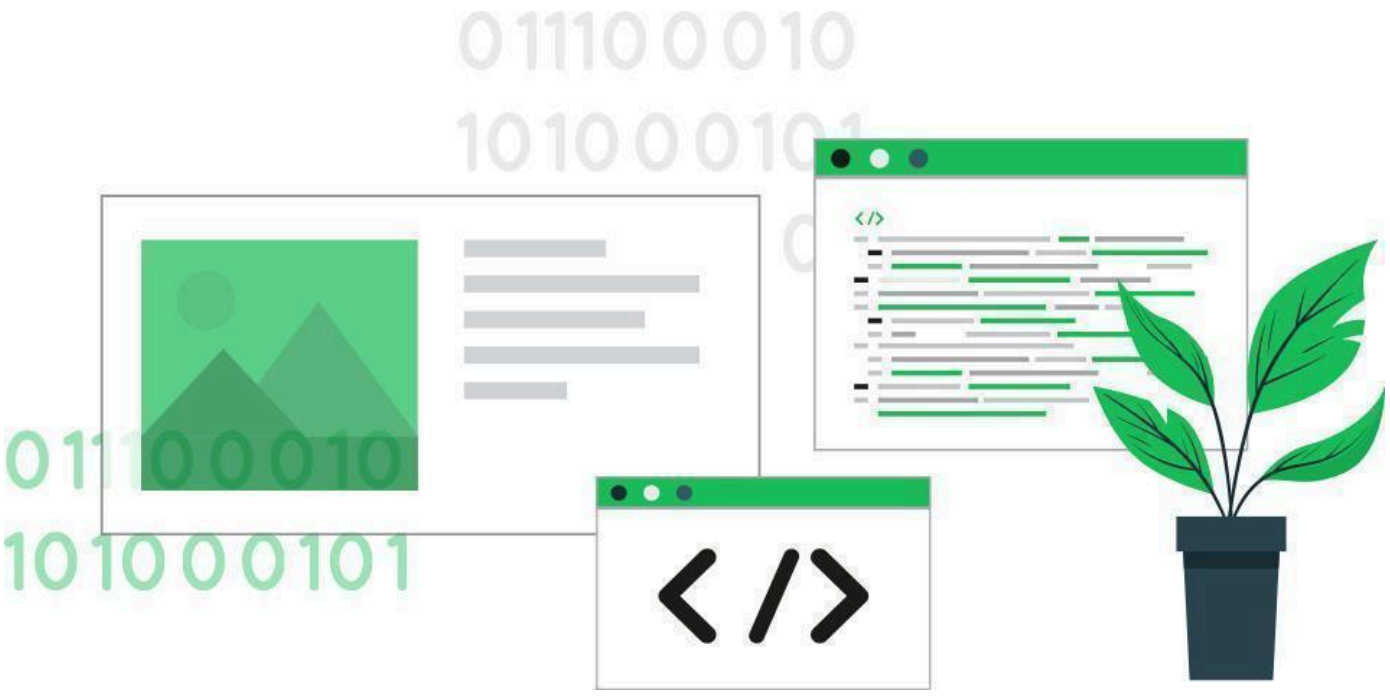
AN AUTHENTIC LEARNING
& GENDER INCLUSIVE
FRAMEWORK FOR TEACHING
INFORMATICS IN SCHOOLS
ACROSS EUROPE

WP2 A Framework and Toolkit for informatics education

Transnational Report



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Executive Summary

The transnational report is a summary and a comparative analysis of the research conducted to develop the first output of the TINKER - an auThentIc learNing and gender inclusive frameworK for tEaching infoRmatics in schools across Europe project, which is co-funded by the Erasmus+ Programme of the European Union.

Research was conducted by nine organizations in six countries (Cyprus, Italy, Greece, Ireland, Netherlands, Croatia). The current state of informatics was explored in all six countries, where 55 teachers of upper primary and lower secondary education participated in the focus groups conducted, and 432 responded to an online survey. The study revealed similarities and differences among countries regarding the state of informatics at the upper primary and lower secondary education level as well as the teaching of informatics in an authentic and gender inclusive approach.

Both the desk and field research have shown that there is a persistent narrative in informatics education, marked by recurring challenges despite variations in curriculum frameworks and pedagogical methodologies. Issues such as inadequate resources, limited teacher training, and the absence of clear guidelines continue to impede progress. Despite concerted efforts to promote authentic learning experiences and initiatives aimed at gender inclusion, barriers like resistance to change, inadequate support structures, and a scarcity of tailored materials and strategies persist, hindering the effective implementation of inclusive and innovative teaching practices. Such practices are essential for equipping students with crucial digital competencies and cultivating learning environments that embrace diversity and equality.

1. Introduction

1.1. Thematic Focus

The TINKER project is an EU-funded project which will develop and implement an **evidence-based, authentic learning pedagogical framework** in teaching informatics, in upper primary and lower secondary education (10-14 years old) through a **contemporary gender-inclusive** approach.

Rooted in authentic learning principles, the project encourages students to engage with real-life tasks, promoting exploration and intentional connections between theoretical knowledge and practical experiences. This pedagogical approach aligns with the latest JRC report (Bocconi et al., 2022) that emphasizes the importance of problem-solving and product creation in informatics curricula, as well as contributes to the EU's goal of ensuring that by 2030, 80% of adults will possess basic digital skills and there will be 20 million ICT specialists across the member states[1].

The project also aims to address and overturn the severe underrepresentation of women and gender minorities in the field, by adopting a progressive gender-inclusive stance. In particular, it will promote gender-inclusive teaching practices creating positive **student-centered** environments that encourage inclusion and interest in informatics. By addressing existing biases, TINKER aims to contribute to a transformative educational experience where gender diversity is not only respected but also valued as an asset. Towards this direction, as a first step, this report aims to:

- Review empirical research and national curricula for informatics teaching and assessment, authentic learning, and gender inclusive practices at local, European and international level;
- Identify key challenges the teachers face for teaching and assessing informatics in upper primary and lower secondary education (10-14 years old).

The consortium aims to create a practical and meaningful for the users' toolkit. Therefore, partners will draw on findings from the desk and field research that were conducted for the development of this output, as well as findings from previous projects and research to:

- Review the national and EU literature to identify the following:
    a) main principles of authentic learning and gender inclusive practices along with key related initiatives in each country and EU level
    b) state-of-the-art about the teaching of informatics (up-to-date picture of content, applications)
    c) teachers' current preparation and needs

- Develop the Pedagogical Framework that will map the following:
    a) **informatics topic areas**, with learning outcomes tailored to the age levels (based on and adapting the Informatics Reference Framework for School) and the recommendations of the JRC 2022 report "Reviewing Computational Thinking in Compulsory Education" (Bocconi et al., 2022)[2]
    b) **principles of authentic learning** in the context of informatics teaching and assessment

[1] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en
[2] https://publications.jrc.ec.europa.eu/repository/handle/JRC128347

c) **gender inclusive practices** when teaching and assessing informatics

- Design and develop the Toolkit that will be a practical guide for the teachers with:
  a) guidelines to design learning scenarios and activities based on the TINKER framework in line with national curricula
  b) template for teachers to design learning scenarios using the Framework
  c) self-reflective tool (i.e. aligned with SELFIE[3]) for teachers to reflect on their teaching practice -whether it follows the TINKER framework (authentic learning and gender inclusive)
  d) collection of 100 learning scenarios for upper primary and lower secondary education (50 per education level) – equal number for development assigned to each partner

[3] https://education.ec.europa.eu/selfie; https://schools-go-digital.jrc.ec.europa.eu/

2. Methodology

The nine partners of the consortium of the TINKER project have collaborated to produce this transnational report based on their national reports. The research adopts mixed methodology to explore the way informatics is taught in upper primary and lower secondary education. More specifically, the research utilizes the methods of a) Desk Research, b) Focus Group, and c) Online Questionnaire-based Survey. In situations where two or more partner organizations were representing the same country, one desk research report and one field research report were written for the specific country with the contribution of all partner organizations. For the purpose of this report, researchers from UNIC, CARDET and CPI in Cyprus and researchers from KMOP and RDPSEA in Greece collaborated in both desk research and field research. Figure 1 below summarizes the methodology that was applied as part of the TINKER approach.

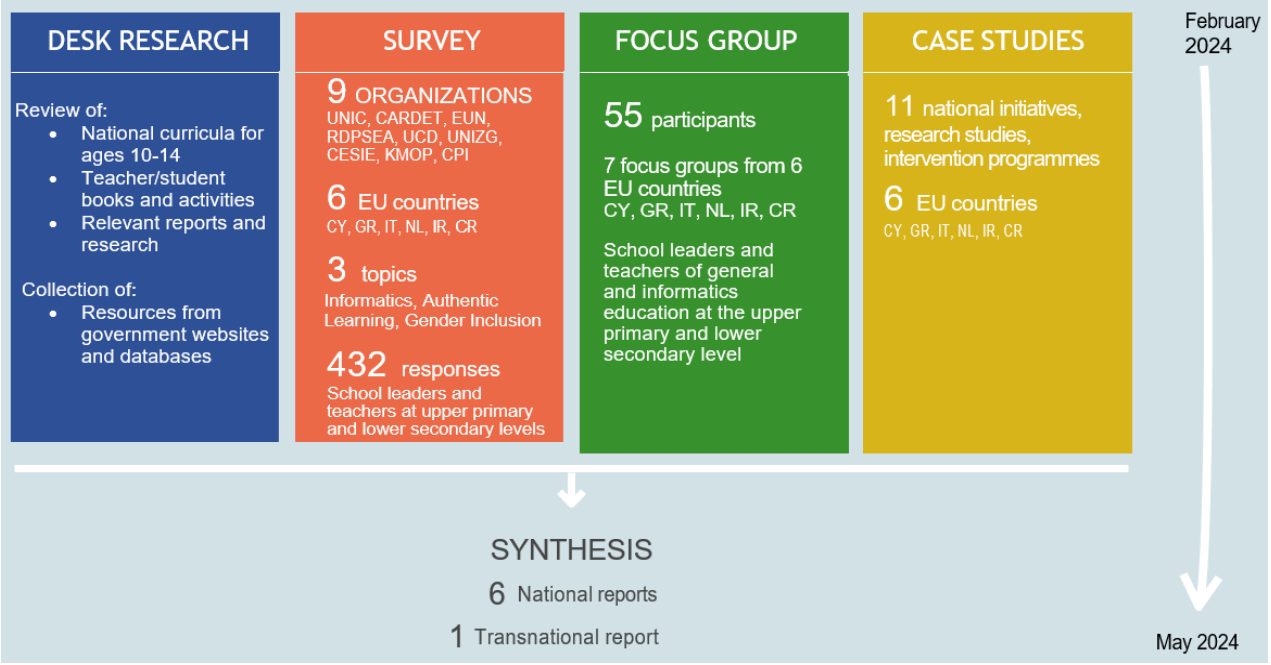

Figure 1. TINKER Research Methodology

2.1. Desk Research

The partner organizations have done their individual research on the status quo of their country regarding (a) the main principles of authentic learning and gender inclusive practices along with key related initiatives in their country and (b) the state-of-the-art about the teaching of informatics (up-to-date picture of content, applications). The guidelines were developed by UNIC, and all organizations contributed by providing their feedback.

2.2. Field Research

The field research of this project aimed at understanding the teachers' current preparation and needs in the field of informatics. To capture these aspects, it was necessary to gain the insights and thoughts of teachers and thus, focus groups and online questionnaire-based surveys were used.

A total of 55 teachers of upper primary and lower secondary education have participated in the focus groups that were conducted in each partner country. The focus groups had at least six participants. UNIC, CARDET and CPI conducted the focus group with 16 participants, KMOP and RDPSEA with 13 participants, University of Dublin with 8 participants while the rest of the partner countries with 6 participants respectively. An online questionnaire-based survey has also been shared with teachers of upper primary and lower secondary education to receive at least 50 responses in each partner country and a total of at least 300 responses cumulatively. The consortium exceeded the target of 300 responses, receiving 432 in total from the online questionnaire-based survey conducted across all six partner countries. This goes beyond the expected 300 responses and covers the requested indicator.

3. Data analysis from the desk research

As part of the desk research, the partners conducted a curriculum map and reviewed the national literature regarding the informatics teaching in upper primary and lower secondary education (10-14 years old), teachers' current preparation and needs and the main principles of authentic learning and gender inclusive practices along with key related initiatives (best practices). In the following subsections, the methodology employed as well as the main findings deriving from the desk research are presented and discussed.

3.1. Current state of informatics education in partner countries

Based on the national and EU literature review, each partner country identified the main principles of authentic learning and gender inclusive practices along with key related initiatives in each country and EU level as well as the state-of-the-art about the teaching of informatics. The current state of informatics education, was guided by the two research questions below:

Research Question 1: *What are the general aims and objectives, core topic areas, competencies, and specific learning outcomes defined in the National Curriculum for the field of informatics?*

Research Question 2: *Which teaching and assessment methods are followed to teach informatics competencies in upper primary and lower secondary education, according to the National Curriculum?*

3.1.1. Current state of informatics education in Cyprus

In Cyprus, informatics education starts in primary through "Design and Technology", "Mathematics", "Physical Sciences" and the introduction of Information Technology through the introduction of "Life Education" courses, focusing on computational thinking and technological literacy. These courses aim to cultivate problem-solving skills and technological understanding. Core topic areas include cultivating students' digital competence, enabling them to use it in their learning process across all subjects and in their future education as a fundamental aspect of 21st-century citizenship and using technology for problem-solving and understanding the relationship between technology, society and the economy. Key areas of "Digital Competence and Internet Safety" include the rules of online behavior – cyberbullying, electronic/online games, information and misinformation and personal data and digital identity. Students are expected to develop competencies like using technology as a tool and understanding the ethical implications of technology use. Specific learning outcomes include using software for presentations and understanding the role of technology in problem-solving. At lower secondary level, informatics becomes a separate subject with a focus on practical applications and problem-solving using computers. The curriculum covers core topic areas like data manipulation, algorithms, and basic programming. Part of the curriculum encompasses instruction on the four fundamental modules of the European Computer Driving License (ECDL) international standard. Additionally, starting from the academic year 2016 – 2017, as per a decree from the Council of Ministers, students have the option to voluntarily undertake these exams to acquire certification in IT skills. Students develop competencies like using computers as a problem-solving tool and designing and implementing algorithms. Specific learning outcomes include understanding how data is represented in computers and designing simple algorithms. Teaching methods emphasize collaboration and use a variety of techniques like demonstrations and computer-aided presentations. Assessment is comprehensive and includes participation,

assignments, and exams to measure students' overall achievement of course objectives. Importantly, both for upper primary and lower secondary education, the ministry's policies emphasize a three-pronged approach: Digitally Competent Schools, Digitally Competent Teachers, and Digitally Competent Students.

Based on "Informatics4All" (Caspersen et al., 2022)[4] concepts related to Informatics are mainly being taught at the secondary level. This could be the result of the fact that the course is being taught separately and is not part of other courses. Notably, although efforts have been made for the updating of the curriculum of Informatics at the secondary level to meet European standards and current trends, efforts should be also made at the primary education level in order for the students to receive the basic knowledge of Informatics at an earlier stage. When it comes to authentic learning and gender inclusive practices, it seems that no clear and adequate guidelines are being provided. However, it must be stressed that there are various educational and informative material on gender equality in education as well as the interdepartmental committee for the promotion of equality between men and women that operates under the Ministry of Education, aiming at the elimination of Stereotypes and Gender Discrimination in education and the prevention and management of gender racism.

Our research strengthens the Eurydice report on informatics education (EC, 2022). While both studies confirm the early introduction of informatics concepts, ours offers a more complete picture. We confirm the report's finding of early exposure, but add a crucial detail: informatics in the Cypriot primary school curriculum is not a standalone subject. It's cleverly integrated into subjects like "Design and Technology," "Mathematics," "Life Education" and "Physical Sciences," infusing informatics throughout the curriculum. This reveals the specific implementation methods used in Cyprus's primary education system. Our research goes beyond confirmation. We detail the specific skills students develop, like software use and problem-solving with technology. This offers valuable insights into the actual learning outcomes in informatics education, something not explicitly mentioned in the Eurydice report.

Finally, we identify areas for improvement, such as incorporating more authentic practices and fostering gender inclusivity within informatics education. These aspects are not addressed by the Eurydice report (EC, 2022). In essence, while our findings support the Eurydice report's core finding, they provide a clearer picture. We reveal specific implementation methods and pinpoint areas for curriculum improvements, providing a more comprehensive understanding of the current state and potential enhancements for informatics education in Cypriot primary schools.

3.1.2. Current state of informatics education in Greece

In Greece, informatics education aims to equip students with computer science knowledge and ICT skills for various uses. Core topics include computer basics, software, internet, and using technology for creation and understanding its role in daily life. Students develop competencies in using hardware and software, creating content, navigating the internet safely, and problem-solving with ICT. Specific learning outcomes include using ICT tools for creation, safe internet use, solving basic ICT problems, and applying these skills in real-world contexts.

Teaching methods combine theory, hands-on activities, and collaborative projects. Assessment is formative, based on classroom participation, assignments, presentations, and self-evaluation. As

[4] https://www.informaticsforall.org/the-informatics-reference-framework-for-school-online-en/

students' progress from upper primary to lower secondary, the focus shifts from foundational skills like word processing to more advanced concepts like programming, research methods, and digital citizenship. This reflects a gradual increase in complexity and a move towards more independent learning and critical thinking.

3.1.3. Current state of informatics education in Ireland

Informatics education in Ireland is structured to provide students with foundational knowledge and skills in computational thinking, programming, digital literacy, and ethical considerations regarding technology use. While informatics isn't a separate subject in primary school, the groundwork is laid through science, engineering, applied technology and math courses. These classes introduce core informatics concepts like algorithms, hardware/software basics, internet safety, and data representation in an age-appropriate way. Hands-on activities, interactive lessons, and discussions on online safety equip students with basic computational thinking, simple programming skills, and responsible digital tool usage. Assessment methods include practical exercises, projects, and quizzes to evaluate students' understanding of online safety, and simple projects to assess data handling abilities.

Building upon this foundation, junior cycle (lower secondary) dives deeper into informatics. Students explore advanced programming concepts, data structures and algorithms, cybersecurity, digital ethics, and computer networks. They develop proficiency in programming, understand data organization and problem-solving techniques, and learn to collaborate and communicate effectively using digital tools. Teaching methods incorporate more complex projects, ethical discussions, and demonstrations to solidify their understanding.

The key difference between primary and secondary level informatics lies in the depth and breadth of content. The lower secondary level tackles more advanced topics, requires a deeper grasp of concepts, and prepares students for future studies or careers in technology-related fields. This structured progression ensures students are responsible and competent users of technology, equipped to thrive in an increasingly digital world.

3.1.4. Current state of informatics education in Netherlands

Dutch informatics education, related to digital literacy, focuses on three main areas: (1) Practical knowledge & competencies (e.g. digital systems, digital media and information, safety & privacy, data & AI); (2) Design and creation; (creating with digital technology & programming) (3) Interaction between digital technology, digital media, people & society (digital technology, yourself, and the other; digital technology, society, and the world). This allows teachers the flexibility to adapt them to their specific teaching methods and school philosophies. As students' progress, the complexity and depth of the content increase. In primary school, they gain a foundation in operating digital systems, navigating information sources, and using technology safely. Lower secondary education builds upon this base by introducing them to advanced software features, data analysis techniques, and exploring the capabilities and limitations of AI. Students also transition from creating basic digital products to using computational thinking to design and solve problems. Furthermore, they delve deeper into the societal impact of technology, considering responsible online behavior, digital identity formation, and the ethical and ecological implications of a technology-driven world. This structured approach equips students with the knowledge and skills to become responsible and competent digital citizens who can thrive in an increasingly digital landscape.

Overall, while informatics education in upper primary and lower secondary education in the Netherlands is still evolving, the establishment of a dedicated National Curriculum reflects a significant step towards equipping students with the essential digital literacy skills needed to thrive in an increasingly digital world. By providing structured learning objectives and teaching methods, the curriculum aims to prepare students to navigate and succeed in an ever-changing digital landscape.

3.1.5. Current state of informatics education in Croatia

Croatia's forward-looking informatics curriculum (established in 2018) prioritizes equipping students with digital competencies from a young age. Core topic areas include using technology for various purposes (e.g., communication, content creation), understanding computer hardware and software basics, and internet safety. Students develop competencies like critical thinking, problem-solving, and communication through hands-on activities. Specific learning outcomes include using software for presentations, navigating the internet safely, and solving basic technological problems.

This student-centered approach emphasizes flexible teaching methods that encourage exploration and collaboration. The national informatics curriculum prioritizes student achievement by outlining clear learning outcomes and encouraging teachers to create authentic learning experiences. With this autonomy, teachers can tailor instruction to optimize outcomes, while fostering a positive classroom environment through motivation, feedback, and open communication built on mutual respect and understanding. This approach requires ongoing professional development for teachers to continually refine their skills. A variety of materials and tools are recommended, like digital content, educational games, programming environments, and multimedia tools, catering to diverse learning styles. Assessment is holistic, focusing on group work and evaluation through methods like self-reflection and peer evaluation, alongside projects and e-portfolios. This ensures a comprehensive picture of student progress and fosters ownership of their learning journey. Overall, Croatia's informatics curriculum aims to prepare students to be successful digital citizens in an increasingly digital world.

3.1.6. Current state of informatics education in Italy

Italy integrates informatics education, or digital literacy, throughout various subjects in primary and lower secondary school. Unlike some countries, informatics isn't a separate subject, but rather a transversal skill woven into lessons like Italian, history, science, music, geography and technology. This aligns with the European Union's key competence framework, which emphasizes responsible and critical use of technology. Core topic areas encompass information literacy, communication and collaboration using digital tools, and creating digital content. Students develop competencies like critical thinking, problem-solving, and using technology safely and ethically.

Students develop a range of skills, from information searching and critical thinking to using technology for communication and creating content. The complexity of these tasks increases as students' progress through school. In lower secondary school, this involves more advanced skills like designing infographics, or even simple programming. By the end of lower secondary school, students take a national exam that evaluates their digital competences as part of the broader European Key Competences framework. There's also a shift in terminology with "computational thinking" replacing "informatics" in recent documents.

Teaching methods and assessment of learning are carried out in accordance with each school's educational offer which is defined by their three-year educational offer plan. Formative assessments are encouraged to support ongoing learning, alongside traditional summative assessments that measure final achievement. For the teaching of digital competencies, computer literacy learning units can be designed, but also individual or group work involving reality tasks or the creation of digital products (presentations, digital stories, interactive or collaborative texts, etc.). Evaluation may be by means of grids or rubrics for process or product evaluation, defined by the teacher on the basis of the initial objectives and learning targets set for the planned learning unit.

3.1.7. Comparisons of the current state of informatics education in partner countries

Informatics education is a critical component of modern curricula, aimed at equipping students with essential digital literacy skills to navigate the increasingly digital world. Across Cyprus, Greece, Ireland, the Netherlands, Croatia, and Italy, informatics education takes on different forms, reflecting unique educational priorities and approaches.

- ***Cyprus***: Integrates informatics into primary education and offers a separate subject in lower secondary. Focuses on computational thinking, problem-solving, and technology applications like website development. Aims for technological literacy and responsible technology use.
- ***Greece***: National Curriculum introduces students to computer science concepts and equips them with ICT skills. Core topics include hardware, software, internet safety, and critical thinking. It aims to provide a strong foundation for further studies or practical applications in computer science.
- ***Ireland***: Integrates informatics across subjects, focusing on foundational skills like coding and digital literacy. Primary education lays the groundwork, while dedicated courses in lower secondary delve deeper into programming and cybersecurity. Prepares students for responsible technology use and potential careers in informatics fields.
- ***Netherlands***: Recently integrated a dedicated digital literacy curriculum with three domains: Practical knowledge & skills, design & creation, and technology's societal impact. Aims to equip students with essential digital literacy skills, from basic functionality to understanding AI and its implications.
- ***Croatia***: Emphasizes student-centered learning and access to digital environments from a young age. Curriculum prioritizes developing digital competencies through interactive activities and hands-on experiences. Utilizes holistic assessment methods to promote deep learning and student ownership of the learning journey.
- ***Italy***: Integrates informatics education transversely across subjects, focusing on digital competence as defined by the European Council. Aims to develop critical thinking, information literacy, and effective use of digital tools for communication and problem-solving. Assessment methods vary by school but emphasize both formative and summative evaluation.

More precisely, our research builds upon the Eurydice report's emphasis on integrating informatics education across Europe. Both studies acknowledge the importance of digital literacy and the diverse approaches nations use to incorporate informatics into their curricula. Like the Eurydice report (European Commission, 2022), we observed a shared focus on equipping students with digital skills and promoting responsible technology use in Cyprus, Greece, Ireland, the Netherlands, Croatia,

and Italy. Both studies also acknowledge the potential of inclusive Informatics education to encourage girls' participation in IT fields.

However, our research offers deeper insights compared to the Eurydice report's Pan-European scope. We provide detailed, country-specific analyses, showcasing the unique strategies each nation employs. For example, Cyprus cleverly integrates informatics within existing subjects, while Greece focuses on introducing core computer science concepts. Ireland integrates informatics across subjects with dedicated programming and cybersecurity courses. The Netherlands offers a comprehensive digital literacy curriculum, and Croatia prioritizes student-centered learning in digital environments from a young age. Finally, Italy integrates informatics across subjects, focusing on developing digital competence and critical thinking skills. This comparative analysis offers practical examples for other educational systems, highlighting the importance of tailoring informatics education to national priorities and educational cultures. Future stages of this project will involve developing a framework for informatics education that incorporates authentic and gender-inclusive practices.

This summary showcases the diverse approaches to informatics education across Cyprus, Greece, Ireland, the Netherlands, Croatia and Italy. While some countries offer dedicated subjects, others integrate it within existing curricula. All countries emphasize the importance of digital literacy and responsible technology use, preparing students to thrive in the digital age. Based on this information, Table 1 reports the topic areas covered and some learning outcomes.

Table 1. Approaches to informatics education in partners' countries.

Country	Informatics as a subject	Topic Areas	Learning Outcomes (Age Specific)
Cyprus	Taught separately in lower secondary education. Integrated into design and technology, life education, mathematics, and physical sciences courses in primary education.	Basic concepts of informatics, computer hardware, operating systems, application software, networks and the Internet, cyberbullying, databases and systems analysis, algorithms, programming, and modern computer applications. Focus on specific applications like computer publishing, website development, and database management.	*Upper primary: Effective information search, basic programming, data use, responsible digital citizenship, cultivation of students' digital competence, technological literacy. * Lower Secondary: Develop problem-solving skills using computers, understand algorithms and computer programs,

			cultivate critical and creative thinking.
Greece	Taught as part of the National Curriculum in upper primary and lower secondary education.	Familiarity with computers, computer software, internet services, creation and expression tools, and understanding the role of computers in daily life.	*Upper primary: Effective information search, basic programming, data use, responsible digital citizenship. Use ICT tools for creating and editing various types of content, navigate the internet safely and effectively, analyze and solve basic ICT-related problems, and apply ICT skills in real-life situations and interdisciplinary projects * Lower Secondary: Develop problem-solving skills using computers, understand algorithms and computer programs, cultivate critical and creative thinking. Further develop IT skills.

Netherlands	Not a separate subject, but digital literacy is incorporated into the curriculum of other subjects (especially in secondary education).	Digital literacy (conscious, responsible, critical, and creative use of ICT, Digital systems, Digital media and information, Safety & privacy, Data, Artificial Intelligence (AI),Creating with digital technology, Programming, Digital technology, yourself, and the other, Digital technology, society, and the world)	Digital Literacy Curriculum Goals (Upper Primary & Lower Secondary): * Practical knowledge & skills: Using digital systems functionally, navigating the digital media and information landscape, handling digital systems, data, and privacy safely, exploring data and data processing, and exploring how AI systems work. * Design and create: Creating with digital technology and programming a computer program using computational thinking strategies. * Interaction between digital technology, digital media, people and society: Making well-considered choices when using digital technology and digital media, and exploring how digital technology, digital media, and society interact.
Croatia	Compulsory subject in grades 5 & 6 (student's age 12-13) and optional subject in grades 7 & 8 (student's age 14-15)	Basic understanding of information and digital technology, programming, using digital tools for communication and collaboration, and understanding of personal data protection.	Ages 12-15: Apply computer technology in problem-solving, create and manage digital content and footprints, and participate in a digital society

Italy	Not a separate subject, but it is foreseen as transversal to all subjects and is highly focused on digital competence.	Digital competence, computational thinking, digital tools and technologies, programming concepts, fundamental software, spreadsheets, word processors.	Master the use of ICT and develop critical skills for their use, be able to produce simple models or graphical representations of their work using elements of technical drawing or multimedia tools, recognize and document the principal functions of a new informatics application, use internet to find the necessary information, develop programming and problem-solving skills.
Ireland	Not a standalone subject in primary or secondary education, but informatics concepts are integrated into various subjects.	* Primary Cycle (Stage 4 - Grades 5 & 6) - Upper primary level: Algorithms, hardware/software basics, internet safety, data representation. * Junior Cycle - Lower secondary level: Programming concepts, data structures & algorithms, cybersecurity, digital ethics, computer networks, coding, digital media literacy.	* Upper primary level: Basic computational thinking, simple programming, digital tool use, data handling, developing their problem-solving skills. * Lower secondary level: Programming proficiency, data structures & algorithms understanding, cybersecurity awareness, digital ethics, collaboration using digital tools.

This analysis of informatics education across Cyprus, Greece, Ireland, the Netherlands, Croatia and Italy, reveals a strong foundation in core areas like data, algorithms, and programming. Countries like Ireland demonstrate successful integration of these concepts into various subjects during primary education. However, there's potential to further expand the scope of informatics education based on the Informatics Reference Framework for Schools (IRFS) (Informatics for All, 2022).

Primary Education:

- Introduce basic concepts of networks & communication and human-computer interaction (HCI) in a way appropriate for young learners. This could involve exploring the internet safely and understanding how we interact with computers through interfaces.
- Consider incorporating design & development principles to encourage students to create digital content like presentations or simple websites.

Lower Secondary:

- While all countries likely address privacy, safety, and security, ensuring a robust and comprehensive curriculum in this area remains crucial.
- Explore integrating modeling & simulation concepts to enhance problem-solving and analytical skills.

3.2. Authentic learning practices in informatics in the partner countries

Based on the national curricula, partners identified the principles of authentic learning that are applied, if applied, when teaching informatics, either as a separate subject or within other subjects at the upper primary and lower secondary education. As outlined in the guidelines, in TINKER we adopt the authentic learning model, a pedagogical approach where students actively work to solve real-world problems, through wide knowledge and skills to create products-solutions (Herrington & Herrington, 2006). To design an authentic learning environment, the principles of authentic context, authentic task, expert performance, multiple roles perspectives, collaboration, articulation, reflection, scaffolding and authentic assessment are required (Herrington & Oliver, 2000; Herrington et al., 2014). Table 2 presents the authentic learning practices being followed in partners' countries. To identify these authentic learning practices, partners were guided by the research question below:

Research Question 3: *As per the national curricula, which principles of authentic learning are applied, if applied, when teaching informatics, either as a separate subject or within other subjects?*

Table 2. Authentic Learning Practices in Partners' Countries.

Key issue	Comments	Recommendations
Authentic contexts that reflect the way the knowledge will be used in real life.	In all countries, besides **the Netherlands**, at both the upper primary and lower secondary education, authentic contexts that reflect real-life applications are encouraged in the relevant curriculums. In **the Netherlands**, at the upper primary education level, the curriculum does not explicitly promote real-life complex problems, while at the lower secondary education, the curriculum promotes to some extent authentic contexts.	- Provide teachers with educational material that connects informatics to real-life problems. - Authentic contexts to be clearly embedded in the curriculum to ensure that they are mainstreamed.
Authentic tasks and activities.	In all countries, besides **the Netherlands**, at both the upper primary and lower secondary education, authentic tasks and activities are encouraged in the relevant curriculums. In **the Dutch curriculum** of the upper primary education level, authentic tasks are described to a small extent, although insufficiently, while at the lower secondary level, the problems described in	- Implement problem-based educational activities in the Dutch informatics education - Implement collaborations with companies and organizations to provide

	the curriculum are neither complex and ill-defined nor completed over a longer period of time.	real-life problems that students can be helped from.
Access to expert performances and the modelling of processes.	In all countries, besides **Ireland**, at both the upper primary and lower secondary education, the access to expert performances and the modelling of processes is absent. In Cyprus, this is applicable to some extent as it depends on each school whether it will organize visits to Research Innovation Centers and Makerspaces and invite experts for guest lectures.	- Provide in a structured way students with access to expert performances and the modelling of processes through various resources and learning experiences. This may include guest speakers, field trips, demonstrations, and videos that showcase real-world applications of the concepts being taught.
Multiple roles and perspectives.	In all countries, besides **Greece** (primary level) and **Croatia** (both primary and secondary level), the relevant curriculum encourages students to explore multiple roles and perspectives in their learning.	- Involve group activities, discussions, and projects that require students to consider different viewpoints and collaborate with peers.
Collaborative construction of knowledge.	In all countries, besides **the Netherlands**, at both the upper primary and lower secondary education, the collaborative construction of knowledge is encouraged in relevant curriculum (e.g. through collaborative learning activities). In **the Dutch curriculum** of the upper primary and lower secondary education level, collaboration is not emphasized in every curriculum goal although it is encouraged in some of them.	- Promote clearly collaborative learning in informatics by problem/project based learning.
Reflection to enable abstractions to be formed.	In all countries, besides **the Netherlands**, at both the upper primary and lower secondary education, reflection is integrated into the learning process to enable students to form abstractions and make connections between their experiences and abstract concepts. In **the Dutch curriculum** of the upper primary and lower secondary education level, discussion and reflection of different concepts and impacts is promoted in multiple curriculum goals, but the measure of reflection depends on the educational activities each teacher chooses to implement.	- Provide teachers with clear examples and activities for students to reflect on their learning, identify patterns, and draw conclusions.
Articulation to enable tacit knowledge to be made explicit.	In all countries, at both the upper primary and lower secondary education, students are encouraged to articulate their thoughts, ideas, and understanding to make tacit knowledge explicit. Although the **Dutch curriculum describes** that students need to be able to explain certain concepts and mechanisms related to digital literacy, it is not explicitly mentioned that students need to publicly present their arguments.	- Integrate public presentations. - Use collaborative forums to enable articulation in students.

Coaching and scaffolding by the teacher at critical times.	In all countries, besides **Greece** and **the Netherlands**, at both the upper primary and lower secondary education, teachers provide coaching and scaffolding at critical times. In **Greece**, there is no mention of coaching and scaffolding by the teacher at critical times, whereas in the **Dutch** curriculum, educational activities proposed do promote a more supportive role of the teacher rather than a didactic one, but the measure of which this principle is being applied is highly dependent on the educational activities of the teachers.	- Provide guidelines that clearly promote the supportive role of teachers rather than the didactic.
Authentic assessment of learning within the tasks.	In all countries, besides **Greece** (secondary education level), **Italy** and **the Netherlands** (both primary and secondary education level), authentic assessment of learning within the tasks is encouraged. At the lower secondary education level in **Greece**, in the National Curriculum there is no explicit mention of authentic assessment of learning within tasks. Similarly, in **Italy**, the National Curriculum of both the upper primary and lower secondary education level, states that each school is autonomous in their approach to assessing the competencies of their students, without properly mentioning authentic assessment. Within the **Dutch** curriculum for digital literacy, no assessment methods are discussed.	- Create an integrated authentic assessment context.

3.2.1. Summary of authentic learning practices

Comparing the approaches to authentic learning practices across **Cyprus, Greece, Ireland, the Netherlands, Croatia, and Italy** reveals both commonalities and areas for improvement. In **Cyprus**, authentic learning practices are more prominent in lower secondary education due to the nature of the Informatics curriculum, yet there's a need to enhance access to expert performances. Similarly, **Greece's** curriculum emphasizes authentic learning but lacks exposure to experts and scaffolding at both levels. In contrast, **Ireland** integrates authentic learning principles effectively, fostering deeper understanding and engagement among students. The **Dutch** curriculum partially incorporates authentic learning but could improve by emphasizing real-world problems and enhancing collaboration. **Croatia's** curriculum is generally aligned with authentic learning principles, yet there's room for **improvement** in the frequency and engagement of authentic tasks and activities. **Italy's** curriculum also aligns with authentic learning principles, but challenges persist in providing access to expertise and opportunities for students to observe experts in action, highlighting the need for facilitation of guest speaker sessions, industry visits, and collaborative projects.

Conclusively, recommendations for enhancing authentic learning practices include establishing partnerships with experts, incorporating guest lectures and industry visits, promoting collaborative projects, and utilizing online workshops. Additionally, increasing the frequency and engagement of authentic tasks and activities, leveraging online assessments for reflection and scaffolding, and mandating authentic assessment practices are crucial steps toward ensuring students' readiness for real-world challenges. By addressing these recommendations, educational institutions can better

prepare students to thrive in an increasingly complex and digital world, fostering critical thinking, problem-solving skills, and real-world application of knowledge.

3.3. Gender-inclusive practices in informatics in the partner countries

Gender inclusive practices in education aim to address hidden gender-related beliefs and promote equality by incorporating critical theory, feminist pedagogy, and intersectionality principles. In subjects like STEM and computing, these practices involve assessing gender bias, raising awareness about gender diversity, using inclusive language, providing accessible examples, and fostering open discussions about gender norms. In computing, strategies include combating stereotypes, showcasing social impact, and engaging students through offline and online activities. Experiential learning plays a key role in fostering all students' motivation, particularly girls and gender minorities, by stimulating initial interest and sustaining it over time. Overall, gender-inclusive practices align with experiential learning and aim to create an inclusive and supportive environment for all students. To identify these gender-inclusive practices, partners were guided by the following research question:

***Research Question 4**: As per the national curricula, how is gender inclusion promoted, if promoted, when teaching informatics, either as a separate subject or within other subjects?*

Table 3. Gender-inclusive practices in the partners' countries

Key Issue	Comments	Recommendations
The materials, content and activities include gender diversity in discussions and representations of figures within the field (refer to the frequency with which diverse figures are presented – e.g., female against male)	In the National Curriculum of **Cyprus, Ireland,** and **Italy**, and based on the document regulating content of school books in Croatia, at both upper primary and lower secondary education level, the materials, content and activities include gender diversity in discussions and representations of figures within the field. In **Greece**, at the primary education level, the material available for informatics does not refer to gender diversity in discussions and representations of figures within the field. At the secondary level, most of the pictures and cartoons used in the computer science textbooks refer mainly to the male gender. In **the Netherlands**, within the proposed National Curriculum, there is no national material or content on digital literacy offered, and it was challenging to perform a tangible analysis of the gender diversity in Dutch informatics educational material.	- Develop guidelines for those working on the national curricula to incorporate diverse gender representation in educational materials, emphasising the importance of balanced imagery in promoting inclusivity.

The materials, content and activities encourage all individuals' empowerment.	From the partner countries, only in **Ireland** and **Croatia** at the upper primary and lower secondary education level, the materials, content and activities encourage all individuals' empowerment.	- Provide students with opportunities to develop leadership skills, critical thinking abilities, and self-confidence, regardless of their gender. - Develop teachers' training programmes to raise awareness about the impact of gender bias in educational materials and strategies to promote empowerment for all. - Create supplementary materials that feature diverse role models.
The materials, content and activities provide role models for all individuals.	Except for **Ireland**, the national curricula of the partner countries do not provide role models from diverse backgrounds and genders to inspire and motivate students. In the Netherlands, within the proposed National Curriculum, there is no national material or content on digital literacy offered, and it was challenging to perform a tangible analysis of the gender diversity in Dutch informatics educational material.	- Employ inclusive language and diverse representations that reflect the full spectrum of gender identities in the case of informatics curricula under reform. - Develop guidelines for content creation and for choosing appropriate representations that emphasise on the importance of avoiding stereotypes and promoting diverse role models.

There isn't gender bias or stereotyping in the representation of characters in text and images, in materials, content and activities.	The national curricula in **Cyprus** and **Ireland** as well as the document regulating content of school books in **Croatia**, do not exhibit gender bias or stereotyping in their representation of characters in text and images in materials, content or activities. On the contrary, in **Italy** and **Greece**, male representations and representations of females in a stereotyped way, dominate relevant national curricula. In **the Netherlands**, within the proposed National Curriculum, there is no national material or content on digital literacy offered, and it was challenging to perform a tangible analysis of the gender diversity in Dutch informatics educational material.	- Raise teachers' awareness on implicit gender-bias or stereotyping in the representation of characters in the text and images, in materials content and activities that they choose to support their teaching.
There isn't gender bias or stereotyping in language, in materials, content and activities.	In the national curricula in Cyprus and Ireland as well as the document regulating content of schoolbooks in Croatia, there isn't gender bias or stereotyping in language in material, content, and activities. On the contrary, in Italy, the Italian language is grammatically gendered with a dominance of the masculine and in the relevant textbooks, the masculine is used for gender-mixed groups. In Greece, male pronouns predominate and the masculine article is used exclusively even when all genders are included in the meaning. In the Netherlands, within the proposed National Curriculum, there is no national material or content on digital literacy offered, and it was challenging to perform a tangible analysis of the gender diversity in Dutch informatics educational material.	- Raise teachers' awareness on the gender stereotypes they might perpetuate through their use of language. - Use gender inclusive language to promote gender equality and eradicate gender bias. - Raise teachers' awareness of their own gender-biased perceptions of learners.
The materials, content and activities promote positive values relating to the acceptance of gender diversity.	From the partner countries, only in **Ireland** and **Croatia** at the upper primary and lower secondary education level, the materials, content and activities promote positive values relating to the acceptance of gender diversity.	- Encourage the use of testimonials and case-studies in which students are introduced to individuals of all genders. - Invite a gender-balanced set of guest speakers and educators to share their experiences.

The materials, content and activities support intersectionality (i.e., diverse perspectives, histories, and experiences are heard).	Except for **Ireland** and **Croatia**, the materials, content and activities do not support intersectionality (i.e., diverse perspectives, histories, and experiences are heard).	- Collaborate with community organisations, cultural institutions, and guest speakers to provide additional perspectives and resources. - Invite parents, and community members to share their expertise, experiences, and cultural traditions with students - Organise awareness campaigns to promote diversity in STEM fields, showcasing the intersectionality of gender, race, ethnicity, and other identities to inspire students from all backgrounds.

3.3.1. Comparisons of Gender-Inclusive Practices

When comparing gender-inclusive practices in teaching informatics across different countries, distinct patterns emerge. Cyprus, with the exemption of the book of Design & Technology, demonstrates a stronger emphasis on gender inclusivity within the informatics curriculum compared to Greece. While Cyprus recognizes the importance of gender inclusivity in informatics education, Greece struggles with pervasive sexist language and biased examples in informatics textbooks, perpetuating the notion of technology as a male-dominated field. For this, Greece focuses on promoting inclusiveness through external resources such as the Rainbow School NGO's guidance for teachers. Additionally, Cyprus advocates for gender-inclusive language and role models in informatics materials, whereas Greece faces challenges in integrating diverse perspectives and experiences into the curriculum. Ireland demonstrates a proactive approach to promoting gender inclusion and equity in education, with a strong commitment to eliminating gender bias and stereotyping in educational settings. In contrast, the Netherlands lacks explicit teaching strategies or learning goals focusing on gender inclusivity, reflecting strong gender-science stereotypes. Ireland offers specific guidelines and initiatives to support gender-inclusive practices in schools, including professional development opportunities for teachers and broader initiatives to challenge stereotypes and biases. Conversely, the Netherlands relies on external resources and guidelines from School and Safety to address gender stereotypes and promote inclusivity. Both Croatia and Italy demonstrate efforts to promote gender inclusion in teaching informatics, with varying degrees of success. Croatia emphasizes respect, tolerance, and acceptance in the informatics curriculum, while Italy faces challenges in addressing gender bias in educational materials and language. Croatia, focuses on integrating diverse perspectives and experiences into the curriculum, with regulations requiring textbooks to promote equality and fairness. Italy emphasizes the use of gender-inclusive language

and the promotion of gender diversity but lacks clear guidelines for addressing gender bias in informatics learning materials.

Across all countries, there is a consensus on the importance of developing detailed guidelines, providing professional development for teachers, updating educational materials, and promoting awareness of gender inclusivity. However, the availability and implementation of external resources vary, with some countries relying on government-funded initiatives (e.g., Ireland) while others utilize NGO support (e.g., Greece). Additionally, there are differences in the emphasis on teacher empowerment, integration into the curriculum, and the use of online platforms to support gender-inclusive practices. In summary, while there is a shared commitment to promoting gender inclusivity in teaching informatics, each country faces unique challenges and adopts different strategies to address them. Collaboration and sharing of best practices across countries can facilitate progress towards creating more inclusive and equitable learning environments for all students**.**

3.4. Best Practices

During the desk research activities, the partner organizations identified two national initiatives (e.g., research study, intervention programmer) for upper primary and lower secondary education which have tested/evaluated an approach in line with principles of authentic learning and/or gender inclusion in the teaching of informatics. It is important to note here that in the Netherlands, a noticeable gap in knowledge and projects within the national initiative for authentic learning and gender inclusivity has been identified. Therefore, only one example of an EU-based initiative implemented in the Netherlands has been provided. These best practices examples are available here.

4. Data analysis from the field research

As part of the field research, focus groups and questionnaires were utilized to gather comprehensive insights on the research topic. In the following subsections, the methodology employed as well as the main findings deriving from the field research are presented and discussed.

4.1. Methodology

This section will provide details about the process followed in undertaking field research and gathering data on the teaching of informatics and teachers' current preparation and needs. In particular, the TINKER survey aimed to better understand the current needs and challenges about teaching and assessing informatics on the grounds of authentic learning and contemporary gender inclusive practices in upper primary and lower secondary education, by asking teachers in upper primary and lower secondary schools in the partner countries, to provide their feedback.

The six partner countries adopted the common methodological guidelines developed by UNIC and agreed by the partnership and the project's field research protocol. All partners conducted a focus group and an online questionnaire-based survey by using Google Forms, in which teachers participated in upper primary and lower secondary schools. The field work research was carried out in the period February – March 2024. All respondents had carefully explained the aims of the project and the research, and how the results from the TINKER survey would be used. They had been assured that confidentiality and anonymity are guaranteed. Regarding the focus groups, they were conducted either face-to-face or via Zoom. Participants proceeded to sign a consent form or provide the corresponding oral consent, which was audio recorded. They were also asked to give prior permission for audio recording. General Data Protection Regulations were adhered to.

A qualitative exploration of the TINKER survey was made, and all answers received were matched with answers with the relevant questions; commonalities were identified, and any other unique information was considered. The project's survey was organized around the following set of topics:

- Informatics
- Authentic Learning
- Gender-Inclusion

4.1.1. Profile of the participants

The number of teachers who participated in the field research is 487. In particular, 55 teachers participated in the focus groups conducted by the TINKER Consortium in partner countries. Moreover, 432 individuals participated in the questionnaire-based online survey. Table 4 represents the number of participants in the field research for each partner country.

Table 4. Number of participants in the field research in the partners' countries

Partner country	Number of participants in the focus groups	Number of participants in the questionnaire-based online survey
Cyprus	16	68
Greece	13	52
Ireland	8	54
Netherlands	6	31
Croatia	6	78
Italy	6	149

Regarding gender, the participant population is predominantly female, with 306 out of 432 being female teachers.

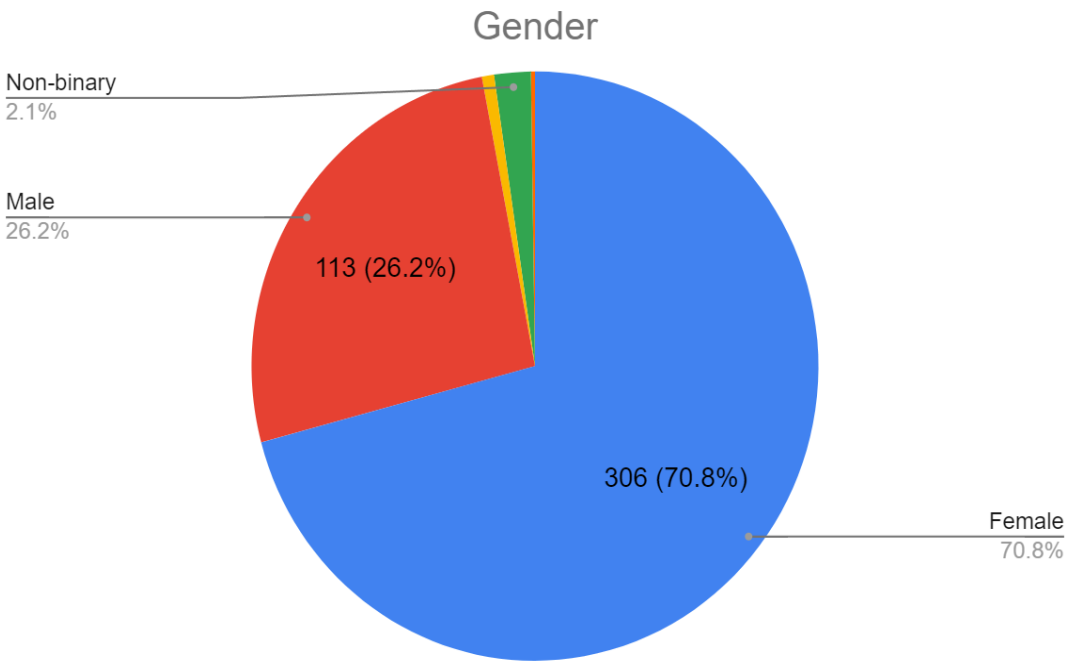

Figure 2. Gender of Survey Participants.

With regard to age groups, the majority of participants (N=163) fall within the 41-50 age group, followed by the 51-65 age group (N=144). The age groups of 31-40 and 20-30 follow with a total of 74 and 44 participants respectively. The age group 60+ was the least selected.

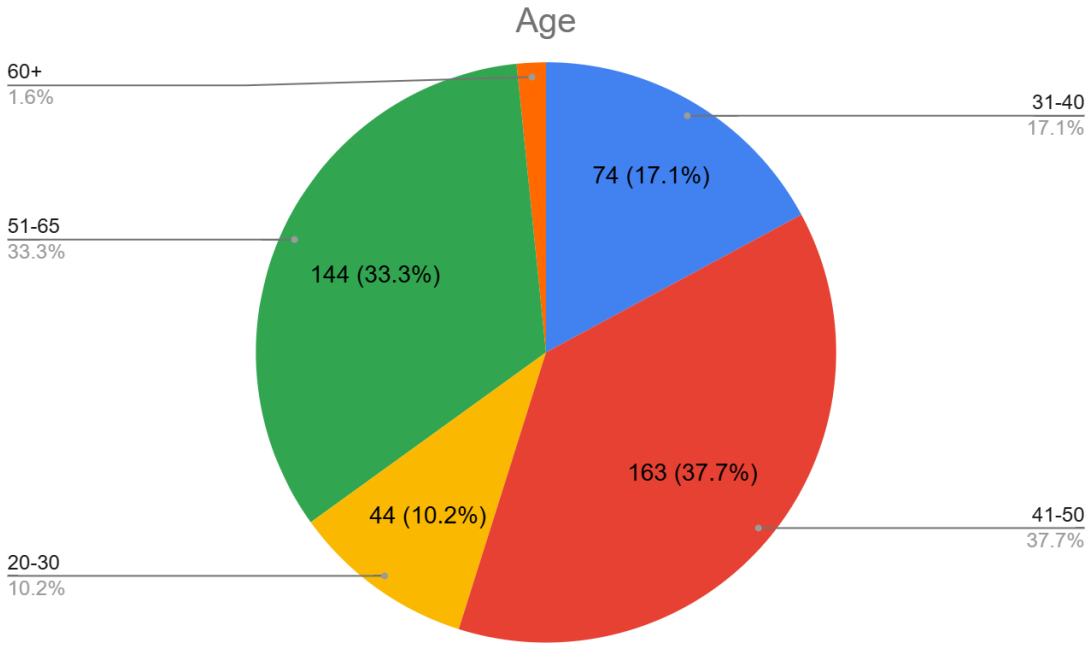

Figure 3. Age of Survey Participants.

4.2. Informatics

After the demographic data, the next section of the questionnaire concerned the topic of informatics in schools. The first question was related to whether the subject is considered a distinct discipline or as part of compulsory subjects. As indicated in Figure 4, the majority of the participants (N=306) report that based on the National Curriculum there is a distinct course for teaching informatics in their country. However, approx. ⅓ of the participants answered that informatics is not a distinct discipline. This highlights the need for curriculum reform in some countries as for informatics competencies to be taught separately.

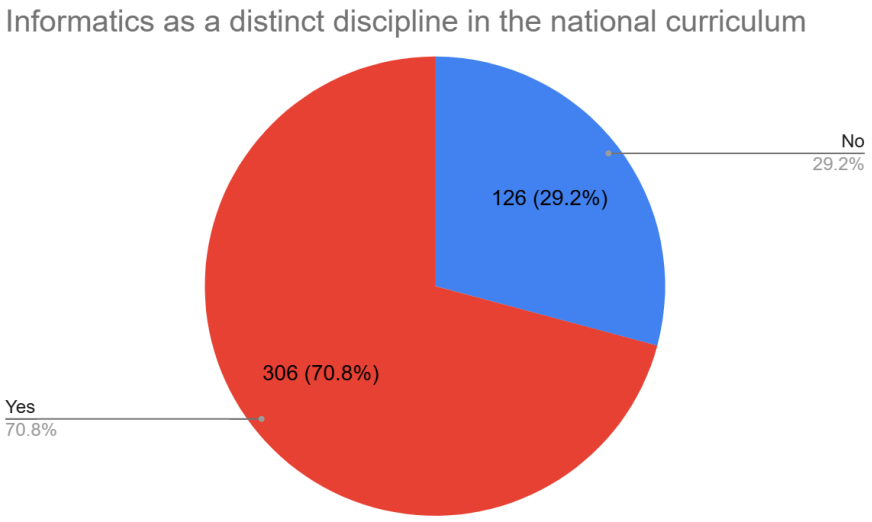

Figure 4. Teaching of informatics in partners' countries.

When it comes to the methods they follow in their school when teaching and assessing informatics competencies, there are some variations in partners' countries' participants' responses. In Cyprus, the most selected method is Problem-Based Learning (PBL) with 54 responses, followed closely by coding and programming exercises with 53 responses. In the Netherlands, PBL and group assignments are the most selected methods with 14 answers each. In **Ireland**, the most selected methods are group assignments or collaborations, coding and programming exercises and simulation and modeling. In **Croatia**, online platforms and interactive tools, quizzes, and coding and programming exercises were the methods that the majority of the participants selected. Similarly, in **Italy** and Greece online platforms and interactive tools were also the most selected methods.

With respect to their level of agreement regarding the easy access to resources including software, hardware, and education materials, the up-to-date and appropriate resources available, the clear and adequate guidelines provided in the National Curriculum about teaching and assessing informatics, and the prerogative that National Curriculum gives the teachers to decide on the teaching approach of informatics, in **Cyprus** the majority of the participants agreed with all four. On the contrary, in **Ireland**, there are mixed perceptions regarding the availability and adequacy of resources for teaching informatics as well as the clearness and adequacy of the guidelines in the National Curriculum. Interestingly, in **Italy** the surveyed teachers took a neutral (neither agree nor disagree) stance on all the statements except on the statements "The access to resources including software, hardware and educational materials is easy" on which most participants either disagreed or fully disagreed and the statement "The National Curriculum gives the prerogative to decide on the teaching approach of informatics." for which most participants agree. In **Croatia**, the most agreed statement is "The National Curriculum gives the prerogative to decide on the teaching approach of informatics" and the least agreed with statement is "The resources available for teaching informatics are up-to-date and appropriate". In the Netherlands, most participants neither agree nor disagree on the statement of adequate guidelines on teaching and assessing informatics in the National Curriculum. On a similar note, the majority of the participants were neutral about the National Curriculum giving a prerogative to decide on the teaching approach of informatics. In Greece, while most participants agree that the access to resources is easy, they neither agree nor disagree that they are up-to-date and appropriate. These findings highlight the varying degrees of support and challenges in promoting effective informatics education across different countries.

Considering the barriers/constraints of IT teaching and assessment, several responses have been received in the partner countries. In **Cyprus**, the majority responded to the lack of professional development and assessment challenges. Most challenges that focus groups' participants pinpointed derive from the structure of curricula at the primary education challenge, and more specifically the fragmentation and lack of a unified approach regarding how informatics is taught. As a result, the most important need deriving from focus group discussion, is the integration of informatics as a compulsory subject with gradual progression as well as the need for a more coordinated teacher preparedness and guidelines in primary schools. In the **Netherlands**, the obstacles that participants mentioned are to a great extent similar to the ones of **Cyprus**. The most important obstacle as rated by the survey participants was the time constraints. The focus group indicated that inadequate teacher training results in barriers to teach and assess informatics. Teachers stated that they lack the skills needed to adequately teach informatics, which makes them insecure to do so. Another obstacle that was mentioned is the inadequate flexibility of the National Curriculum of informatics

education. Participants indicated that there is a lack of consensus about the key elements of informatics education and digital literacy. In turn, this leads to different forms of informatics education around schools. Additional obstacles that have been noted were the lack of resources and the high workload for teachers, as they need to adapt the content to their students. Some additional constraints have been identified in the case of Greece. In **Greece**, time pressure and the schoolbook structure do not favor the development of digital skills. In this spirit, there is much room for improvement in the overall Informatics evaluation process to equip prospective netizens with digital competencies to improve the quality of their daily life, addressing possible problems. The lack of training, and an unclear orientation, do not foster the cultivation of mental abilities when using digital tools. In **Ireland**, limited resources, engagement issues and lack of professional development were perceived as significant obstacles. The limited resources have been also highlighted by the focus group participants, who cited as a common challenge the limited access to devices and technology resources, such as computers or laptops, which can impede students' engagement in digital learning activities. In **Italy**, limited resources, lack of time and lack of professional development were highlighted as the most important obstacles and barriers in teaching and assessing informatics. This in line with the focus group participants' responses who highlighted the lack of supply of materials. The same obstacle, namely, the limited resources along with the large number of pupils in classrooms have been also pointed out by the survey and focus group participants in **Croatia**. Again, focus group participants' responses match the ones of questionnaire participants. Specifically, participants mentioned the lack of adequate hardware equipment, classroom space and time constraints. Some additional challenges identified from focus group participants in Croatia include the different populations of students and the individual differences in knowledge acquisition speed, motivation, etc.

Figure 5 presents the total responses received in partners' countries regarding the obstacles/barriers that exist in teaching and assessing informatics competencies. From the responses received, participants considered the limited resources, the large number of students in the classroom and the lack of professional development as very important obstacles/barriers when teaching and assessing informatics. Assessment challenges, limited collaboration opportunities, changing curriculum standards and engagement issues have been also rated by most of the participants as important. The least important barrier is considered to be the gender and diversity imbalance.

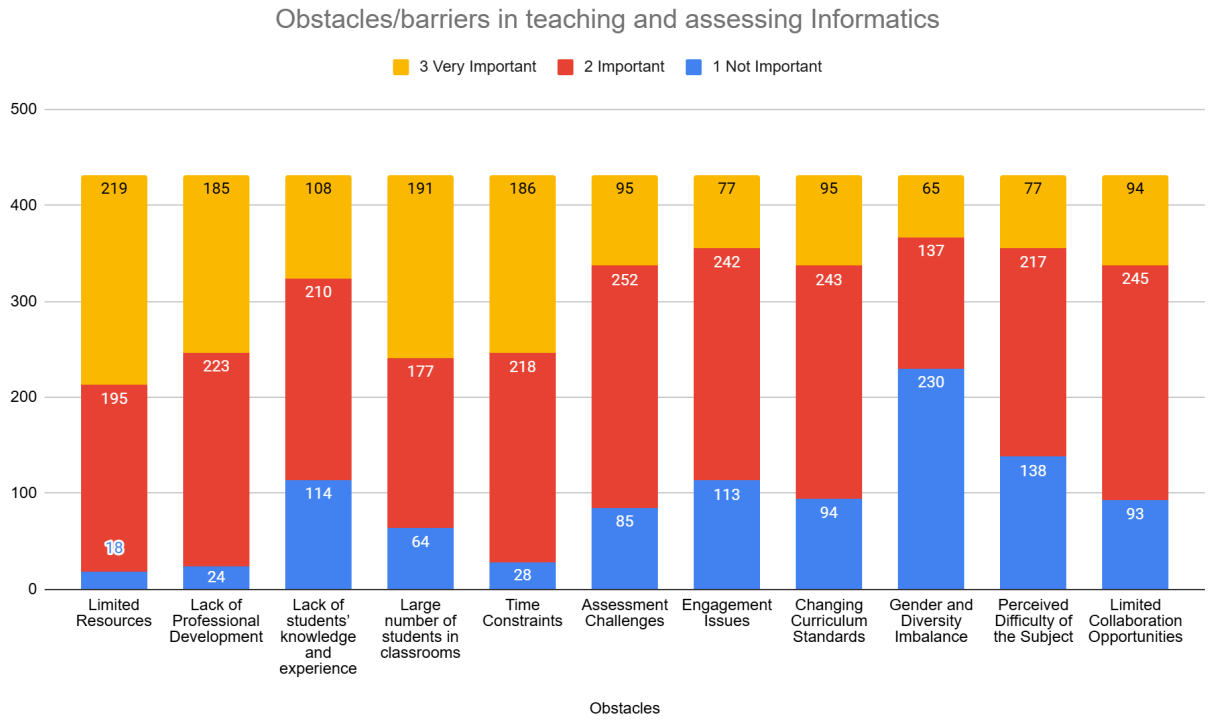

Figure 5. Obstacles/ barriers in teaching and assessing informatics in the partners' countries.

In conclusion, the barriers and constraints in informatics teaching and assessment are prevalent across partner countries, highlighting common challenges faced by educators in delivering effective informatics education. Key obstacles include inadequate teacher training, limited resources, time constraints, and fragmented curricula. "These challenges hinder the development of digital skills among students and limit their engagement in digital learning activities. Addressing these barriers requires coordinated efforts to integrate informatics as a compulsory subject with gradual progression, enhance teacher preparedness through professional development, and provide clear guidelines for curriculum implementation. Additionally, there is a need for greater flexibility in national curricula to ensure consensus on key elements of informatics education and digital literacy. By overcoming these obstacles, countries can better equip students with the digital competencies necessary for success in their daily lives and future careers.

4.3. Authentic Learning

When it comes to the familiarity with the term "authentic learning", besides **Italy's** focus group participants, in the rest of partner countries participants seemed not familiar with the context and the dimensions of authentic learning. In fact, it appears that although teachers incorporate authentic learning practices in their instruction, they do not realize that these parts constitute authentic learning ingredients. The survey results further support this view. As presented in Figure 6, most participants feel "moderately familiar" with the term (N=149), followed by 115 and 73 participants who reported "Very familiar" and "Slightly familiar", respectively.

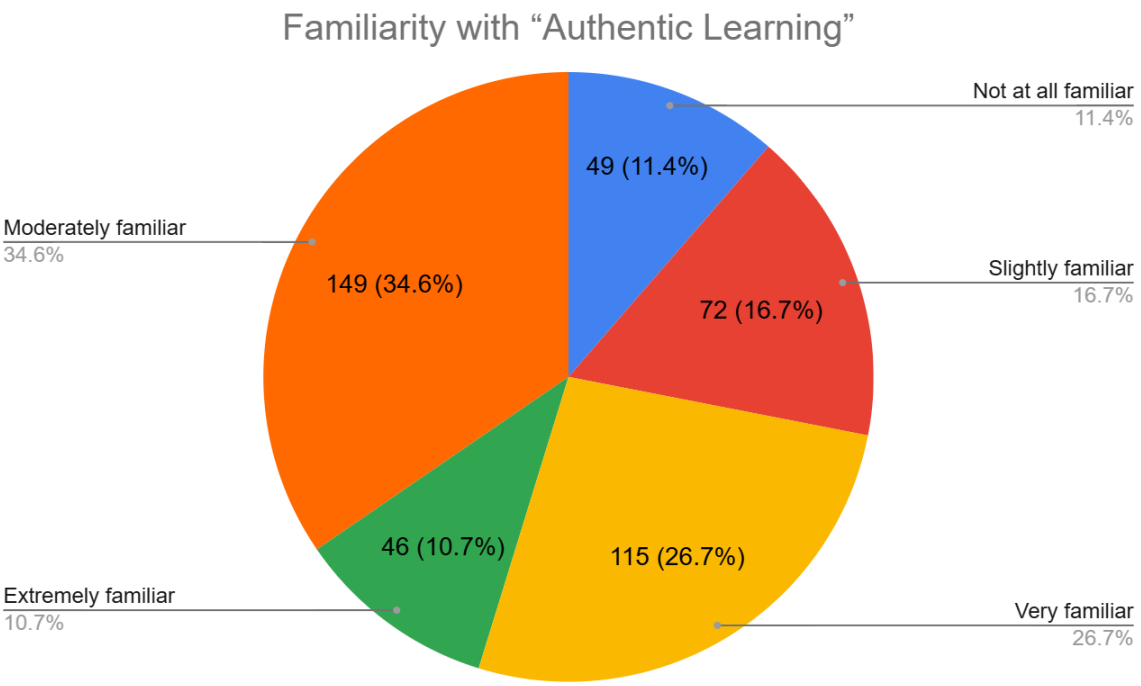

Figure 6: Familiarity with the term “Authentic Learning”.

This finding is also supported by the fact that participants do not completely agree that the National Curriculum fosters authentic learning. Specifically, participants from **Cyprus** neither agree nor disagree with the statement that the National Curriculum promotes the use of authentic learning while in **Greece** only 1.9% of the participants completely agree that the National Curriculum fosters authentic learning. In **Croatia**, the majority of teachers neither agrees or disagrees with the claim that the National Curriculum promotes the use of authentic learning and that was also the median answer value for all used teacher groups. Similarly, in **Italy**, when asked whether the National Curriculum promotes the use of authentic learning, the majority of participants neither agrees nor disagrees (44.4%), while a good sample agrees (37.3%) and another small number of participants reported that they absolutely agree with this statement (5.6%). In **the Netherlands**, most participants (58.1%) were neutral about the National Curriculum's promotion of authentic learning. These percentages highlight a diverse understanding of the curriculum regarding authentic learning. This is not surprising, as responses to the previous question indicated that a majority of teachers are relatively unfamiliar with the concept of authentic learning.

On the contrary, in **Ireland**, both the focus group and survey’s responses suggest that the National Curriculum in various contexts promotes the use of authentic learning by emphasizing active, inquiry-based, and hands-on approaches across different subjects. Additionally, 61.1% of the questionnaire participants agreed that the National Curriculum promotes the use of authentic learning.

Considering the barriers/constraints in applying authentic learning when teaching informatics, all barriers/obstacles were considered as important by the participants. This is because a maximum of 80 out of 432 participants found one obstacle unimportant.

Similar to the answers provided when the survey participants were asked about the barriers/constraints in teaching and assessing informatics, the obstacles that were rated as "Very important" for authentic learning in Informatics are the lack of professional development and the large number of students in classrooms. Equally important are the assessment challenges, curricula rigidity and limited resources. Importantly, the focus group participants in each country have provided some additional challenges that they face when applying authentic learning in their teaching. As noted by focus group participants in Croatia, there's a need for more practical examples and real-world applications of taught concepts. This finding aligns with the results of the focus group held in Greece, where participants also mentioned the absence of authentic learning scenarios in school textbooks.

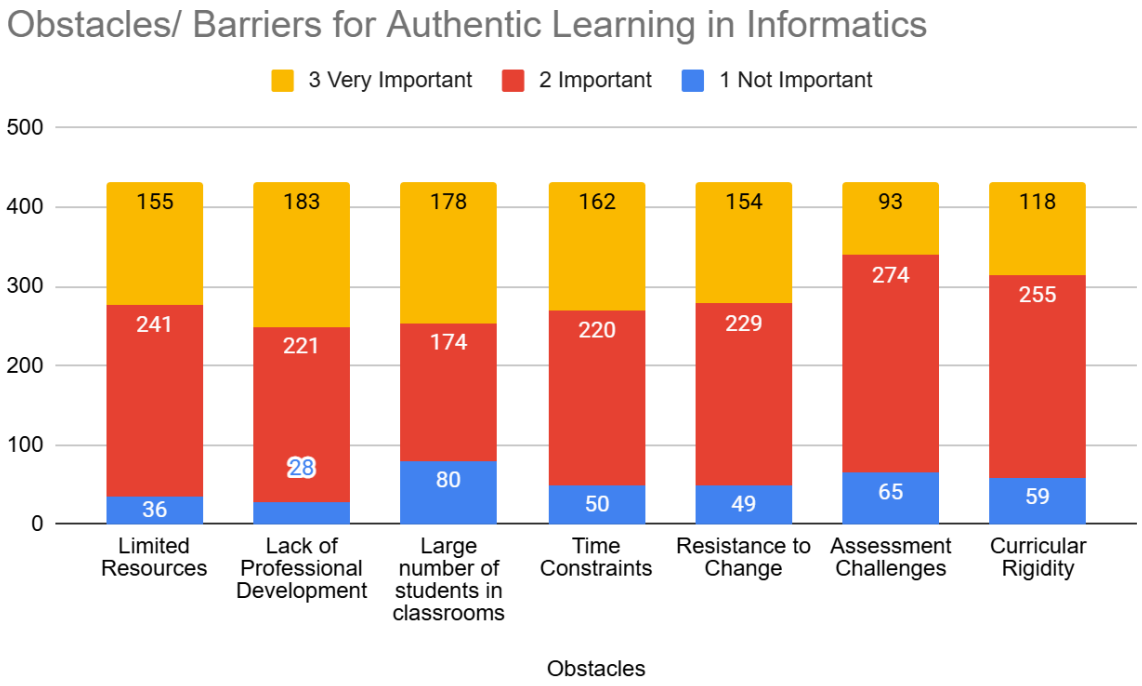

Figure 7. Obstacles/Barriers for Authentic Learning in informatics in the partners' countries.

4.4. Gender Inclusive Practices

In **Cyprus**, **Croatia**, **the Netherlands**, and **Italy**, questionnaire participants were asked about their views on gender inclusion in informatics education. Specifically, they were asked whether they believed the National Curriculum promoted gender inclusion and if the national education system offered specific approaches to tackle gender stereotypes in informatics teaching. Surprisingly, the majority of respondents across these countries remained neutral on both questions. This reflects diverse perceptions regarding efforts toward gender inclusion in informatics education across these countries. In **Greece**, only 2 participants (4%) completely agreed that the National Curriculum directions on Gender Inclusion are adequate, while only 4 participants (8%) reported their agreement that the National Educational System provides adequate directions in empowering educators to challenge gender stereotypes in the classroom. Therefore, it seems that the educational systems in the partner countries do not favor gender inclusion implementation. Not surprisingly and in line with the desk research findings, in **Ireland**, most participants agree that the National

Curriculum promotes gender inclusion when teaching informatics and that the guidelines provided on the National Curriculum about how to approach gender inclusion when teaching informatics are clear and adequate.

Considering the gender-inclusive practices teachers follow in their school when teaching informatics, participants reported various answers. In **Cyprus**, the most selected practices are "Equitable Access to Resources" (88.2%), "Promote collaborative learning environments where students work in diverse teams," (75%) and, "Encourage diversity in projects" (73.5%). In **Ireland**, “Equitable Access to Resources” (64.8%) and “Use of an inclusive curriculum design” (61.1%) received the most answers. The equitable access to resources is also the most common answer (78.8%) of the survey participants in **Greece**, followed by fostering of a supportive and inclusive learning environment (75%). In **Croatia**, all gender-inclusive practices, besides the use of an inclusive curriculum design, were used by 60% to 80% of teachers. These responses demonstrate a commitment to fostering gender-inclusive environments and practices in informatics education, aiming to create equal opportunities and promote diversity among students. In **Italy**, most respondents (71.1-75.4%), mentioned that the strategies for gender inclusion mainly being followed when teaching informatics is fostering a supportive and inclusive learning environment, promoting collaborative learning environments where students work in diverse teams and encouragement of diversity in projects. In the case of **the Netherlands**, the most selected practices were the use of diverse role models (67.7%) and encouragement of diversity in teams (58.1%). These responses demonstrate that beyond anything schools are devoted to fostering a supportive and inclusive learning environment through collaborative activities in teams and projects that reflect diversity.

Several significant obstacles in applying gender inclusion in informatics teaching have been highlighted by the **partner countries**. Figure 8 illustrates that the obstacles reported as “Very important” by most participants, are the lack of awareness or training among teachers about gender-inclusive teaching practices (36.8%) and the inadequate support for gender inclusion (35.6%). The lack of inclusive policies and practices is also considered as an important barrier and by most of the participants (57.4%) it was rated as “Important”. This is in line with the majority of focus groups’ participants' observation that the absence of formal guidelines on gender inclusion further complicates efforts, leading to inconsistencies in practice.

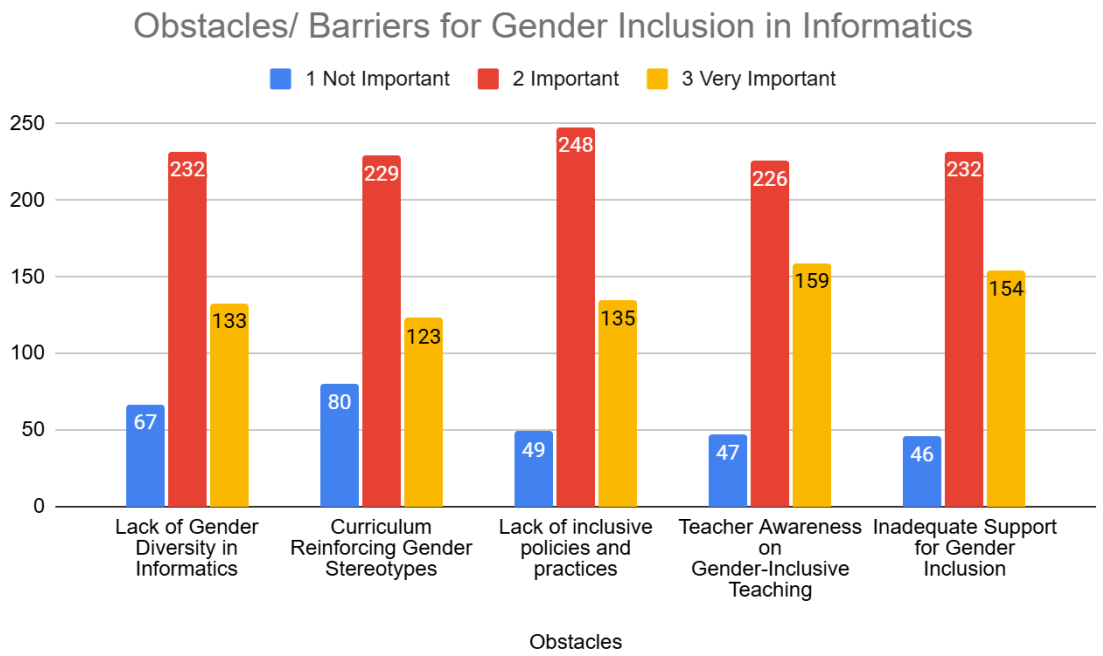

Figure 8. Obstacles/ Barriers for Gender Inclusion in Informatics in the partners' countries.

Teachers in **the partner countries** expressed a strong interest in receiving additional training on a diverse range of topics related to both new and traditional technologies. Specifically, they highlighted the importance of gaining proficiency in coding, artificial intelligence, video editing, and robotics, among others. Furthermore, educators expressed a desire to learn more about gender inclusion broadly. This suggests a commitment to fostering inclusive learning environments. In terms of skills development, teachers emphasized the need for enhanced communication, empathy, critical thinking, and creativity. They also stressed the importance of inclusivity awareness, differentiated learning, psychological principles for managing classroom dynamics, and fostering bias-free environments. Moreover, there was a consensus on the importance of professional development, adaptability, and flexibility in incorporating values of inclusion and equality into both informatics education and general teaching practices. Overall, teachers showed strong interest in gaining the knowledge and skills to deliver engaging and inclusive informatics education emphasizing new technologies and fostering inclusivity.

School leaders hold a pivotal role in fostering gender-inclusive environments within schools, particularly in the context of teaching informatics. Respondents from **the partners' countries** emphasized the importance of school leaders in this regard, suggesting that they could serve as advocates for gender equality, promote authentic learning experiences, ensure equitable access to resources, and integrate inclusivity into the school's vision and policy. School leaders play a pivotal role in coordinating projects, establishing action plans, and promoting diversity in informatics programs. However, respondents also highlighted the need for additional support for school leaders, including resources for designing educational programs, guidance from educational institutions, and clear funding guidelines. Furthermore, respondents emphasized the significance of ongoing professional development for teachers and external training on gender inclusion to address

persistent stereotypes. Overall, there is a consensus among respondents that school leaders should take proactive measures to create a gender-inclusive environment in informatics education.

To sum up, taking into consideration the findings from the field research conducted in the partner countries, the obstacles identified, such as insufficient resources and biased curriculum materials, underscore the complexity of fostering gender inclusion. Despite these challenges, a shared commitment to professional development among teachers suggests a strong willingness to implement gender-inclusive practices in informatics education.

School leaders emerge as crucial facilitators in this endeavor, with a pivotal role in advocating for gender equality, promoting diversity, and providing support and resources to teachers. Therefore, to advance gender inclusion in informatics education, concerted efforts are needed, including comprehensive teacher training, unbiased curriculum materials, and proactive leadership from school administrators.

5. Discussion

Combining insights from literature reviews, focus group discussions, and questionnaire responses on teaching informatics in an authentic and gender-inclusive approach in the **partner countries**' educational settings reveals several key themes and insights. These shed light on the state of informatics education, authentic learning practices, and gender inclusion initiatives, offering a comprehensive understanding of the subject. The desk research involved in each partner country a comprehensive literature review, analyzing the content of the National Curriculum frameworks, guidelines provided and textbooks used for the teaching of informatics. Through this review, the consortium aimed to assess the current landscape of informatics teaching and assessment and examine the degree to which authentic learning and gender-inclusive practices are incorporated into teaching as well as understanding how informatics competencies are assessed. In primary education, informatics is taught as a separate subject in Greece, while in Cyprus the learning outcomes are integrated in other subjects, optional and compulsory respectively, while in Italy and Netherlands the focus is mostly on digital competencies. In Ireland, informatics is not a standalone subject in primary and secondary level, but informatics concepts are integrated into various subjects. In contrast, in secondary education, Cyprus and Greece deliver informatics as a separate compulsory subject, while Italy integrates this into other subjects. In Croatia, informatics is a compulsory subject in grades 5 and 6 (student's age 12-13) and optional subject in grades 7 and 8 (student's age 14-15). The "Informatics4All" framework acknowledges that there can be differences in how informatics education is delivered and the specific areas of focus. This allows for tailoring the curriculum to different contexts and student needs (Caspersen et al., 2022). The "Informatics4All" framework can be implemented by placing a stronger emphasis on core areas like data and information, algorithms, computing systems, and networks and communication. This ensures students develop a strong foundation in these essential informatics concepts. Despite the growing recognition of informatics education's importance and attempts to integrate it into the curriculum, challenges remain in establishing it as a distinct subject with a well-defined structure and dedicated time allocation.

Although a desk review suggests the National Curriculum provides a framework and incorporates elements of authentic learning and gender inclusion, field research in **partner countries** identifies challenges that impede effective implementation.

In **Cyprus**, there's an interesting dynamic revealed when combining the results from both the focus group and survey regarding authentic learning. Notably, not all teachers consider themselves familiar enough with the term, while the majority neither agree nor disagree that the National Curriculum promotes its use. This ambiguity may stem from some teachers' perceived lack of a comprehensive understanding of authentic learning. Concerning gender inclusion, despite some instances of equal representation of male and female figures and role models identified in the National Curriculum based on desk research, there are still areas for improvement. Focus group participants highlighted the absence of official guidelines for gender inclusion in informatics, emphasizing the need for more comprehensive strategies to incorporate diverse perspectives. This includes examples, case studies, and readings from various cultures, genders, races, abilities, and socioeconomic backgrounds. These sentiments align with the survey findings, which indicate a neutral stance regarding whether the National Curriculum promotes gender inclusion or provides specific approaches to address gender stereotypes in informatics teaching. The survey also highlights several challenges hindering gender inclusiveness, such as insufficient resources and funding, curriculum materials reinforcing gender stereotypes, and a lack of awareness or training on gender-inclusive teaching practices.

In **Greece**, while the curriculum outlines fundamental objectives such as fostering familiarity with technology, cultivating critical thinking, and applying ICT skills, there are notable gaps in aligning teaching and assessment methods with the development of digital competencies. Additionally, educators' familiarity with authentic learning frameworks and their ability to teach and evaluate Informatics competencies appear to be lacking, reflecting a need for comprehensive professional development initiatives. Moreover, the curriculum's deficiency in addressing gender inclusion is evident, as it fails to provide tailored approaches or materials that cater to diverse student demographics. This oversight perpetuates gender stereotypes and hinders the creation of an inclusive learning environment.

In **Ireland**, the survey suggests that while many educators incorporate authentic learning into their teaching, challenges such as time constraints and resource limitations hinder its full implementation. Educators also express a strong need for continuous training and updated resources to keep pace with the rapidly evolving digital landscape. Similarly, while the focus group indicates efforts by some educators to promote gender-inclusive practices, the survey reveals challenges such as gender imbalances in the field and curriculum materials reinforcing stereotypes.

In the **Netherlands**, although based on the desk research, a statutory National Curriculum on digital literacy is currently being developed, guidelines on how to promote gender inclusion or authentic learning in informatics education are still lacking. The biggest challenges teachers face while teaching and assessing informatics are a too high workload, inadequate teacher training, and lack of resources. When gender inclusion is included, sensitivity issues arise as well (personal belief, beliefs of parents, etc.).

In **Croatia**, the survey data analysis revealed that teachers typically use authentic learning practices in their teaching and that their opinions about the National Curriculum are slightly shifted towards positive. However, they point out that learning outcomes as defined by the national curricula are difficult to achieve. They find professional seminars relatively useful and consider the major obstacles to informatics teaching to be inadequate hardware and software resources, large number of pupils, time constraints, and a lack of opportunities for professional development. The need for assessment materials that students could use to get feedback on their learning progress, but also to expand their knowledge and interests, has been also pointed out.

In **Italy**, regarding authentic learning, while a significant majority of questionnaire respondents have at least a moderate level of familiarity with the concept, there remains over a fifth who are either slightly familiar or unfamiliar with it. This discrepancy can be attributed to the absence of explicit mention of authentic learning in the curriculum, despite the presence of some related aspects within it, as verified by the desk research. The primary barriers and obstacles to implementing authentic learning in informatics education include limited resource availability, inadequate professional development opportunities, resistance to change, as well as the absence of clear guidelines and effective courses on the topic. At the same time, regarding gender inclusion, there seems to be a lack of awareness regarding the presence of gender stereotypes in learning materials and content, as well as potential gender biases. Both questionnaire respondents and focus group participants emphasized the absence or insufficient support for initiatives aimed at promoting gender inclusion as the most significant obstacle to addressing gender inclusion in upper primary and lower secondary schools.

6. Implications for Policy and Practice

Drawing from the above insights, the report can propose several recommendations to serve as a roadmap:

Curriculum Reform: Advocate for the incorporation of informatics as a compulsory subject with a well-defined structure at the primary education level. This would alleviate the burden on educators who currently integrate informatics into other courses and ensure that informatics receives dedicated attention within the curriculum. More importantly, on the curriculum under reform, digital skills (as described in the European Digital Competence Framework for Citizens in DigComp 2.2 (Vuorikari, Kluzer, & Punie, 2022) should be mapped within the thematic units of the various school subjects, while taking in account the dimensions of gender inclusion and authentic context. This may also involve updating curriculum guidelines to explicitly promote the use of authentic learning and gender inclusion practices in informatics education and providing educators with clear guidelines and resources to support implementation.

Teacher Training and Guidelines: Develop improved coordination in teacher training and provide clear guidelines within primary schools to support educators in teaching informatics effectively (in accordance to a reformed curriculum that integrates the various digital skills, mapped throughout the subjects). This should address educators' sense of unpreparedness and limited knowledge, possibly through professional development opportunities within school hours and by equipping the educators with the necessary skills and knowledge to effectively teach and assess informatics competencies, including authentic learning methodologies and gender-inclusion principles. This could involve workshops, seminars, and ongoing support from educational experts to address resistance to change and ensure successful adoption of new pedagogical approaches.

Authentic Learning Practices: Enhance the integration of real-world contexts, tasks, and problems into informatics education. This can be achieved by providing teachers with resources and training on authentic learning practices, fostering a deeper understanding of how to apply informatics concepts to real-life situations. Schools should explore flexible scheduling options and allocate dedicated time for authentic learning activities within the curriculum to overcome the time constraints effectively.

Gender Inclusion: Take steps to ensure gender inclusion in informatics education materials and practices. This includes representing diverse gender identities in examples, case studies, and role models, as well as providing guidelines for gender-inclusive approaches in curriculum development and teaching practices and training on how to address gender stereotypes and create a more inclusive environment.

Diversity and Inclusion: Broaden the scope of diversity and inclusion beyond gender to encompass various cultural, racial, ability, and socioeconomic backgrounds. Incorporate examples, case studies, and readings from diverse perspectives to create a more inclusive learning environment.

Holistic Understanding of Authentic Learning: Provide educators with a holistic understanding of authentic learning practices to better integrate them into informatics education. This may involve

offering professional development opportunities focused specifically on authentic learning methodologies.

Access to technology resources and necessary tools/equipment: Advocate for policies that prioritize equitable access to technology resources and support initiatives aimed at reducing barriers to digital learning. Governments and educational institutions should also prioritize resource allocation to ensure that schools have access to the necessary tools and equipment to support authentic learning practices.

Monitoring and Evaluation: Establish mechanisms for ongoing monitoring and evaluation of curriculum implementation, including feedback from educators, students, and stakeholders, to identify areas for improvement and ensure continuous progress towards achieving educational goals.

Encourage Collaboration: Encourage collaboration among teachers, school leaders, policymakers, and stakeholders who advocate for educational and continuous professional development opportunities. This collaboration aims to facilitate the sharing of best practices and resources for effectively integrating informatics, authentic learning, and gender-inclusive practices into the curriculum.

STEM role models: Include role models from STEM professionals explaining their profession, experience and expertise as it has been identified as a potential means of positively affecting authenticity of learning and gender inclusion in informatics.

Across **all countries**, despite variations in curriculum structures and approaches to informatics education, consistent themes of inadequate resources, limited teacher training, and a lack of clear guidelines persist. Authentic learning practices and gender inclusion initiatives face barriers such as resistance to change, insufficient support, and a dearth of tailored materials and strategies. These challenges hinder the effective implementation of inclusive and innovative teaching methods aimed at equipping students with essential digital competencies and fostering an environment that values diversity and equality. Addressing these issues requires concerted efforts, including comprehensive professional development programs, increased resource allocation, and the development of inclusive policies that prioritize the needs of all learners. Building on these findings, the next step of this project is to develop a concrete pedagogical framework that integrates authentic learning and fosters gender inclusion in informatics education. This framework will outline a comprehensive action plan to transform primary school informatics education, fostering a generation equipped to thrive in the digital world. By implementing these interconnected actions under the umbrella of Curriculum Reform, we can significantly enhance primary school informatics education. This fosters a generation equipped with the digital literacy skills and confidence needed to thrive in the ever-evolving digital world. By overcoming these obstacles collectively, educators and policymakers can work towards creating a more equitable and inclusive informatics education system that empowers students to thrive in an increasingly digital world.

7. Conclusion

Discussing the vital conclusions in light of the TINKER approach, it is evident that there is a need for a concrete pedagogical framework to include authentic learning and gender inclusion in teaching informatics education.

Considering the key findings through the lens of the TINKER approach, it becomes clear that there is an imminent need for a concrete pedagogical framework to incorporate authentic learning and gender inclusion in teaching informatics education. This need is especially pronounced in countries and educational levels where informatics is not a standalone subject. Informed by the research, the pedagogical framework should guide students in developing digital critical thinking alongside foundational informatics competencies.

To achieve this, teachers require training on implementing authentic learning and promoting gender inclusion within their informatics classrooms. The TINKER approach may serve as a crucial element in driving successful educational reforms in our partner countries.

References

Bocconi, S., Chioccariello, A., Kampylis, P., Dagienė, V., Wastiau, P., Engelhardt, K., Earp, J., Horvath, M. A., Jasutė, E., Malagoli, C., Masiulionytė-Dagienė, V., & Stupurienė, G. (2022). Reviewing computational thinking in compulsory education. In A. Inamorato Dos Santos, R. Cachia, N. Giannoutsou, & Y. Punie (Eds.), Publications Office of the European Union. https://doi.org/10.2760/126955

Caspersen, M. E., Diethelm, I., Gal-Ezer, J., McGettrick, A., Nardelli, E., Passey, D., ... & Webb, M. (2022). *Informatics reference framework for school*. https://www.informaticsforall.org/the-informatics-reference-framework-for-school-release-february-2022/

European Commission, European Education and Culture Executive Agency (2022). *Informatics education at school in Europe*, Publications Office of the European Union. https://data.europa.eu/doi/10.2797/268406

European Commission. (n.d.). *Europe's digital decade: Digital targets for 2030*. Retrieved May 28, 2024, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

European Commission. (n.d.). *SELFIE: A tool to support learning in the digital age*. European Education Area. Retrieved May 30, 2024, from https://education.ec.europa.eu/selfie

European Commission. (n.d.). *SELFIE: Discover your school's digital potential*. EU Science Hub. Retrieved May 30, 2024, from https://schools-go-digital.jrc.ec.europa.eu/

Herrington, A., & Herrington, J. (2006). What is an authentic learning environment? In A. J. Herrington & J. Herrington (Eds.), *Authentic learning environments in higher education* (pp. 1-13). ISP

Herrington, J., Reeves, T. C., & Oliver, R. (2014). Authentic learning environments. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of research on educational communications and technology (pp. 401-412). Springer.

Herrington, J., & Oliver, R. (2000). An instructional design framework for authentic learning environments. *Educational Technology Research and Development*, 48(3), 23–48. https://doi.org/10.1007/BF02319856

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens-With new examples of knowledge, skills and attitudes*. EUR 31006 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-48882-8, doi:10.2760/115376, JRC128415. https://publications.jrc.ec.europa.eu/repository/handle/JRC128415