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Informatics and Constructionism for Transdisciplinary Teacher Training

Informatica e Costruzionismo per una Formazione Insegnanti Transdisciplinare

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ABSTRACT

Italy has recently reformed secondary school teacher training, introducing–for the first time–3 ECTS specifically dedicated to digital competencies. While these are traditionally approached from a technological and instrumental perspective, this position paper calls for a cultural shift, suggesting informatics as a foundational and transdisciplinary component of teacher education across all subjects. To address this need, the University of Trento introduced the Informatics for Learning course in its teacher training program. This paper examines the course design, implementation, as well as participants' reflections on potentially applying its content within their disciplines. Guided by a constructionist approach, the course emphasized active exploration and reflection, helping teachers understand how integrating informatics fosters critical thinking and metacognition. The paper highlights the transformative potential of informatics in teacher training and its importance for preparing educators for the challenges of a rapidly evolving digital society.

Keywords: Teacher Training, Informatics for Learning, Constructionism, Computational Thinking, Informatics.

RIASSUNTO

L'Italia ha recentemente riformato la formazione degli insegnanti delle scuole secondarie, introducendo per la prima volta 3 CFU specificamente dedicati alle competenze digitali. Mentre quest'ultime sono tradizionalmente affrontate da una prospettiva tecnologica e strumentale, questo documento propone un cambiamento culturale, suggerendo per l'informatica un ruolo fondamentale e transdisciplinare nella formazione degli insegnanti in tutte le discipline. Per rispondere a questa esigenza, l'Università di Trento ha introdotto il corso Informatics for Learning nei propri percorsi 60CFU. Questo documento analizza la progettazione del corso, la sua implementazione e le riflessioni dei partecipanti sulla possibile applicazione dei contenuti all'interno delle proprie discipline. Guidato da un approccio costruzionista, il corso ha enfatizzato l'esplorazione attiva e la riflessione, aiutando gli insegnanti a comprendere come l'integrazione dell'informatica possa favorire il pensiero critico e la metacognizione. L'articolo mette in evidenza il potenziale trasformativo dell'informatica nella formazione degli insegnanti e la sua importanza per preparare gli educatori ad affrontare le sfide di una società digitale in rapida evoluzione.

Parole chiave: Abilitazione all'Insegnamento, Pensiero Computazionale, Costruzionismo, Informatica, Apprendimento.

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1. INTRODUZIONE

In recent years, Italy has undertaken significant reforms in the training and recruitment of secondary school teachers, aligning with the objectives of the National Recovery and Resilience Plan (PNRR). A pivotal development in this context is the introduction of the "Percorsi 60 CFU" (60 ECTS training programs), established by the Decreto-Legge 36/2022. The structure of these programs is as follows:

- *Transversal courses* (24 ECTS): This component encompasses various areas, including pedagogical and didactic training, inclusive education, psychology/sociology/anthropology, school legislation, digital/linguistic competences.
- *Subject-specific didactics* (16 ECTS): assigned to didactical methodologies related to the specific subject area of the teaching qualification.
- *Supervised teaching practice* (20 ECTS): Direct teaching practice in schools and indirect activities, such lesson planning and reflection on teaching experiences.

Beyond completing a restructuring process that had been stalled for years, this reform represents a significant milestone as it marks the first integration of digital competencies into Italian pre-service teacher training programs across *all* subjects. After numerous yet fragmented efforts to enhance digital skills among in-service teachers, the inclusion of up to 3 ECTS credits dedicated to this topic in the broader framework of the transversals courses marks a major step forward. It provides prospective teachers with an opportunity to reflect on the role of digital literacy in schools, embedding it within a wider discussion on pedagogical principles and fostering a more cohesive and progressive approach to teacher education.

In July 2024, the University of Trento started to offer 14 specialized training programs aligned with Italy's teaching subjects ("classi di concorso"), preparing future educators to teach at both lower secondary (grades 6–8) and upper secondary (grades 9–13) levels. These programs encompass a broad spectrum of disciplines, including humanities (Literary Subjects, Latin, Philosophy, and History), languages (English and German), and STEM fields (Mathematics, Physics, Natural-Chemical- Biological Sciences, and Computer Science).

To meet the digital competencies requirement, a cross-disciplinary course titled *Informatics for Learning* was established as a mandatory component for participants across all fields, from the humanities to the sciences. The choice of the term "informatics" and the decision to link it to "learning" is motivated by our perspective on the role of digital technologies in schools, one that views the informatics not merely as a technological aid for teaching, but as a foundational component of a broader educational framework.

1.1. Position statement

Inspired by a constructionist foundation rooted in the work of Seymour Papert (1991), *we advocate for incorporating informatics as an essential topic in teacher education*. This approach not only addresses the need for technological proficiency but also drives a cultural shift that positions informatics as an essential component of learning in today's digital age. Informatics must be no longer seen merely as a technical tool but as a lens through which students and educators can understand, critique, and shape the increasingly interconnected digital world.

The goal of this paper is to promote a transdisciplinary approach to teacher education that prepares educators to navigate the rapid social and technological transformations shaping contemporary society. By embedding informatics into teacher training, we aim to empower educators to design meaningful, interdisciplinary learning experiences that are relevant to students' lives and futures. This requires cultivating a mindset among teachers where informatics transcends individual disciplines, serving as a unifying framework that connects diverse areas of knowledge and pedagogy.

As informatics and technology continue to influence every aspect of society - from communication and work to civic engagement and cultural expression - the need for educators who deeply understand these dynamics has become increasingly urgent. Our implementation of digital competence credits serves as a pioneering model for teaching informatics across all subjects, demonstrating its potential to support critical thinking, problem-solving, and metacognitive skills. These are not just technical competencies but essential tools for fostering active, informed, and engaged citizenship in a rapidly evolving world.

1.2. Structure of the paper

To substantiate our position statement, Section 2 explores the theoretical framework underlying the Informatics for Learning course and provides an overview of the main themes addressed during the lectures. The constructionist approach (Papert, 1990) served not only as the conceptual foundation but also as the methodological backbone of the course. Participants engaged in hands-on, interactive, and introspective activities designed to encourage reflection on how informatics - particularly through foundational competencies such as computational thinking (Wing, 2006; Wing, 2011) - can support higher-order thinking skills, including problem-solving, decision-making, and metacognition (Yadav, 2022; Montuori *et al*., 2024). This approach allowed us to collect participant feedback throughout the course to understand their views on digital technologies. Section 3 analyzes this feedback to assess initial perspectives and identify any shifts. Finally, Section 4 presents conclusions, offering recommendations for future iterations of the course, discussing opportunities for further research.

2. THEORETICAL FRAMEWORK

2.1. Technological Pedagogical Content Knowledge

To help participants situate information technology and informatics within their specific disciplines, we adopted the Technological Pedagogical Content Knowledge (TPACK) model (Koehler & Mishra, 2009) as a guiding framework. TPACK identifies three core domains of teacher knowledge - technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) - and highlights the critical intersections between these domains (Figure 1).

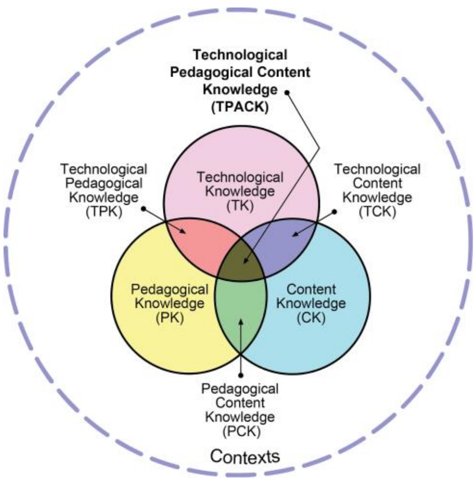

Figure 1 - The TPACK framework

While training programs for both pre-service and in-service teachers are often limited to building competencies in the TK domain (general digital skills) or the TPK domain (knowledge of digital tools to enhance teaching), we focused on the TPACK intersection as a lens to conceptualize informatics not only as a technological tool but as a an integral element of the teaching and learning practices in each respective discipline. This perspective aligns with the observations of Mishra, Koehler, and Kereluik (2009), who highlighted that much of educational technology innovation has focused on the tools themselves rather than exploring how technology fundamentally could shape the teaching and learning of specific subjects.

TPACK, by contrast, encourages educators to develop flexible and sustainable knowledge frameworks not tied to the unique features of any specific technology. Instead, it anchors them in essential principles of effective teaching and learning, empowering teachers to use technology to enhance pedagogy and deepen subject understanding.

2.2. Informatics as a medium for thinking

Moving beyond the view of information technology as merely a tool, the next step is to conceptualize what informatics is and the role it can play in learning. We use the term 'informatics' because it conveys a broader perspective than information technology, framing it as a scientific discipline with its own epistemology. Our definition aligns with Denning's (1999) notion of "computing":

"*The body of knowledge of computing is frequently described as the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application*".

This view emphasizes the deep connection between informatics and information, presenting informatics as a discipline that structures and transforms how we understand and interact with information, posing itself as a distinct medium. To frame the relation between informatics, humans and knowledge we embrace Borba and Villareal's (2005) concept of "humans-with-media" that overcomes the dichotomous division between humans and technology, instead prompting a blended vision. More specifically, they refer to Lévy's (1993) notion of *thinking collectives* to emphasize that knowledge is a product of collectives composed of human and non-human actors, and that each new media allows for a reorganization of thinking that in turn allows for new knowledge.
Applying this perspective in our context, the course challenges the conventional boundary between humans and technology, instead suggesting that they can work together in generating knowledge. Borba and Villareal argue that information technology (or, in Levy's word, technology of intelligence) should be seen as an active participant in cognitive and learning processes, not just a tool. With this perspective, the course encourages educators to view informatics as an integral part of educational practice and cognitive development. Just as writing expanded the scope of human memory and reasoning (Levy, 1993), informatics can facilitate innovative approaches to problem-solving and interdisciplinary exploration, supporting future teachers in cultivating a comprehensive view of education and preparing students for life as engaged citizens in a digital society.

2.3. Constructionism

Papert's theory of constructionism provides a concrete educational approach that aligns with the blended view of humans and technology as co-constructors of knowledge (Papert, 1991; Kafai, 2006). Papert's constructionism emphasizes learning through active creation, where students engage in meaningful projects that connect with their personal experiences and facilitate deeper understanding. It is the ideal method to encourage educators to integrate informatics as an interactive, reflective discipline rather than a static tool. By doing so, informatics is presented not only as a medium for cognitive development but as a dynamic partner in the educational journey, offering a new dimension for exploring problem-solving, creativity, and collaboration (Israel-Fishelson *et al*., 2022).
Papert's constructionism expands on constructivist principles by adding two critical elements: learning becomes especially powerful when students actively create meaningful artifacts for themselves or their communities, and technology serves as a key facilitator in this creative process (Ackermann, 2001). This approach goes beyond mere information absorption; it engages students in constructing mental models through interaction with "objects to think with"—whether concrete or

abstract. Constructionism thus positions the computer as a valuable partner in knowledge generation and the development of critical, reflective thinking. This approach embodies Borba and Villareal's blended vision, cultivating a classroom culture where informatics forms the foundation for innovation, creativity, and interdisciplinary exploration.

In his influential book *Mindstorms*, Papert (1980) shares how his fascination with gears as a child laid the foundation for understanding complex mathematical concepts like proportions, fractions, and even differential equations. Gears became a personal "object to think with," providing a tangible model that helped him grasp ideas that would otherwise remain abstract. This personal connection is essential to Papert's theory: learning is both a cognitive and affective experience. When students find objects that captivate them, they are more likely to engage deeply and personally in the learning process.

The modern equivalent of Papert's gears, according to him, is the computer. Unlike gears, which have limited applications, the computer serves as a flexible, universal medium capable of representing and simulating a vast array of systems and concepts. This versatility allows students to explore and understand complex ideas in dynamic ways. Far from being a mere tool for calculation, the computer is a "Protean machine," embodying limitless potential for learning. It allows learners to become explorers, testing their ideas and seeing immediate results, fostering a cycle of action, feedback, and refinement. This immediacy supports iterative learning, where students are encouraged to experiment, make mistakes, and adjust their approaches. Papert's constructionism calls for a fundamental shift in traditional teaching. Instead of transmitting ready-made knowledge, teachers in a constructionist framework create conditions that encourage students to explore and discover on their own. The teacher's role is to offer tools and experiences that guide learners in building their understanding actively. Through this process, students experience learning as an exploratory journey, where each step is a self-directed opportunity to deepen their knowledge. These ideas are exemplified in the "*8 Big Ideas*" of constructionism[1], summarized in Figure 2:

1. *Learning by Making*: True understanding comes from creating something meaningful. This is especially powerful when learners engage with challenges or projects that matter to them.
2. *Technology as Expression*: Used effectively, technology is a medium for personal expression and creativity, allowing learners to construct and interact with their creations in new ways.
3. *Hard Fun*: The best learning experiences are challenging yet enjoyable, sparking persistence and interest, even in the face of difficulty.
4. *Reflection on Learning*: Students should be encouraged to think about how they learn, fostering meta-cognition in acquiring new knowledge.
5. *Time to Explore*: Rather than following a tightly controlled schedule, learners benefit from extended time to engage deeply with complex tasks, nurturing patience and independence.
6. *Valuing Mistakes*: Mistakes are essential to progress. By analyzing errors, students develop resilience and an understanding that success often requires trial and error.
7. *Modeling Lifelong Learning*: Teachers should exemplify continuous learning, showing students that learning is a nonlinear, iterative process.
8. *Preparing for a Digital World*: Digital literacy is as crucial as traditional literacy in today's world. Understanding how technology works empowers students to learn more effectively and prepares them for future challenges.

[1] https://www.stager.org/articles/8bigideas.pdf

Constructionism offers a powerful framework for teachers to consider: it positions students not as passive recipients of knowledge but as active creators in their learning. By embracing constructionist principles, teachers can explore the transformative role of technology, particularly computers, in the classroom, discovering new ways to support students as they build, reflect, and connect learning with their own experiences in an increasingly digital world.

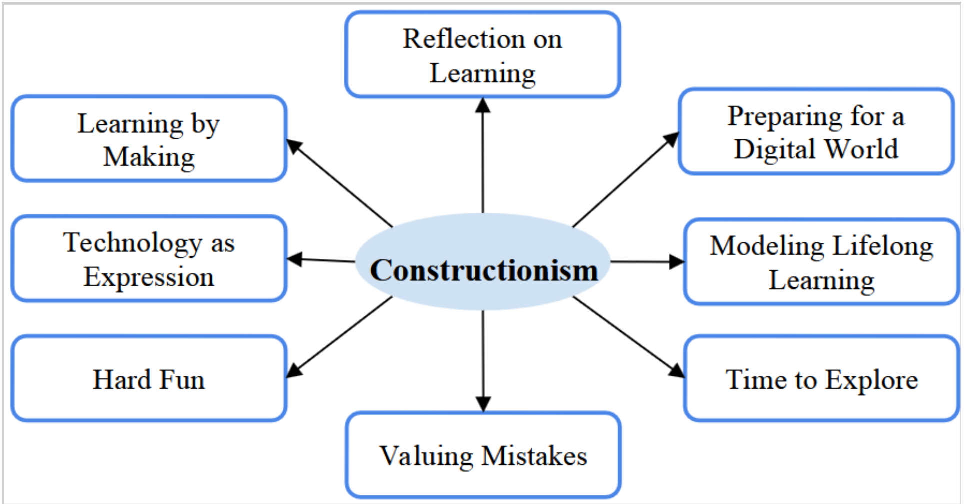

Figure 2 - The 8 key concepts of constructionism in our vision

2.4 Computational Thinking

At the heart of this transformation lies the challenge of identifying the core epistemology of informatics and how it can be applied across disciplines. This is where *computational thinking* (CT) becomes essential. Defined by Wing (2006) as the mental process of *formulating a problem* and *expressing its solution* in such a way that it can be effectively carried out by an *external agent*, whether that agent is a computer, a human, or a combination of both.

The act of *problem formulation* is deeply connected to the constructionist idea of creating something personal and meaningful. In CT, formulating a problem is not merely a technical task - it requires learners to reflect on their own understanding, reframe challenges in ways that resonate with their context, and build solutions that are uniquely their own.

In CT, *solving problems* involves several interconnected components: decomposition, abstraction, pattern recognition, algorithm development, and debugging. While these skills are traditionally associated with computing, their applications extend well beyond the realm of logical reasoning. CT encourages methodical problem-solving approaches, requiring learners to break down complex challenges into manageable parts, identify underlying patterns, and construct structured, sequential solutions. These practices not only build computational proficiency but also foster a systematic, transferable problem-solving mindset applicable across disciplines and contexts. In this light, CT emerges not only as a cornerstone of informatics but also as a transferable skill set that transcends disciplinary boundaries, fostering problem-solving and critical thinking abilities applicable to a wide range of contexts (Bocconi *et al.*, 2022). By integrating CT into the constructionist framework, educators can empower students to engage with informatics as a tool for inquiry and innovation, shaping how they learn and interact with the world around them.

The requirement for the solution to be *executed by a third agent* highlights the importance of reformulating the problem and translating solutions into actionable steps. This process necessitates a problem-solving approach grounded in the principles of syntax, semantics, and structure. This critical aspect creates a strong connection between computational and linguistic skills in education, offering opportunities for interdisciplinary applications across both humanities and sciences.

The integration of informatics into learning and problem-solving can be approached by reflecting on the solution process, deliberately incorporating linguistic elements, considering the role of the solution executor, emphasizing interaction, and addressing complexity through strategies like error analysis and decomposition. This reflective and systematic process engages metacognition and higher-order thinking skills (HOTS), significantly enhancing the quality and depth of learning (Paludo and Montresor, 2024).

In recent years, researchers have increasingly focused on the intersection of digital skills, critical thinking, and metacognition in teacher training, with "digital skills'" broadly defined as the ability to use digital tools (e.g., Fedeli, 2022). However, less attention has been given to the role of informatics and computational thinking as core topics for teacher education, despite their alignment with Competence 3.4 (Programming) and Competence 4 (Problem Solving) in the DigComp 2.2 framework (Vuorikari *et al*., 2022), which encompasses a wide range of digital competencies. However, within this framework, we consider computational thinking to be one of the most critical components. At its core lies the interplay between programming, linguistics, and metacognition—a powerful triad that, when nurtured together, provides a robust foundation for problem-solving. Computational thinking facilitates structured approaches to tackling complexity, linguistic skills enable precise communication of solutions, and metacognition fosters awareness and adaptability in the learning process. Together, these interconnected skills not only improve problem-solving but also develop transferable strategies applicable across diverse disciplines and contexts, ultimately elevating the depth and quality of learning experiences.

2.5 Artificial Intelligence (AI)

A final theme of the course is the role of artificial intelligence (AI) in education. The rise of powerful large language models (LLMs) accessible to all has brought both significant challenges and opportunities to the educational landscape (Manyika et al., 2019). A course dedicated to the role of informatics in education would be incomplete without addressing this pivotal topic.

Current efforts to integrate AI into education typically follow two main directions: *AI Literacy* (AIL) and *AI for Education* (AIED). AIL focuses on equipping students with metaknowledge about how AI functions, enabling a conscious, informed, and ethical use of the technology. This involves teaching students not only how to interact with AI but also to critically evaluate its outputs and understand its implications. In contrast, AIED emphasizes leveraging AI tools to enhance teaching and learning processes, addressing both pedagogical and instrumental needs (Ranieri et al., 2023). Examples of AIED applications, as identified by Ranieri et al., include smart tutoring systems, personalized content recommendations, and adaptive learning platforms that tailor experiences to individual learners' needs.

From our perspective, AI serves as a perfect "*object to think with*" (Papert, 1990), aligning seamlessly with constructionist approaches to education. Beyond being a tool for automation or efficiency, AI offers a conceptual and practical framework for learners to engage in meaningful problem-solving, foster creative exploration, and develop metacognitive skills. Its value lies not only in its functionality but also in its ability to inspire curiosity, encourage reflection, and promote critical thinking about its inner workings and broader applications. By interacting with AI, learners are invited to experiment, iterate, and explore, making it a medium for active discovery and self-directed learning.

This constructionist approach reframes AI from being merely a tool for delivering knowledge to a catalyst for deeper thinking and collaboration. By positioning AI within this framework, the course highlights its potential to transcend automation, empowering learners to think critically, construct meaning collaboratively, and reimagine the possibilities of education in the age of AI.

3. THE "INFORMATICS FOR LEARNING" COURSE

The course's first edition was held over two weeks between August and September 2024, encompassing four sessions that blended lectures with hands-on activities, totaling 18 hours. The first three sessions, led by a researcher in informatics education, introduced the themes listed in the previous section and encouraged participants to explore its connections across humanities and sciences. The final session, led by an educational researcher, focused on the instrumental use of digital technologies in education.

Due to the gap between the new and previous qualification processes, almost the totality (99%) of the 206 participants were already experienced teachers, averaging 6.3 years in the profession (SD = 3.6), with 16% having over a decade of experience.

At the end of the course, participants were required to submit an essay based on the following task:

> *"In group, write a critical essay analyzing the applicability of the knowledge acquired during the course to your discipline, including:*
>
> - *concrete proposals on how to apply the methods and technologies learnt, in the form of activities to be carried out in class or exercises to be proposed at home; concrete examples are welcome;*
> - *or a reasoned reflection on why what has been proposed is not suitable for one's own disciplinary context"*.

To exploit the heterogeneity of the group and value each individual's experience, each lecture was characterized by a constant interaction with the participants. During the first two sessions, we used Google Forms (GF) to collect as many authentic points of view as possible and at the same time to be able to observe perspectives' changes. Participants who agreed to contribute provided pseudo-anonymized responses using self-generated codes. The GFs were administered both synchronously in the classroom and asynchronously between sessions (see Figure 3). The collected answers constituted the incipit and initial hook for continuing with the subsequent lecture.

3.1 Content and Approach

The first session of the course was designed to set the scene: through a combination of direct instruction, live questionnaires, discussions on the answers, and hands-on activities, participants were encouraged to reflect on their view on informatics, both broadly and within their specific disciplines, while also introducing key concepts like constructionism and computational thinking. This introductory lecture was particularly valuable for involving participants from both sciences and humanities fields equally, ensuring even initially hesitant individuals felt included and involved. The second session focused on AI and consisted of two parts. The initial one was dedicated to a brief historical overview, a spotlight on some key technical information, and a presentation of different LLMs. In the second part, participants engaged in group discussions about the possible role of AI in different disciplines and hands-on activities where they were asked to design a teaching proposal that would help students use AI to take the initiative in their own learning. The third lecture was completely dedicated to hands-on activities with Scratch, while the last one served to provide a broad overview of digital tools for education.

To facilitate and encourage discussions during the first two lectures, eleven questionnaires (via Google Form) were introduced (Figure 3). These were designed primarily to actively engage participants and stimulate meaningful dialogue throughout the sessions, rather than to conduct a scientific analysis of the participants. Responses were collected in real time, with the data displayed and analyzed live to enhance interaction and support dynamic discussions. Nevertheless, the insights gained from these questionnaires merit further examination in this section.

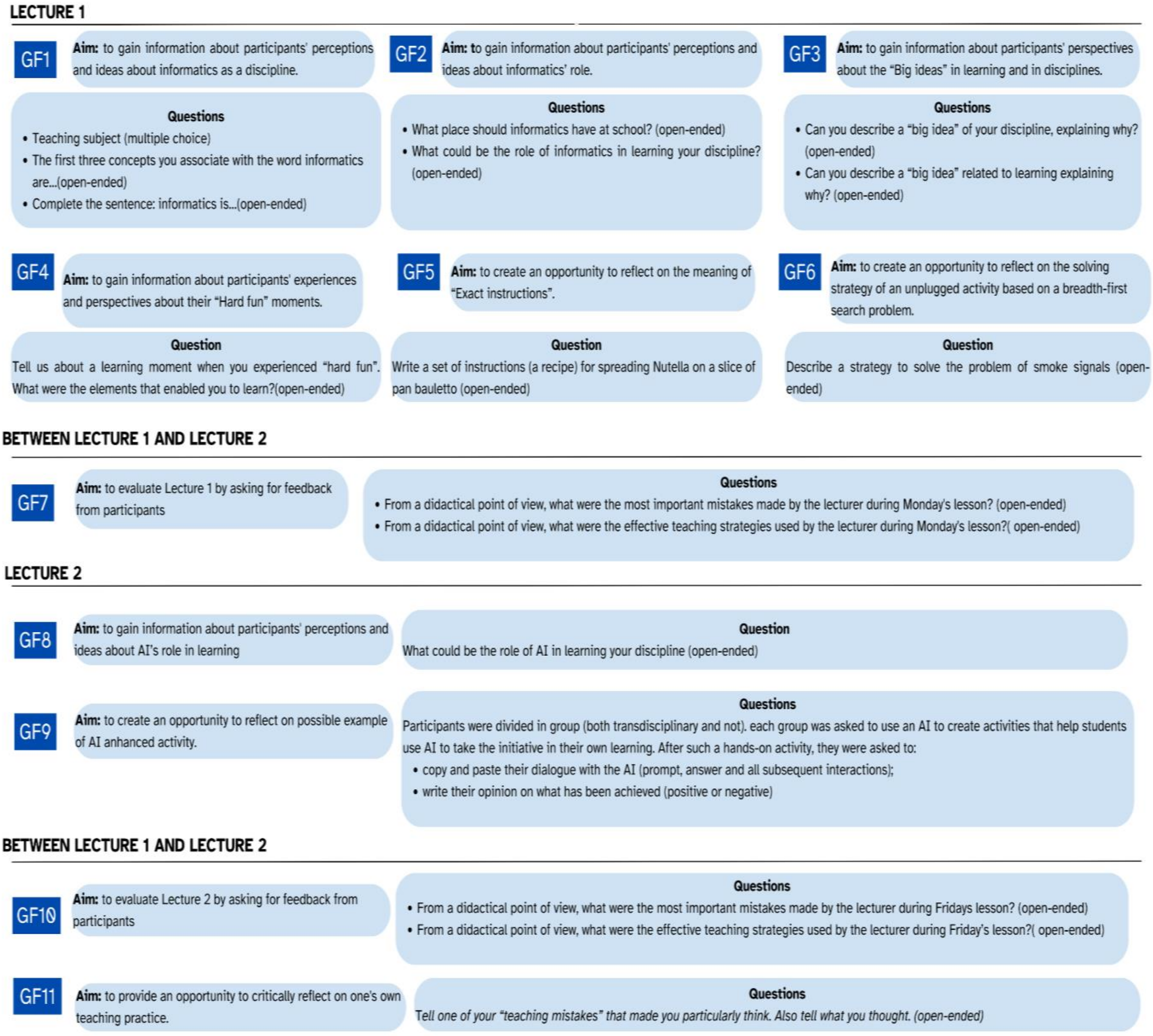

Figure 3. Content and structure of GF interactions

3.2. Analyzing participant views on informatics

The qualitative data collected were analyzed using thematic analysis (Braun & Clarke, 2022). To provide evidence supporting our position statement, we will rely mostly on the answer given in GF1 and GF2 during Lecture 1, in GF8 and GF9 during Lecture 2, and in the final essays. Initial data collected among participants in all teaching subjects (except Computer Science) revealed a prevalent view: informatics is perceived primarily as a technical skill rather than a foundational competency for all learners (see Figure 4, 5 and 6).

Figure 4: Concepts associated with the word *informatics* by 114 humanities and language teachers

Figure 5: Concepts associated with the word informatics by 59 STEM teachers (except Informatics)

Figure 5: Concepts associated with the word informatics by 12 Informatics teachers

This evidence highlights an underlying misconception that creates a gap in the traditional educational narrative - one that this course aims to address by reframing informatics as a cross-disciplinary skill that enhances both cognitive and creative abilities. Additionally, GF2, which collected 183 responses on perceptions of the role of informatics, provides further insight into this misconception. Regarding the role of informatics in schools (in general), some responses reveal a strong awareness of the need to integrate it as a distinct discipline across all types and levels of education. However, approximately 30% of the responses describe the role of informatics in purely instrumental terms, further reinforcing the prevalence of a widespread distorted perspective. The responses in GF2, which explored participants' view on the role of informatics within their respective disciplines, offer insights into how these perceptions are shaped by their domain of expertise. Among the 183 responses, only 17% attribute a supportive role to informatics in enhancing the learning process. In the remaining responses, informatics is seen primarily as a tool to support and facilitate teachers and teaching, rather than as a transformative element for student learning.

During the second part of lecture 2, GF8 asked teachers' their perspective on AI's role in their discipline's learning process. 23% of 128 answers presents a pessimistic (12 answers) or a neutral/ambivalent (17 answers) view. Each of the remaining 99 answers offers an optimistic point of view, giving also concrete examples of possible uses. Among the emerging perspectives, one of the most representative says "*It could be a form of verification of their language competence. [...] the more linguistically competent the children are, the more they will be able to use the tool. [...] Analysis of the AI's output can help learners to evaluate themselves and provide a stimulus for improvement.*" which depicts a constructionist use of prompting and output reading. Another instead puts higher emphasis on engaging with errors in a constructionist way by doing reverse-engineering "*In the reverse case, it might be useful to show the students the mistakes made by the AI in math and physics and to comment on them together, in order to teach them not to report uncritically the answers obtained; furthermore, again starting from the automatically generated answers, it might be useful to get the students to think about how they would modify/improve them.*" This highlights the shifts in perspectives and teachers making their own constructionist approach as well as the concept of reorganization of thinking in action enabled by informatics.

The 53 essays (see instructions in Section 3.1) produced for the final part of the course constitute the result of individual and group elaboration of the course's contents and experience. The interplay of visions, schematized in Figure 6, shows growing awareness on the value of informatics in bridging modern educational approaches and meeting the real-world's needs. Participants, through reports of designed and performed educational activities, advise how such involvement of informatics leads to learning as a dynamic and interactive process able to foster critical thinking and creativity in their students. The thoughtful integration of tools and approaches is shown to positively impact both students and teachers. By blending traditional didactic methods with this perspective on informatics, the learning process is enhanced in quality, fostering meaningful engagement while preserving the integrity of the curriculum. Digital tools, AI and programming are reported and demonstrated by numerous in-class experiences to promote interdisciplinary collaboration and to elicit active involvement of students in this learning journey. At the same time, teachers benefit from these approaches and endorse their fundamental role in promoting holistic and responsible use of tools and methods they present.

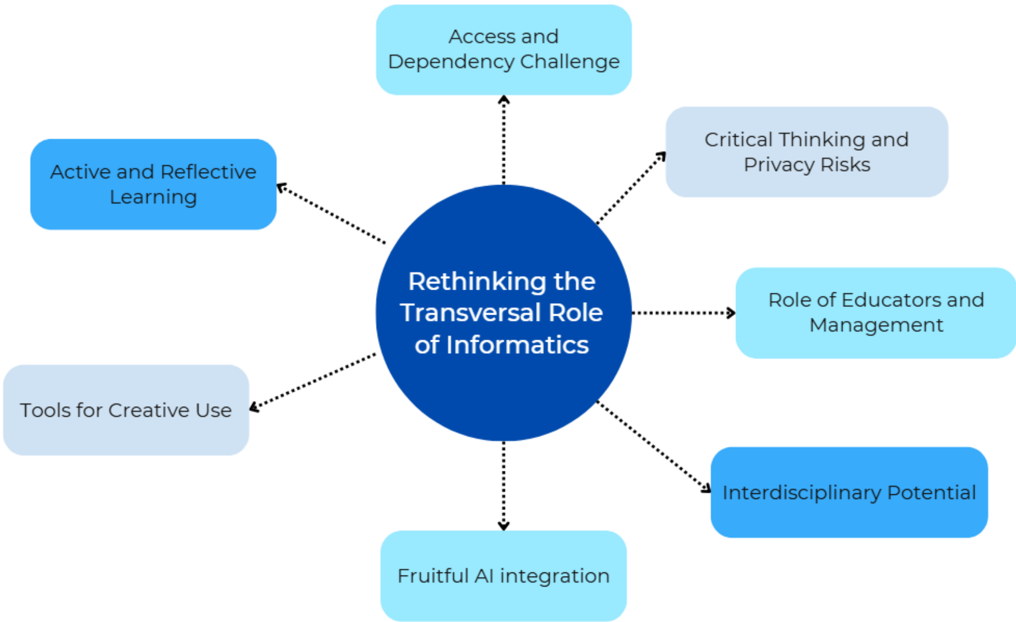

Figure 6: Recurring themes from final essays analysis

4. CONCLUSIONS AND RECOMMENDATIONS

The Informatics for Learning course represents a significant advancement in teacher training, demonstrating how informatics can serve as a transformative, interdisciplinary tool for both learning and teaching. By fostering a more comprehensive integration of informatics into educational practices, this approach extends beyond the digital competencies typically addressed in the DigComp 2.2 Framework (Vuorikari *et al.*, 2022) and the Digital Competence Framework for Educators DigCompEdu (Redecker, 2017), or listed in recent scoping reviews about digital competences and teacher training in Italy (Fedeli, 2022). By integrating informatics into pedagogical practices, educators can engage students more effectively, foster critical thinking, and develop problem-solving skills essential for navigating a digital society.

To maximize the course's impact, future iterations should strengthen the connection between informatics and specific subject areas. This can be achieved through a combination of joint sessions that foster collaboration among all teachers and separate sessions tailored to the unique needs of humanities educators on one side and STEM educators on the other.
The course's outcomes underscore the urgency of integrating informatics into teacher training programs universally. Informatics, viewed not merely as a technical skill but as a foundational framework for interdisciplinary learning, equips teachers to navigate and address the challenges of an increasingly interconnected and digital world. Including informatics as a core component of both pre-service and in-service training ensures that educators can cultivate digital literacy, critical thinking, and creativity in their students. By championing informatics as a transdisciplinary medium, this program provides a compelling model for modernizing teacher education and aligning it with the demands of a rapidly evolving society. Its broader adoption will empower teachers and learners alike, fostering innovation, adaptability, and a culture of continuous learning in education.

The implementation of this course opens several avenues for future research, including longitudinal studies to evaluate the long-term impact of informatics education on teachers' practices and students' learning outcomes. Particular attention could be given to how informatics shapes students' metacognition, creativity, and collaborative problem-solving across disciplines.

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REFERENCES

Ackermann, E. (2001) Piaget’s constructivism, Papert’s constructionism: What’s the difference? *Future of learning group publication*, 5(3), 438.

Borba, M. C., & Villarreal, M. E. (2005). *Humans-with-media and the reorganization of mathematical thinking: Information and communication technologies, modeling, visualization, and experimentation*. Springer.

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE.

Cruz-Benito, J. (ed.) (2022). *AI in Education*. MDPI, Basel, Beijing, Wuhan, Barcelona, Belgrade, Manchester, Tokyo, Cluj, Tianjin.

Denning, P. J. (1999). *Computer Science: The Discipline*. Retrieved from https://denninginstitute.com/pjd/PUBS/ENC/cs99.pdf

Fedeli, L. (2022). A Multidimensional Perspective on Digital Competence, Curriculum and Teacher Training in Italy. A Scoping Review on Prospective and Novice Teachers. In: Tomczyk, Ł., Fedeli, L. (eds), *Digital Literacy for Teachers. Lecture Notes in Educational Technology*. Springer, Singapore.

Israel-Fishelson, R., & Hershkovitz, A. (2022). Studying interrelations of computational thinking and creativity: A scoping review (2011–2020). *Computers & Education*, 176, 104353.

Kafai, Y. (2006) *Constructionism. In The Cambridge Handbook of the Learning Sciences*. Cambridge University Press.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? Contemporary Issues in *Technology and Teacher Education*, 9(1), 60-70.

Lévy, P. (1993). *As tecnologias da inteligência: O futuro do pensamento na era da informática* (C. da Costa, Trans.). Editora 34.

Manyika, J., Bughin, J. (2019). *The coming of AI.* Spring.

Mishra, P., Koehler, M. J., & Kereluik, K. (2009). The song remains the same: Looking back to the future of educational technology. *TechTrends*, 53(5), 48–53.

Montuori, C., Gambarota, F., Altoé, G., Arfé, B. (2024) The cognitive effects of computational thinking: A systematic review and meta-analytic study. *Computers & Education*, Volume 210.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. Basic Books.

Papert, S., & Harel, I. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 1-11). Ablex Publishing Corporation.

Paludo and Montresor (2024) Fostering Metacognitive Skills in Programming: Leveraging AI to Reflect on Code. *2nd International Workshop on Artificial Intelligence Systems in Education*, Bolzano, Italy 25-28 November 2024

Ramón, García-Perales., Ascensión, Palomares-Ruiz. (2020). Education in Programming and Mathematical Learning: Functionality of a Programming Language in Educational Processes. *Sustainability*, 12(23).

Ranieri, M., Cuomo, S., Biagini, G. (2023). *Scuola e Intelligenza Artificiale: Percorsi di Alfabetizzazione Critica*. Roma: Carocci.

Redecker, C. (2017). European Framework for the Digital Competence of Educators: DigCompEdu. Luxembourg: Publications Office of the European Union.

Resnick M., Maloney J., Monroy-Hernández A., Rusk N., Eastmond E., Brennan K., Millner A., Rosenbaum E., Silver J., Silverman B., and Kafai Y. (2009). Scratch: programming for all. *Commun*. *ACM* 52, 11 (November 2009), 60–67

Richard, Noss., Celia, Hoyles. (2017). *Constructionism and Microworlds*. 29-35.

Vuorikari, R., Kluzer, S. and Punie, Y. (2022). DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and *attitudes*. Luxembourg: Publications Office of the European Union.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33–35.

Wing, J. M. (2011). Research Notebook: Computational Thinking-What and Why. *The Link Magazine*, 20–23.

Yadav, A., Ocak, C., & Oliver, A. (2022). Computational Thinking and Metacognition. *TechTrends*, 66(3), 405–411.

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