. The students organised themselves into groups of two or three. Each group chose one of the topics on offer and presented a miniature. This resulted in a total of 23 miniatures. The themes of these miniatures are listed in Table 1.

Many of the groups chose health and well-being topics, i.e., the third learning objective of ESD, as the manifest image. In this way, ESD topics became a natural part of the education of these pre-service teachers, and the scientific aspects of these topics were integrated spontaneously and naturally. Fifteen out of 23 groups used the topics of health, medicine and environmental health to shape their lifeworld approach. This is consistent with the assumption that health, medical and environmental health topics are attractive and can help motivate students to learn science. It should be noted that the students were not forced to choose ESD topics.

Table 1. The themes of the miniatures.

Title	Topic	Description of the
1. Air pressure and altitude training	Blood and pressure	How the decrease in air pressure at altitude is used for endurance training
2. Blood pressure and thrombosis	Blood and pressure	Why and how thrombosis occurs in the low-pressure system of the blood circulation
3. ECG and atrial fibrillation	Blood and pressure	How wearables are used to detect atrial fibrillation
4. Measure blood pressure correctly	Blood and pressure	Why blood pressure must be measured at heart level
5. Blood pressure monitor	Blood and pressure	How blood pressure monitors work
6. X-ray and fractures	Radiation exposure and medical imaging	History of the X-ray and modern application
7. 5G and radiation exposure	Radiation exposure and medical imaging	How dangerous is 5G?
8. Nuclear war and radiation exposure	Radiation exposure and medical imaging	What is radioactivity and when is it dangerous?
9. X-ray images and radiation exposure	Radiation exposure and medical imaging	How are X-rays taken and how high is the radiation exposure?
10. CT and radiation exposure	Radiation exposure and medical imaging	How does computer tomography work and how high is the radiation exposure?
11. Afraid of radiation?	Radiation exposure and medical imaging	How high is the radiation exposure in daily life?
12. Skateboarding and moment of inertia	Musculoskeletal apparatus and mechanics	Which tricks in skateboarding use moments of inertia?
13. Strength and climbing stairs	Musculoskeletal apparatus and mechanics	How high is your physical performance when climbing stairs?
14. Free fall and drop tower	Musculoskeletal apparatus and mechanics	How do air pressure and gravity interact during free fall?
15. Musculoskeletal system and back pain	Musculoskeletal apparatus and mechanics	Why do so many people have back pain in their lives and what can be done about it?
16. Arm muscles and lever laws	Musculoskeletal apparatus and mechanics	How to explain the anatomy of the arm muscles using the law of leverage
17. Bungee jumping	Musculoskeletal apparatus and mechanics	The law of energy and the law of springs applied to bungee jumping
18. Hearing loss	Acoustics and the ear	Everything that can lead to hearing loss
19. Volume and hearing	Acoustics and the ear	Why too much volume damages our hearing.
20. Frequencies and hearing	Acoustics and the ear	Which frequencies are damaged by noise trauma?
21. Frequencies and audible range	Acoustics and the ear	At what frequencies is the normal human hearing range?
22. Directional listening and "cosmophone	Acoustics and the ear	How do you localise a sound source and is there such a thing as sound in a room?
23. Doppler effect	Acoustics and the ear	How do you use the Doppler effect to determine velocities?

4.2. Terminology Problems

During the research process, it became apparent that the original Sellarsian terminology was not fully understood by the pre-service teachers and needed to be partially replaced with more appropriate terms. First, the pre-service teachers preferred to use the term lifeworld image instead of the term manifest image. Also, in the discussion, students discussed the term persons. The discussion went in two directions. Some asked whether only humans can be persons. Can an AI (e.g., Siri) be considered a person? Is a potted plant that you address by name a person? One student talked about her friend who is convinced that the yeast dough she prepares every Sunday so that a yeast cake can mature and grow is a person. She was convinced that the dough will develop better if she talks to it regularly. Another person talked about Gaia, the hypothesis that the earth is like Mother Earth and as such represents a person.

The other strand of the discussion centred on the question of whether people are sometimes treated as *things* rather than people. In this context, someone talked about the way surgeons see their patients "as a rectangle under green sheets", as opposed to how a child psychiatrist, for example, sees his clients. Another example that led to a heated discussion was abortion. Is the foetus conceived as a person or as a thing during an abortion? And after how many weeks of development does an embryo become a person?

4.3. Closing the Loop

Closing the loop was a term that quickly became standard in the preparation and evaluation phase of the groups. Closing the loop meant looking at both images equally, the lifeworld image and the scientific image. Many groups began with a sequence of images from the lifeworld, then moved on to the scientific image and then returned back to the lifeworld image. The following example presents a description of a miniature that the students submitted themselves after the course.

Example: We chose the approach "from the lifeworld image to the scientific image". To do this, we considered the central question "Why do you have to move your feet in an aeroplane?" and based our miniature on this. We thought it would be easier for the pupils if we first drew on their previous knowledge from everyday life and then went into the theory behind it. This is how we started our miniature by asking the class and the pupils why they should move in an aeroplane. To do this, we asked the class to post their thoughts online on Menti. We then reviewed the blood loop, which we had already learnt in the first semester. We also showed a video/animation that illustrated the blood circulation again. [One of us] took over and did an experiment with the students where they were physically activated. She divided the pupils into groups of two and handed out balloons for them to blow up. The groups then had to stand back to back and use body movements, but without hands, to move the balloon from the floor to their backs. In the second step, the same procedure was used, with the difference that the groups of two had to take a step forwards on a repeated command and were only allowed to hold the balloon with their hands behind their backs until L. said that they could continue. [The third of us] then took the floor and explained to the class the problem that the blood in the low-pressure system does not flow back to the heart by itself. He referred to our experiment by showing the hands with the valves in the veins and the movement of the body with the muscle contractions of the skeletal muscles. In this way he explained why the blood returns to the heart. Finally, we returned to the guiding question from the beginning, why we need to move in an aeroplane, and solved this question with the newly acquired knowledge of how the veins work.

This group favoured starting with the lifeworld image because they felt that students would understand the topic more easily if they could relate it to their everyday knowledge. They chose the situation in an aeroplane on a long-haul flight, where people are advised to move their legs from time to time to avoid thrombosis. They then switched to the scientific image by presenting the venous side of the circulatory system and the mechanisms in the veins that transport blood back to the heart. They illustrated this fragile transport mechanism (pressure through the muscles and valve mechanism through the venous valves) with the balloon "experiment". This sequence is part of the holistic transfer back to the lifeworld image, which leads to the answer to the original lifeworld question.

Some groups started with the scientific image and then transferred to the lifeworld image with the holistic eye. As a rule, these groups did not make a second switch back to the scientific image. As this pattern was only revealed by the retrospective analysis, it could not be discussed with the pre-service teachers. However it seems that this characteristic use of the tool was based on a linear, sequential conception of transfer steps that preferred a start and an ending in the lifeworld image.

4.4. The Scientific Transfer

The scientific transfer is the switch from the manifest image to the scientific image. The tool describes this shift as a change from a person-oriented image to a moving matter image. The students interpreted this concept to mean that they had to find the things that were important in their chosen topic. It turned out that this process was a very helpful tool for didactic reduction, i.e., for focussing on the most important scientific message of the miniature. Through these iterative processes, students developed a more nuanced understanding and application of the scientific transfer, which increased their pedagogical effectiveness: the orientation to things in the scientific image brought the factual nature of the scientific image into play. For example, in the miniature about directional hearing, it was the careful introduction of appropriate physical things (air molecules and photons) that ultimately helped distinguish facts from fiction. The teachers wrote in their reflection:

"We started with the cosmophone from the glacier garden. It claims that the acoustic messages we send out into the universe will travel forever in space. We had our classmates discuss the extent to which this could be true. With this confrontation task, we wanted to encourage them to think about how sound propagates. Some gave the analogy of water and said that air waves probably also would stop at some point".

Obviously the students were equating a third type of wave, water waves, with acoustic and electromagnetic waves without realising that there are three different particles behind them. The instructor's response pointed out the danger of mixing fact and fiction when he replied:

"The introductory part of your lesson highlights the danger of [...] esotericism, i.e., the use of scientific terms in a way that is not scientifically appropriate. The cosmophone, the sound of the universe: these are all interesting metaphors, but they can contribute to misconceptions about science and should therefore be used with great caution".

4.5. The Holistic Transfer

The holistic transfer shifts from a moving matter perspective to a person-oriented perspective. The challenge for the students was to identify concrete people to enrich their teaching approaches. They did this on three levels. The primary personal dimension concerned the students in the classroom, here the pre-service teachers acting as students. The classroom represents a community in which the individuality of the pupils is directly integrated. This was illustrated through interactive experiments, such as the experiment in which students moved balloons without their hands to understand the muscle pump mechanism in veins. Other examples included auditory experiments to test frequency and loudness perception and demonstrations of the Doppler effect using mobile sound sources. These activities created a dynamic learning environment in which students experienced physics in a social and lively context. Student-initiated discussions on current topics such as the effects of 5G mobile phone radiation or the interpretation of X-ray images were further examples of this personal engagement.

The role of the teachers as persons were also important, especially when sharing personal stories or resources to enhance the learning experience. For example, one student teacher shared his skateboarding accident and used his X-rays as a teaching tool. Another brought anonymised x-rays from his father, who was a radiologist, into the classroom.

A poignant example was the inclusion of the war in Ukraine in the discussion about radioactivity and its effects on people, which directly addressed the students' current fears and concerns.

The teaching modules also addressed issues relevant to the wider community, such as hearing loss, cardiac arrhythmia and hypertension. Whilst these topics may not have affected directly the young pre-service teachers, they had a community relevance as many of them had relatives or acquaintances affected by these diseases, so the students could relate to these topics on a personal level.

Beyond the expected personal references, the students brought innovative ideas to their lessons. One surprising element was the use of fictional characters who, despite their unrealistic characteristics, were used effectively to create a relatable lifeworld perspective. Another intriguing approach was to deviate from a purely human perspective and consider the perception of animals, as was evident in a discussion about the auditory experiences of dogs. This conversation broadened the scope of the lifeworld image to include non-human perspectives and fostered an engaging dialogue about the effects of different sound frequencies on animals, taking into account the students' personal experiences with pets at events such as New Year's Eve celebrations.

The systematic consideration of people in the broadest sense had an important influence on the character of the miniatures. People were considered in a concrete, personalised way, not simply as signs of social aspects or as vague targets for instruction and education. Through the different person-oriented levels of teaching, the pre-service teachers were able to create a multi-dimensional lifeworld image that enriched the learning environment with direct, personal and community connections, as well as innovative and unexpected perspectives.

4.6. The Lifeworld Image and Sentiments

One characteristic of the observed educational setting was that the lifeworld image in class was characteristically permeated by sentiment, a term that the Cambridge Dictionary defines as "a thought, opinion, or idea based on a feeling about a situation or a way of thinking about a thing". The lifeworld image was person-oriented and thus inherently rich in sentiment.

In contrast, the switch to the scientific image, the scientific transfer, often led to a noticeable drop in sentiment. For example, when a lesson on radioactivity began with references to the conflict in Ukraine, there was a palpable tension in the classroom. However, this tension dissipated when the focus shifted to the scientific explanation of physical radiation, was replaced by a fairly detached atmosphere. This pattern was repeated in several lessons, including the one on blood pressure measurement, where the initial physical explanations about blood pressure left the classroom atmosphere cool and uninvolved.

The emotional climate changed dramatically when the abstract scientific content was personalised by measuring the blood pressure of one student in the classroom, who showed an unusually high reading. This caused excitement and concern at the same time.

Characteristically, the teachers often tended to avoid these emotional reactions. They wanted to focus on the scientific content rather than exploring its affective dimension. However, the importance of sentiments in the educational process was often reconsidered during the lesson assessment. Neglecting sentiments was then conceived as a double failing: Teachers missed opportunities to address students' confusion and to use sentiments to motivate scientific enquiry.

Usually, sentiments in the classroom were not merely incidental, but were evoked by the scientific content itself. Students' immediate reactions, be it concern about health indicators or amazement at physics demonstrations, were powerful emotional drivers. The teachers' own passions, such as an engineer-turned-teacher's fascination with MRI technology, also had a significant impact on student engagement, even if they were unaware of the technical details. Empathy emerged as an important factor in the classroom. Affective empathy was evident in the shared concern for a classmate's health, while cognitive empathy played a role in students' efforts to understand a patient's dilemma regarding medical procedures like radio imaging.

In addition, the lifeworld image was linked to normative implications and value judgements. Educational miniatures often contained an underlying moral that invited students to reconsider lifestyle choices based on scientific knowledge. These implications were typically definite, unambiguous and incontestable principles. For example, high volumes can damage your ears, so do not listen to music at high volumes through your headphones. An abdominal CT scan can cause high radiation exposure, so patients should ask their doctors if it is necessary. Blood clots in the deep veins of the legs can cause thrombosis, so people should move their legs in the airplane.

4.7. The Role of the Teacher

One of the most important findings seems to be that the framework conceives the role of the teacher in a new, "two-eyed" light. Indeed, in all three phases of the miniature—preparation, realisation and assessment—the pre-service teachers had to switch between two different roles. In the scientific transfer in the TES loop (Figure 1), the pre-service teachers (here as teachers in the miniature) saw themselves in an expert role, i.e., their responsibility and identification lay with the scientific image. To symbolise this situation, we created Figure 3. The teacher, the small figure between the two images, points to the scientific image.

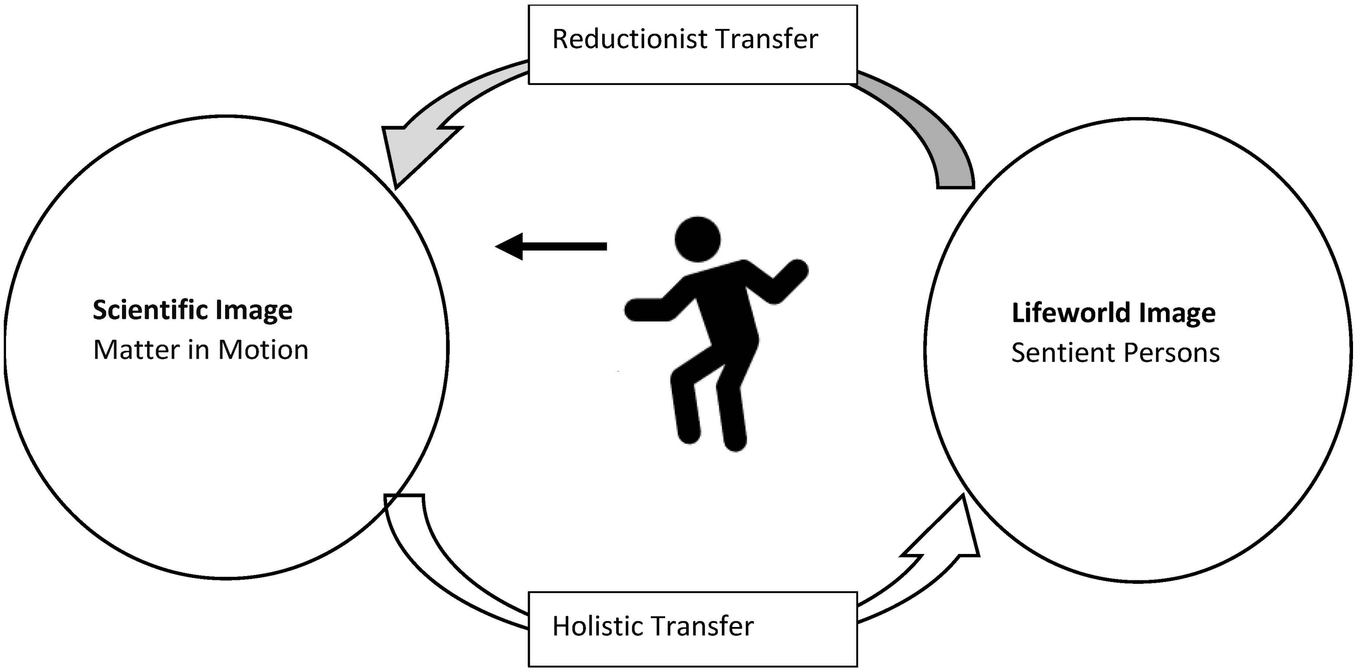

Figure 3. Reductionist transfer: The teacher in the role of the expert looking at the scientific image [38].

In contrast, in the case of the holistic transfer, they had to involve in the lifeworld of their audience. Now, they saw their role as teachers in helping their students to interpret scientific facts and evidence in the light of lifeworld contexts and preferences, either of themselves, or else of other people like patients or environmentalists etc. Figure 4 has proved helpful in symbolising this second role.

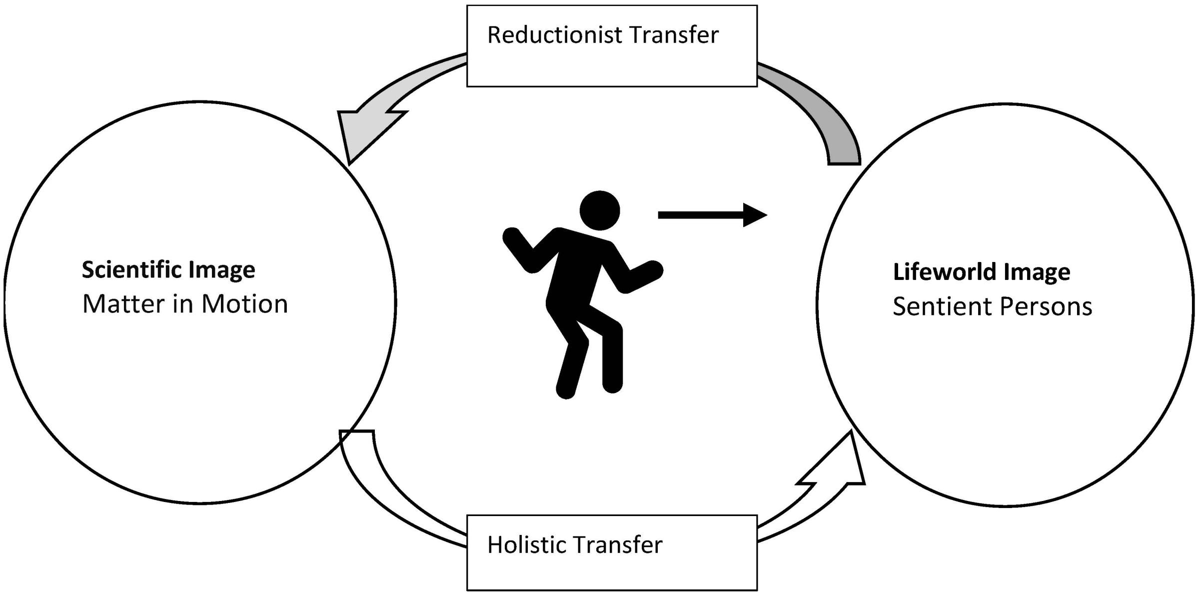

Figure 4. Holistic transfer: the teacher in the hermeneutic role, looking at the lifeworld image [38].

4.8. "Learn a Lot, but Also Feel the Spark of Magic"

The analysis of the summaries submitted showed that the students found the concept of miniatures and the two-eyes principle helpful. One group wrote:

"Overall, we find the concept of these miniatures very exciting and appealing to future science teachers. The miniature has shown us that we are really excited about teaching science and the 'two eyes' have given us a new perspective on teaching".

It was also clear that the pre-service teachers used the terminology introduced during the module in creative and thoughtful ways. For example, in their reflection on their miniature, one group wrote:

"It's also good to have a good mix between the lifeworld and the scientific world in the classroom, so that people-oriented and things-oriented students are given equal consideration".

Most of the comments also pointed out that it was particularly helpful that the "TES" approach consistently and systematically takes the students' lifeworld into account. One group wrote that this was an antidote to the "disenchantment of the world". The most striking argument, however, was that the TES approach focussed equally on scientific knowledge and its life-world interpretation. One group wrote:

"We believe that students can learn a lot in our miniature, but also feel the spark of magic that science can provide".

5. Discussion

5.1. Scientific Literacy and TES

The double role of the teacher seems to be a new concept that, as far as we know, has never before been conceived in literature. Indeed, switching between the two eyes to close the loop and the need for the teacher to switch between the two roles (expert and hermeneut) proved challenging but rewarding. It seems that our students found the holistic change of perspective and the associated hermeneutic role of the teacher more difficult. The expert role is more conventional for a science teacher and the pre-service teachers had most probably experienced their own science teachers in this role.

In fact, the transfer from the lifeworld image to the scientific image is close to the structure suggested by classical concepts of scientific literacy, such as the theoretical framework used in the 2006 PISA project, which is very common among science educators. The core of this framework is represented by scientific competencies. A scientifically literate person must be able to identify scientific issues, explain phenomena scientifically and use scientific evidence. This is very much in line with the shift from the lifeworld image to the scientific image, and scientific literacy in this sense suggests that this is all that needs to be done.

This type of scientific literacy may unconsciously have dominated the conceptual approach of the pre-service teachers which then assumed that scientific transfer in principle answers all questions posed in the lifeworld image. This then may have implied that, starting from the scientific image, the holistic transfer is perceived as an illustration and application of the scientific findings. Once this step has been taken, the circular process is immediately complete and there are no questions left.

A critical examination of the miniatures reveals that many of these indeed reflect the classical concept of scientific literacy. From this point of view, they are examples of well-built context-based science education. This is, of course, a good outcome of an educational process, but it is not the kind of innovation that the project was looking for. The pragmatic challenge for the pre-service teachers was to move away from the linear concept of context-explanation-prediction and to identify a truly two-eyed view onto two complementary images. The findings of this research show that this goal has not yet been fully achieved, but at the same time the findings have suggested some important complementarities that may prove to be helpful in working towards this goal.

5.2. Scientific Image vs. Lifeworld Image

As described, the pre-service teachers preferred the complementarity between scientific image and lifeworld image to the one between scientific image and the Sellars' manifest image. Indeed, in Sellars' view, the manifest image is philosophical in the sense that is far from a common-sense experience or conception of the world and of ourselves [25]. Thus, in the context of science education, the term lifeworld image seems more appropriate because it signals that our interest is not in philosophical theory, but in the lifeworld of our students. The concept of the lifeworld introduced by the phenomenologist Edmund Husserl comes very close to Sellars' concept of the manifest image, but has a more existentialist character than the concept of the manifest image [39]. Sellars himself was well aware of Husserl and his concept of the lifeworld, a term that became widely known through Habermas' theory of communicative action in the 1980s.

5.3. Orientation to Things vs. to People

As already mentioned, students were unsure how to apply the Sellarsian notions of matter in motion as the primitive ontological building blocks of the scientific image and of (sentient) persons as the primitive ontology of the manifest (lifeworld) image. To make these two (essential aspects) of the ontological complementarity of these images more comprehensible, we draw on occupational and career research, which in the last decade has identified person-orientation and thing-orientation as fundamental aspects of personality components in a dispositional-motivational complex [40]. We therefore suggested to label the lifeworld image as person-oriented (or people-oriented, as the term is also used in the literature) and the science image as thing-oriented [41]. This complementarity also reflects the person-thing discussion described in Section 4.2. It may help the students to better understand the ontological terminology of moving matter and sentient persons.

5.4. Position Observations vs. Sense Perceptions

The students were right to point out that there are questions concerning the definition of persons and things. In fact, to our knowledge, no coherent definition of things and people is given in the extensive literature on the subject, apparently on the assumption that the difference is clear. Here, a second complementarity that can be derived from moving matter and sentient persons may be of help, the one between between positional observations and sense perceptions as elaborated by Esfeld within the Sellarsian approach [24]. Indeed, the physical things in the scientific images of the miniatures were, for example, air molecules and their moving positions in an acoustic wave, or blood particles and their kinematic effect on the blood vessel wall, or mass particles in a skateboard and their rotation around the axis of symmetry. The biological things involved in the miniatures include the cilia and their positions on the ear, or the body collecting potential energy as the pupils run up the stairs, or various bones and muscles and their positional arrangement in the arm skeleton.

Sellars' ontological concept of point particles was instrumental in guiding students towards an optimal scientific transfer. According to Sellars, these elementary particles are defined solely by their relative position and have no sense properties. They are the theoretical entities that constitute material reality as arrangements of imperceptible point particles in motion.

These ontological considerations enabled the students to refine their choice of elements. By moving closer to Sellars' concept, they were able to abstract complex phenomena to their basic interactions, such as the interaction between air molecules and cilia in sound reception, rather than relying on more concrete but less basic elements such as hearing aids.

In the holistic transfer, these things had to be connected with the senses of the people involved. In the miniatures this was mainly through experiments, either physical or biological or both. Others were videos, student experiences, memories of certain scenes, etc., etc. Note that these sensory experiences did not take place in a solipsistic vacuum, but within (different, sometimes overlapping) communities. The first and omnipresent community was of course the classroom, with the pupils, but also, and importantly, with the teacher. However, many other communities appear in our miniatures, such as the teenagers (who listen to loud music), the skateboarders, the patients, the citizens, etc.

5.5. Facts vs. Values

Another important complementarity in the alternation between the lifeworld and scientific images is the one between facts and values, whereby values are used here in the broadest sense and include moral, social, political and aesthetic aspects as well as feminist and religious viewpoints, i.e., all areas that contain an evaluative aspect [42].

There was little discussion of values in the pre-service teachers' miniatures. In most cases, principles of action were derived directly from evidence without embedding them in a concrete context. For example, from the illustration of hearing and the physical explanation of loudness, the conclusion was drawn that loud music should not be listened to. Or the miniature about thrombosis ended with the principle that you need to get enough exercise on long-haul flights. In moral philosophy, the tendency to infer directly from "being" to "ought" is known as the naturalistic fallacy (or, not quite identically) the is-ought fallacy. A reflective balance should always be negotiated between evidence-based principles and intuition-based value judgements [43].

TES seems to be a way of introducing value discussions and judgements beyond the scientific method into science lessons, thus avoiding the naturalistic fallacy. The critical moment is the holistic transfer, in which an interpretative element is essential. Scientific knowledge is important for decision-making, especially in health and environmental issues. But the holistic transfer between evidence-based principles, which are part of the scientific image, and value judgments, which are part of the lifeworld image, is the one that explicitly includes the freedom of thought, feelings, norms and actions of the people involved.

5.6. Fact-Related vs. Sentiment-Laden Discourse

In order to distinguish the discourse in the science picture from the discourse in the lifeworld picture, we suggest to use the two complementary terms fact-related and sentiment-laden. We derive these terms to characterise discursive resources from the recent results of an extensive language analysis [44] which showed that since the 1980s, the use of sentiment-laden words in Google Books has steadily increased, while the use of factual words has systematically decreased. This pattern was also observed in fiction and non-fiction books, as well as in the extensive linguistic analysis of New York Times articles since its inception.

In our context, it is interesting to note that the authors provide about two dozen keywords for each cluster, e.g., mind, imagination, wisdom, wise, hunch, understanding, suspicion, believe, think, etc., for sentiment-laden discourse, and scientific, chemicals, model, method, fact, data, etc., for what they call fact-related discourse. A preliminary idea, yet to be tested, is to provide teachers with these discursive resources to help them create teaching materials for synoptic transfer.

5.7. Limitations

5.7.1. Limitations of Action Research

Critics of action research criticise its narrow scope and claim that its impact rarely extends beyond the immediate group of participants, calling into question its scalability and broader educational benefits. However, such criticisms often overlook the theoretical generalisability of case studies and cross-case analyses of qualitative action research, which hold the potential for far-reaching transformative effects [45].

In the present context, our research findings are referred to as educational tools—a deliberate emphasis on teaching strategies that prioritise experiential learning and discovery over didactic presentation. The expectation is that subsequent research might derive alternative tools through the lens of Scientific Holism, tailored to the contextual demands of the situation.

The intended scope of Scientific Holism extends beyond the boundaries of science education and ESD. It is hypothesised that the basic tool of synoptic transfer, as illustrated in Figure 1, could be adapted to support practices in science communication, philosophy of science, health and medical education, education for sustainable development (ESD) and civic education. Although each field may produce different tools, the core frame has the potential to underpin them all and promote a methodological pluralism that can enrich educational research and practice across a spectrum of disciplines.

5.7.2. The Question of Cultural Appropriation

The final consideration within this discussion relates to the inspiration of Indigenous TES, and the discourse on cultural appropriation. We could have confined our argument to Sellars' philosophical approach. and labelled our methodology a synoptic transfer approach, but we find that Sellars' pursuit of a third categorical shift after 1962—a unifying ontological category that would subsume 'matter in motion' and 'persons in communities'—is a compelling rationale for engaging with TES in its Indigenous conception. This concept inherently favours the equal presence and complementary application of both images, which have been fundamental to the Indigenous approach from the outset.

The indigenous sciences might represent, as Sellars probably would suggest, "perennial philosophies"—person-centred, imbued with sentiment and based on complex categorical reasoning. These philosophies span a continuum from the ancient scriptures to contemporary analytic philosophy [25]. Indigenous TES addresses the image of the lifeworld with a deep and consistent emphasis on emotion, spirit and wholeness. This perspective was particularly well received by our pre-service teachers as it provided an enriching educational experience without compromising the centrality of scientific enquiry.

In this way, the indigenous principle of TES proves to be an authentic counterpoint to the danger of scientism and promotes a balanced approach to ESD that upholds faith in scientific method. As voices criticising the dominance of scientism over public discourse grow louder, especially during the COVID-19 pandemic, it is becoming increasingly important to monitor scientism in education [8,12].

The prevailing literature on science education offers strategies to counter scientism, but often overlooks the fundamental dichotomy between fact-related, rational analysis and the realm of sentiments [9]. The marginalisation of personal beliefs, including alternative worldviews and spiritualities, under the guise of scientific absolutism is reminiscent of Weber's notion of 'disenchantment'.

If we adopt a definition of dignity as recognising and cultivating an individual's worth through substantive learning experiences [46], then the problem of scientism in education goes beyond pedagogical concerns and touches on the dignity of students. A scientistic educational environment compromises the personal and emotional dimensions of learning and can thus hinder intellectual growth and personal well-being.

TES offers a perspective that recognises complementary 'whole truths'—one based on evidence-based rigour and the other based on the intuition-based interpretation of experiences of persons in communities. This gift of multiple perspectives is not merely conceptual but serves as a practical way of exploring research directions that take into account both scientific knowledge and the humanistic dimensions of education. It has demonstrated its ability to promote inclusivity and dignity in Canadian Aboriginal educational contexts and holds promise in similarly supporting students in diverse cultural contexts who seek to balance scientific understanding with an excitement for the wonders and the dignity of our world.

As mentioned, TES raised interesting questions for the pre-service teachers about the fluidity of the boundaries between things and persons, and even leaves open the possibility that certain (or probably all) phenomena can be conceived of as both things and persons, depending on one's perspective. Note that this question may be particularly relevant to ESD, since from a Sellarsian perspective it is precisely the question of whether a phenomenon is understood as a person or as a thing that determines whether or not we conceive of our relationship to it/them in terms of rights and obligations [24]. In indigene TES, this is a much concerned aspect, as the following quote shows:

"The Indigenous ways of living in nature are strongly place based and the goal of Indigenous Sciences [worldimage] is to become open to the natural world with all of one's senses, body and spirit. Self-identities of Indigenous people are inextricably tied to their place in contrast to the common Eurocentric notion of land as a commodity. In the Indigenous Worldimage, the Earth is so sacred that it is "Mother", the source of life. Indigenous Sciences represent a way of knowing which is relevant to all aspects of Indigenous tradition. They are contextual and experiential, in direct contrast to many Western Sciences. In verb-based Indigenous languages, knowing is more about the journey than the destination. Indigenous Sciences is a plural term because of the diversity related to the strongly rooted place-based" [16].

This kind of approach to nature, which deeply impressed the pre-service teachers, is often used to argue that Two-Eyed Seeing could be a King's road to sustainability [47].

6. Conclusions

6.1. A Pedagogical Framework

All in all, our study has shown that the scientific holism approach is a good way to better address ESD topics in science education than a conventional scientific literacy approach.

However, it also became clear that the new role of the teacher poses significant challenges, and the research process identified several ways in which teachers can be supported in managing the two transfer steps. Based on the considerations in the previous section, these aspects can be listed in complementary form, as shown in Table 2.

Table 2. Pedagogical complementarities resulting from the research process.

	Scientific Image	**Lifeworld Image**
Observational level	Position observations	Sense perceptions
Ontological level	Things-oriented	Person-oriented
Reflective level	Factual judgements	Value judgements
Discursive level	Fact-related (evidence-based) discourse	Sentiment-laden (intuition-based) discourse

The idea is that teachers can use the contents of the table above to structure the two images in their lessons. Accordingly, Figure 1 also underwent considerable adaptions during the research process. From a philosophical point of view, these substitutions may be debatable, but they proved to be viable, useful and stable during the teaching process. The instrument that emerged from this action research process is shown in Figure 5. We call it a pedagogical model of scientific holism and synoptic transfer ("Two-Eyed Seeing"). It should be understood as a pedagogical tool that emerged from the idiosyncratic context of our student teacher education. A different context might have led to a different model, but it is assumed that it would still have the basic features of the ontological model (Figure 1).

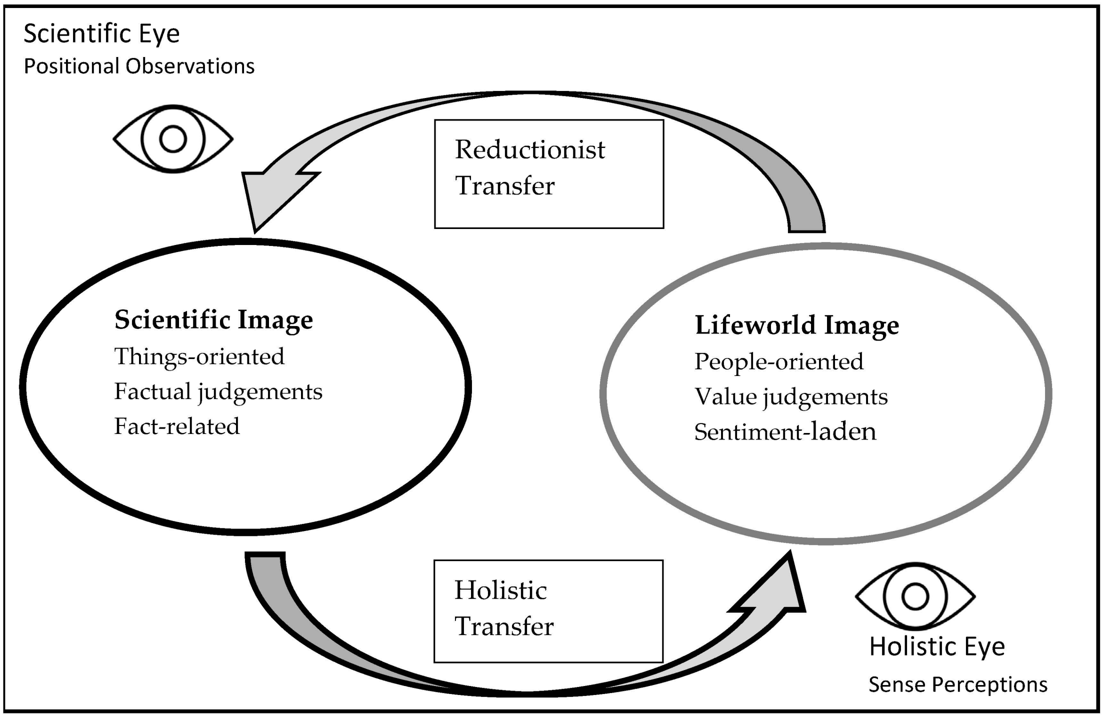

Figure 5. A pedagogical framework of Scientific Holism and Two-Eyed Seeing.

6.2. Beyond Educational Contexts

In this paper, it was suggested that Wilfrid Sellars' concept of stereoscopic view might be a helpful philosophical basis for a framework Scientific Holism. The research process provided the educational tool of TES, inspired by Indigenous wisdom and presented in Figure 5 and Table 2. We have suggested that such a framework may be helpful for the discussion of sustainable development issues in the context of ESD, but also more generally in the context of public understanding of science and in policy discourse. In this last paragraph, we would like to come back to these considerations.

As was pointed out, one of the most interesting findings of this study is that it assigns a new role to the teacher as a moderator in the transfer processes. From the Sellarsian perspective, we would consider this role of the moderator or facilitator to be similar to that of the philosopher, standing outside both the scientific and the manifest image. In particular, it should be noted that the role of expert on the scientific image does not mean embracing scientism, just as the role of expert on the manifest image(s) of the audience does not mean going native in an ethnographic sense.

TES in these contexts redefines the role of the teacher, not as a partisan promoter of science in the classroom, but as a moderator between the truth of the scientific image and the truths of the students' various holist images of a world we do not know from a point of nowhere. In this role, the teacher avoids scientism and the natural fallacy that confuses facts (of the scientific image) with values (of the manifest image).

We believe that this role may be generalized to other contexts. For example it can open up new perspectives is shared decision-making in medicine [48]. Interestingly, in shared decision-making in medicine, the role of the moderator is replaced by a working alliance between the doctor and the patient. However, Figures 2 and 3 might suggest a role of the GP between patient and medical expert that closely resembles the role of the science teacher in the classroom.

Another concept in this area is the approach of co-construction in pedagogy, a distinctive approach to learning that involves participants from pedagogical communities of practice, such as teachers and learners, engaging in social co-construction to develop solutions and knowledge to address relevant real-world problems through cross-boundary dialogue and problem-solving processes that span more than one discipline [49].

6.3. Applying the Framework to the Public Sphere

Looking at COVID-19 from a two-eyed perspective, in the scientific image, the pandemic can be described in terms of facts, i.e., things and their relative positions to each other. People are positioned relative to each other and thus infect each other, viruses adhere to cell receptors and thus penetrate cells, or, importantly, positions in epidemic diagrams spread in time and relative to each other. These facts of the scientific image allow an understanding as a prediction ex ante.

This is not the case with the transfer to the manifest image, which is based on a ex post interpretation [50]. The transfer from the scientific image to the manifest image is about how the effects of the moving matter can be perceived by real people in real communities. Take, for example, social distancing as a public health measure. The predicted effect of this measure is favourable in terms of the facts. The pandemic could be contained and fewer people could become infected, sick and eventually die.

On the other hand, social distancing in the manifest image can evoke negative feelings such as sadness, loneliness and anger in people. It can also lead to moral and normative conflicts, for example when older people are isolated in retirement homes and perhaps even die not from the virus but from social isolation. The emotionally charged interpretation of social distancing can therefore—intuitively or rationally—be deeply controversial.

The discussion about COVID-19, the pandemic and the way it should be dealt with has triggered a strong social controversy. In Switzerland, for example, COVID-19 has left its mark on Swiss society and created deep rifts that still exist three years after the pandemic. TES, the tool of synoptic transfer, cannot make these conflicts and inconsistencies disappear. But it can locate them within the theoretical frame of Scientific Holism and thus make them accessible for analysis and discussion. It takes the edge off the controversy because it recognizes the possibility of two (or more) complementary whole truths about two ontologically different images, both of which are necessary in order to know one's way around [25].

We believe that this pluralism of truths could be helpful in mitigating the tendency towards fierce controversy—especially without falling into the postmodern trap of anything goes [51]. In scientific holism, science has an undisputed primacy for understanding as a prediction of matter in motion. The point, however, is that it also clearly accepts and names the limits of science for understanding as interpretation, as giving and creating meaning for the people in the communities involved.

Consider again the deficit thinking identified at the beginning of this article as one of the most persistent challenges to science communication. synoptic transfer would not deny the shortcomings of laypeople, but it would limit these shortcomings to the scientific image and equally point out the limitations of scientific experts in interpreting science in the manifest image, a stance that prohibits contributions that rely on persuasion and assume a paternalistic relationship between science and the public [4]. This would avoid the cardinal error of deficit thinking, which focuses on getting the facts right rather than understanding the interplay of information, social structures, media ecologies and socio-psychological dynamics [3].

Conversely, and equally important, TES or synoptic transfer also enables a clear rejection of fake news and science denial within the scientific image and thus promote trust in science.

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