FEDORA

Future-oriented Science Education – A Delphi Study on Policymakers' Perspectives

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FEDORA - Future-oriented Science EDucation to enhance Responsibility and engagement in the society of Acceleration and uncertainty This project received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement n° 872841 **www.fedora-project.eu**

Overall Objectives

- **Develop guidelines** to renew science education targeting at researchers, teachers, educators in formal, non-formal and informal contexts in order to bridge any misalignment
- **Engage** policymakers to generate a set of considerations around the various aspects of project, prior to they being exposed to the FEDORA concept
- **Compile** policymakers' recommendations for a synthesis of theoretical constructs or frameworks
- **Offer guidelines** for research and educational institutions to futurize science education

Theoretical background

- "Future" as a burgeoning theme at high-level policymaking (OECD 2020; 2021; UNESCO, 2021)

- Within STEM education, examples of latest research on "future" –
  - ➢ teachers' understanding of future-oriented pedagogy (Sachyani et al., 2023);
  - ➢ How science teaching develops students' future-scaffolding skills and agency (Levrini et al., 2021; Rasa et al., 2022)
  - ➢ Future-oriented skills and learning with technology (Aurava & Sormunen, 2023)

- Researchers define future-oriented skills by OECD Learning Compass 2030 (Aurava & Sormuene, 2023; Sachyani et al., 2023), albeit some criticism (Hughson & Wood, 2022)

- Gaps in how science education can promote future-oriented skills and conditions of success → lack common understanding

- Past Delphi studies in SE – a) focused on specific content knowledge; b) involved a range of stakeholders (teachers, students, scientists) but excluded policymakers (e.g. Charro, 2021; González-García et al., 2021; Krijtenburg- Lewerissa et al., 2019; Sakhnini & Blonder, 2015)

Methods

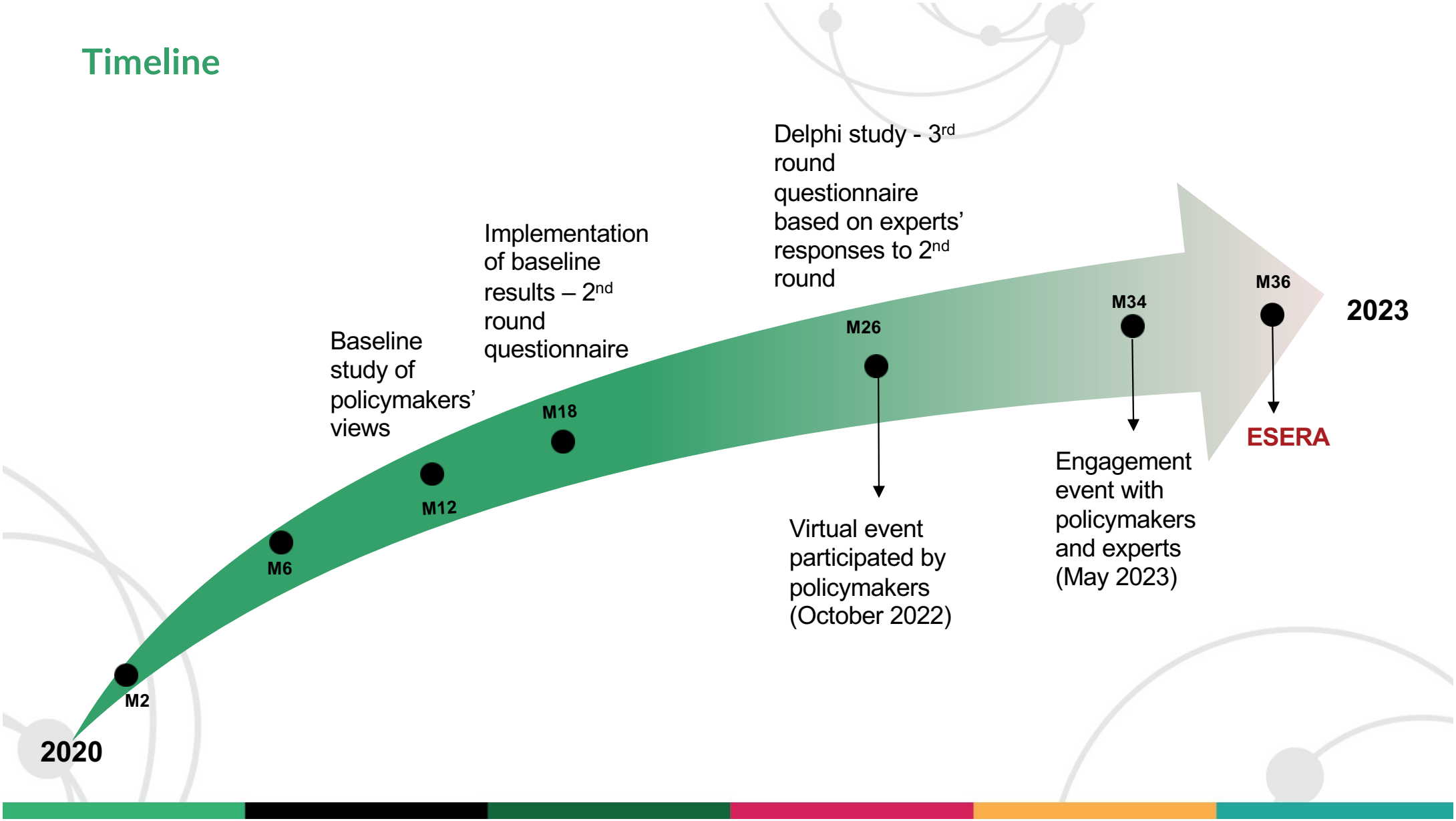
Specific goal – consensus building among policymakers on future-oriented science education

What is Delphi study?
"a method for the systematic solicitation and collection of judgements on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses." (Delbecq et al., 1975, p. 10)

Characteristics –
a) group interaction and responses;
b) multiple rounds of questionnaires until consensus reached;
c) "controlled feedback" by the researcher during the course; by nature reducing diverse opinions to major or popular views

(Murry & Hammons, 1995)

Timeline


2020
M2
M6
M12
M18
Baseline study of policymakers' views
Implementation of baseline results – 2nd round questionnaire
Delphi study - 3rd round questionnaire based on experts' responses to 2nd round
M26
Virtual event participated by policymakers (October 2022)
M34
Engagement event with policymakers and experts (May 2023)
M36
ESERA
2023

Sampling

Questionnaire	Completion	Number of respondents	Response rate
Round 1 (baseline)	March 2021	35/73	48%
Round 2	September 2022	22	63%
Round 3 (final)	March 2023	18	82%

- No attempt to be representative by nature –

"The Delphi group size does not depend on statistical power, but rather on group dynamics for arriving at consensus among experts. Literature recommends 10-18 experts on a Delphi panel" (Okoli & Pawlowski, 2004, p.19).

Research instruments

FEDORA final-round questionnaire

Page 1: General information

We are grateful for your continued support of the FEDORA Project. Your input has been valuable. We are now approaching the last phase of the project in which we need one last response from you to the survey as we consolidate the outcomes.

As you know, we are exploring possible solutions to the gap between the knowledge and skills produced by traditional educational organisations and what the society needs. The overarching goals of FEDORA are to suggest a future-oriented approach to science education and to foster anticipatory policymaking that aligns with this approach. Some future-scaffolding skills include scenario thinking, systems thinking, thinking beyond the realm of possibilities, action competence and managing uncertainty and complexity.

Once you responded to the latest version of the survey, we will compile recommendations for a framework that sheds light on future-oriented science education. We will also contact you again in due course to invite you to some project activities should you wish to engage further.

For consensus building and consolidation, we would greatly appreciate if you filled in this final survey by February 15th, 2023.

Page 7: Policymakers' recommendations

22. What do you think are the major obstacles to uptake of research in the policymaking process? Please rank the categories in order of significance.

	Limited openness by politicians (M=7.4)	Policymakers' insufficient understanding of research evidence (M=7.3)	Traditional decision-making process (M=6.9)	Lack of political will (M=6.4)	Jargon not correspond with policy environment (M=5.7)
1	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐

22.a. Comments

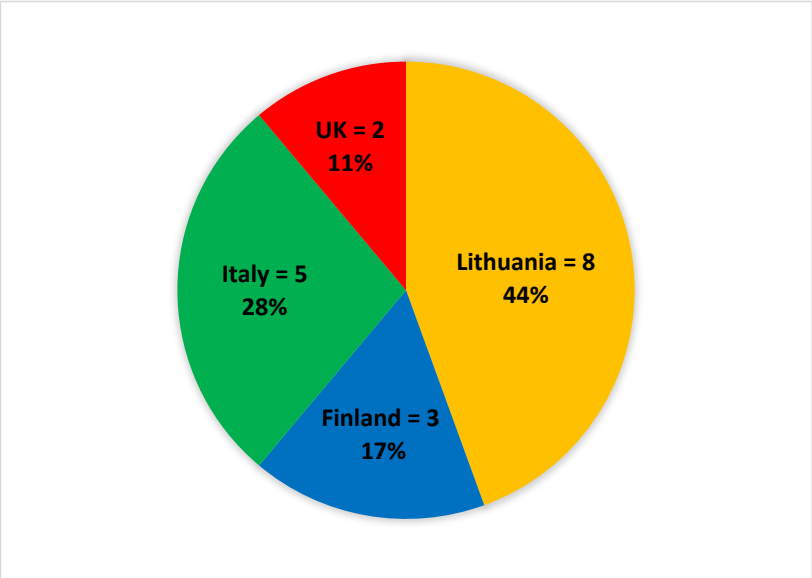
- Baseline and Round 2 – Demographics, open and closed questions
- Final round – Demographics and closed (ranking) questions, with options for comments
- Three domains for opinion questions - a) views on future-oriented skills; b) policymakers' recommendations; c) views on *European sustainability competence framework*

Demographics of Delphi respondents

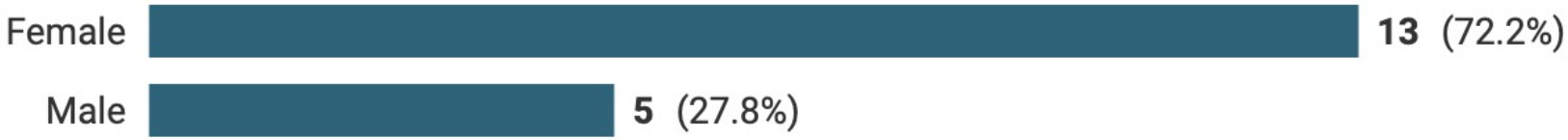
n = 18 (final round)

Examples of current positions –
policy advisors or expert groups;
research council members;
assessment/exam board managers;
academics; teacher educators;
curriculum developers

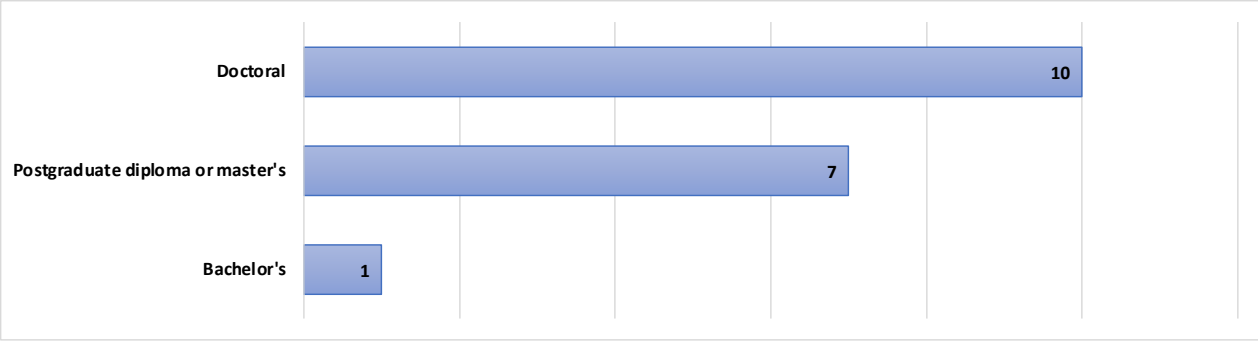
Base country



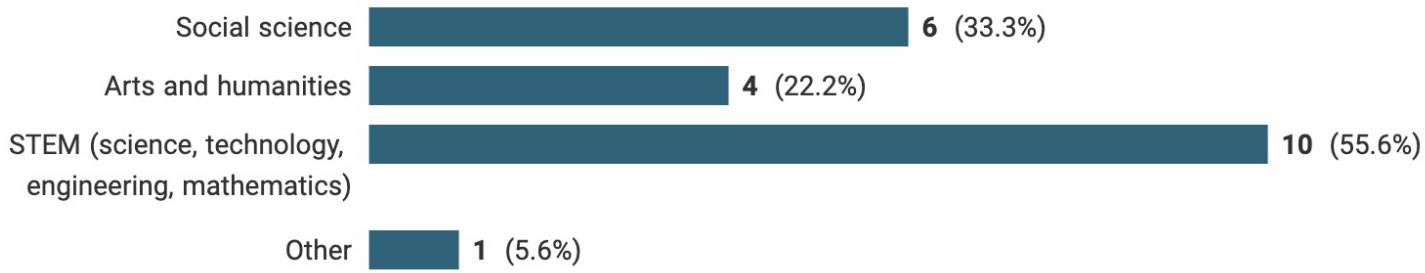
Gender distribution



Highest degree completed



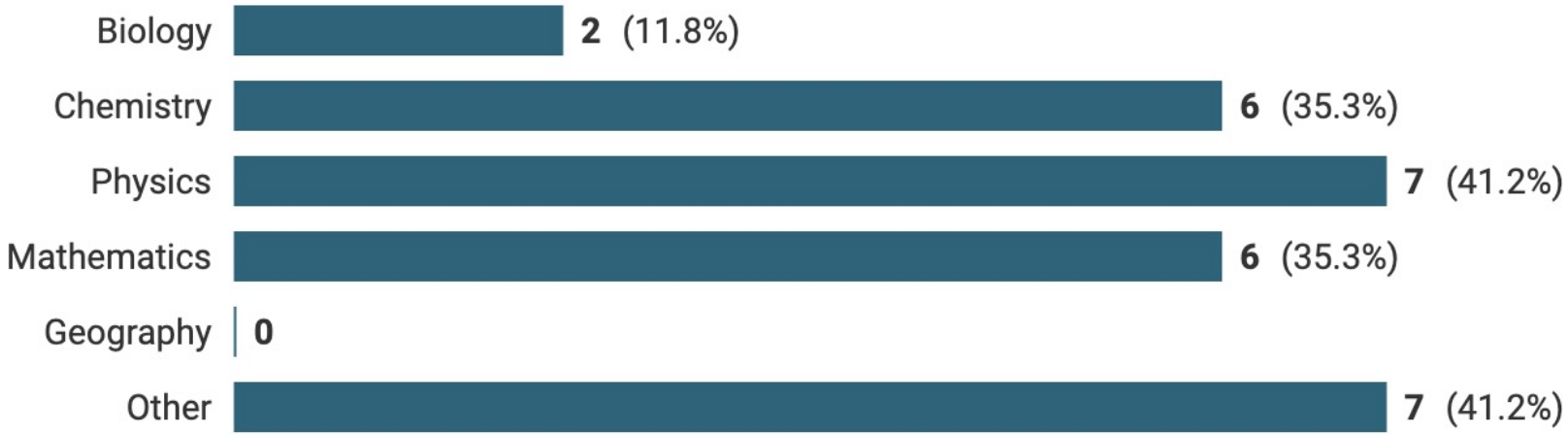
Subject studied



NB - 'Other' includes environmental science
(Participants may select more than one option)

All participants (but one) have teaching experiences at various levels

Subject taught



NB – 'Other' includes language/language arts, educational science, and other social science and humanity subjects
(Participants may select more than one option)

Analytical methods

- Content analysis for qualitative data (Round 1 and 2)
- Descriptive statistics for quantitative data (all three rounds)

Also in final round (quantitative analyses only) –

- group's prioritised categories measured by mean rank of each option in the respective question item
- agreement measured by Kendall's coefficient of concordance, *W* (Kendall & Gibbons, 1990; Field, 2005; Okoli & Pawlowski, 2004)
- commonly used for determining agreement between raters
- enable researchers to "make a realistic determination of whether any consensus has been reached, whether the consensus is increasing, and the relative strength of consensus" (Schmidt, 1997, p.765)

- All results achieved statistical significance ($p < .05$); null rejected

Analytical methods

e.g. How significant are the statements from the *European sustainability competence framework*?

Statistics

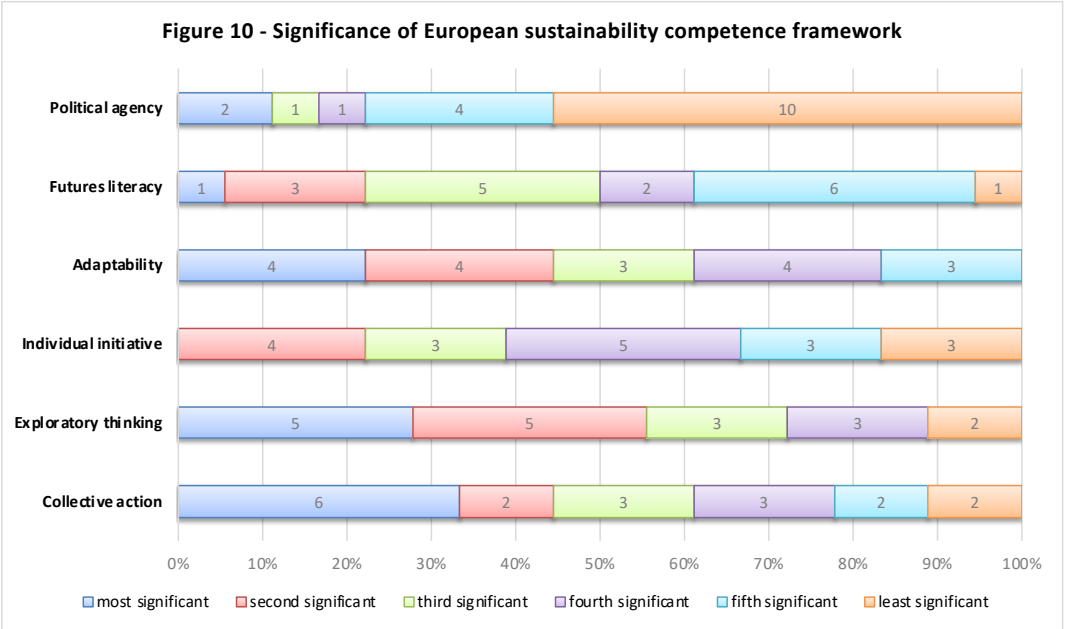
		Collective_action	Exploratory_thinking	Individual_initiative	Adaptability	Futures_literacy	Political_agency
N	Valid	18	18	18	18	18	18
	Missing	0	0	0	0	0	0
Median		3.00	2.00	4.00	3.00	3.50	6.00
Mode		1	1[a]	4	1[a]	5	6
Minimum		1	1	2	1	1	1
Maximum		6	6	6	5	6	6

a. Multiple modes exist. The smallest value is shown

Test Statistics

N	18
Kendall's W[a]	.208
Chi-Square	18.730
df	5
Asymp. Sig.	.002

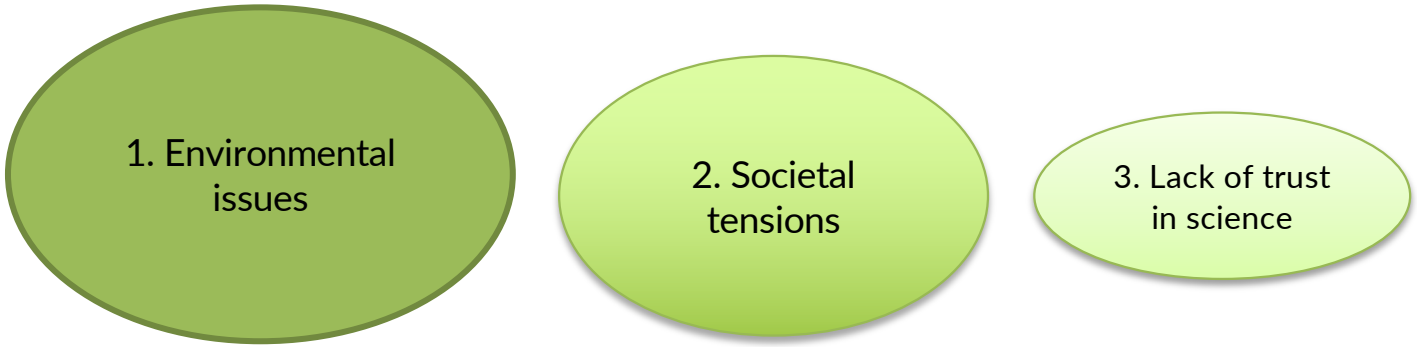
a. Kendall's Coefficient of Concordance



Result highlights

High consensus

What are the central challenges for science and the future society?



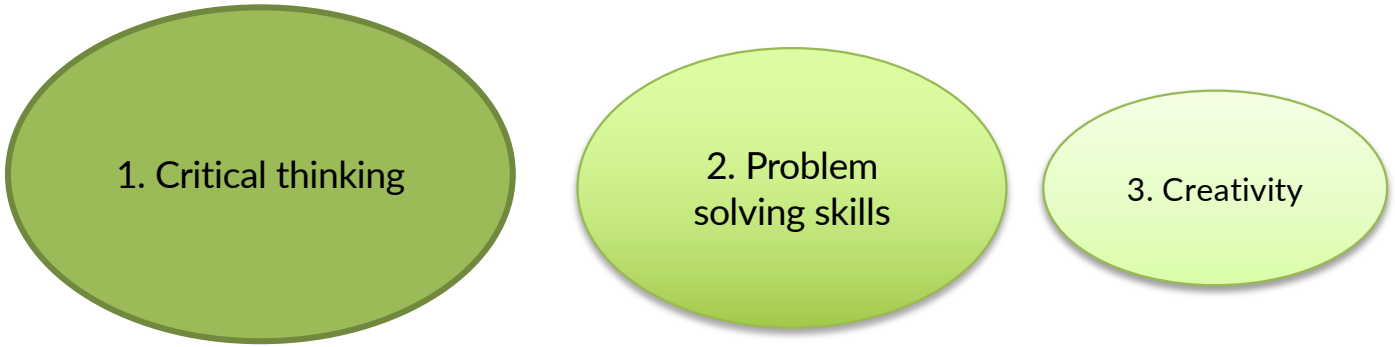
4. economic issues; 5. new disease or viruses; 6. automatisation

Additional suggestions – AI and ethics; teacher education

Result highlights

High consensus

What are the key competencies students will need to address future challenges in science and the society?



4. social intelligence; 5. metacognitive skills; 6. digital skills; 7. communicative skills

Additional suggestions – system thinking; management of personal responsibility

Result highlights

*Highest consensus of all questions

How can the competencies for imagining the future and addressing future challenges be integrated into science education?

4. promoting collaborative skills; 5. project-based learning; 6. inclusion of various
7. stakeholders in designing curricular; 8. reducing focus on content

Additional suggestions – integrating sustainability into teacher education; empathy

Result highlights

Low consensus

What are the key components of effective policy to foster future-oriented skills?

1. Collaboration between stakeholders

2. Greater consistency in educational goals and the designed resources

3. Provision of teacher training opportunities

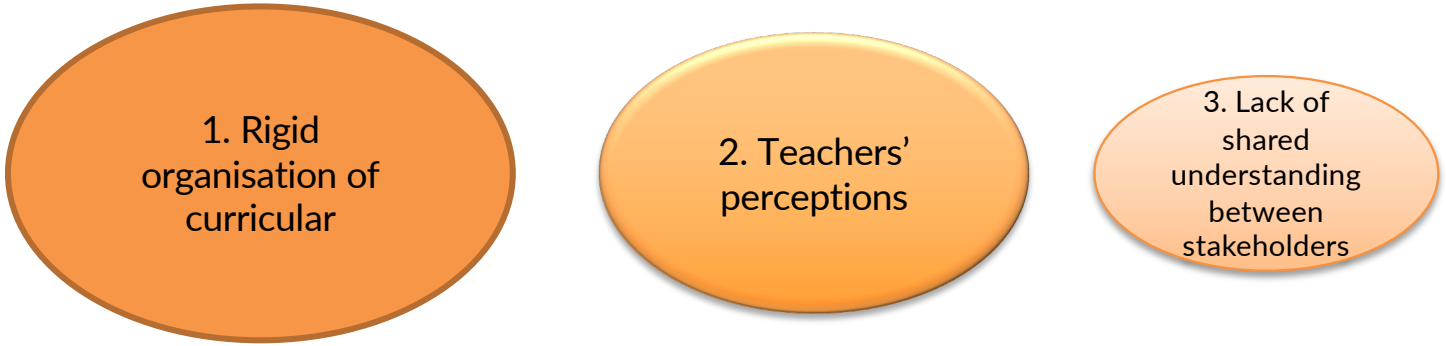
4. greater emphasis on addressing fundamental educational needs

Additional suggestions – educating teacher educators; freedom of research and research integrity

Result highlights

Low consensus

What are the obstacles to science education reform?



4. teachers' skills; 5. lack of resources

Additional suggestions – teachers' education; people's opinion about the role of education; emphasis on school assessment; competences of teacher educators; research-based solutions; authorities' perception; lack of political will and imagination

Result highlights

*Lowest consensus of all questions

Please rank the statements from the *European sustainability competence framework* in order of significance.

4. futures literacy; 5. individual initiative; 6. political agency

European sustainability competence framework

AREA	COMPETENCE	DESCRIPTOR
3. *Envisioning sustainable futures*	3.1 **Futures literacy**	To envision alternative sustainable futures by imagining and developing alternative scenarios and identifying the steps needed to achieve a preferred sustainable future.
	3.2 **Adaptability**	To manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.
	3.3 **Exploratory thinking**	To adopt a relational way of thinking by exploring and linking different disciplines, using creativity and experimentation with novel ideas or methods.
4. *Acting for sustainability*	4.1 **Political agency**	To navigate the political system, identify political responsibility and accountability for unsustainable behaviour, and demand effective policies for sustainability.
	4.2 **Collective action**	To act for change in collaboration with others.
	4.3 **Individual initiative**	To identify own potential for sustainability and to actively contribute to improving prospects for the community and the planet.

Bianchi, G., Pisiotis, U., Cabrera Giraldez, M. GreenComp (2022). The European sustainability competence framework. Bacigalupo, M., Punie, Y. (Eds), EUR 30955 EN, Publications Office of the European Union.

More results

(in descending order of importance ranked by the respondents)

Competencies students need for envisioning the future –

1. Critical thinking
2. Interdisciplinarity
3. Imagination

Major obstacles to uptake of research in policymaking process –

1. Policymakers' insufficient understanding of research evidence
2. Limited openness by politicians
3. Traditional decision-making process

Sentiment students should have in order to think about their own future –

1. Feeling of agency
2. Growth mindset
3. Sense of hope

Sentiment students should have in order to think about the global future –

1. Feeling of agency
2. *Informed about global issues
2. *Aware of the impact of their actions on the environment (*equal ranking)

Conclusion & Recommendations

- Higher agreement level reached on questions related to competencies students need for the future and what the future challenges are (i.e. relatively clear consensus by our Delphi panel).
- Questions related to the *European sustainability competence framework*, aspects of policymaking or reform reflected lower agreement level (i.e. more diverse views).
- Recommendations –

  a) Stakeholders at different capacities review existing curriculum objectives or assessments – to what extent they converge or diverge from this common understanding.

  b) Future studies to consolidate/validate this consensus, e.g. by involving more countries and/or stakeholders in science education.

- Comments or questions most welcome!

5. Making proactive and anticipatory policies

Education policies can determine how future-oriented science education can be enacted in schools. Hence, understanding policymakers' views is directly relevant to our goals in FEDORA because those views inevitably shape the decision-making, enactment and evaluation of proactive and anticipatory policies. The project employed Delphi methodology to delve into the judgements and opinions about future-oriented science education held by policymakers and professionals specialised in curriculum design, assessment, teacher education and higher education. Led by the University of Oxford, three rounds of questionnaires were distributed to a selected group of experts from the participating countries. The questionnaire in each new round captured and reflected participants' responses from the previous round so that experts' opinions could be pooled towards reaching a consensus. The following table illustrates the operations in the three cycles of the entire study.

The Delphi Process in FEDORA Project

Questionnaire	Completion	Number of respondents	Response rate
Round 1 (baseline)	March 2021	35	48%
Round 2	September 2022	22	63%
Round 3 (final round)	March 2023	18	82%

The key results from the final round of the Delphi study ill… takeholders have weighted various fact… education. In each of the following … nce for the respective theme. Over … petencies that students need for … European sustainability competen… mong the questionnaire responder…

Central challenges for science and the future society

- Environmental issues (1)
- Societal tensions (2)
- Lack of trust in science (3)

Key competencies that students will need to address future challenges in science and society

- Critical thinking skills (1)
- Problem-solving skills (2)
- Creativity (3)

Competencies students need for envisioning the future

- Critical thinking (1)
- Interdisciplinarity (2)
- Imagination (3)

Ways to integrate competencies for imagining the future and addressing future challenges

- Inclusion of interdisciplinary approaches (1)
- Promoting imagination/creativity (2)
- Inclusion of socio-scientific issues (3)

Obstacles to reform of science education

- Rigid organisation of the curriculum (1)
- Teachers' perceptions (2)
- Lack of shared understanding between stakeholders (3)

Sentiment students should have in order to think about their own future

- A feeling of agency (1)
- A growth mindset (2)
- A sense of hope (3)

Sentiment students should have in order to think about the global future

- A feeling of agency (1)
- Informed about global issues (=)
- Aware of the impact of their actions on the environment (=)

Major obstacles to uptake of research in policymaking process

- Policymakers' insufficient understanding of research evidence (1)
- Limited openness by politicians (2)
- Traditional decision-making process (3)

Key components of effective policy to foster future-oriented skills

- Collaboration between stakeholders (1)
- Greater consistency in educational goals and the designed resources (2)
- Provision of teacher training opportunities (3)

Significance of the statements from the European sustainability competence framework

- Exploratory thinking (1)
- Adaptability (2)
- Collective action (3)

LEGEND

- (1) MOST IMPORTANT
- (2) SECOND IMPORTANT
- (3) THIRD IMPORTANT
- (=) EQUAL RANKING

FEDORA

https://www.youtube.com/watch?v=W0muUdSTytI&ab_channel=formicablu

https://www.fedora-project.eu/

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ORIGINAL RESEARCH

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-centered 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, 2012) 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

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