

Research Article

Sources of knowledge and trust in authorities as prerequisites of pre-service teachers' reflective judgment skills in the context of socioscientific issues

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Developments in science and technology enrich life in the 21st century. To cope with life in society, reflective judgment and decision-making abilities on both the individual and societal levels are needed. Schools must prepare the younger generations to become responsible citizens who are able to make reflective judgments. This study elaborates on how pre-service teachers in Türkiye make reflective judgments as persons who will go on to teach secondary school-level students in the future. The study focuses on sources of information students use, their trust in expert knowledge, and levels of reflective judgment skills. The study is based on a qualitative approach combining analyses of recordings of classroom discussions and interviews. The study found different levels of reflective judgment skills among the students and identified the sources of knowledge they select to make judgments and measured their trust in expert knowledge. The more students trust expert knowledge, the more reflective they are toward developments in science and technology.

Keywords: Science education; Pre-service teacher education; Socioscientific issues; Reflective judgments

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1. Introduction

Science and technological advancements are expanding tremendously every day, and these advancements influence society at large, in both positive and negative ways. As a result of these developments, it is no longer possible to give easy answers on how to solve many of the local and global challenges of the age we live in (Sjöström et al., 2016). For the younger generation to become responsible citizens, education has to focus on developing individuals who are capable of using scientific information and understanding the nature of scientific knowledge (Holbrook & Rannikmae, 2007).

To become responsible citizens, students need to identify socioscientific issues, draw evidence-based conclusions to comprehend natural and societal environments and the changes they undergo due to human activity, and make decisions on them (Holbrook & Rannikmae, 2009). Students' ability to achieve these skills is contingent on their ability to identify and understand

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real-world problems. However, a corresponding skillset is needed to respond to them. The challenges of scientific and technological developments expand, and societal challenges raised by them also influence science education (Marks & Eilks, 2009). Authentic real-world problems, which emerge from the reciprocal relationship among science, technology, and society, are thus seen as key instruments to develop advanced scientific literacy (OECD, 2015). One central objective of science education has changed due to this influence from science literacy to scientific literacy (Zeidler et al., 2011). Scientific literacy is needed beyond understanding science for later application. Contextualized scientific literacy or even critical scientific literacy is required to be a responsible citizen in contemporary society (Sjöström & Eilks, 2018).

Advanced scientific literacy is required for making informed decisions, by assessing, synthesizing, and evaluating numerous data and information sources, sound moral reasoning on ethical concerns, and grasping the complexity of interconnections inherent in socioscientific issues (Cebesoy & Chang Rundgren, 2023; Zeidler, 2001). Socioscientific issues (SSI), as drivers for the development of scientific literacy, are suggested to play an important role in developing corresponding skills (Zeidler, 2021). In SSI-based lessons, students are confronted with science-related real-life situations and are expected to understand associated problems and potential solutions for them. Some of the ultimate goals of employing SSI in a teaching scenario are to develop students' reasoning skills, to enable them to look at societal developments critically and to raise people who question, discuss, defend, and produce arguments to disprove opposing points of view (Zeidler et al., 2005; Zeidler et al., 2009).

The nature of SSI helps to address controversial issues from multiple critical perspectives (i.e. scientific, economic, environmental, sociological, ethical, and political) (Chang Rundgren & Rundgren, 2010; Sadler 2009). Students' social duty is increased, their ethical and moral ideals are cultivated, and their characteristics and values should change from being local individuals to global citizens (Lee et al., 2011). There is a growing body of literature suggesting the importance of SSI and highlighting their direct relation to numerous thinking skills, such as informal reasoning (Chung et al., 2016), moral reasoning (Zeidler, 2021), reflective judgment (Karışan et al., 2018), decision-making (Sadler & Zeidler, 2005), and scientific thinking (Calik & Coll, 2012), as well as important concepts like the nature of science (Eastwood et al., 2012), education for sustainable development (Eilks & Rauch, 2012), and developing global citizenship skills (Powell et al., 2021). Baytelman et al. (2020) found that individuals' epistemic beliefs and prior knowledge about SSI can also predict their argumentation skills.

There has been extensive research conducted to examine the connection between teaching using SSI as a framework and the development of higher-order thinking skills. This implies that scholars and researchers have already studied how using SSI-based teaching methods can impact the enhancement of skills like critical thinking, problem-solving, and analytical reasoning. The current study adds to the previous research by illuminating a specific topic in the context of SSI-based instruction and advancing the field. Specifically, it focuses on the reflective thinking of pre-service teachers. The study aims to understand how these teachers engage in reflective thinking processes when they were exposed to SSI-based teaching methods. It explores how they consider their sources of knowledge and the extent to which they rely on authoritative sources in the context of teaching SSI. By focusing on a particular aspect of the relationship between SSI-based teaching and higher-order thinking skills, specifically how pre-service teachers think and make decisions when engaging with SSI content, the present study essentially presents a new research study that builds upon the foundation of earlier investigations. In this sense, Authorities are seen as sources of information based on expert knowledge. The study aimed to explore how knowledge and trust in authorities on three different socioscientific issues, namely food additives, industry 4.0, and nuclear energy use can be utilized to gain a better understanding of their reflective judgment skills.

2. Background

SSI are authentic and controversial issues with no definite solution (Sadler & Zeidler, 2005; Zeidler

& Keefer, 2003). Stolz et al. (2013) suggest authenticity and controversial nature as the most important criteria of SSI to be used for science teaching. Other criteria are that evaluation is undetermined in socioscientific respect, that debate about them is possible, and that arguments in the debate come, among others, from science and technology. In SSI that are generally controversial in nature, opposing views exist among people on the issue in question. Individuals are expected to defend their opposing views during SSI-based discussions. The source of information used in the debate appears to be positively related to the quality of these discussions (Baytelman et al., 2020; Barzilai et al., 2015; Karışan et al., 2018). However, one has to be aware that scientific information used by the majority of the public often is filtered by those transferring and using the information, such as journalists, politicians, or pressure groups concerning the public (Stuckey et al., 2015), or teachers when it comes to formal learning.

The source of knowledge or the famous question “How do we know what we know?” is an important component of epistemology (Dew & Foreman, 2020; Hofer, 2016). It has always been an issue debated by philosophers (Bernecker & Pritchard, 2011), psychologists (Fosshage, 2011; Gladwell, 2007), and educators (Pigott et al., 2021). Knowledge can only be effectively explained through its sources (Audi, 2002) and there is a direct relation between sources of knowledge and justifications. However, justification of a belief does not guarantee that it is true, because a person could be convinced in creating ideas based on felt evidence that is ultimately deceptive. Potential sources of knowledge on a vague problem may shed light on the vagueness of the issue. The role of the authority or individuals’ trust in an authority is a determinant variable for well-grounded debates (Audi, 2002). Unconditional trust in authority can cause problems, just as not trusting at all can cause different problems. Aside from the source itself, feelings about the authority behind the source can also form the ground for an individual’s justifications for an ill-structured problem. Audi explores the different ways in which individuals acquire knowledge and justifiable beliefs. He categorizes sources of knowledge into four main groups: consciousness, experience/reason, perception, and memory. Audi discusses perceptual knowledge, emphasizing the reliability of our senses in providing us with accurate information about the external world. Audi critically examines each source of knowledge, considering their strengths and limitations. He also addresses scepticism and defends the notion that these sources can provide reliable and justifiable knowledge, even though they may sometimes be fallible. Audi’s (2002) sources of knowledge theory was used as a theoretical structure in order to explore the pre-service teachers’ sources of knowledge in the present study.

King and Kitchener (2002) defined ill-structured problems, such as SSI, as issues that cannot be solved by the mechanical application of an algorithm; defined as a matter requiring judgments based on the strength of available evidence and the adequacy of arguments. These problems cannot be solved concretely (Kuhn, 1991). Individuals who encounter ill-structured problems are expected to use their skills such as critical thinking, scientific discussion, and reflective judgment in the solution process, as well as using their knowledge and being able to reflect on the source of their knowledge. Reflective thinking requires a process that reveals what individuals know and how; this is a concept that was first described in the educational literature by Dewey (1910). According to Dewey, the first step of reflective thinking includes uncertainty. At this stage, individuals are faced with a problem that does not have a definite solution, like in SSI that are controversial in nature. As a second step, a definition of the problem is needed which can be seen as an introduction to the reflective thinking process. Forming a hypothesis, reasoning, testing the hypothesis, and solving the problem are listed as other stages of reflective thinking according to Miettinen (2000).

The epistemological beliefs of individuals affect their reasoning processes (Bendixen et al., 1998; Tuncay-Yüksel et al., 2023). For this reason, individuals' thoughts about how they know what they know are seen as an important step in reflective thinking (Woodwell, 2013). The answers to questions such as what and how we know, what our sources of knowledge are, and what our reliance is on authority can be listed as important criteria that show the reflective judgment level.

King and Kitchener (2002) consolidated these criteria and formulated a model aiming at uncovering individuals' approaches when confronted with ill-structured problems. This model examines their information sources, their adherence to authority, their epistemological beliefs, as well as whether their ethical and moral judgments are founded on a singular truth or interconnected multiple truths.

Individuals who make decisions on ill-structured issues are expected to realize that the solutions are open to criticism and re-evaluation in light of new findings (King & Kitchener, 2004). Teachers need to develop corresponding skills and are expected to transfer these skills to their students. An individual who makes reflective judgments, while focusing on the dilemma, tries to understand the relationship between concepts by referring to their prior knowledge (Karışan et al., 2018). This person should also have a multi-faceted viewpoint on the problem. Individuals who approach problems in this way offer "more accurate, more solidly based" solutions that can be obtained with current evidence rather than "absolute truth" in solving ill-structured problems (Sadler, 2011). Therefore, the reflective judgment process needs to be improved by developing problem-solving skills and critical attitudes of individuals. Individuals who can provide efficient answers to challenges they encounter possess a valuable skill that benefits both themselves and the society in which they live; this is what teachers should prepare their students for (Yin, 2015; Zeidler et al., 2005). It is critical for teachers to expose their students to ill-structured problem scenarios throughout their teaching and to allow students to participate in the resolution to raise individuals with these talents. That means, first of all, teachers need to be knowledgeable and critical of sources of information and they need to reflect on the varying quality and nature of information obtained from experts, compared to their personal experiences, the media, and the social environment (Belova et al., 2017). The model, known as the reflective judgment model [RJM], forms the theoretical background of the present study.

The RJM is a seven-step model, with each step containing its logical unit. These steps are differentiated into three categories, showing reflective reasoning levels: pre-reflective, quasi-reflective, and reflective (see King and Kitchener (2002) for a detailed description). A summary of the RJM by King and Kitchener is given in Table 1. Individuals in these categories have different

Table 1

Stages of reflective reasoning according to King and Kitchener 2002

Stage 1 to-3: Pre-reflective reasoning	At these stages, persons believe "knowledge is gained through the word of an authority figure or through firsthand observation, rather than, for example, through the evaluation of evidence. They believe that what they know is absolutely correct and that they know with complete certainty. People who hold these assumptions treat all problems as though they were well-structured (defined completely and resolved with certainty." (King & Kitchener, 2002, p. 39)
Stages 4 and 5: Quasi-reflective reasoning (Stages 4 and 5)	At these stages, it is recognized "that knowledge - or more accurately, knowledge claims - contain elements of uncertainty, which they attribute to missing information or to methods of obtaining the evidence. (King & Kitchener, 2002, p. 40)
Stages 6 and 7: Reflective reasoning	At these stages, persons accept "that knowledge claims cannot be made with certainty, but are not immobilized by it; rather, they make judgments that are "most reasonable" and about which they are "relatively certain," based on their evaluation of available data. They believe they must actively construct their decisions, and that knowledge claims must be evaluated in relationship to the context in which they were generated to determine their validity. They also readily admit their willingness to reevaluate the adequacy of their judgments as new data or new methodologies become available." (King & Kitchener, 2002, p. 40)

solution strategies to problems. It is crucial to ensure that students confront everyday life challenges during the educational and training process, to encourage them to explore viable solutions to address problems, and to conduct profit and loss analyses with a critical viewpoint in circumstances when they cannot find a solution. It is important to analyse the thinking mechanisms of individuals who encounter ill-structured problems, to determine from which angle they look at events, how they structure information, how much they trust authorities, or how they make a judgment by evaluating the multidimensional structure of the event from different perspectives as it is typical for dealing with socioscientific issues, as discussed in the introduction. The RJM can be used as a tool to analyse the level of judgment skills students develop.

3. Research Questions

The research questions of this study are:

RQ 1) What are the sources of knowledge that pre-service teachers refer to when making judgments on SSI?

RQ 2) How do pre-service teachers trust authorities in various SSI?

RQ 3) How advanced are pre-service teachers' reflective judgment skills across different SSI?

4. Method

4.1. Approach

A case study research design was used in the present study (Merriam & Tisdell, 2015). This design tries to give the reader a holistic view. According to Yin (2015), a case study is an investigation of a phenomenon within its real-life context which is open to the use of theory or conceptual categories that guide the research and analysis of data.

4.2. Study Context

This research was conducted in a 14-week 'socioscientific issues' elective course for pre-service elementary teachers. It was a general elective course open to all pre-service teachers from any subject (e.g. elementary science education, math education, early childhood education etc.). The course content aimed to address the issues that are ubiquitous in modern society, which were open for debate and convenient for classroom discussion. For this purpose, pre-service teachers discussed various SSI: the Istanbul Canal Project, the Akkuyu Nuclear Power Plant project, the use of food additives, the development in Industry towards the application of Industry 4.0, artificial intelligence, wearable clothes, vaccines, etc. Three SSI out of twelve, namely food additives, Industry 4.0, and the building of the Akkuyu nuclear power plant in Türkiye, formed the data source of this study. There are various reasons to select these three issues. First, these issues are relevant to real-world concerns. Food additives impact our daily lives as consumers, Industry 4.0 represents a transformative technological shift with far-reaching implications, and the construction of a nuclear power plant raises important environmental, safety, and energy policy questions. Second, by choosing these distinct issues, we aimed to expose students to a diverse range of topics that span different aspects of science, technology, society, and ethics. This diversity encourages students to think critically and engage with a variety of perspectives. Third, each of these issues integrates multiple disciplines, such as science, technology, ethics, economics, and politics. Exploring these topics allows students to see how different fields intersect and contribute to our understanding of complex real-world challenges. These issues have also global implications. Food additives are relevant to health and safety worldwide, Industry 4.0's technological advancements are reshaping industries globally, and the construction of a nuclear power plant in one country has international implications due to its environmental and geopolitical impact. Moreover, the Akkuyu nuclear power plant in Türkiye case is particularly relevant to the local and cultural context of Türkiye. It provides an opportunity for students to explore how socioscientific issues are influenced by regional dynamics and cultural values.

To sum up, we incorporated these three socioscientific issues into the present study context to offer students a well-rounded educational experience that combines scientific knowledge with critical thinking, ethical considerations, and an understanding of the complex interactions between science, technology, and society. Throughout the course, pre-service teachers engaged in discussions about controversial issues and were allowed to defend their positions. Each lesson lasted an average of 90 minutes. 12 out of the 14 weeks were dedicated to these activities. The classroom discussions were held as panel discussions. Two groups, consisting of three students each, argued the SSI in question. At the beginning of the term, students were informed which SSI they would have to discuss and in which session. The students were asked to prepare the discussion by searching for any pro- and con arguments to be used in the debate, concerning the pro or con side they were assigned to. Students were asked to find arguments along the following perspectives: scientific, environmental (if the topic had such a point, for instance, the Istanbul Canal or the Akkuyu nuclear power plant, etc.), ethical, sociological, economic, and political. In the discussions, the panellists (six students in total) raised their pro and con arguments about the current issue for about 60 minutes. Three students attended as jury members and were responsible for following the discussion carefully, taking notes, and grading the panellists. Panellists and jury members changed each week so that all students could experience the process. The rest of the students observed the panel discussion. At the end of the panel discussions, all students had a chance to comment on the debated issue, if they agreed or disagreed with the panellists, and to formulate their position and arguments. This post-discussion lasted approximately another 30 minutes but varied, depending on the issue.

4.3. Participants

Participants were 25 third-year pre-service teachers (16 female, 9 male), and had an average age of 24 years (ranging from 22-30) studying at a university's Department of Elementary Science and Computer and Information Technologies Education in the 2020 spring semester. The students were studying to become teachers on the lower secondary schooling level, more specifically teaching in grades 5-8 (age range 11-14). All but one of the participants were student teachers; one participant (age 30) was already working as a teacher at that time.

4.4. Data Collection

Pre-service teachers' classroom discussions and semi-structured interviews were used for data collection. The course was administrated as an online course due to the COVID-19 pandemic; classroom discussions were automatically recorded with the prior permission of all participants. These video recordings formed one source of data for the current study. Pre-service teachers' classroom recordings were transcribed verbatim and analysed to explore the student teachers' sources of knowledge and trust in authorities.

Additionally, Prototypic Reflective Judgment Interviews (PRJI) according to King and Kitchener (1994) were used for data collection based on the original English version. All pre-service teachers were interviewed following the classroom discussions. For this study, the focus was laid on three sessions (food additives, Industry 4.0, and nuclear energy power plants). Each of the three sessions was followed by seven standard questions (see Appendix 1) aimed at encouraging pre-service teachers to explain their positions. The interviews were used as an additional data source to triangulate classroom discussions, and to explore the reflective judgment levels of participants, but also for a better understanding of participants' sources of knowledge and trust in authorities. All the interviews lasted between thirty to forty-five minutes and were audio recorded and transcribed verbatim.

4.5. Data Analysis

Qualitative content analysis according to Mayring (2004) was used to explore pre-service teachers' sources of knowledge and trust in authorities, in both data sources, namely classroom discussions, and interviews. Deductive content analysis, which is used when the structure of the analysis is

operationalized based on previous knowledge, was used to explore sources of knowledge. Inductive content analysis, in which categories are largely derived from data, was used to explore trust in authorities. Analysis of reflective judgment skills was done by Prototypic Reflective Judgment Interviews (PRJI) analysed by ratings based on King and Kitchener (1994).

Assessment of Source of Knowledge: Audi's sources of knowledge theory (Audi, 2002) was used as a theoretical structure to explore the pre-service teachers' sources of knowledge. The theory addresses four standard basic sources: consciousness, experience/reason, perception, and memory.

Assessment of Trust in Authorities: Inductive content analysis, in which categories are largely derived from the data, was used to explore the pre-service teachers' trust in authorities. In this method, researchers run open coding and create categories (see Table 2).

Assessment of Reflective Judgment Skills: Preservice teachers' interview responses were evaluated using the framework developed by King and Kitchener (1994). In the reflective judgment model, there is a 7-step hierarchical order that classifies the reflective thinking skills of individuals from simple to complex. The lower levels contain more simple thinking structures compared to the upper levels, the higher the level, the more complex the thinking skills are (King & Kitchener, 2002). The seven steps are grouped under three reasoning/reflection categories. According to this grouping, the first three levels are considered pre-reflective, the 4th and 5th levels quasi-reflective, and the 6th and 7th levels reflective. Pre-reflective thinkers exhibit a disposition characterized by concrete beliefs and unwavering convictions, often exemplified by statements such as "If it is on the news, it has to be true." They tend to avoid questioning established authorities, embracing a worldview that perceives definite right and wrong solutions for every issue. Their thought processes lean towards rigid adherence. On the other hand, quasi-reflective thinkers recognize the inherent complexity and ambiguity of certain problems, acknowledging that not all questions possess clear-cut answers. They display a degree of scepticism towards authorities, understanding that absolute trust in them might be unwarranted. For instance, a quasi-reflective thinker might ponder, "Different experts could be influenced by commercial interests or personal experiences, potentially impacting their perspectives on matters like health and well-being." Reflective thinkers, in contrast to the preceding categories, approach situations with an inquisitive mindset. They wholeheartedly endorse the belief that one's vantage point influences their perception. Embracing the notion that truth can evolve over time, they are more inclined to question prevailing narratives and examine alternative viewpoints. For instance, a reflective thinker might express, "While proponents present compelling evidence, it's crucial to remain cautious, as new evidence from deniers could potentially alter the balance of the argument." Reflective thinking stands as the pinnacle of intellectual growth, encompassing a dynamic and adaptable approach to understanding the complexities of the world.

Since thinking processes as such are complex, the reflective judgment process is also a complex one. King and Kitchener (1994) proposed an analysis method to determine the reflective thinking level of individuals. In this method, dominant steps in the thinking structure that individuals exhibited while thinking reflectively are to be identified leading to a three-digit scoring. Each student's scores were summarized into a three-digit code. Each of the seven questions was categorized and the three-digit codes express the most dominant codes in terms of frequency, followed by the second and third dominant codes. If only one level of judgment was identified, raters assigned the same score to all digits (e.g., 3-3-3). If a rating contained another level of reasoning in addition to the most dominant style it is added to the third place (e.g., 3-3-4). If there were three or more different levels of judgment, they were rated concerning their dominance (e.g. 3-4-5). To calculate the stage each digit was differentially weighted (50% for the first digit, 30% for the second, and 20% for the third) to reflect the relative proportion of emphasis given to the particular developmental levels. The stage expressed the level of reflective judgment skill as pre-reflective for stages smaller than 3, quasi-reflective at stages bigger than 3 up to 5, and reflective above 5 (King & Kitchener, 1994).

Table 2

Inductive categories for trust in authorities

<i>Level</i>	<i>Justifications</i>
Trust	Experts follow ethical values Experts have profound knowledge Experts may have varying interpretations, but based on their expertise Experts have different fields of expertise but are trustable
Low trust	I listen to experts but prefer to make my own choices I listen to experts, but I prefer trusting my personal experiences Cultural views can be as similarly important as knowledge Experts have different fields of expertise but are not trustable as such Experts can also be subjective
No trust	Experts may be wrong Experts may look for personal benefits Experts may give an opinion based on money Experts may give an opinion based on what they think is popular

4.6. Trustworthiness

Triangulation, checking members, and providing thick description methods were used to obtain valid and reliable results (Guba & Lincoln, 1994). Interview results were triangulated with preservice teachers' classroom discussions. Trustworthiness was tested in terms of inter-rater reliability. Two researchers with expertise in education evaluated each pre-service teacher's interview transcriptions and graded documents using the source concerning knowledge and trust in authorities. The level of agreement between the two researchers was calculated by percentage agreement according to Miles and Huberman (1994). The interrater reliability was found 75% for reflective judgment and 85 % for pre-service teachers' source of knowledge and trust in authorities' analyses. Due to the complex nature of the reflective judgment analysis, interrater reliability was below the expected value (80 %). The two researchers came together and discussed the similarities and differences in their coding in search of inter-subjective agreement (Miles & Huberman, 1994). After reaching a consensus on the coding process, two researchers independently analysed five more preservice teachers' reflective judgment interviews. The interrater reliability was raised to 85%, which is determined to be an acceptable level (Miles & Huberman, 1994). After reaching a trustable coding scheme the analysis continued to the rest of the data. Thick descriptions of participants, data collection procedures, data collection tools, and data analysis procedures were used to enhance the external validity.

4.7. Ethical Issues

Pre-service teachers' classroom discussions were recorded on video. Permission was taken from the ethics committee of the university. All participants signed a form of consent regarding the video recordings. Before each lesson, the pre-service teachers were reminded that the discussions were being recorded, and all sessions began with the consent of the participants on the recordings. Interviews were also recorded with the consent of the participants. Anonymity and confidentiality of all data were assured to the participants. Pre-service teachers' real names were not used anywhere. Instead, the study used pseudonyms.

5. Findings**5.1. Sources of Knowledge**

In terms of expert knowledge, the majority of references made by the preservice teachers were related to "school knowledge." This suggests that they often turned to what they had learned through formal education and academic instruction as a trusted source of information most references were made to school knowledge with 20 references (Table 3). 25 references were made

Table 3
Sources of knowledge that pre-service teachers refer to when making judgments (P = pre-reflective, Q = quasi-reflective, R = reflective reasoning)

Themes / Codes	Food Additives			Industry 4.0			Nuclear Energy			Selected quotes
	P	Q	R	P	Q	R	P	Q	R	
Consciousness										The problem is not the food additive itself, it is the amount of it, if it is used in safe amounts, it will not do any harm (consciousness of a PT, who is in favour of the use of food additives)
School	10		2	1	1	2	2	2	2	
Literature				1	2	3	2	1	3	
Scientific conference									4	
Authorities (chemists, food engineers, doctors, food authority)	1	1		3			2	1	1	
Experience and Reason										
E code reading	0	6	10							Media is used to fake people, companies change slogans to shift the focus elsewhere. They say 'sugar-free' on the other side they use aspartame which is not healthy (Reasoning of a PT who is against the use of food additives)
Reasoning				1	1	3			5	
Assumption (dying from hunger, dying from unhealthy foods)						2			4	
Inferences (serial production, cheap production, energy saving, robots will control the world, robots take our jobs)									6	
Conclusion (Industry 4.0 reduces the work accidents, and death rates)										
Personal experiences (allergy, cheap product access, heart palpitation)	4	3		1	1	3	1	2	2	
Perception										
Social media (Instagram, videos, TV, newspaper, Internet, Facebook, Twitter, YouTube)	1	1		5	1	2	2	2	1	Research findings might be biased, scientists sometimes care about their wallets instead of human health (Perception of a PT who is against the use of food additives)
Social life (friends, family, neighbours)	2	0		2	1				2	
Games										
Memory										
Curiosity				1	1	1	2	3	3	We can never trust nuclear energy, remember Chernobyl. People are still suffering from its longitudinal effects (Memories of a PT who is against nuclear energy)

to authorities or authority knowledge expressed in the scientific literature of conferences. Furthermore, the research found that a significant number of references were made to "authorities" or "authority knowledge" found in scientific literature and conference presentations. This indicates that the preservice teachers placed considerable trust in information that came from well-established experts in the field, as represented by published scientific works and presentations at academic conferences. In total, there were 45 references (Table 3) where preservice teachers explicitly revealed their trust in authorities through their responses to the PRJI. This shows that these individuals have a substantial reliance on authoritative sources when forming their own beliefs and understanding of various subjects. With 69 references, far more reference was made to experiences and reasoning. The perception was influenced by social media and private communication; games played also a role with 22 references. 20 references were made to memory but were restricted only to two of the three SSI and referred to single topics, like the Chernobyl nuclear accident in 1986.

5.2. Trust in Authorities

The pre-service teachers expressed both trust and mistrust in authorities during their debates and interviews (Table 4). With 86 mentions of trust, almost equally distributed over the four categories referring to ethical values, experts' profound knowledge, expertise, and trust in experts' interpretations, the number was similarly high but a little smaller than for mistrust with 99 mentions. Also here the mentions were almost equally distributed with the most mentions referring to the influence of money on authorities (n=29) or authorities supporting popular positions (n=24). In the low trust category, 116 mentions were recorded with the most references to preferring own choices (n=28) and better trusting own experiences (n=27).

Also evident in Table 4 is the heightened prevalence of mistrust among students advocating for the critical stance toward one of the three developments. There are only 16 mentions of mistrust

Table 4

Pre-service teachers' trust in authorities

Themes / Sub-themes	<i>Food additives</i>		<i>Industry 4.0</i>		<i>Nuclear energy</i>	
	Pro	Con	Pro	Con	Pro	Con
Trust						
Experts follow ethical values	5	1	9	0	7	0
Experts have profound knowledge	2	2	4	3	6	0
Experts may have varying interpretations, but based on their expertise	7	4	5	3	4	2
Experts have different fields of expertise but are trustable	5	2	3	2	9	1
Low Trust						
I listen to experts but prefer to make my own choices	4	7		10		7
I listen to experts, but I prefer trusting my personal experiences	3	6	2	8		8
Cultural views can be as similarly important as knowledge	5	4	4	3		4
Experts have different fields of expertise but are not trustable as such	2	5	6	5		6
Also, experts can be subjective	3	2	1	6		5
Do not trust						
Experts may be wrong	1	10	0	4	2	6
Experts may look for personal benefits	0	6	0	5	1	10
Experts may give an opinion based on money	0	9	2	7	2	9
Experts may give an opinion based on what they think is popular	3	8	4	6	1	3

among the students that represent the positive view of one of the developments, whereas 83 mentions of mistrust are mentioned among students representing the critical side. The opposite can be found in the trust category. That is, 66 mentions of trust were found among students arguing about the developments in a positive way and only 19 mentioned trust to justify criticism.

5.3. Reflective Judgment Skills

According to King and Kitchener (1994), Table 5 gives an overview of the levels of reflective judgment among the 25 pre-service teachers. One can see that there are students, like Nina, that developed a high level of reflective judgment skills with dominant codes of 6 and 7 leading to an overall weighted stage score higher than 6. Other students were mixed like Ela, having the level of reflective judgment in the case of food additives, but showing pre-reflective judgment skills in the other two SSI debates.

Table 5

Pre-service teachers' three 3-digit scores for reflective judgment

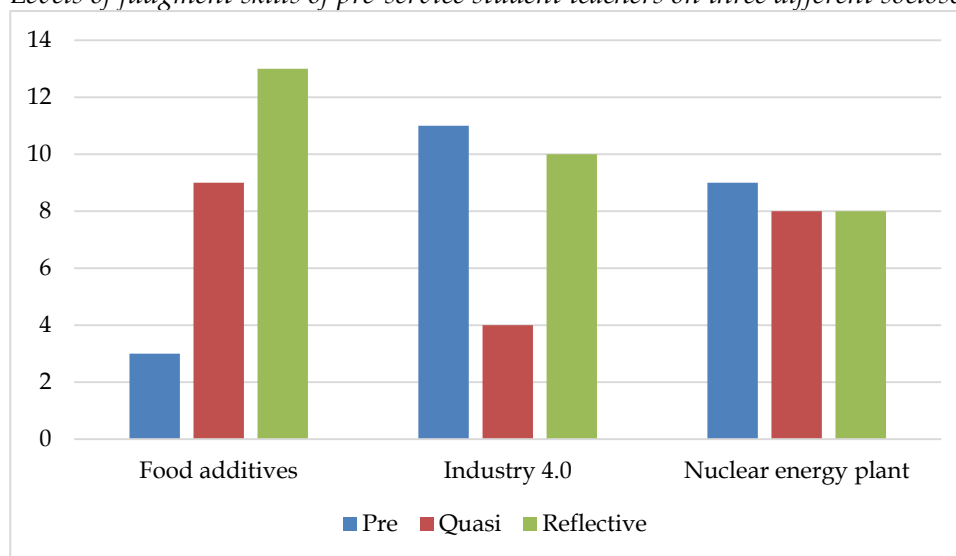
Name	Food Additives			Industry 4.0			Nuclear Energy		
	3-digit	Weighted score	Stage	3-digit	Weighted score	Stage	3-digit	Weighted score	Stage
Alp	4-3-5	3.9	Q	4-4-5	4.2	Q	3-3-4	3.2	Q
Hera	4-5-6	5.7	R	5-5-6	5.2	R	6-6-7	6.2	R
Kendal	2-3-4	2.7	P	5-5-6	5.2	R	5-6-7	5.7	R
Belma	3-3-4	3.2	Q	2-2-3	2.2	P	1-1-2	1.2	P
Melina	5-5-6	5.2	R	5-5-6	5.2	R	6-6-7	6.2	R
Nina	6-6-7	6.2	R	6-6-7	6.2	R	6-6-7	6.2	R
Urlau	3-3-4	3.2	Q	2-3-4	2.7	P	3-4-5	3.7	Q
Milan	6-6-7	6.2	R	5-5-4	4.8	Q	6-6-7	6.2	R
Annke	4-5-6	4.7	Q	6-6-6	6	R	7-5-6	6.2	R
Anil	1-2-3	1.7	P	1-2-3	1.7	P	5-4-3	4.3	Q
Wisdom	2-4-3	2.8	P	1-2-3	1.7	P	2-2-3	2.2	P
Beggy	5-5-4	4.8	Q	5-5-4	4.8	Q	2-2-3	2.2	P
Bursa	3-3-5	3.4	Q	5-6-6	5.2	R	2-2-3	2.2	P
Ela	7-7-6	6.8	R	2-2-2	2	P	2-3-1	2.1	P
Esma	6-6-7	6.2	R	5-5-6	5.2	R	3-3-4	3.2	Q
Dila	7-5-6	6.2	R	5-5-6	5.2	R	3-3-4	3.2	Q
Ferdi	5-6-4	5.1	R	2-2-3	2.2	P	2-2-3	2.2	P
Feyyaz	5-5-6	5.2	R	2-2-3	2.2	P	3-3-4	3.5	Q
Feyza	6-6-2	3.3	Q	1-2-3	1.7	P	3-4-5	3.7	Q
Eser	4-3-2	3.3	Q	3-4-5	3.7	Q	2-2-3	2.2	P
George	5-6-7	5.7	R	2-2-4	2.4	P	4-3-5	3.9	Q
Gillian	6-5-4	5.3	R	5-6-7	5.7	R	6-6-7	6.2	R
Henry	6-6-7	6.2	R	6-6-7	6.2	R	5-6-4	5.1	R
Kim	5-5-6	5.2	R	3-2-1	2.3	P	3-2-4	2.9	P
Kimberly	5-5-4	4.8	Q	2-3-4	2.7	P	3-2-4	2.9	P

Note. P: Pre-reflective; Q: Quasi-reflective; R: Reflective reasoning.

When summing up the stage scores of the three SSI (Figure 1), one can see the level of reflective judgment is highly developed only by 31 students (31 cases out of 75), whereas 21 students showed quasi-reflective and 23 pre-reflective judgment skills.

Figure 1

Levels of judgment skills of pre-service student teachers on three different socioscientific issues



6. Discussion

Educators who know the reasoning levels of their students in their classes can construct lessons in light of this knowledge. For teachers whose purpose is to develop students' thinking and questioning skills and to teach the tentative nature of knowledge, the questionability of authority, the possibility of multiple solutions in some situations, and the analysis of profit and loss determining the current situation are important for predicting which direction to go (Zeidler & Nichols, 2009). In the literature, we encounter different studies in which individuals make reflective judgments during the discussion of SSI, analyze the available data, examine the opinions of authorities, and propose plausible solutions as result of their evaluations (e.g., Callahan, 2009; Subiantoro et al., 2013; Zeidler et al., 2009).

In the analysis of the data in this study, we see that the pre-service teachers from this study used multiple sources of information for their discussions. Learned knowledge from school and evidence from science were only two sources among others. At least important for the students were their own reasoning and experience (Fischer, 1980). Other sources were information from the social environment, social media, or memory (Kim Yoo-Lee & Joanna Sin, 2011). Students trust in authorities, and in expert knowledge, but only to a certain extent. Low to no trust mentions were with more than 200 identified mentions more than double as high as mentions of trust with less than 100. It is either that the students do not know or see the value of evidence from science, or they do not trust enough in it (Akerson et al., 2006). From the data, it can be seen that mistrust was especially high when students were critical of scientific and technological advancements.

Missing knowledge or missing trust might also have contributed to levels of reflective judgment skills (Zeidler et al., 2005), although a direct relation cannot be obtained from the data. Reflective judgment skills were quite developed in student teachers' performance in discussions in several cases. It is, however, that from the 75 discussion performances (25 student teachers in each of the three discussion situations) 31 were rated as reflective. Another 21 discussion performances were ranked as quasi-reflective and 23 as pre-reflective. This picture is like what is reported in the literature that performance levels of undergraduate students are mixed and circle around the quasi-reflective stage (Wood et al., 2002).

The literature says that it is difficult to develop reflective judgment skills in a short amount of time (Kitchener et al., 1993). But, taking the goal into account that generally high school students should have developed a certain level of scientific literacy and judgment skills when leaving school, the data shows that judgment skills even after 2-3 years of university are not developed

throughout to the highest levels in different contexts, in this case, the SSI of food additives, Industry 4.0 and building a new nuclear energy plant. Data also shows that there was no progression within the course among the students being asked to perform three times on SSI and even being able to observe the performances of their classmates (Karisan et al., 2018).

The three examples show that on average, the performances in reflective judgment skills are context-bound (Karisan et al., 2018). Concerning the issue of food additives, there were more reflective and less pre-reflective judgment performances. In the question of Industry 4.0, we see a polarized picture with many reflective and pre-reflective performances and only a few quasi-reflective ones. In the nuclear energy issue, we see a balanced distribution in pre-, quasi-, and reflective performances. This might lie in the different nature of the SSI. The food additive issue is directly related to students' life and is currently relevant to them in terms of potential consumer behaviour. Industry 4.0 is in the future and no one really can predict how it will affect students' life, so chances and fears might be in balance, having fears often connected to pre-reflective judgments. The nuclear energy issue is more concrete, and students might be aware of the risk of using nuclear energy but also see it as a chance to reduce climate gas emissions. Here it is also to be said that nuclear energy risks are especially high for the local and regional environment surrounding the new nuclear energy plant. In this case, the plant is built about 500 km away from where the students were living.

Overall, we see a mixed picture. There are many indicators for developing reflective judgment skills on one side, but there are also many pre- and quasi-reflective performances. Students refer their knowledge to evidence-based thoughts and expert knowledge. But, evidence and reference to expert authorities make up only part of what the student teachers use when discussing SSI (Kolstø, 2001).

7. Conclusion

This study, naturally, has some limitations. It is a case study from one university and a set of only 25 students. It is based on a certain course given and focused on only three SSI, although of different nature. Nevertheless, some indications can be learned from the data and analysis reported in this article.

Responsible citizens should be reflective judges when it comes to SSI (Eilks et al., 2014). School education should guide students to become reflective judges, which means prospective teachers have to develop both skills in reflective judging and knowledge about how lower levels of judgment skills, different sources of information, and degrees of trust in expert knowledge influence the judgment process. Especially, the question of trustworthiness seems to be important in becoming reflective judges on SSI (Kitchener et al., 1993). From this study, it seems that a higher proportion of students are not yet at the level of being reflective judges for the three SSI discussed in this study. They neither developed corresponding skills in school education nor in the first years of university. The absence of these skills makes the necessity of developing better judgment skills both in school and the first years of teacher education very clear for a sustainable change in classrooms concerning practices promoting relevant skills for making reflective judgments on SSI. More investment is needed in confronting school and university students with SSI, allowing them to reason and discuss them and to reflect on how judgments can be made based on reliable knowledge obtained from experts, and then how this also needs to be reflected in the foreground of norms and values (Zeidler et al., 2011).

Directions for future research are both empirical and practical in nature. Research should better reveal the connection between judgment skills, information used, and trust in sources of information. Reasons for mistrust in expert knowledge should be identified and connected to prior education. On the practical side, curriculum development is needed to allow school and university learners to systematically develop reflective judgment skills in connection to SSI and media use (Belova et al., 2018; Zeidler et al., 2011). This is especially a challenge in the permanently growing

amount of information provided on the Internet and social media and the accelerating change in society by modern technologies in the 21st century.

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Appendix 1. Reflective Judgment Interview Standard Probe Questions

1. What do you think about these statements?

(Note: If no particular point of view is endorsed, ask: 1a) Could you ever say which was the better position? How? Why not? How would you go about making a decision about this issue? Will we ever know for sure which is the better position? How/Why not? To allow participants to share an initial reaction to the problem presented. Most state which point of view is closer to their own.

2. How did you come to hold that point of view?

To find out how the respondent arrived at the point of view, and whether and how it has evolved from other positions on the issue.

3. On what do you base that point of view?

To find out about the basis of the respondent's point of view, such as a personal evaluation of the data, consistency with an expert's point of view, or a specific experience. This provides information about the respondent's concept of justification.

4. Can you ever know for sure that your position on this issue is correct? How or why not?

To find out about assumptions concerning the certainty of knowledge (e.g. whether issues like this can be known absolutely and what the respondent would do in order to increase the certainty, or why that would not be possible.

5. When two people differ about matters such as this, is it the case that one opinion is right and one is wrong?

If yes, what do you mean by "right"?

If no, can you say that one opinion is in some way better than the other?

What do you mean by better"?

Assesses the adequacy of alternative interpretations; to see if dichotomous either/or view of the issue (characteristic of the early stages) is held; to allow the participant to give criteria by which she or he evaluates the adequacy of arguments (information that helps differentiate high-from middle-level stage responses).

6. How is it possible that people have such different points of view about this subject?

To elicit comments about the respondent's understanding of differences in perspectives and opinions (what they are based on and why there is such diversity of opinion about the issue).

7. How is it possible that experts in the field disagree about this subject?

To elicit the respondent's understanding of how he or she uses the point of view of an expert or authority in making decisions about controversial issues.