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Policymakers' Views of Future-Oriented Skills in Science Education

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The rapid changes in science and society during the last decade have demonstrated the need for readiness to address the uncertain future through the development of future-oriented skills. Despite previous attempts, there is still no consensus regarding what is meant by "future-oriented skills" and how these could be integrated into science curricula. Stakeholders' views about what future-oriented skills are and how they should be taught would provide a clearer understanding of their needs and their perceived characteristics of effective new teaching approaches. Thus, given the pivotal role that policymakers play in education policies, this study investigated the views of 35 policymakers based in the United Kingdom, Italy, Finland, and Lithuania. Participants completed an online survey that elicited their views on future-oriented skills, as well as ways of integrating them into national science curricula. The data analysis included descriptive statistics and qualitative analysis based on the principles of thematic analysis. The qualitative analysis followed a combination of inductive and deductive coding approaches. The findings of this study highlight that among other skills, participants stressed the need for introducing problem-solving and critical thinking in science classrooms in order to better address the uncertainty of future challenges, such as environmental issues. Therefore, policymakers seem to agree that there is a need for moving away from traditional teacher-centred approaches when teaching future-oriented skills. These results provide valuable insights into policymakers' needs and expectations. In doing so, this study can serve as a starting point for a systematic approach toward integrating future-oriented skills into science curricula.

Keywords: future challenges, futures education, future-oriented skills, science curriculum, policymakers' views

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INTRODUCTION

Future-oriented skills are part of what are often called the "twenty-first century skills." Politicians, employers, and educators alike have advocated students' acquisition of twenty-first century skills in order to deal with some pressing issues (Wagner, 2015) such as climate change and environmental pollution. The ability to foresee future scenarios, anticipate potential problems and critically engage with problem-solving strategies are skills that students need to develop in order to function effectively in their everyday lives. Given its conceptual, as well as methodological qualities, future-oriented skills in education can be regarded as part of educational innovation.

Although there may be numerous issues related to the implementation of educational innovation, such as future-oriented thinking, the conceptualisation and generation of educational policies are prerequisite for educational systems in setting new and innovative objectives for educational practice. Policymakers play a central role in how new approaches to curriculum, instruction and assessment are framed in a particular national context (Sebba, 2007). Debates in educational policymaking have been framed from the point of view of interactions between research, policy and practice (Locke, 2009), and how research evidence can inform policymaking (Vanderlinde and van Braak, 2010; Cherney et al., 2012). The significance of mediation for bridging and linking between educational research and policy has been highlighted (Saunders, 2007). Yet, despite such wealth of research at the nexus of educational policy, research and practice, research about policymakers' own views of educational innovation has been understudied in the context of science education (Fensham, 2009). Future-oriented skills are no exception to this observation where empirical investigations into policymakers' own views about the matter have been rare.

The study explores how a sample of policy makers from Italy, Finland, Lithuania, and the United Kingdom view future-oriented skills in the context of science education to illustrate what is envisaged to be significant skills of the future, as well as possible ways of incorporating these skills into science education curricula. By doing so, the empirical study takes an inclusive and participatory approach to investigating relevant stakeholders' views of contemporary reforms in education.

Educational Innovation and Future-Oriented Skills

Recent trends in science education have included an emphasis on "twenty-first century skills." Politicians, employers and educators alike have advocated students' acquisition of twenty-first century skills in order to deal with some pressing issues (Wagner, 2015) such as climate change and environmental pollution. Since the assumed future is a rapidly changing world of fierce global competition, education should focus on knowledge-intensive sectors, highlighting that "each citizen will need a wide range of key competences to adapt flexibly to a rapidly changing and highly interconnected world" (p. 13). In the same vein, scholars within the field of Education for Sustainable Development (ESD) have discussed the need for including a problem-driven and solution- oriented approaches to teaching about global "wicked" issues such as climate change, poverty and pandemics (e.g., Wiek et al., 2011).

Although the term "twenty-first century skills" is commonly used in educational contexts as a desirable student outcome, there is no clear definition on what is precisely meant by this concept (Kereluik et al., 2013). OECD has indicated that "developments in society and economy require that educational systems equip young people with new skills and competences, which allow them to benefit from emerging new forms of socialisation and to contribute actively to economic development under a system where the main asset is knowledge" (OECD, 2019, p. 5). In order to prepare students for this future, the OECD had proposed three "dimensions" in twenty-first century skills and competences: (a) information, (b) communication, (c) ethics and social impact (p. 8). All three dimensions encompass numerous skills. The OECD paper explicitly names the following 15 twenty-first century skills and competences: "creativity/innovation, critical thinking, problem solving, decision making, communication, collaboration, information literacy, research and inquiry, media literacy, digital citizenship, ICT operations and concepts, flexibility and adaptability, initiative and self-direction, productivity, leadership and responsibility" (p. 21). Likewise, the European Union (EU) formulated a framework for "Lifelong Learning as a key measure in Europe's response to globalisation and the shift to knowledge-based economies" (European Union, 2006, p. 10).

These conceptualisations contribute to the definition of future-oriented skills, as they refer to skills that are necessary to navigate the imagined futures. However, it can be argued that there is a distinct preceding set of skills that one should demonstrate in order to imagine the possible futures. These are often termed "future-scaffolding skills" and they refer to "the capacity of organising knowledge in the present imagining futures and moving dynamically and consciously, back and forth, globally–locally, between different "space" and "time dimensions" (Tasquier et al., 2019). The ability to think forward through time is considered advantageous and at times even essential for survival (Suddendorf and Corballis, 2007). Given that students are often regarded as future "problem solvers" (Wiek et al., 2011) this ability to foresee future scenarios in order to anticipate potential problems and to critically engage with problem-solving strategies effectively in their everyday lives is of great importance.

Recent accounts of OECD Future of Education and Skills 2030, such as the OECD Learning Compass (OECD, 2018), highlight the interplay between knowledge, values and skills through the lens of anticipation, action and reflection. Although conceptually, these skills are part of a broader definition of twenty-first century skills and future-oriented skills, they emphasise foresight, anticipation, risk assessment, and imagination (Levrini et al., 2019).

Arguments for the inclusion of future-oriented as well as future scaffolding skills in education have been raised given increasing concerns that the schooling systems, are not able to prepare today's learners for the fast-changing world in which they will live and work. For instance, ESD teaching approaches is "envisioning a better future," because it aims to establish a link between long term goals and immediate actions, as well as to motivate people to take action (Rieckmann, 2012). Similarly, teaching and the learning about socio-scientific issues (SSI), such as climate change, promotes the idea of science education for global citizenship (Lee et al., 2012), as it highlights the breath of values, knowledge and perspectives, as well as the various stakeholders that contribute to SSIs at a global level.

Although there may be numerous issues related to the implementation of educational innovation, such as future-oriented thinking, the conceptualisation and generation of educational policies are prerequisite for educational systems in setting new and innovative objectives for educational practice. Policymakers play a central role in how new approaches to curriculum, instruction and assessment are framed in a particular national context (Sebba, 2007). Debates in educational policymaking have been framed from the point of view of interactions between research, policy and practice (Locke, 2009), and how research evidence can inform policymaking (Vanderlinde and van Braak, 2010; Cherney et al., 2012). The significance of mediation for bridging and linking between educational research and policy has been highlighted (Saunders, 2007). Yet, despite such wealth of research at the nexus of educational policy, research and practice, research about policymakers' own views of educational innovation has been understudied in the context of science education (Fensham, 2009). Future-oriented skills are no exception to this observation, as empirical investigations into policymakers' own views about the matter have been rare. The few studies that have addressed the issue of future-oriented skills in education aimed to explore the extent to which these skills are present in policy documents, such as curricula and textbooks (e.g., Matthewman and Morgan, 2014; Pauw and Béneker, 2015).

This study aims to address this gap by exploring policymakers' views about future-oriented skills in the context of four European countries with a range of educational systems. These countries are Italy, Finland, Lithuania, and the United Kingdom and they represent different regional and cultural traditions from the Baltic to the Mediterranean. As such, they have vastly different educational systems and varying traditions in educational reform, although in the case of Italy, Finland and Lithuania there is also some common educational approaches given these countries are part of the European Union.

Research on the Inclusion of Stakeholders in Educational Innovation

Although there is an increasing emphasis on future-oriented skills in terms of their relevance for effective participation of regular citizens in contemporary issues and problems faced by society (e.g., Levrini et al., 2019), the question remains as to how the content of future-oriented skills can be shaped in order to impact teaching and learning. Considering the vast range of stakeholders in educational research, policy and practice, it becomes imperative to investigate how different cohorts that have a stake in education may define as priorities for student learning. In other words, it is important to incorporate the different stakeholders in the conceptualisation and implementation of educational innovation such as the embedding of future-oriented skills in science education. Understanding different stakeholders' views are particularly important because research has shown that there are gaps between different stakeholders' expectations. For instance, there is research that demonstrates gaps between what students might like to pursue in their education and how school science has been taught, as well as gaps between employees' opinions and school science education goals (Choi et al., 2011). Likewise, there may be issues related to teachers' role in supporting students to engage in lessons that would enhance their future-oriented skills. Many teachers would not have received any training to teach components of future-oriented skills such as critical thinking and, as a consequence, they may not feel confident about teaching such skills (Post et al., 2011). In the case of school science, apart from students and teachers, there are various other stakeholders such as members of school boards, parents and teacher training providers (see **Figure 1**).

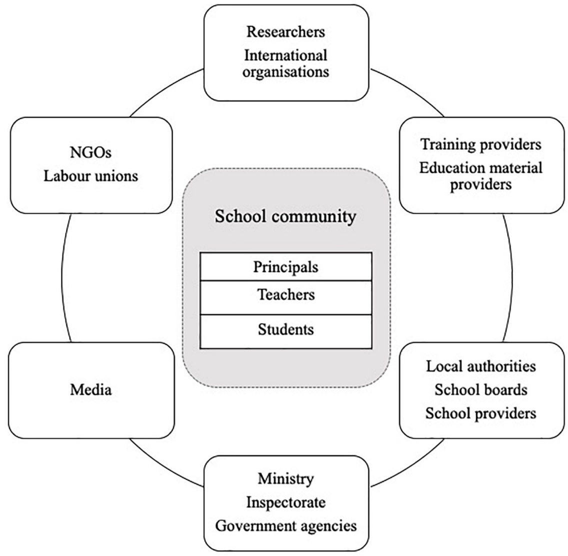

FIGURE 1 | Stakeholders in education. Adapted from Burns and Köster (2016).

Policymaking in education may follow different routes depending on the various national and socio-cultural contexts. Therefore, the term "policymaker" is significantly dependent on the various traditions and degrees of stakeholders' involvement in the policymaking process. However, despite this heterogeneity, the stakeholder groups that shape nation-wide policymaking can be generally regarded as policymakers. These are policy actors previously who serve as the "architects of policy," including politicians, civil servants and advisers (Bangs et al., 2010). In order to design, generate and implement educational policies, policymakers participate in a multifaceted process that includes multiple cycles of agenda setting, formulation, legitimation, implementation, evaluation and maintenance, succession or termination of education policies (Jann and Wegrich, 2007). **Figure 2** illustrates the policy cycle theory that has been used in numerous frameworks and adapted by many policymakers and implementers (e.g., DeLeon, 1986).

Thus, it can be argued that the design and implementation of innovations, such as future-oriented science education need to be explored from the view of such stakeholders. According to a report by OECD, there have been at least 450 education reforms between 2008 and 2014 in OECD countries (OECD, 2015). Yet,

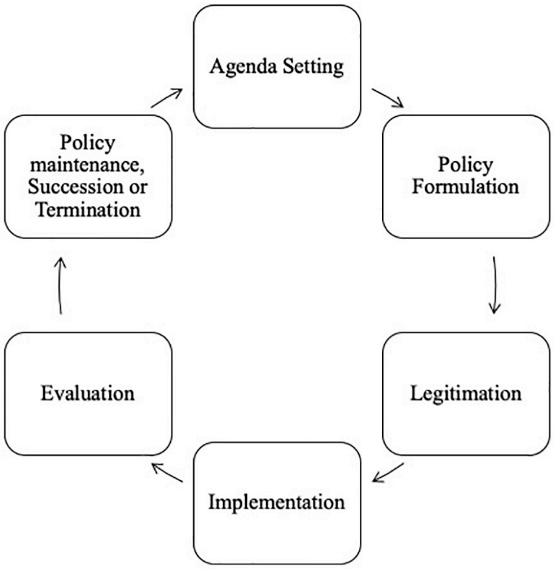

FIGURE 2 | Theories of the policy cycle. Adapted from Jann and Wegrich (2007).

evidence for the effectiveness of these policies is fairly scarce. Researchers have highlighted that even when reforms do have an impact, stakeholders can be dissatisfied with the outcomes of the implementation of the policy, and they tend to hold policy makers accountable for them. Some recent European Union-funded projects have nevertheless tapped into providing some evidence on how various stakeholders might perceive what innovation can look like in science education. For example, the PROFILES project (Bolte et al., 2012) involved stakeholders from science and the science education community in a Delphi study to explore what content needs to be identified for science curricula. Other studies such as Gören Niron (2013) researched views of policy makers, academics, and practitioners about governance of early years education in Turkey. As a result, a framework was developed aligning with policies of international organisations and existing systems of the European Union countries, by taking into consideration current policy frameworks. The research illustrated the divergences in different stakeholders' views on endorsement of educational models in general and possible implementation in the Turkish context in particular.

The cultural context of policy making may also influence how educational policies are interpreted, particularly when they involve themes that may deem to be sensitive in particular social traditions. For example, in a research study conducted with policy makers, health-care providers, teachers, and religious scholars in Saudi Arabia (Horanieh et al., 2020), stakeholders differentiated between who should be in charge of designing the programmes and who should deliver them. For instance, researchers observed tension on the role of religious scholars within these two phases of implementation, as some of their beliefs were not aligned with the teaching content. Furthermore, particular topics of innovation may demand that researchers generate specific methodological approaches. In investigating various stakeholders' views in environmental education, Eisenhauer and Nicholson (2005) recognised that different stakeholder groups have different understandings of wetlands and associate diverse meanings with these landscapes, and that these types of differences are factors in many attempts to design communications about controversial environmental issues. The researchers used focus group and social research survey methods to gather information about the diverse perspectives held by stakeholder groups.

Taking into account (a) the relevance of future-oriented learning as contributing to twenty-first century skills and the need to include such skills in science education curricula, as well as (b) the central role that policymakers play in shaping national curricula and teaching practices, this study focused on policymakers as major stakeholders in education. In this study, the term "policymakers" refers to those stakeholders who engage in the design of curricula, assessments, and teacher training frameworks for implementation at a national level. Nevertheless, other stakeholders, such as educational researchers, teachers, and examiners would equally be important to investigate in further studies. The study, thus, aimed to provide some insights into policymakers' views and set the ground for further investigations following a systematic participatory approach to educational innovation.

Context of Science Curriculum Policy

This study explores policymakers' views about future-oriented skills in Italy, Finland, Lithuania, and the United Kingdom. These countries were included to demonstrate the relevant heterogeneity within European countries with regard to their educational system, as well as the degree of stakeholder engagement in educational policy.

Out of the four countries, Italy has the most centralised educational system, as the Ministry of Education, University and Research (Ministero dell'Istruzione, dell' Università e della Ricerca, MIUR), is responsible for setting the minimum standards and education principles. However, some decisions can be made at a regional level and schools demonstrate relative autonomy with regard to curriculum and assessment (Figueroa et al., 2017). As a result, school reforms are proposed, managed, and regulated centrally. Parliamentary initiatives for educational reforms often arise from downstream consultation with political parties or parliamentary groups. Formal consultations for parliamentary proposals take place as a result of conversations with spontaneously formed expert groups, that may consist of academics, teacher associations, student associations, and private institutions.

Educational policies in the United Kingdom are designed and implemented at a nation level. Unlike Scotland, Wales and Northern Ireland, England does not have its own devolved government (National Education Systems, 2022). Thus, education in England is overseen by the Department for Education. Although there are various types of schools in England (e.g., state-funded and independent schools), all are subject to assessment and inspection by Ofsted (the Office for Standards in Education, Children's Services, and Skills). The state-funded education system is divided into Key Stages based upon age groups (Government Digital Service, 2014). The National Curriculum provides pupils with an introduction to the essential knowledge they require to be educated citizens. It covers what subjects are taught and the standards children should reach in each subject. There are several examination boards (also known as awarding bodies) set award qualifications in state schools and colleges across England. Exam boards follow strict guidelines from Ofqual (Office of Qualifications and Examinations Regulation) to regulate standards and ensure parity. However, the content and format of examination varies from board to board (Cullinane et al., 2019). In summary, although the curriculum is national and centralised, there can be variations in how policies get interpreted and implemented at the level of schooling given the specifications of particular examination boards.

Lithuania's education system is more decentralised than centralised. National institutions, municipalities and educational institutions all share responsibility for the quality of the education provided. The parliament (Seimas) forms education policy at the national level. It adopts laws and declarations and initiates educational reforms and policy changes. The government and the Ministry of Education, Science, and Sport (and other related ministries) also formulate and implement education policy and adopt and implement legal acts other than laws and declarations. The parliament adopts the main laws and legal acts regulating the system of education and science, which are applicable at a national level. The Ministry of Education, Science, and Sport or the government adopts other legal acts applicable at the national level such as the description of the primary, lower secondary, and upper secondary curriculum. The municipalities set and implement their own strategic education plans that are in accordance with the national documents.

Finally, Finland has a decentralised education system, as local authorities have considerable autonomy. However, this autonomy is situated in a complex context: the strategic government programme sets key goals, the parliament is responsible for related legislation, the Ministry of Education and Culture oversees policy implementation, while the Finnish National Agency for Education is responsible for developing curricula and related requirements as well as expenditures and supporting teachers. Furthermore, the Finnish Education Evaluation Centre acts as an external evaluator of educational institutions, while the Regional State Administrative Agencies evaluate issues related to regional equality. The OECD Policy Outlook (OECD, 2021) lists key stakeholders: The Association of Finnish Local and Regional Authorities, the Confederation of Finnish Industries, the Confederation of Unions for Professional and Managerial Staff, student and parent associations, and organisations representing educational professionals. National core curriculum reforms take place approximately once per decade. This process takes place at three levels: state, municipal, and school, as the national core curriculum is adapted to use. However, this takes place over a cyclical process during which stakeholders and institutions collaborate closely; curricula are drafted, commented on and improved over many iterations. Furthermore, after the core curriculum is finalised, municipalities develop a detailed local curriculum that corresponds to the extensive goals and criteria set by the core curriculum. In this process, schools are often given considerable autonomy.

While similar rhetoric about the significance of educational reforms may be present, particularly in relation to twenty-first century skills, the precise ways in which such policies would be conceptualised and implemented in each country are expected to differ given the structural changes in the education systems. For example, in a country such as Finland where the education system is decentralised and teachers have much say in the development of policies, one would expect that teachers' views about future-oriented skills will be represented to a greater extent than in a system such as Italy which has a fairly centralised system where ministry level professionals drive educational reforms. However, such details are a matter of empirical questions and as such, they provided the motivation for the study reported in the rest of the paper.

Research Questions

The empirical study was guided by the following three research questions:

1. What future challenges do policymakers in Italy, Finland, Lithuania, and the United Kingdom anticipate and how can future-oriented skills in science education address them?
2. What factors do policymakers perceive as barriers for curriculum change to integrate future-oriented skills in science education?
3. What are policymakers' views for including future-oriented skills in science curricula?

MATERIALS AND METHODS

Context of Research

The research was conducted in the context of a funded 3-year project that included partners from Italy, Finland, Lithuania and the United Kingdom. The primary objective of the project was to enhance future-oriented thinking in science education through engagement with a range of stakeholders such as policymakers, teachers and students.

Sample

Since the target population of this study was policymakers in science education, judgemental sampling was used to generate lists of potential participants, based on their professional experience and their role within education policymaking in their country. To obtain relative heterogeneity between experts (Bolger and Wright, 2011), it was decided to include participants with experience and demonstrable impact on: (a) science education assessment, (b) curriculum, (c) teacher training, or (d) general education (e.g., Ministry of Education). This would allow comparisons between the participating countries, as well as areas of expertise. A questionnaire was distributed via individual email invitations to experts from each national context.

The sample consisted of 35 education policymakers based in Italy, Finland, Lithuania, and the United Kingdom. **Figure 3**

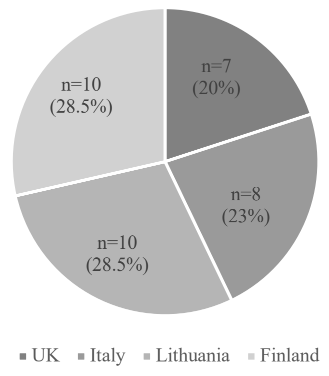

FIGURE 3 | Sample distribution per country (N = 35).

shows the sample distribution per country. Out of 35 participants, 21 were female and 13 were male; their age was M = 51.82 years (SD = 7.7). The majority of the participants held a Ph.D. (60%) or a Master's (29%) diploma and their academic background included STEM (63%), Social Sciences (29%) and Arts and Humanities (17%). Almost all the participants (94%) had teaching experience [M = 18.7 years (SD = 10.3)] in secondary (63%) and/or higher (57%) education. Their roles covered a range of areas in education policy from teacher education (e.g., university professors) to centralised education policy (e.g., adviser to president), while the average length of service in their current position was M = 9.56 years (SD = 8.8).

Selected Sub-Group

In order to increase the homogeneity of the sample, a matching method was performed based on participants areas of expertise; four representatives from each country (overall n = 16) were selected based on their expertise in: (a) science education assessment, (b) curriculum, (c) teacher training, or (d) general education. This selection would allow comparisons between experts from the same areas of expertise. It would also enable us to detect trends and patterns in policymakers needs and views that could be later compared and contrasted against the views of the rest of the sample.

Instrument

A questionnaire was designed to capture experts' views of future-oriented skills in science education from a range of policy levels (e.g., curriculum developers, assessment boards, teacher trainers). The questionnaire was conceptually developed based on previously published studies and reports. However, since the questionnaire was adapted for the needs of this study, its content validity was examined by a panel of 10 experts in future-oriented skills. The questionnaire was revised based on the panel's feedback until consensus was reached.

With regard to the designed questions, Part 1 of the questionnaire included questions regarding the participants' demographic information. In addition to demographic questions commonly used in educational research (e.g., age), this section included questions that are relevant to policymakers' academic and professional background. As part of their professional background, a set of questions regarding their teaching experience was included, as this could be a potential contributing factor to the shaping of their views regarding future-oriented competencies in science education.

Questions included in Part 2 address policymakers' views. Questions 12–16 (**Appendix**) aimed to elicit policymakers' definitions on future challenges and key future-oriented and future-scaffolding skills, as well as their views on how these can be integrated into science education. These questions were produced based on open-ended questions developed by Rieckmann (2012). Question 18 includes a set of recommendations previously published by the European Commission regarding science education for responsible citizenship (European Commission, 2015). This question aimed to explore policymakers' views on how relevant and plausible they find the stated recommendations. The questions included in Part 3 referred to policymakers' recommendations. The items that are included in this part are adapted items by Jones and Walsh (2008) and aim to identify common obstacles, as well as recommendations for the uptake of research evidence from science education and policymaking.

Data Collection and Analysis

The questionnaire included both closed and open-ended questions. With regard to the closed-ended questions, descriptive statistics were performed in order to examine participants' demographic information, as well as their agreement with the presented statements (e.g., Likert scale items). The open-ended questions of the questionnaire were analysed through a qualitative analysis based on the principles of thematic analysis. The qualitative analysis followed a combination of inductive and deductive coding approaches. In the first coding phase, deductive coding was performed based on the themes-topics derived by the questionnaire questions. During this phase, the participants' answers were clustered according to the topics presented in the question items (e.g., future challenges). In the second coding phase, open coding was performed to identify the initial codes based on the participants' answers. In the third coding phase, the open codes were clustered into larger categories and all the codes and sub-codes were organised hierarchically to reflect the initial themes-topics. Some of the qualitative data were quantified in order to illustrate emerging trends in participants views.

In order to explore potential trends in policymakers' views and recommendations by country, a more fine-grained analysis was conducted on experts in a selected sub-sample (n = 16). The aim of this analysis was to discuss any country-specific obstacles, challenges and needs. For this reason, we examined the extent to which policymakers from the same national context would refer to the same themes and codes that were presented in the previous section. In doing so, we included only the codes that appeared in more than two documents within the same group. Thus, only the themes and codes in which policymakers from the same national context showed agreement will be presented. The aim of this analysis was to reveal potential country-specific needs and nuances that may be influenced by the educational context of the four countries included in the study.

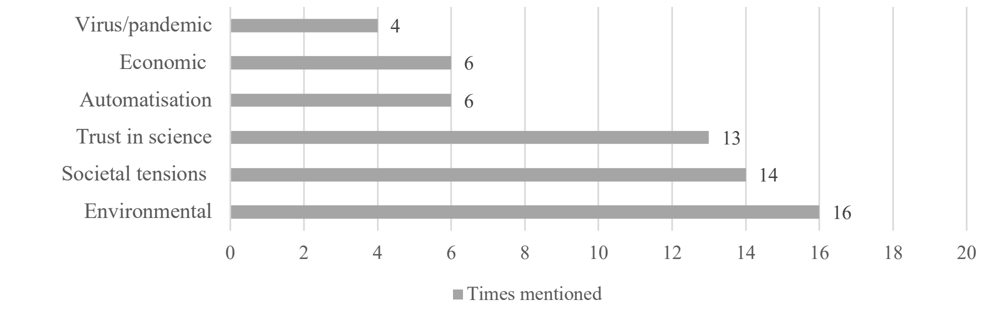

FIGURE 4 | Future challenges.

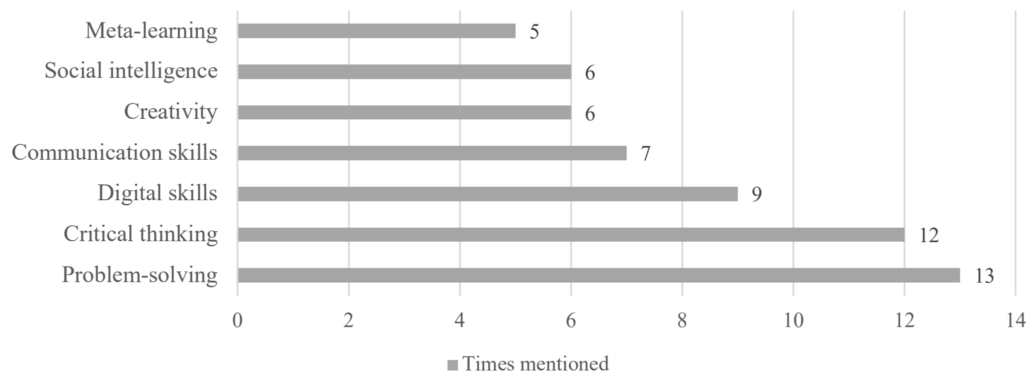

FIGURE 5 | Key competencies for addressing future challenges.

RESULTS

Future Challenges

As can be seen in **Figure 4**, environmental issues, such as climate change and sustainability were the most frequently mentioned challenges. Societal issues, such migration and civil rights were mentioned by almost half of the participants. In addition, a number of participants identified the lack of trust in science and scientific thinking as potential future challenges.

Key Future Competencies

In the following question, policymakers were asked to identify some key competencies that would be necessary in order to face future challenges in science and society. As presented in **Figure 5**, the majority of the policymakers referred to problem solving competencies, as well as critical thinking and digital skills. In addition to the competencies presented in **Figure 5**, some policymakers referred to national or international frameworks describing core student competencies for science education. For example, one policymaker referred to "PISA 2025 Strategic Direction and Vision for Science framework" and "OECD's Learning Compass 3030."

With regard to students' personal future, policymakers expressed the need for a "growth mindset" or "lifelong learning" (9/33), as "students should feel empowered to improve themselves." This was linked to the concept of personal agency that was present (e.g., "they can and need to actively shape their future"). Some policymakers also mentioned students' professional future as "*[students should think] what skills will they need to thrive in their careers and personal lives.*" With regard to the global future, 17/33 policymakers mentioned that students should feel a sense of agency, for example "They should feel to be active agent for projecting and taking care of global future." In addition, some policymakers (7/33) referred to the environmental issues (e.g., "Sustainability and Climate change") as issues that students may have to address utilising future-oriented skills. When asked about the role of technology in students' future lives, most of the participants held neutral views (15/33) (e.g., "we can't even imagine what technology may bring . . . we need to have an open mind"), while some of them (6/33) stressed the positive impact of technology on individuals' daily lives (e.g., "it is used for solving future problems or challenges").

Proposed Curriculum Approaches

With regard to the ways in which these competencies could be integrated into science education curricula, most of the participants mentioned the need for more interdisciplinary approaches in teaching science. For example, one policymaker suggested the introduction of "courses with two teachers (history and science, art and science.). We should mix subjects more." Another participant stated that "*Institutions have to permit students to make flexible choices. Students must be able to complete* *their studies with soft skills (problem solving and decision making, creativity and innovation, complexity, etc.) and core competencies (philosophy, statistics, etc.).*" In addition, participants suggested that the integration of multiple stakeholders into the policy decision-making processes would be beneficial (e.g., "close collaboration with universities, schools and other working life is a key for success").

Another suggestion was the integration of more student-centred approaches, such as project-based learning, as according to a policymaker "*A learning process has to be based on an authentic and situated learning task and hands-on work.*" Participants suggested that within this student-centred learning environments, there will be more opportunities to promote creativity and imagination, as well as problem-solving. In order to achieve this goal, it was suggested that there should be a shift from the content-oriented curriculum to teaching and learning approaches that would facilitate collaboration and the discussion of open-ended issues (e.g., socio-scientific issues). The frequencies of the participants' answers as can be seen on **Figure 6**.

Teacher training and professional development was regarded as the most relevant recommendation by the majority of the policymakers, even though less than half of them regarded it as plausible (**Figure 7**). The same trend was observed for the rest of the stated recommendations; although more than half of the participants found all of the recommendations relevant, significantly fewer found them plausible (i.e., easily applied within the curriculum).

Barriers for Curriculum Change

With regard to which obstacles that policymakers identify for curriculum change, participants indicated that teachers' perceptions and skills often influence the adaption of new teaching approaches. For instance, one policymaker stated that "*Traditional teaching still prevails; even new teachers often find themselves in an unfavourable environment for change.*" In addition, participants mentioned that the rigid organisation of the curricula in their national context is a factor that hinders educational reforms ("*I think that there are issues due to the need for a national curriculum and national assessments*"). The frequencies of the themes identified in this category are presented in **Figure 8**.

Regarding potential obstacles for the uptake of research findings by policymaking in education, participants mostly agreed that the low scientific understanding of policymakers, as well as the limited openness by politicians, are potential hindering factors. The frequencies of policymakers' agreement with the presented statements are presented in the figure below (**Figure 9**).

In addition to the statements presented in **Figure 9**, the questionnaire included an open-ended item that prompted additional comments on potential obstacles for the uptake of research findings by policymaking in education. Almost all the participants stated that the traditional decision-making processes do not leave room for new evidence that would lead to policy changes. Participants mentioned among other factors, the lack of political will and incentives, the lack of communication channels, as well as the low participation of multiple stakeholders in the decision-making. Some representative examples of coded segments are presented in **Table 1**.

In addition, participants referred to time restrictions (e.g., "*Politicians do not understand how much time and effort is needed to get quality learning outcomes*"), as well as policymakers' low understanding of research findings (e.g., "*The biggest problem is the lack of literacy of a significant number of politicians*").

Policymakers' Recommendations

In the last part of the questionnaire, participants were prompted to provide some key components of effective policies to enable future-oriented skills. Their answers were clustered into four themes: collaboration between stakeholders, opportunities for teacher training, consistent goals and resources, and addressing fundamental needs. The themes, as well some example segments are presented in **Table 2**.

Country-Specific Views

The fine-grained analysis showed that policymakers from Finland and United Kingdom tended to show the most homogeneity, followed by Lithuania and, lastly, Italy. Despite the various patterns in which policymakers responded to the questionnaire, the qualitative analysis revealed that *teacher training*, *competencies*, as well as their *willingness* to collaborate, are considered obstacles for effective curriculum and policymaking changes. This view was shared among policymakers in all the participating countries, as well as areas of expertise.

United Kingdom

With regard to future challenges, two English policymakers referred to "*fake news,*" "*conspiracy theories and alternative facts*" (ENG3) and students' need to "*think critically about evidence that is presented by e.g., the media*" (ENG4). As key future competencies, English policymakers identified "problem solving" (ENG3; ENG4) and "*critical thinking,*" ["*e.g. being able to think critically about evidence that is presented by e.g., the media, challenges related to the internet and global society*" (ENG4)]. Three out of four English policymakers emphasised the importance of scientific reasoning and understanding of "how science works," while they considered the content-heavy curriculum currently taught in the ENG as an impeding factor for curriculum change. To integrate these competencies into current science curriculum they suggested the introduction of "the big picture" with regard to scientific concepts. One of the English policymakers stated: "*the science curriculum therefore needs to be designed so that pupils build knowledge of important scientific concepts over time and that they learn how these concepts are connected into general scientific principles/ideas*" (ENG2). Moreover, a gradual introduction of open-ended issues, such as socio-scientific issues (e.g., "*COVID,*" "*socio-environmental*" issues) was suggested as a way of integrating future-oriented competencies into science curriculum. With regard to effective policymaking, participants called for evidence-based decision-making (ENG3; ENG4) arguing that the latter "*should be based on sound systemic research findings, not popularity*" (ENG3).

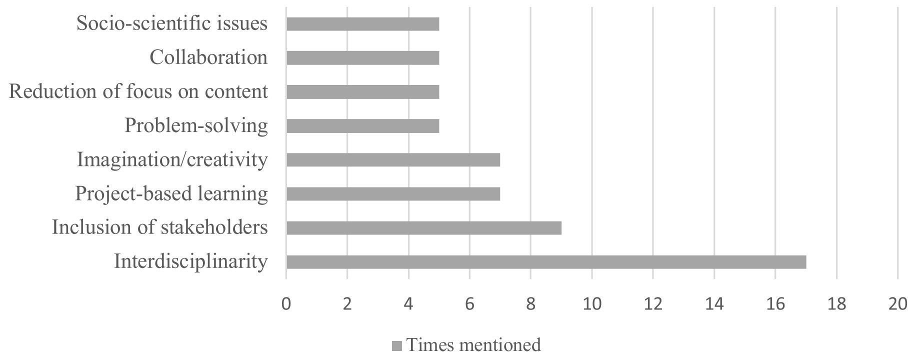

FIGURE 6 | Ways of introducing future-oriented competencies in science curriculum.

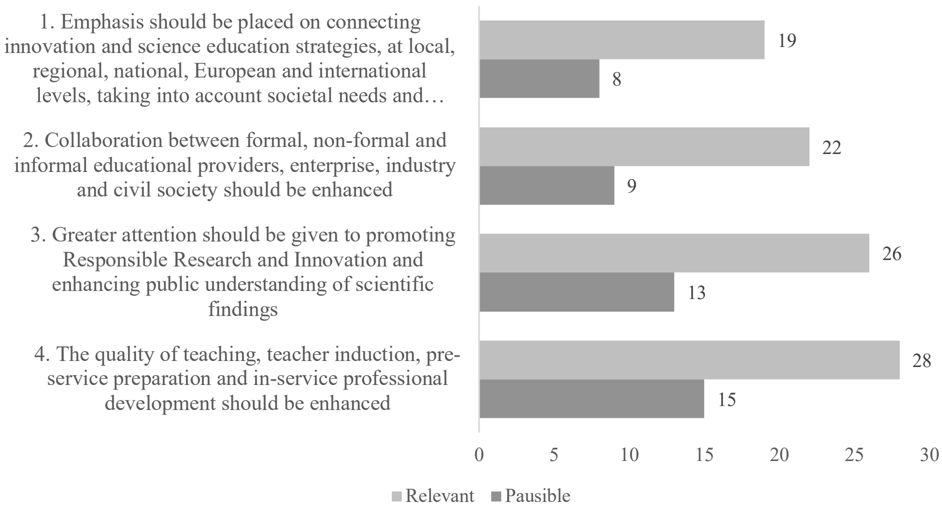

FIGURE 7 | Policymakers' views on European Commission's recommendations. Adapted from European Commission (2015).

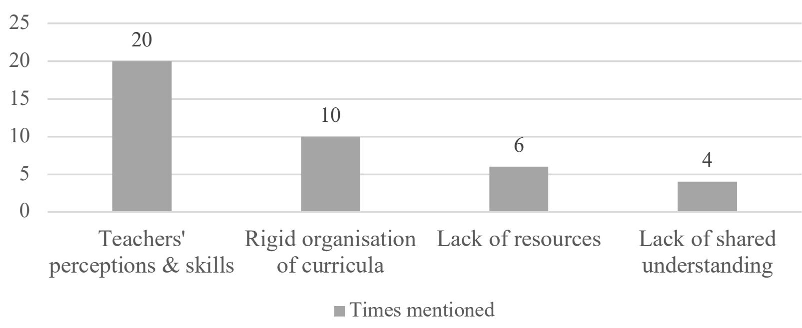

FIGURE 8 | Obstacles for curriculum change.

Finland

Policymakers in Finland indicated that environmental issues [e.g., "*climate change*" (FIN3)] and automatisation ["*digitalisation*" (FIN1)] will be some of the main future challenges. They argued that students will need a "interdisciplinary" attitude to address future challenges [e.g., *learning from history, data mining* (FIN3)], as well as "*creativity*" (FIN1; FIN4). Participants mentioned future-oriented skills, such as the "*readiness for life-long, continuous learning*" (FIN2) and "*the importance of learning to learn competence*" (FIN1). One participant referred to a specific approach with which the Finnish curriculum addressed these challenges: "*In order to support the*

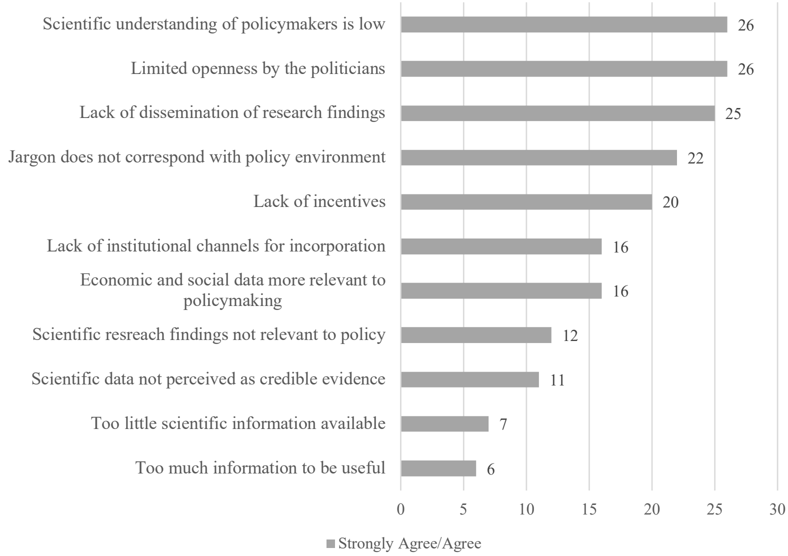

FIGURE 9 | Obstacles to the uptake of research information in the development of policymaking.

TABLE 1 | Example segments with policymakers' views on traditional decision-making processes in education policy.

Example segment	Country
"*Policymakers tend to seek 'scientific arguments' for the decisions already made*"	Lithuania
"*Universities, primary schools, secondary schools and industries need to talk together more than [they do] now.*"	Italy
"*Political will–popularity and party politics being favoured over sound research-based approaches"*	United Kingdom
"*. . .the politicisation of educational policymaking might make it harder and harder for scientific experts to get heard*"	Finland

TABLE 2 | Absolute frequencies of themes and example segments regarding key components of effective policies.

Theme	Frequency	Example segment
Collaboration between stakeholders	12/35	*"Policymakers need to be more open, listening to the words and recommendations of scientists. Unfortunately, some politicians think they are the wisest and just don't hear the expert insights of scientists."*
Opportunities for teacher training	7/35	*"Organise research-oriented pilot projects that support the professional learning of science teachers and at the same time the dissemination of the policy or strategy and pilot project outcomes."*
Consistent goals and resources	7/35	*"Agreed and accepted by all the stakeholders' vision of the system."*
Addressing fundamental needs	5/35	*". . .exploring world developments and communicating tendencies for "here and now." Future is built here and now; thus, science can be better related to nowadays."*

learning of transversal competences in science classrooms, year 2014 framework curriculum emphasises collaborative classroom practices and engagement of students in multidisciplinary, phenomenon- and project-based studies" (FIN1). Regarding the obstacles for effective policymaking, policymakers in Finland noted that researchers are often disinterested in engaging with policymakers (FIN1; FIN2): "*Science education researchers themselves do not take seriously research policy partnership and research practice partnership.*" (FIN1). The lack of dialogue and communication channels between researchers and policymakers was also mentioned when describing the tradition decision-making processes in education policy.

Lithuania

Apart from environmental issues, policymakers in Lithuania considered "*societal tensions*" (LTH1; LTH2) as future challenges. *"Creativity"* was mentioned as a desirable future-oriented competency (LTH2; LTH4), as well as "*digital skills*" (LTH1; LTH3). In order to integrate these skills into the curriculum, participants suggested the adoption of "interdisciplinary" and "transversal skills" (LTH2; LTH3). They also expressed the need for increased consistency between goals and resources in education policy (LTH2), as well as the collaboration between different stakeholders: "*Close science, business, and education system collaboration starting from kindergarten to higher education.*" (LTH1).

Italy

Policymakers based in Italy expressed a range of views and needs. They agreed that there is an increased need for students to trust science: "*Science has to (re)build a relationship of trust with society, according to new media*" (IT2) and "*to overcome the widespread negative attitude toward scientific rationality*"(IT1). Problem-solving was considered one of the key future competencies for science education (IT1; IT2).

Overall, although the policymakers in each country did refer to some specific themes, there was significant consistency across them in how they viewed future-oriented skills and the content of the science curriculum and pedagogical approaches required for teaching innovative skills.

DISCUSSION

As contemporary societies are faced with rapid changes in technology, science, and society, the ability to anticipate future scenarios is increasingly becoming a crucial skill for survival (Suddendorf and Corballis, 2007). Given the importance of these skills, this study aimed to investigate policymakers' views on future-oriented skills in science education and the ways in which they can be introduced through current national curricula. Despite our intention to provide a comparative account of policymakers' views in four European countries, a significant finding of the study is that even though the participants were situated in vastly different national educational policy contexts, they expressed fairly similar views of future-oriented skills and their pedagogical affordances. One possible explanation is that in the context of the empirical study, policymakers focussed on some global outcomes for education rather than nation-specific outcomes. This approach is extensively described by Global Education Policy scholars through the "World Society" theory suggesting that policymakers and governments often receive pressure to demonstrate that they are building a "modern state" according to international standards and the values of the West (Meyer et al., 1997; Verger, 2014).

With regard to possible challenges of the future, policymakers emphasised environmental challenges, such as climate change, while fewer participants referred to future viruses or pandemics. This finding illustrates that despite the overwhelming attention that COVID has received in the past years, policymakers agree that pressing global issues, such as climate change, should be a lasting priority for school curricula (Casas et al., 2021). With regard to the conceptualisation of future-oriented skills, among other skills, policymakers stressed the need for introducing *problem-solving* and *critical thinking* in science classroom, as they believed that these skills would equip students to better address the uncertainty of future challenges (e.g., environmental issues). This finding is in line with current global education policies that have emphasised the importance of such skills, such as the global competency (OECD, 2016) and global citizenship education (UNESCO, 2014). In addition, student competencies for environmental sustainability have been highlighted in the recently published European sustainability competence framework, which encompasses future literacy and adaptability as core competencies for envisioning sustainable futures (Bianchi et al., 2022).

While discussing the importance of these skills, policymakers suggested the inclusion of more interdisciplinary approaches to teaching science (e.g., the combination of school subjects) in combination with project-based and student-centred approaches. In addition, they suggested the introduction of socio-scientific issues (SSI) as a vehicle to introduce global challenges and future-oriented skills. SSI have been introduced in science education as "open-ended" scientific issues with societal impact (Zeidler et al., 2005), as a way of introducing authentic problems from an interdisciplinary perspective (e.g., scientific, social, political). However, in this study, policymakers have demonstrated the opportunity to use such issues to teach about risk and decision-making with regard to the short-term as well as long-term future (Branchetti et al., 2018; Levrini et al., 2019). Therefore, policymakers seem to agree that there is a need for moving away from traditional teacher-centred approaches when teaching future-oriented skills. In addition, they perceived the rigid organisation of knowledge within current curricula as a barrier to the adoption of more innovative approaches to teaching about science and society. For instance, in the case of the United Kingdom, taught curricula are highly influenced by high-stakes assessments, which gives teachers little freedom to follow innovative teaching methods (e.g., Childs and Baird, 2020).

Since educational policies influence how teaching and learning are framed in practice, policymakers recognised the need for engaging a range of stakeholders (e.g., teachers, researchers) in the design and implementation of the science curriculum. There was an almost unanimous expression of the need for inclusion of teachers in decision-making processes, as well as their support throughout the implementation of new future-oriented teaching strategies. This observation shows that policymakers were aware that change in educational practice is often difficult and complex (Guskey, 2002) given that when new policies on curriculum, instruction, and assessment are introduced, teachers play a key role in transforming such policies for implementation in their classrooms (van der Heijden et al., 2018). There is substantial amount of research on how teachers engage with educational policy, ranging from rejection to assimilation of new policies (Cotton, 2006) depending on their educational philosophy, the context of their schools and their professional goals (Ryder et al., 2018). Policymakers in this study emphasised the need for teacher education and training programmes, that would allow teachers to engage in more student-oriented interdisciplinary approaches to teaching future-oriented skills. However, although they identified a need to enhance the quality of teaching though teacher training and professional development, they recognised the difficulties in addressing this issue. Previous literature refers to these difficulties that often include technical, cultural as well as political dimensions of teacher education (e.g., Johnson, 2006).

Although the study provides insights into policymakers' views about future-oriented skills in science education, it is also constrained by a set of limitations. There is an assumption in our study that the policymakers' statements are authentic. In other words, we assumed that their statements correspond to actual conceptualisations and decision-making that policymakers engage in when formulating policies. However, policymakers may not always be willing to disclose the full account of how educational policies may be shaped, nor share their personal opinions when they represent their governmental vision for the policies that are put in place. Furthermore, there may be discrepancies between beliefs and actions where policymakers' beliefs may not necessarily correspond to how they ultimately shape educational policies due to various reasons including political pressures. In addition, this study aimed to elicit policymakers' ideas regarding the possibility of introducing future-oriented skills in national curricula. In that sense, the study captured policymakers' views in the agenda setting phase of the policy cycle (Jann and Wegrich, 2007). Taking into account the multiple steps that the policymaking process includes, future studies can investigate further views of the stakeholders in light of policy design, evaluation and revision.

CONCLUSION AND IMPLICATIONS

The overall findings of this study can serve as baseline information for a systematic approach toward integrating future-oriented skills into science curriculum. Given the role of policymakers in the process of developing and implementing national curricula, the findings of this study illustrate that policymakers support the inclusion of future-oriented skills in science classrooms. Although they provide ways in which they can be integrated into science curricula future studies should examine whether such skills are clearly presented in learning outcomes and textbooks.

With regard to teacher training, this study suggests the inclusion of future-oriented skills in teacher education programmes. By being exposed to global challenges (such as SSI) and ways of teaching about them, teachers will gain the knowledge and strategies for introducing such topics in their classrooms. However, teachers are likely to be reluctant to adopt innovative teaching approaches, unless these are approved by official policies, outlined by curricula and textbooks. Thus, further research can explore the degree to which future-oriented skills are included in current science curricula, as well as existing opportunities for teachers to engage with relevant teaching resources.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

OI contributed to the development of the survey and to the data collection and analysis and wrote the first draft of the manuscript. SE contributed to the conception of the study, wrote parts of the manuscript, and revised and edited the final version. Both authors contributed to the article and approved the submitted version.

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APPENDIX

Policymakers' Views Questionnaire

TABLE A1 | Open-ended items used in policymakers' views questionnaire.

1. Country
2. Gender
3. Age
4. Highest degree or level of education
5. Professional background
6. Area of expertise
7. Length of service in your current position (in years)
8. Do you have any teaching experience?
9. How many years of teaching experience do you have?
10. Have you taught science subjects (Biology, Physics, Chemistry)?
11. In which educational level have you taught?
12. What are, in your opinion, the central challenges for science and society of the future?
13. What key competencies will be needed for students to address the future challenges in science and society?
14. What competencies do students need for envisioning the future?
15. How can the competencies for addressing and imagining the future can be integrated into science education? For example, what can be included in the science curriculum?
16. What do you think is important for secondary school students to think about in relation to (a) their future (b) the global future (c) the role of technology in sharing their future?
17. What are some obstacles to the uptake of scientific information in the development of policy making?

TABLE A2 | Closed-ended items used in policymakers' views questionnaire (raking).

18. Please rank the following items.
a) The quality of teaching, teacher induction, pre-service preparation and in-service professional development should be enhanced to improve the depth and quality of learning outcomes
b) Collaboration between formal, non-formal and informal educational providers, enterprise, industry and civil society should be enhanced to ensure relevant and meaningful engagement of all societal actors with science and increase uptake of science studies and science-based careers and employability and competitiveness
c) Greater attention should be given to promoting Responsible Research and Innovation and enhancing public understanding of scientific findings and the capabilities to discuss their benefits and consequences
d) Emphasis should be placed on connecting innovation and science education strategies, at local, regional, national, European and international levels, taking into account societal needs and global developments

TABLE A3 | Closed-ended items used in policymakers' views questionnaire (scale).

19.To what extent do you think that the following can be obstacles to the uptake of scientific information in the development of policy-making?	1	2	3	4	5
	Very much				**Not at all**
a) Too much scientific information to be useful					
b) Too little scientific information available					
c) Jargon does not correspond with policy environment					
d) Scientific data not perceived as credible evidence					
e) Scientific research findings not relevant to policy					
f) Economic and social data more relevant to policy-making					
g) Lack of institutional channels for incorporation					
h) Lack of incentives					
i) Lack of dissemination of research findings					
j) Limited openness by politicians					
k) Scientific understanding by policy-makers is low					