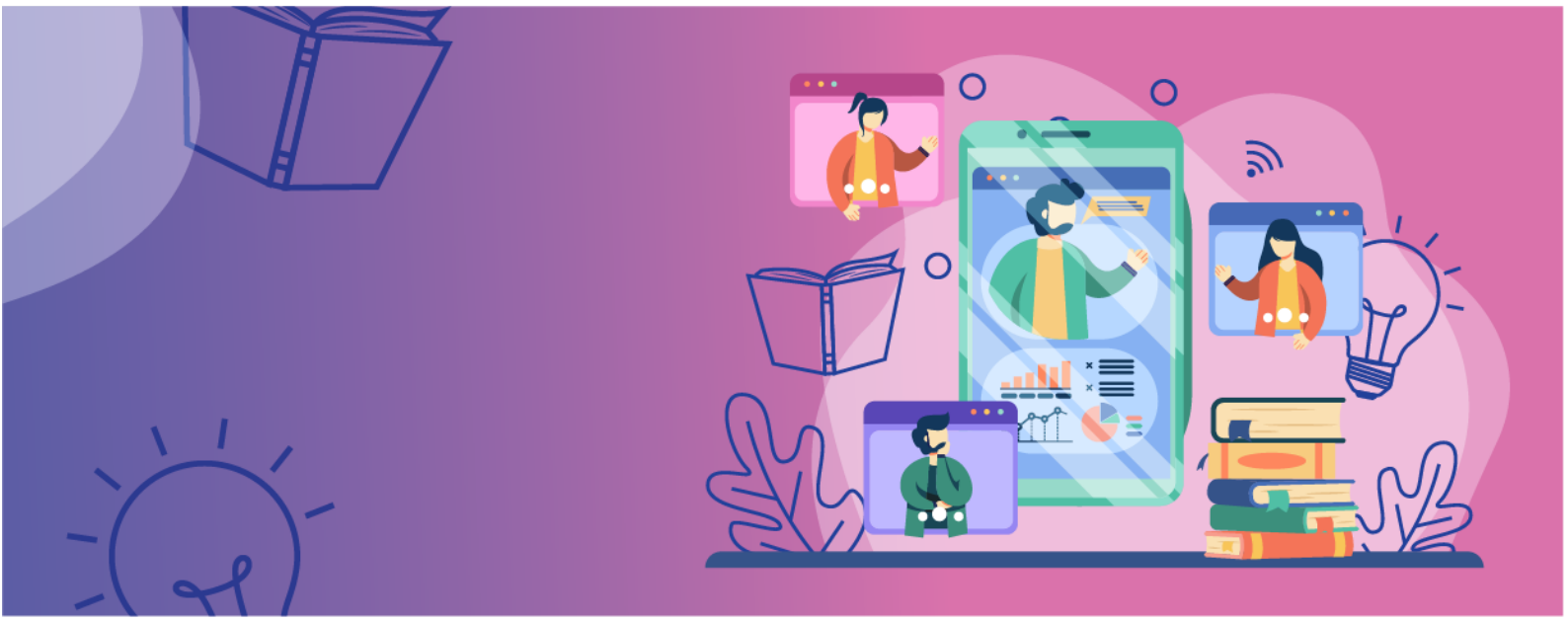
DIGITAL FIRST

DIGITAL FIRST

Digital Tech as the First Language:

Informatics for Digital Natives

D3.9 Recommendations: towards functional approach in teaching and assessing informatics



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1 Introduction

The rapid digital transformation of society has fundamentally changed the way children learn, communicate, create, collaborate, and participate in civic life. Digital technologies are no longer used solely as technical tools; they have become integral to personal expression, social interaction, information access, problem-solving, creativity, and decision-making. As a result, informatics education must move beyond teaching isolated technical skills and instead help learners understand and use digital technologies as meaningful tools for communication, inquiry, innovation, and responsible participation in society.

Within this context, the Digital First project explores a functional approach to teaching informatics inspired by Halliday's seven functions of language. This approach positions digital technology as a communicative and social medium through which learners express identity, construct knowledge, collaborate with others, solve problems, exercise creativity, investigate questions, and engage in ethical and responsible digital citizenship. By focusing on the purposes for which technology is used, rather than on tools alone, the project seeks to make informatics education more relevant, authentic, and connected to the realities of young people's everyday experiences.

To support this vision, the project established a series of Dialogue Clubs involving teachers, school leaders, researchers, parents, policymakers, and other educational stakeholders across ten European countries. Through structured dialogue and collaborative reflection, participants examined how children engage with digital technologies across the seven functional dimensions and identified the pedagogical approaches, competences, and support structures needed to strengthen informatics education. The Dialogue Clubs provided a unique opportunity to capture diverse perspectives, share practices, and co-create recommendations grounded in classroom realities and emerging educational challenges.

This report presents the outcomes of that collaborative process. It summarises the implementation of the Dialogue Clubs, analyses participant feedback and thematic findings, and translates the collective insights into practical recommendations for teaching, assessment, school leadership, parental engagement, and digital rights education. The recommendations aim

to support educators and decisionmakers in developing learning environments that empower students to become confident, creative, critical, and responsible users of digital technologies.

2 The Dialogue club's methodology

Within the **Digital First** project, the **Dialogue Clubs (DCs)** constitute a participatory pedagogical framework designed to foster cross-institutional dialogue and collaborative exchange across primary, secondary, and higher education stakeholders. Series of Dialogue Clubs supported cross-institutional collaboration in teaching informatics at national and European levels. Dialogue Clubs are platforms to co-create a sustainable dialogue about teaching informatics, the teacher's new role and competences, and how to increase their 'readiness' to fully integrate effective pedagogical approaches in their provision. The main role of Dialogue Clubs was to create a motivating environment for the exchange of opinions and ideas and the co-creation of new approaches in teaching informatics.

The Dialogue Clubs methodology operationalises a paradigm shift toward **functionalism**, treating digital technology and informatics as a horizontal language and communicative medium for problem-solving, personal expression, and civic action. Rather than functioning as traditional one-way webinars or formal validation panels for pre-written policies, Dialogue Clubs operate as dynamic, collaborative forums. Their primary purpose is to co-create sustainable pedagogical strategies, evaluate teacher readiness, and identify critical success factors for implementing functional informatics across European classrooms.

The Dialogue Club methodology is anchored in three complementary theoretical traditions:

- **Socio-cultural learning theory** (Vygotsky, 1978): Emphasises that cognition develops through social interaction and language. Dialogue Clubs provide an environment where educators, parents, and specialists articulate daily practices, interrogate tensions, and jointly construct pedagogical meaning.
- **Dialogic speech communication** (Bakhtin, 1986): Posits that utterance exists within responsive chains of communication. The methodology creates neutral "inter-stakeholder spaces" that demand actively responsive understanding rather than passive reception, ensuring all participants both speak and listen.
- **Communities of practice** (Wenger, 1998): Builds sustainable professional engagement around three core pillars: mutual engagement, shared repertoire and joint enterprise.

The aim was for the diverse group of stakeholders participating to have opportunities to interact and communicate with the Dialogue Club participants. Not only to learn about their diverse experiences of informatics education in schools and learn from their different perspectives and expertise but also to feel part of a community where the emphasis is on reciprocity and the development of meaning and action. Interaction between the participants of the Dialogue Clubs

is designed to contribute to the development of mutual engagement, shared repertoire and a sense of joint enterprise. In the Digital First project, this means:

- mutual engagement – everyone sharing ideas and expertise and adding to their own or their institution's/agency's knowledge
- shared repertoire – developing an understanding of the theory and practice of teaching informatics in primary and secondary schools and innovative pedagogical strategies for teaching informatics needed for high-quality functional approach to teaching informatics from different perspectives
- joint enterprise – a strong sense of purpose in sharing and identifying informatics teachers' competences and forward-looking learning analytics framework for informatics.

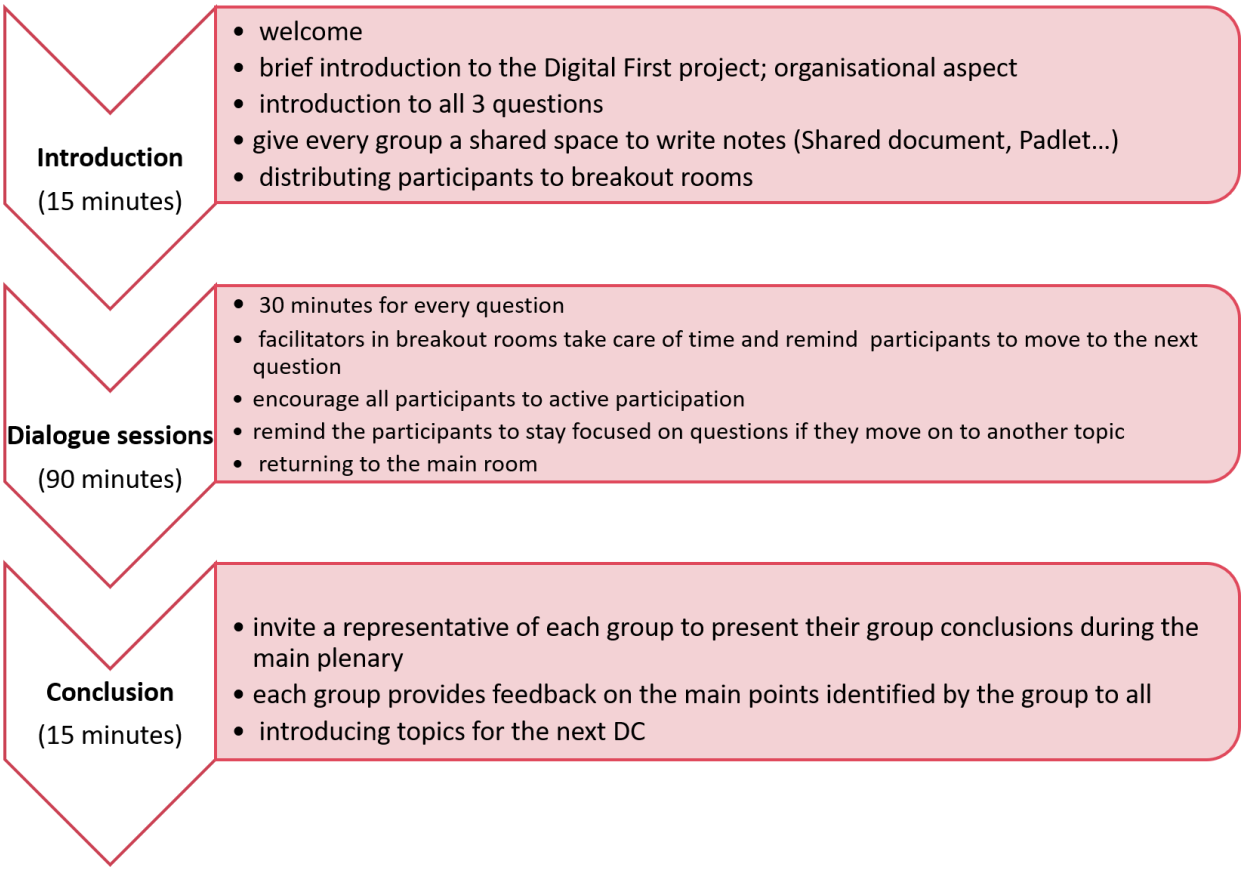


Figure 1. Dialogue Club's flow

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3 Implementation of Dialogue Clubs in Digital First project

The implementation of the Digital First Project included a series of Dialogue Clubs, which aimed to enable stakeholders with diverse perspectives to interact and engage in dialogue, establish multi-stakeholder European learning communities, and contribute to and inform the identification of the key success factors for the functional approach to teaching informatics.

Following the initial structuring and partner preparations in late 2024, the consortium deployed a distributed network of online Dialogue Clubs across European primary, secondary, and higher education ecosystems. The Dialogue Clubs were organised and conducted at country level in the partner countries. Implementation was supported with the common Guidelines designed to ensure consistency of approach across all countries responsible for running the DCs. They provided a common structure for each DC to promote interaction and dialogue and offered suggestions to encourage all participants to share their views and to learn from one another's expertise and knowledge. Dialogue Clubs were conducted online using web-conferencing software with breakout functionality alongside shared interactive digital whiteboards.

Rather than serving as passive administrative check-ins or validation meetings for pre-determined curricula, the implementation phase tested whether a dialogic, multi-stakeholder model could successfully gather grassroots teacher reflections, capture authentic student interactions with digital technology, and build a lasting community of practice. The feedback gathered across this multi-year rollout serves as both an empirical assessment of the methodology itself and an iterative bridge connecting classroom realities to upcoming school piloting and policy deliverables.

3.1 Key Dialogue Clubs' participation figures

Between November 2024 and June 2025, the consortium executed the full sequence of the seven thematic Dialogue Clubs across all **10 participating partner countries**: Bulgaria, Croatia, Cyprus, Finland, Greece, Italy, Lithuania, Portugal, Slovenia, and Spain.

Across the core sequence, a total of **70 Dialogue Club sessions** were convened, engaging **923 cumulative participants**:

- Dialogue Club 1 (Personal function): 159 participants (121 teachers, 21 parents and 17 wider stakeholders)
- Dialogue Club 2 (Representational / Informative function): 155 participants (109 teachers, 19 parents and 27 wider stakeholders)
- Dialogue Club 3 (Interactional function): 147 participants (113 teachers, 15 parents and 19 wider stakeholders)

- Dialogue Club 4 (Instrumental function): 119 participants (92 teachers, 15 parents and 12 wider stakeholders)
- Dialogue Club 5 (Imaginative function): 116 participants (87 teachers, 16 parents and 13 wider stakeholders)
- Dialogue Club 6 (Heuristic function): 117 participants (77 teachers, 25 parents and 15 wider stakeholders)
- Dialogue Club 7 (Regulatory function): 110 participants (77 teachers, 22 parents and 13 wider stakeholders)

	DC 1	DC 2	DC 3	DC 4	DC 5	DC 6	DC 7	T
Bulgaria	16	12	15	9	11	6	6	75
Croatia	12	25	16	12	9	11	8	93
Cyprus	5	6	5	4	4	4	4	32
Finland	6	4	4	4	4	4	3	29
Greece	27	24	18	16	13	17	12	127
Italy	5	7	7	7	6	6	6	44
Lithuania	38	31	35	31	33	25	29	222
Portugal	15	15	15	15	17	17	17	111
Slovenia	23	16	18	13	14	17	15	116
Spain	12	15	14	8	5	10	10	74
TOTAL	159	155	147	119	116	117	110	923

Table 1. Participation in 10 countries

The geographic distribution achieved wide cross-national variation, with total participation across all seven clubs ranging from concentrated cohorts in Finland (29 total) and Cyprus (32 total), to medium-sized networks in Italy (44), Spain (74), Bulgaria (75), and Croatia (93), and major multi-stakeholder mobilizations in Portugal (111), Slovenia (116), Greece (127), and Lithuania (222). The participants comprised in-service informatics teachers, general primary and secondary educators, school leaders, academic researchers, teacher trainers, educational policymakers, and parents.

	KPI
Dialogue Clubs established for Informatics teachers	10
Teachers who participated in the Dialogue Clubs	674
Actively engaged teachers	674
Actively engaged parents and other participants	249
Total number of Dialogue Club sessions	70

Table 2. Key performance indicators

3.2 Dialogue Clubs' participants' feedback

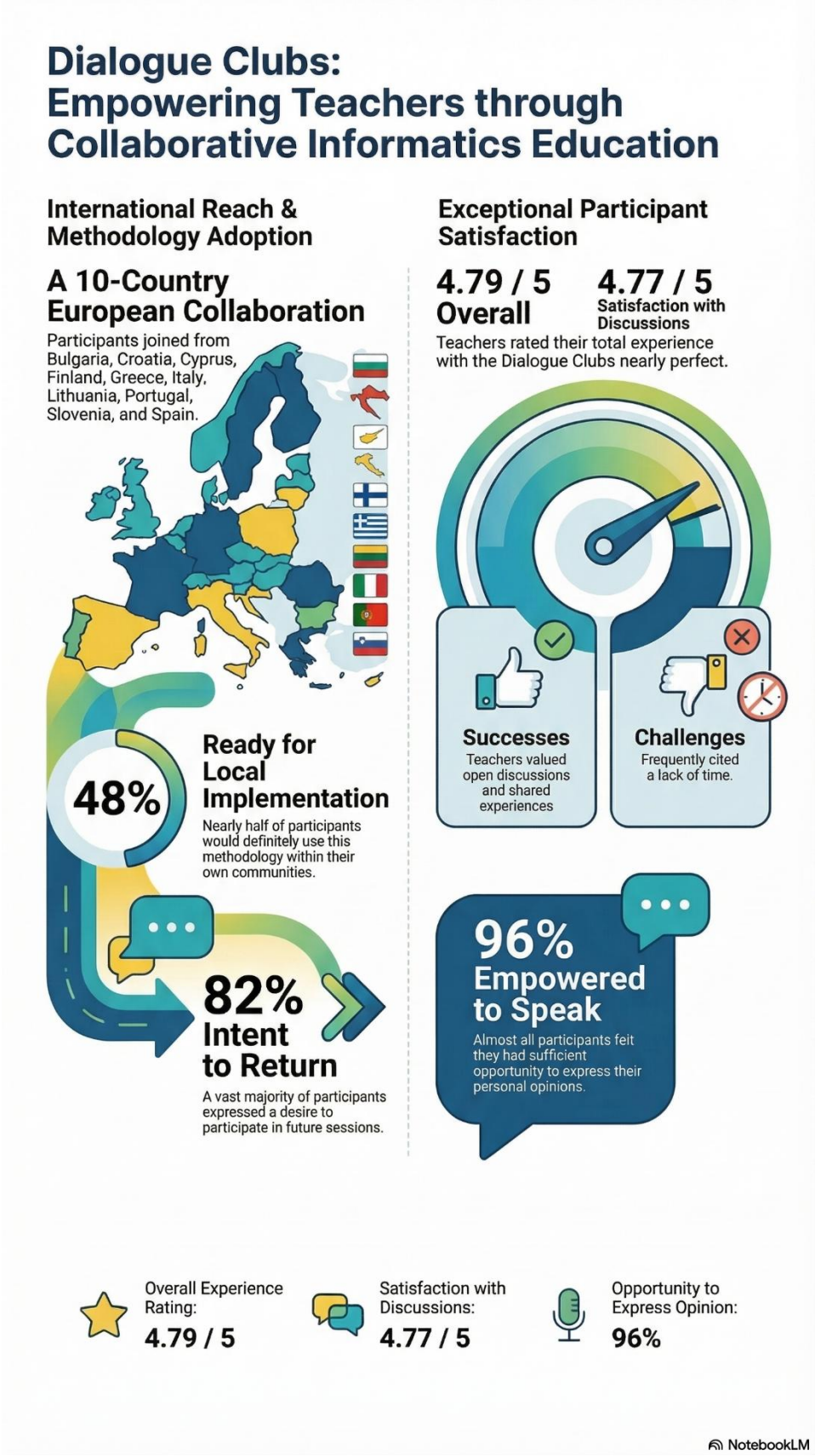


Figure 2. Infographics with participants feedback (AI modified)

Teachers and other participants, including school leaders and policymakers, rated their experience with the Dialogue Clubs very highly, with an average overall satisfaction score of **4.79 out of 5**.

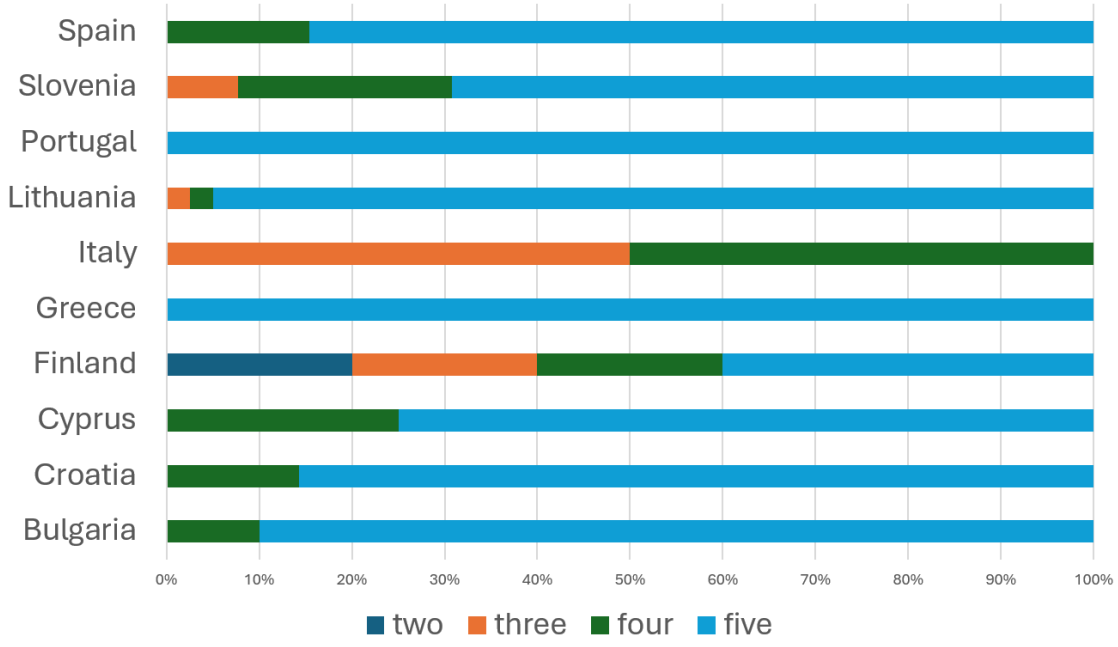


Figure 3. Overall experience

Specific feedback regarding their experience included the following:

- **Satisfaction with discussions:** Participants were specifically satisfied with the dialogue sessions, giving them an average rating of 4.77 out of 5.
- **Opportunity for expression:** A vast majority (96%) felt they had sufficient opportunities to express their opinions on the topics discussed.
- **Future participation:** There was strong interest in continued engagement, with 82% of participants stating they would participate in a Dialogue Club again if given the opportunity.
- **Methodological adoption:** Many participants saw value in the format itself, with 48% saying they would definitely use the Dialogue Club methodology to organise similar events in their own communities, and another 45% saying they might do so.

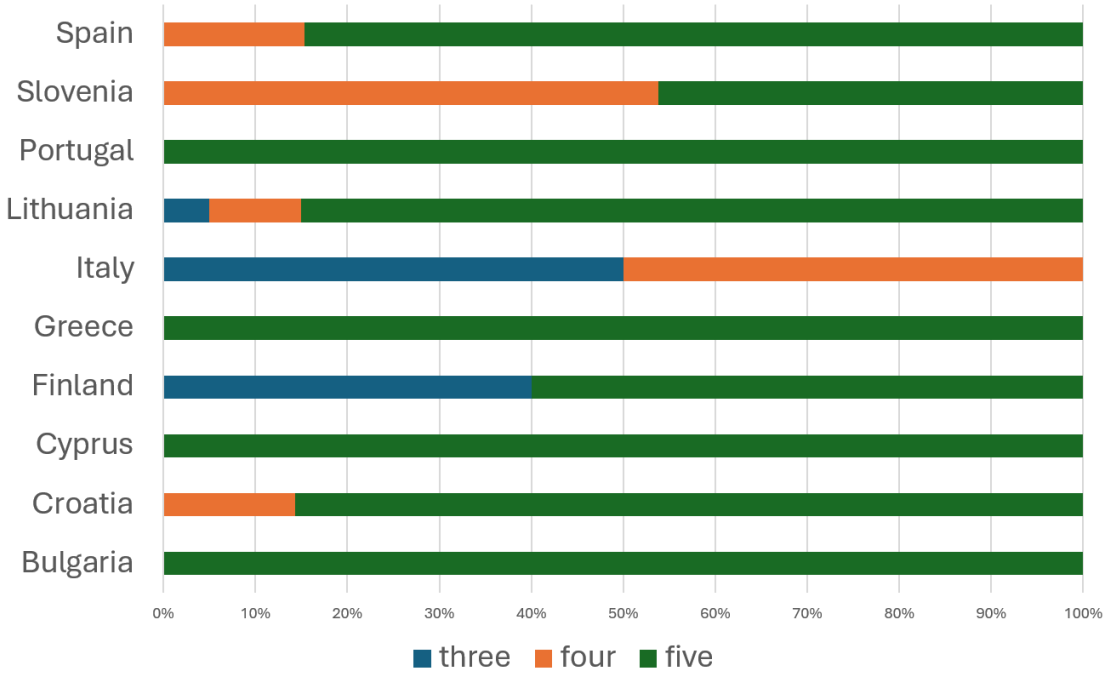


Figure 4. Satisfaction with discussion

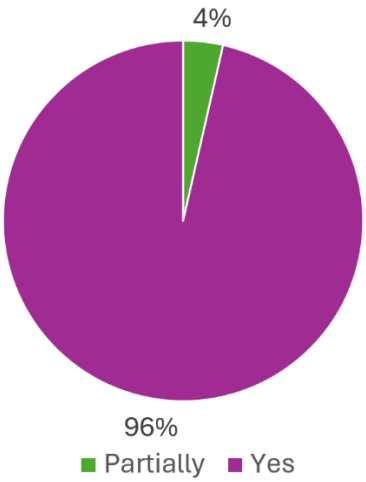


Figure 5. Opportunities for expressing opinions

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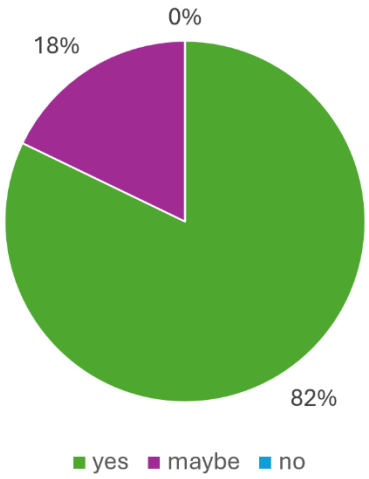


Figure 6. Future participation

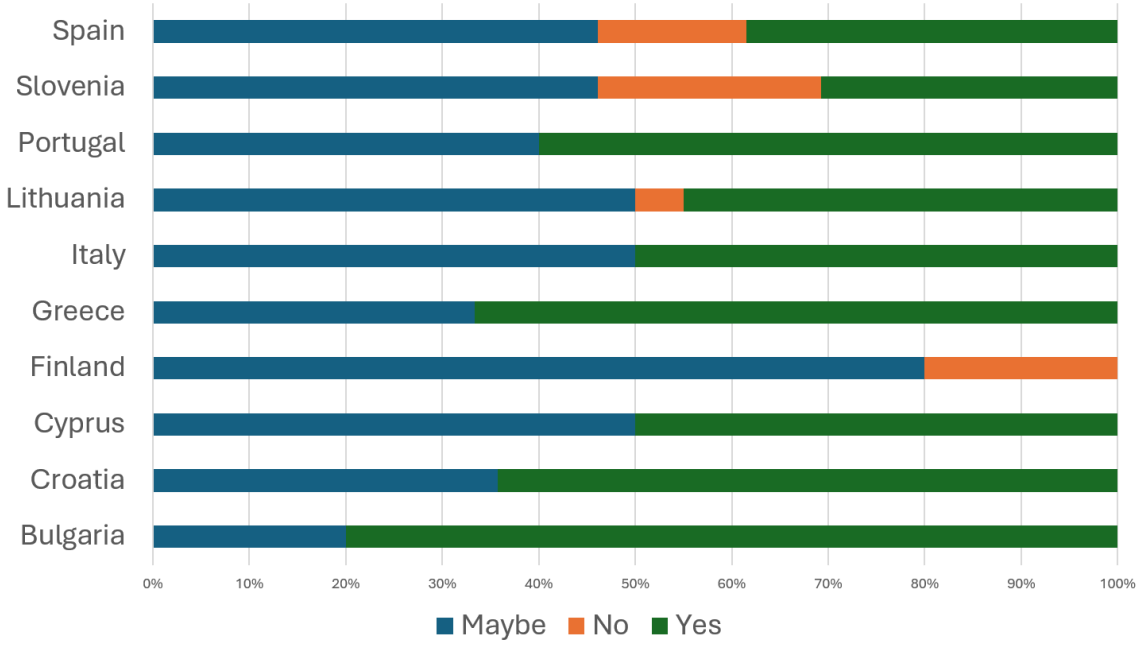


Figure 7. Would you use Dialogue club's methodology to organise something similar in your community?

Qualitative Feedback Participants highlighted several specific aspects they liked and disliked about the programme:

- **Positive Aspects:** The most valued features were the **open discussions**, the opportunity to **share opinions and experiences** with colleagues, and the exchange of **good practices**.

- **Areas for Improvement:** The primary complaint centred on **time constraints**. Word clouds from the sources indicate that participants often felt there was a **lack of time** for discussions or that the sessions were too short.
- **Recommendations:** To improve future sessions, participants suggested providing **short summaries** of all discussions and ensuring even more **time for discussions** on interesting topics.

3.3 Thematic areas of the Dialogue Clubs

Much like language, informatics is a tool for expression and problem-solving. In today's world, sound IT skills are necessary for everything from accessing and validating information to communicating effectively and solving everyday problems. Whether it's locating a friend in need or creating a unique, low-cost birthday present, IT skills play a crucial role. Furthermore, advanced IT solutions are indispensable for tackling the defining challenges of our time, such as green transition and environmental sustainability, both of which are inextricably linked to digital transition. **The DIGITAL FIRST project proposes a new approach to teaching informatics, one where the function of IT skills is at the forefront and serves as the ultimate goal of the educational process.**

Dialogue Clubs were dedicated to innovative pedagogical approaches considering digital tech as the first language of digital natives and upgrading traditional approaches to teaching informatics with Halliday's seven functions of a child's language. In Dialogue Clubs pedagogical strategies to approach each of these functions in the classroom were discussed, as well as how to assess teaching results thus achieved.

Halliday's systemic functional linguistics understands texts as pieces of communication constructed for social purposes. When we listen to, read or view a text, and when we speak, write or create a text, we are drawing on three systems of culturally constructed meaning from which we simultaneously make our choices. The first is the topic, what the social group regards as important to talk and write about (called the field); the second is the interpersonal, the words we choose that position us as authoritative or kind or fearful, and that position the audience as colleagues or novices or enemies (called the tenor); and the third are the language choices that make our text sound formal and written-like, or informal and spoken-like (called the mode).

3.3.1 Personal function of digital technology



Children use social media platforms and gaming apps to express emotions and shape their identities, often through avatars, creative content, and private messaging. These tools offer a space for self-expression, allowing children to explore who they are, share personal experiences, and connect with others in ways that feel safe and authentic. Visual and interactive features, like emojis, filters, and short videos, make it easier to communicate feelings, though they can sometimes oversimplify complex emotions. While digital platforms offer anonymity and time for reflection, they also risk encouraging superficial interactions, cyberbullying, and identity mimicry without proper guidance. To support healthy emotional development and self-expression, educators and parents must teach digital literacy, emotional awareness, and responsible online behaviour, ensuring that digital life complements real-world relationships.

3.3.2 Informative/Representational function



Children use digital tools to organise and share factual information through engaging presentations, infographics, and collaborative documents, often using ready-made templates to streamline their work. These tools help structure content into clear sections, support real-time editing, and allow for creative visual expression, though students sometimes prioritise aesthetics over substance. To deepen understanding, they turn to AI tools, video tutorials, and mind maps, while also learning to verify sources and discuss content with peers and teachers. Digital platforms enhance communication of complex ideas through animations, simulations, and interactive apps, making abstract concepts more accessible and engaging. However, without proper guidance, students may over-rely on AI or struggle with critical thinking, highlighting the need for balanced digital literacy education that blends creativity, collaboration, and analytical skills.

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3.3.3 Interactional function



Children use digital platforms, social networks and gaming apps to spark and sustain friendships, sharing memes, collaborating in games, and chatting after school, often blending social and academic life. From school-supported tools to global gaming communities, these platforms help children connect, but also raise concerns around safety, privacy, and screen time. Collaborative digital projects and team-based games foster communication, critical thinking, and peer learning, especially when guided by teachers. While digital tools can boost confidence and bridge distances, they can also dilute emotional depth and hinder face-to-face social skills if overused. Striking a balance between online and offline interaction, alongside digital literacy education, is key to nurturing healthy, meaningful relationships in a tech-driven world.

3.3.4 Instrumental function



Children use digital communication tools and virtual environments to express their needs, ask for help, and collaborate in both academic and social settings, blending formal and informal communication styles. Whether it's solving homework problems, reporting issues, or coordinating group projects, they rely on a mix of messaging apps, AI tools, and virtual assistants to seek support and share preferences. These platforms also help children develop problem-solving strategies, from trial and error to peer collaboration and creative brainstorming. While digital communication boosts confidence and reduces social anxiety, it can also lead to misunderstandings and overdependence on technology without proper guidance. Ultimately, with structured support from teachers and parents, digital tools empower children to express themselves, think critically, and navigate challenges with growing independence.

3.3.5 Imaginative function



Digital tools are transforming how children tell stories and engage in imaginative play, blending creativity with digital literacy and collaboration. Such platforms allow students to animate ideas, build virtual worlds, and craft interactive narratives, often as part of cross-curricular projects guided by teachers. From designing comics to engineering virtual escape rooms, children develop problem-solving and emotional expression while learning to plan, sequence, and share their creations. Sharing through online platforms builds confidence and communication skills, though safe environments and

teacher support are key. Ultimately, digital storytelling nurtures imagination, resilience, and real-world skills, preparing students for a future where creativity and technology go hand in hand.

3.3.6 Heuristic function



Children are diving into digital technology to explore new topics with impressive creativity and structure, using online shared boards and AI to research, organise, and present their ideas. From early on, they learn to cite sources and build mind maps, presentations, and e-books, often guided by teachers through project-based learning that links classroom knowledge to real-world applications. Sharing and collaboration platforms fuel curiosity and collaboration, while games and coding tools turn mistakes into powerful learning moments. Despite their enthusiasm, many students still struggle to evaluate online content critically, often relying on the first search result or unverified sources. To truly empower young learners, schools must invest in digital literacy, teacher training, and engaging platforms that promote autonomy, creativity, and responsible online behaviour.

3.3.7 Regulatory function



Children are increasingly using digital platforms and online games to collaborate, lead, and shape group dynamics in creative ways. These platforms empower quieter or tech-savvy kids to take initiative, enforce rules, and guide peers, often mimicking real-world leadership roles. While digital spaces offer new opportunities for expression and teamwork, challenges like digital inequality, inconsistent rule enforcement, and lack of digital rights awareness persist. Educators and families play a crucial role in supporting ethical behaviour and helping children understand their rights under laws like the Digital Services Act and the UN Convention on the Rights of the Child. By integrating digital literacy, real-life examples, and collaborative strategies into education, we can help students become confident, responsible digital citizens.

4 Recommendations and pedagogical guidance for functional approach to teaching informatics

4.1 Recommendations for teaching informatics through the seven functions

Teaching informatics through Halliday's seven functions shifts the focus from technology as an end in itself to technology as a means of communication, expression, inquiry, creativity, collaboration, problem-solving, and participation. This functional perspective aligns informatics education more closely with learners lived experiences and the demands of contemporary society. By integrating the personal, representational, interactional, instrumental, imaginative,

heuristic, and regulatory dimensions of technology use, schools can cultivate digitally competent, critically informed, creative, and responsible citizens who are equipped to participate fully in an increasingly digital world.

4.1.1 Personal function: Expressing identity, feelings, and values

The personal function emphasises the use of digital technologies to express emotions, opinions, identities, and personal experiences. Informatics education should help learners move beyond the superficial customisation of avatars and online profiles towards a deeper understanding of digital identity formation. Students should critically examine how social media platforms, filters, algorithmic visibility, and curated online personas may influence self-perception and behaviour.

Teaching should also include explicit development of digital emotional literacy. Learners need opportunities to consider how communication through emojis, memes, images, short messages, and voice notes both enhances and limits emotional expression. Understanding the differences between online and face-to-face communication can help students develop empathy and communicate more responsibly in digital environments.

Educators should address the opportunities and risks associated with anonymity online. While anonymous spaces can support participation by introverted or neurodiverse learners, students must understand the permanence of digital footprints, personal data protection, and the long-term consequences of online activities.

Assessment of this function may include reflective digital portfolios, blogs, or simulated social media profiles in which students document their learning journeys and express personal viewpoints. Peer feedback activities can further evaluate students' ability to communicate authentically, respectfully, and empathetically.

Recommendations from the piloting:

- Ground self-expression in concrete case studies: Training and pilot sessions revealed that students often treat digital identity abstractly. Activities should connect directly to students' everyday lives using real or self-case studies (e.g., analysing actual social media scenarios, debating the boundaries between public and private personas) rather than relying on generic safety advice.
- Balance identity awareness with creative confidence**:** Evaluation demonstrated a strong paired within-student gain on personal expression (+1.10 on the common item) and high awareness of digital identity management (mean 4.80), but lower confidence in expressive digital media creation (mean 3.80). Scenarios must provide structured media-creation templates, so students do not feel self-conscious or linguistically overwhelmed when expressing feelings and opinions online.

- Multi-disciplinary delivery: As demonstrated in piloting the Personal function succeeds most effectively when informatics teachers co-teach with language and literature educators. This positions digital communication as a horizontal vehicle for literacy, self-representation, and emotional expression rather than an isolated computer-lab exercise.

4.1.2 Representational and Informative function: communicating knowledge and understanding

The representational or informative function focuses on using technology to communicate facts, explain ideas, organise information, and construct knowledge. In an age of information abundance, students require more than technical search skills; they must learn how to evaluate information critically and responsibly.

Teaching should actively challenge the tendency to rely on the first result returned by a search engine. Learners should develop strategies for refining searches, comparing sources, verifying information, and recognising misinformation. As artificial intelligence becomes increasingly embedded in digital information environments, students should also gain a conceptual understanding of machine learning and generative AI systems. Understanding how AI produces outputs helps learners recognise the possibility of inaccuracies, biases, and hallucinations, reinforcing the importance of human verification.

Students need be encouraged to balance visual design with intellectual rigour. Attractive presentations and infographics should not be valued solely for aesthetics but also for the accuracy, relevance, and organisation of the information they communicate. Collaborative digital tools, cloud-based repositories, and shared workspaces can further support collective knowledge construction and information management.

Assessment might focus on students' ability to transform data into meaningful representations, create information products for authentic audiences, and demonstrate critical evaluation of sources and evidence.

Recommendations from the piloting:

- Provide pre-vetted media kits and localized artifacts: Teachers reported that media literacy scenarios placed a heavy preparation burden on educators to find appropriate, age-specific news stories, advertisements, and mock web pages. Resources must supply ready-to-use, localized media kits (e.g., applying the CRAAP test or "Media Detective" worksheets) to avoid consuming preparation time.
- Plan for offline, function-preserving fallbacks: In schools, unreliable internet connections interrupted live source-verification activities. Teachers must have function-preserving contingency options: if connectivity fails, students should analyse pre-downloaded

articles, static screenshots, or paper-based data cards, ensuring that critical inquiry and representation continue uninterrupted.

- Prioritize information architecture over graphic polish: Verified paired data showed significant gains in representational capability (+0.63 in Primary, +0.22 in Secondary), but teachers observed that students frequently prioritized templates, animations, and visual aesthetics over substantive truth and logical data structuring. Rubrics must explicitly reward information hierarchy, citation integrity, and source justification rather than visual decoration alone.

4.1.3 Interactional function: building relationships and collaboration

The interactional function views technology as a tool for creating, maintaining, and strengthening relationships. Informatics education should therefore develop students' capacity to collaborate effectively in digital environments while maintaining respectful and inclusive communication.

Many collaborative projects result in students simply dividing tasks rather than genuinely working together. Teachers should design activities that require discussion, co-creation, peer review, and shared responsibility. Digital tools should support meaningful collaboration rather than parallel individual work.

Blended approaches that combine online collaboration with face-to-face interaction can strengthen interpersonal relationships and reduce the risk of digital isolation. Such approaches enable students to experience both the efficiency of digital communication and the richness of direct human interaction.

Anonymous participation tools can also provide safe opportunities for quieter learners to contribute ideas and ask questions. By creating inclusive and supportive communication environments, schools can encourage broader participation while maintaining appropriate expectations for respectful behaviour.

Assessment should focus not only on final products but also on collaborative processes. Version histories, contribution records, and reflective evaluations can provide valuable evidence of participation, communication, and teamwork.

Recommendations from the piloting:

- Overcome "regulatory anxiety" through explicit norms: Teacher training evaluations revealed that educators frequently harbour "regulatory anxiety", a fear of managing unpredictable student social dynamics, online hostility, or exclusion. Training must provide explicit classroom discussion norms, safe digital spaces, and restorative conversation guides to equip teachers to mediate peer conflicts constructively.

- Structure roles to prevent device monopolization: In group work, shared computers often result in experienced students dominating the keyboard while others disengage. Scenarios must assign rotating, observable group roles (e.g., Operator/Driver, Planner, Evidence Checker, and Reporter) with timed transitions so that every learner actively contributes.
- Focus on communication habits, not just written netiquette rules: Pilot data (showing a verified +0.38 paired gain in interactional capability) emphasised that knowing rules does not automatically produce polite behaviour. Activities must use role-play, small-group case analysis, and simulated message boards to actively practice tone adjustment, constructive critique, and empathy

4.1.4 Instrumental function: solving problems and meeting needs

The instrumental function highlights technology as a means of achieving goals and solving practical problems. Informatics education should therefore provide authentic opportunities for students to apply computational thinking to challenges that matter to them and their communities.

Students need to learn to decompose complex problems into smaller and more manageable components. This process helps learners develop confidence when faced with uncertainty and promotes systematic approaches to problem-solving. Equally important is cultivating resilience through trial and error. Errors, debugging, and failed attempts should be recognised as essential elements of learning rather than indicators of failure.

The growing availability of artificial intelligence presents both opportunities and challenges in this area. Students should be encouraged to use AI tools to support learning, reflection, and debugging while avoiding overreliance on automatically generated solutions. The emphasis should remain on understanding, reasoning, and independent problem-solving.

Authentic projects addressing local or school-based challenges provide powerful opportunities for applying instrumental technological skills. Digital surveys, voting systems, and participatory design activities can also give learners a voice in shaping their learning experiences.

Assessment should focus on project development, problem-solving processes, iterative improvements, and the quality of solutions produced, rather than solely on final outcomes.

Recommendations from the piloting:

- Anchor tools in authentic school projects: Productivity tools (shared documents, task management, calendars) received very high approval when linked directly to existing academic workflows (e.g., coordinating a geography presentation or tracking homework).

Conversely, abstract software demonstrations were perceived as tedious or overly mechanical.

- Implement gradual, stepped tool introduction in primary: Younger learners easily become disoriented when faced with complex cloud folder structures and file-saving paths. Teachers must introduce productivity software gradually, establishing strict naming conventions, automated login routines, and simplified interfaces before progressing to multi-user collaborative folders.
- Design for high baselines (ceiling effects): Pilot evaluations noted that students already enter with high baseline confidence regarding basic tool use (e.g., ~4.3 on a 5-point scale). To avoid disengagement among older students, instrumental tasks must incorporate meaningful automation, spreadsheet logic, or project workflow optimization rather than basic typing or filing.

4.1.5 Imaginative function: creativity, storytelling, and innovation

The imaginative function recognises technology as a medium for creativity, storytelling, design, and artistic expression. Informatics education should nurture learners' capacity to create original digital artefacts while developing both technical and creative competences.

Creative digital production ought to be developmentally appropriate, beginning with simple visual storytelling tools and progressing towards more sophisticated environments for animation, programming, game development, multimedia production, and generative AI. This progression enables learners to build confidence while gradually increasing technical complexity.

Digital storytelling must be extended beyond informatics lessons. Students can use technology to explain scientific concepts, represent historical events, explore literary themes, and communicate ideas across the curriculum. Such applications reinforce the role of technology as a communication tool rather than merely a technical subject.

As learners become older, concerns about peer judgement often increase. Teachers should therefore provide supportive environments for sharing creative work, including opportunities for anonymous publication, digital exhibitions, and constructive peer feedback.

Assessment is expected to value originality, narrative coherence, technical implementation, usability, and reflective evaluation of the creative process. Multimedia portfolios and digital showcases provide particularly effective approaches for assessing imaginative work.

Recommendations from the piloting:

- Scaffold open-ended creativity to reduce "innovation anxiety": both the teacher training analysis and teacher reflections highlighted that total creative freedom causes "choice

paralysis" and student dissatisfaction. Teachers should provide structured starting points, constraint guidelines, and minimum criteria so students make steady progress.

- Calibrate tool complexity and setup time: The deployment of Minecraft Education in Secondary schools faced significant hurdles: complex login credentials, licensing barriers, and steep software learning curves consumed entire 45-minute lessons, leaving insufficient time for actual game design. Tool selection must match lesson length; where block hours are unavailable, lighter 2D platforms (e.g., Scratch, Twine, Book Creator) or pre-configured worlds should be chosen over heavy 3D environments.
- Manage student expectations and normalize iteration: Students frequently hold unrealistic ambitions (e.g., expecting to create commercial-grade 3D games immediately), leading to disappointment. Scenarios must teach pre-production planning, storyboarding on paper, asset creation, and prototype testing, while using the digital portfolio to celebrate iterative progress rather than finished perfection.

4.1.6 Heuristic function: inquiry, exploration, and discovery

The heuristic function focuses on curiosity, investigation, experimentation, and discovery. Informatics education should encourage learners to ask questions, explore possibilities, and construct understanding through inquiry-driven learning.

Physical computing, robotics, and tangible technologies can make abstract computational concepts visible and accessible. By observing how systems behave and identifying why errors occur, students learn to view mistakes as valuable learning opportunities. Such experiences contribute to the development of a growth mindset and support deeper conceptual understanding.

Teachers can adopt questioning strategies that encourage investigation rather than simply delivering answers. Open-ended challenges, inquiry-based projects, and problem scenarios can inspire learners to develop hypotheses, test ideas, and draw conclusions independently.

Students are expected to take steps towards formal research practices. The transition from everyday internet searching to structured academic inquiry requires instruction in source evaluation, citation practices, evidence gathering, and scholarly communication.

Assessment can involve investigative processes, research quality, evidence-based reasoning, and reflective understanding of learning journeys. Reflection logs and inquiry portfolios can capture both outcomes and thought processes.

Recommendations from the piloting:

- Pre-agree on permitted tools with school IT administrators: Piloting of the AI scenario was severely disrupted because school network firewalls and municipal IT policies blocked access to artificial intelligence platforms that were not pre-approved for minors. Schools must conduct technical pre-audits and secure necessary administrative permissions and privacy compliance well before classroom delivery.
- Deconstruct abstract concepts with tangible and mathematical anchors: Teaching abstract algorithms (such as the mathematical modulo operation in programming) created steep learning bottlenecks for primary and lower-secondary pupils. Teachers must deconstruct complex concepts through unplugged activities (e.g., Bebras task cards, physical robotics with Micro:bit, or peer debugging) before translating them into code.
- Develop process-oriented rubrics for open-ended exploration: Teachers voiced significant concern regarding how to grade heuristic inquiry, where there is no single "correct" answer. Evaluative rubrics must assess the inquiry trail, how students framed questions, analysed AI hallucinations, documented debugging iterations, and verified facts, rather than grading only the final output.

4.1.7 Regulatory function: governance, leadership, and digital citizenship

The regulatory function concerns the ways technology is used to organise activities, establish norms, exercise leadership, and support participation in democratic communities. Informatics education should therefore help students understand the social, ethical, and legal dimensions of digital technologies.

Students need to be actively involved in developing classroom agreements, digital citizenship expectations, and acceptable use guidelines. Participation in rulemaking encourages ownership, accountability, and responsible behaviour. At the same time, digital environments can provide valuable leadership opportunities for learners who may not traditionally assume leadership roles within the classroom.

Teaching should also connect digital citizenship with broader societal frameworks, including the General Data Protection Regulation (GDPR), the European Union Artificial Intelligence Act, the Digital Services Act, and children's rights in digital environments. Students should develop an understanding of privacy, transparency, algorithmic decision-making, artificial intelligence, platform accountability, and human oversight.

When digital conflicts arise, schools should prioritise restorative and educational responses rather than relying solely on punishment. Incidents involving online behaviour, privacy breaches, exclusion, or misuse of technology can become valuable opportunities for ethical reflection and conflict resolution.

Assessment might focus on students' leadership skills, ethical reasoning, decision-making, and understanding of digital rights and responsibilities. Simulated case studies, collaborative projects, and observations of leadership behaviours can provide meaningful evidence of learning in this area.

Recommendations from the piloting:

- Move from passive awareness to active rule co-creation: The pilots revealed that while students universally score high in generic safety awareness ("I know I must stay safe"), they struggle to apply this to real-world behavioural regulation. Scenarios must involve students in creating digital classroom charters, moderating simulated group boards, and evaluating privacy trade-offs.
- Address the gap between social media familiarity and data privacy: Students frequently understood basic photo-sharing rules but were unaware of metadata, automated algorithmic tracking, and commercial data harvesting. Regulatory scenarios should include hands-on audits of app permissions, cookie policies, and browser digital footprints.
- Differentiate delivery across age cohorts: Primary pupils responded with very high enthusiasm to mission-based safety activities (post-mean 4.91), whereas Secondary pupils demonstrated critical detachment if the lessons felt moralistic or overly restrictive. Secondary regulatory instruction must focus on digital rights, algorithmic transparency, intellectual property, and real-world legal frameworks (e.g., GDPR, EU AI Act) rather than basic behavioural rules.

4.2 Recommendations for key stakeholder groups

The findings synthesised across the Dialogue Clubs establish that digital technologies have become deeply embedded in the personal, cognitive, social, and academic lives of children and adolescents. Rather than treating digital devices merely as subjects of isolated technical study or as threats to be banned, the Dialogue Club framework advocates for **moving from prohibition to functional empowerment with** a **functional, supportive pedagogical paradigm**. Outright prohibitions are ineffective, often serving only to increase curiosity about forbidden activities and driving communication into unmonitored spaces.

Effective digital education requires shifting towards **responsible, supervised utilisation**. Digital platforms must be treated as **horizontal communicative and problem-solving media** that complement face-to-face interactions, analogue thinking, and traditional literacy. Consequently,

comprehensive guidance must address four interdependent stakeholder groups: **educators**, **school leaders**, **parents and families**, and **students themselves**.

4.2.1 Recommendations for educators and classroom pedagogy

Educators serve as critical facilitators bridging children's informal technology use with academic rigor, ethical reflection, and structured learning. Classroom guidance across the seven digital functions centres on four core areas: Critical information verification & AI literacy, Creative construction & imaginative scaffolding, Collaborative dynamics & democratic decision-making and Normalizing errors & developing heuristic resilience.

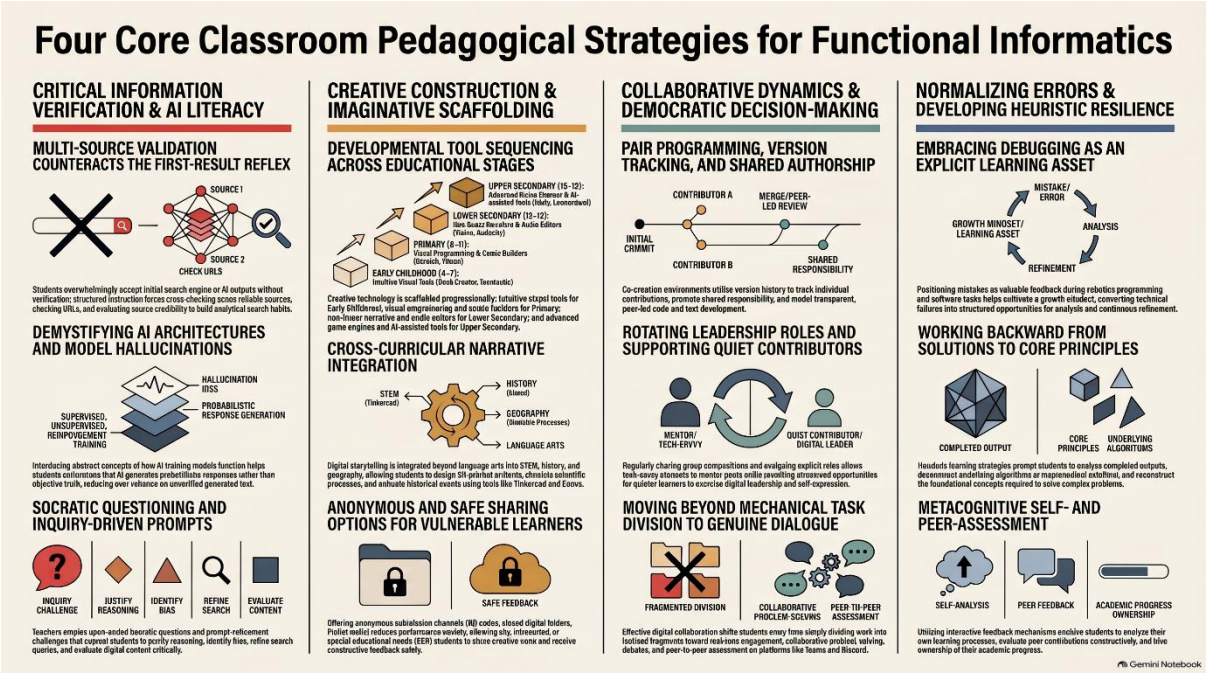


Figure 8. Core strategies for functional approach in informatics (AI modified)

Critical information verification and AI literacy

Counteracting the "first-result" reflex: Students habitually rely on the first search link or accept artificial intelligence outputs uncritically at face value. Educators must explicitly teach structured search algorithms, keyword refinement, and multi-source cross-checking.

Understanding AI model mechanics: Students should be introduced to how artificial intelligence architecture function (supervised, unsupervised, semi-supervised, and reinforcement learning). Understanding model design helps learners comprehend why AI hallucinations happen and why independent human verification is required.

Academic research routines: Foundational academic practices, such as using specialized search tools, evaluating link integrity, noting access dates, and using referencing conventions, should be embedded early.

Prioritizing depth over aesthetics: Because students often prioritise visual animations, emojis, and pre-made templates over substance, teachers must guide them to balance presentation design with content depth and source credibility.

Scaffolded digital creativity and storytelling

Age-appropriate tool sequencing: digital tools must align with developmental capabilities:

- *Early childhood (Ages 4–7):* Intuitive, drag-and-drop, and voice-assisted tools with minimal typing demands.
- *Primary school (Ages 8–11):* Structured visual creation platforms combining media types, introductory coding, and comics.
- *Lower secondary (Ages 12–14):* Interactive storytelling, audio editing, 3D modelling, and non-linear branching environments.
- *Upper secondary (Ages 15–18):* Advanced coding, game engines, vector design, and supervised generative AI tools.

Scaffolding and cross-disciplinary projects: Complex environments require teacher templates, tutorial videos, and peer mentorship. Creative storytelling should be integrated across subjects, such as illustrating historical narratives or animating scientific phenomena.

Emotionally safe sharing environments: While younger students eagerly share creations, older students frequently experience anxiety regarding peer judgment. Educators should offer anonymous or indirect sharing avenues, such as QR codes, shared digital boards and closed group repositories, alongside constructive feedback rubrics.

Active collaborative learning and problem-solving

Beyond mechanical task division: In online group work, students frequently split tasks mechanically rather than engaging in collective discourse. Educators should structure activities to require interactive debate, real-time co-authoring, and peer code reviews.

Algorithmic decomposition and trial-and-error: Teachers should instruct students to break complex challenges into smaller component parts (decomposition), encourage experimentation, and promote iterative testing and prototyping.

Democratic feedback platforms: Incorporating interactive tools enables anonymous questioning and inclusive classroom polling, giving quieter students a comfortable voice.

Reframing errors through heuristic reflection

Embracing errors as learning assets: Within programming and robotics, mistakes and debugging should be highlighted as standard, valuable learning moments rather than failures.

Socratic questioning and backward logic: Employing open-ended questioning and techniques like "working backward" from solutions helps students understand core concepts and articulate logical justifications.

4.2.2 Recommendations for schools and institutional leadership

School leadership teams establish the infrastructural, ethical, and organizational conditions for safe digital adoption.

Dimension	Policy and operational mandates
Device integration & inclusivity	▪ Allow and supervise digital devices for pedagogical tasks rather than enforcing blanket bans. ▪ Actively bridge digital divides by providing hardware and reliable connectivity to economically vulnerable students. ▪ Support multi-platform accessibility for students with special educational needs.
Safe school platforms	▪ Deploy vetted, institutional platforms for academic communication and file storage. ▪ Implement secure, discreet reporting channels for students to report cyberbullying or abuse confidentially.
Group dynamics & leadership	▪ Regularly rotate collaborative teams and group roles to cultivate empathy, prevent entrenched hierarchies, and counter digital exclusion. ▪ Create safe digital spaces that empower introverted and reserved students to take informal leadership roles.
Curricular integration	▪ Embed digital citizenship, digital rights, and netiquette across civic education, languages, and social sciences, rather than confining them to isolated computer science lessons. ▪ Treat online disciplinary incidents (e.g., unauthorized image sharing) as teachable moments for ethical discussion rather than applying purely punitive measures.

Professional development	▪ Provide ongoing teacher professional development in digital pedagogy, emerging generative AI tools, and human rights and data privacy legislation.

Table 3. Suggestions for organisational conditions

4.2.3 Recommendations for parents and family engagement

Home-school collaboration is essential for establishing consistent online guidance and modelling healthy digital habits:

Maintaining open dialogue: Parents should engage in ongoing conversations about children's online activities, gaming communities, and social media interactions without immediately resorting to surveillance or punishment.

Establishing balanced screen routines: Families should co-create clear boundaries that balance digital leisure with physical activities, family interactions, and adequate sleep.

Awareness of algorithmic traps and virtual economies: Parents must be educated on how platform algorithms maximize user retention, the risks of in-game financial transactions, and the dangers of age misrepresentation.

School-sponsored family workshops: Schools should organize parent workshops focusing on parental control setups, cybersecurity basics, cyberbullying awareness, and understanding platforms like Discord, TikTok, or Minecraft.

4.2.4 Guidelines for students

To navigate digital spaces with confidence, students should develop personal responsibility, critical awareness, and digital self-regulation.

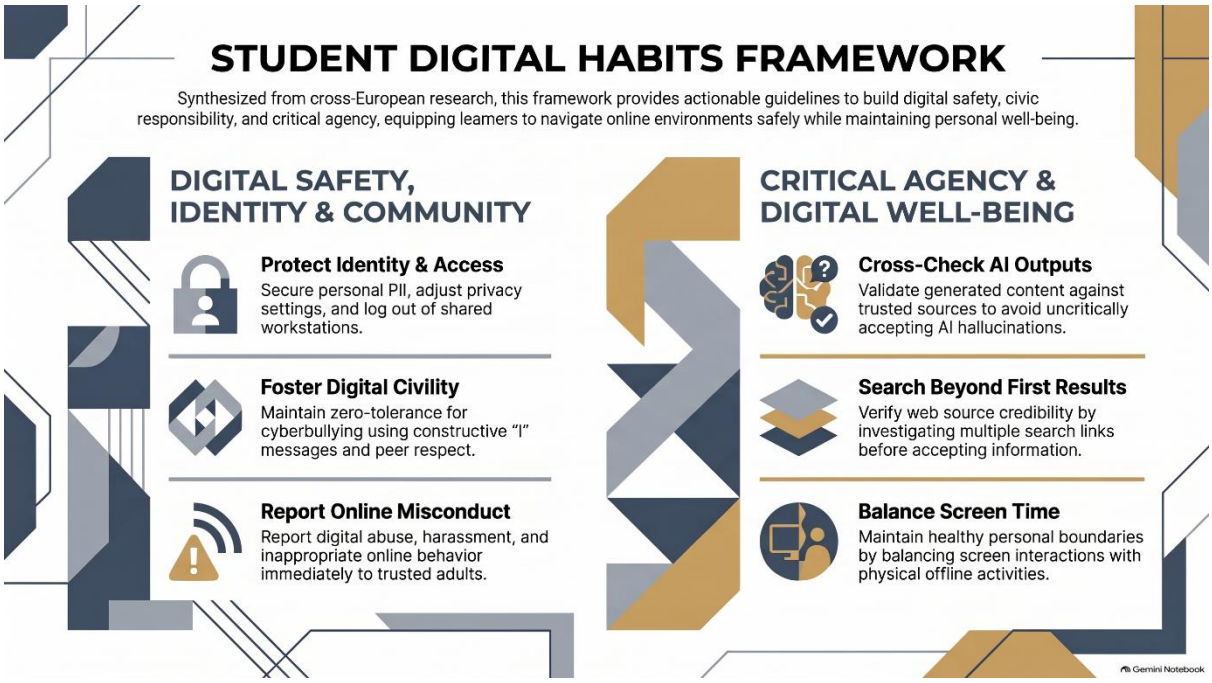


Figure 9. Guidelines for students (AI modified)

Protect personal identifiable information: Never share home addresses, phone numbers, passwords, school names, or real-time geolocation data online.

Differentiate accounts and manage sessions: Recognize the distinction between institutional school accounts and personal profiles and develop the consistent habit of logging out of shared school workstations.

Digital etiquette and bullying intervention: Practice respect across in-game chats and messaging platforms, refuse to participate in cyberbullying, and report inappropriate behaviour or online harassment to trusted adults.

Critical validation of digital outputs: Recognize that search engines and AI assistants can produce biased, incorrect, or hallucinated content; avoid copying unverified text directly into schoolwork.

Balancing online and offline life: Actively schedule daily screen-free periods dedicated to offline hobbies, sports, and face-to-face peer interactions.

4.2.5 Institutional actions for rights education

A central conclusion across the Dialogue Clubs is that **students demonstrate limited awareness of their digital rights**, often understanding basic photo permissions while remaining unaware of

data profiling, algorithmic manipulation, and voice privacy. Schools and educators must bridge legal frameworks and classroom practice.

Comprehensive consent policies

Schools should adopt comprehensive consent policies that reflect the realities of modern digital learning environments. Traditional consent forms often focus solely on photographs, but schools increasingly collect and process a wider range of personal data, including voice recordings, video footage, biometric information, and students' creative work produced through digital platforms. Consent procedures should therefore clearly explain what data may be collected, how it will be used, who may have access to it, how long it will be retained, and the rights available to students and parents. Schools should also review consent arrangements regularly to ensure they remain aligned with emerging technologies, educational practices, and legal requirements. Clear and transparent consent processes help build trust, strengthen data protection practices, and promote greater awareness of digital rights within the school community.

Early childhood foundation

Education about rights, consent, and digital identity should begin at an early age and be developed progressively throughout a child's schooling. Around the age of eight, children are often ready to engage with age-appropriate discussions about personal information, online sharing, digital footprints, and respectful online behaviour. Rather than relying solely on classroom instruction, schools should use experiential learning approaches that allow pupils to explore these concepts through real-world scenarios. Role-playing activities, simulations, storytelling, collaborative projects, and participation in Safer Internet campaigns can help children understand the practical implications of giving consent, protecting personal information, and respecting the rights of others. Developing these foundations early supports informed and responsible participation in increasingly digital learning and social environments.

External professional partnerships

Schools can strengthen digital rights education by collaborating with external professionals who bring specialised expertise and authentic perspectives. Data protection specialists, legal educators, cybersecurity officers, and other relevant experts can provide workshops, case studies, and interactive sessions that help pupils and staff understand the real-world implications of privacy, data protection, cyber security, and online rights. Such partnerships enable learners to engage with current challenges, examine realistic scenarios, and explore how digital rights are protected in practice. In addition, these collaborations can support teachers by providing up-to-date knowledge, practical resources, and professional learning opportunities. By

connecting classroom learning with professional expertise, schools can create richer and more meaningful educational experiences that prepare students to navigate digital environments safely, responsibly, and confidently.

4.2.6 Recommendations for policymakers

Policymakers can facilitate the transition towards a functional approach to informatics education by ensuring that curricula, assessment frameworks, and educational policies recognise the diverse ways in which learners use digital technologies to communicate, create, collaborate, investigate, solve problems, and participate in society. Curriculum reforms need to move beyond a narrow focus on technical knowledge and coding skills to encompass digital creativity, critical thinking, ethical decision-making, digital citizenship, media literacy, and the responsible use of emerging technologies, including artificial intelligence.

National and regional authorities are encouraged to provide schools with clear guidance, sustainable funding, and high-quality professional development opportunities that enable teachers to implement functional and learner-centred approaches to informatics. Assessment policies can promote authentic tasks, project-based learning, portfolios, collaborative activities, and other methods that capture students' ability to apply digital competences in meaningful contexts rather than relying solely on traditional testing.

Efforts to promote equitable access to digital technologies remain essential to ensure that all learners, regardless of their socio-economic background, have opportunities to develop advanced digital competences. Particular attention needs to be given to reducing digital divides, supporting vulnerable groups, and fostering inclusive learning environments where every student can participate fully in digital learning.

Policy frameworks would benefit from strengthening cooperation between schools, families, higher education institutions, industry, and civil society organisations to create a shared vision for digital education. By embedding functional perspectives into educational policies and long-term strategic planning, policymakers can help prepare learners not only to use technology effectively but also to engage critically, creatively, and responsibly in an increasingly digital world.

5 Conclusion

The Dialogue Clubs and piloting conducted within the Digital First project demonstrate the value of a functional approach to teaching and assessing informatics. Bringing together a wide range of stakeholders from different educational contexts created a rich space for reflection on how digital technologies shape children's learning, communication, creativity, relationships, and participation in society. The exceptionally positive feedback from participants confirms that collaborative dialogue can serve as a powerful mechanism for professional learning, community building, and the co-creation of innovative educational practices.

The findings reveal that children already engage with digital technologies across all seven functional dimensions identified by Halliday's framework. They use technology to express themselves, share information, build relationships, solve problems, create new content, explore ideas, and participate in digital communities. However, the Dialogue Clubs also highlighted important challenges, including unequal levels of digital competence, difficulties in assessing functional outcomes, the need for stronger critical thinking and digital literacy skills, growing dependence on artificial intelligence tools, and limited awareness of digital rights and responsibilities.

The recommendations developed through the Digital First project emphasise that effective informatics education should place meaningful activities, authentic communication, and real-world problem-solving at its core. Teachers need support to design learning experiences that integrate technical knowledge with creativity, collaboration, inquiry, and ethical reflection. Schools should establish organisational conditions that enable safe, inclusive, and innovative use of digital technologies, while parents and wider communities should be recognised as essential partners in supporting children's digital development.

The recommendations presented in this report advocate a shift from viewing informatics primarily as a collection of technical skills towards understanding it as a meaningful tool for communication, creativity, inquiry, problem-solving, participation, and responsible digital citizenship. A functional approach encourages educators to focus not only on what students know about technology, but also on how and why they use it in authentic contexts. This requires learning experiences and assessment practices that recognise diverse forms of digital expression, collaboration, innovation, and critical thinking. By embedding the seven functional dimensions across teaching, learning, and assessment, schools can better support the development of digitally competent, confident, and reflective learners. The recommendations offer practical guidance for teachers, school leaders, policymakers, and families to create learning environments in which informatics becomes a vehicle for purposeful action, lifelong learning, and active participation in an increasingly digital society.

Ultimately, the functional approach proposed by the Digital First project offers a framework for preparing young people not only to use technology but also to understand its role in their lives and society. By viewing informatics as a language for communication, creativity, inquiry, and participation, education systems can foster digitally competent citizens who are capable of navigating complex digital environments with confidence, critical awareness, responsibility, and purpose. The outcomes of the Digital First project provide both practical guidance and a foundation for future innovation in informatics education across Europe.

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