Manu Ahedo Santisteban
Professor | Universidad Rey Juan Carlos (Spain) | manuel.ahedo@urjc.es

Stefanos Armakolas
Laboratory Teaching Staff | University of Patras (Greece) | stefarmak@upatras.gr

Alexandra Gössl
Center for Learning System Design Staff | University for Continuing Education Krems (Austria) | alexandra.Goessl@donau-uni.ac.at

Anthi Karatrantou
Laboratory Teaching Staff, | University of Patras (Greece) | akarat@upatras.gr

Stefan Oppl
Full Professor | University for Continuing Education Krems (Austria) | Stefan.Oppl@donau-uni.ac.at

Christos Panagiotakopoulos
Professor Emeritus | University of Patras (Greece) | cpanag@upatras.gr

Alessandra Romano
Associate Professor | Department of Social, Political and Cognitive Sciences | University of Siena (Italy) |alessandra.romano2@unisi.it

Teresa Torres-Coronas
Professor | Universitat Rovira i Virgili (Spain) | teresa.torres@urv.cat

Rethinking Adaptive Teaching for Inclusion in Higher Education. A methodological framework

Ripensare l'insegnamento adattivo per l'inclusione in Higher Education. Un framework metodologico

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ABSTRACT

The article explores the contribution of adaptive teaching principles to foster inclusive practices in HEIs. It deals with three main research questions: 1) What does it mean to teach adaptively? 2) How could professors adapt digital tools to the educational needs of students? How could professors adapt assessment tools to students' needs? To provide practical examples about teaching adaptively, the arguments are grounded in the results emerging from the exploratory qualitative phase of the biennial research project T.E.S.T. - Technology for STEAM Teaching.

Keywords: Inclusion | Adaptive teaching | Transformative Practices | Professional Development | Faculty

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Corresponding Author: Alessandra Romano | alessandra.romano2@unisi.it

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Credit author statement: The article is the harvest of two years of discussions among the Co-Authors. Only for scientific reasons, it is worth to say that (a) the Co-Authors chose to follow the criterion of the alphabetical order by last name for the list of the Authors; (b) paragraphs 1. Introduction. Adapting (Methodological) Differences for Student (Multiple) Diversities, 2. Research Design, and 4. Conclusions. Why adaptive teaching matters for inclusive learning in HEIs are to be attributed to Alessandra Romano, paragraph 3.1. The profile of the Adaptive Teacher is to be attributed to Christos Panagiotakopoulos, Anthi Karatrantou, and Stefanos Armakolas, paragraph 3.2. Adapting tools and devices is to be attributed to Stefan Oppl and Alexandra Gössl, paragraph 3.3. Adapting evaluation is to be attributed to Teresa Torres-Coronas and Manuel Ahedo Santisteban.

1. Introduction. Adapting (Methodological) Differences for Student (Multiple) Diversities

Higher Education institutions (HEIs) are facing an unprecedented digital transition. The realm of online and distance learning of post-digital scenarios exacerbated disparity in students' achievements and participation in university classrooms. Students with learning disabilities and neurological disorders, indeed, found themselves too often left behind from the mainstream classes, especially when they had no access to compensatory tools (Ianes & Bellacicco, 2020). More attention has to be paid to explore the usage of digital technology to address student diversity and cultivate inclusive contexts (Visvizi et al., 2023). Digital technology plays a pivotal role in designing and implementing adaptation, personalization or individualization strategies for meeting the *students where they are* and engaging them in a meaningful and inclusive curriculum (Hardy, 2019).

Within this background, in Higher Education the number of students with intersecting dimensions of diversity and vulnerability is growing up, especially in STEAM disciplines (Science, Technology, Engineering, Arts, and Mathematics), usually characterised by highly technologically and digitally approaches (Pfeifer et al., 2020).

Despite this highly technologically and digitally density in STEAM courses, it exists an institutionalised *hiatus* between the research interest in strategies that advocate for student engagement and the "ordinary materiality" of everyday practices, where most professors remain sceptical about the feasibility of meeting the educational needs of all students in the classroom (Westwood, 2018). In this regard, when we mention "diversity" and "inclusion", we recognize that "inclusion has been conceptualised in many different ways" (Westwood, 2018, p. 1). We[1] do not refer only to special educational needs but broadly to a wide range of multiple dimensions that could intersect in student identity and positionality: different learning styles, disabilities, impairments, but also socio-economic differences and disadvantages, racial prejudices, gender inequality, unequal access to resources, just to mention the commonest ones (Westwood, 2018; Hardy, 2019). We deliberately adopt an intersectional lens (Collins, 2016; Nichols & Stahr, 2019) through which to analyse students' diversity: this intersectional perspective takes into account "multiple interacting system of power and oppression connected to mutually constructed social positionalities (culturally defined status categories, for example, race; gender; lesbian, gay; bisexual; transgender; queer plus+; economic class, dis/ability; nation, religion; age; ethnicity)" (Glover Reed et al., 2021, p. 151).

According to the conceptual framework presented here, we, as professors from different scientific backgrounds, were confronted with some *research questions*: How could we valorise the digital skills acquired during the post-pandemic scenario? What does it mean to teach adaptively? How could we adapt digital tools to the educational needs of students? How could we adapt assessment tools to students' needs?

This article makes an effort in the direction of responding to those challenges. It proposes reflections for discussing adaptive teaching frameworks in HEIs that could foster inclusive practices. To provide practical examples about teaching adaptively, the arguments are grounded in the results emerging from the exploratory qualitative phase of the biennial research project *T.E.S.T. - Technology for STEAM Teaching*[2].

1 As co-researchers and co-authors, we belong to different scientific backgrounds: one author comes from the field of didactics and special education, two authors come from the ground of management studies, one author comes from computer science, two authors come from educational technology and STEAM education, and one author comes from social sciences. As an international, intersectorial group of scholars, we made the effort to challenge the "classic" vocabulary of research upon adaptive teaching, and to investigate multiple processes of learning enabled by teaching adaptively.

2 Project T.E.S.T. Reference Number: 2021-1-IT02-KA220-HED-000032085. See the project website for more information: https://project-test.unisi.it/

2. Research Design

2.1 The framework of the T.E.S.T. Project

This paragraph briefly mentions the overall structure of the T.E.S.T. Project. The *T.E.S.T. project* is a biennial research project funded by the European Commission[3].

The purpose of the project was to construct collaboratively a learner-centred instructional model for adaptive teaching in HE, with a main focus on STEAM disciplines. The project design consisted in three different but interconnected phases:

1. the first phase was an exploratory qualitative study on adaptive teaching and took almost the first year of the project;
2. the second phase was an action-research, which implied the development of
   a. a core curriculum for the adaptive teacher in HEIs,
   b. a methodological repertory of learner-centred digital devices, techniques, and assessment tools to facilitate adaptive learning, materialised in a toolbox, to be both elaborated and tested in each country of the consortium;
2. the third phase was a recursive testing, implementation and validation step, with the testing and the amelioration of the core curriculum and the co-creation of an interdisciplinary community of adaptive professors.

These last two steps are not completely sequential, but empirically and practically overlap from one step to another.

Figure 1. Research Phases of the T.E.S.T. Project

3 The university teams who played in the consortium of the project are: University of Siena (Italy); Academy of Fine Arts of Naples (Italy); University of Cote d'Azur (France); University of Patras (Greece); Università Rovira i Virgili (Spain); University of Krems (Austria); University of Zagreb (Croatia). The consortium also hosts technical partners, such as Conform (Italy), Eco (Spain) and EFMD (Belgium).

2.2 Methods and materials

In the article we choose to present only the reflections on adaptivity for inclusive practices. Consequently, we introduce the results emerging from the first qualitative phase of the project, leaving the articulation of the other two phases to other joint publications[4]. The first exploratory qualitative phase included two main steps:

– the conduction of a comparative national desk analysis carried out in seven different European countries (Italy, Spain, Belgium, France, Croatia, Austria, and Greece);
– the conduction of 27 focus groups carried out with faculty members and university students. Specifically, 9 focus groups were conducted with STEAM professors, 9 focus groups were conducted with STEAM students (bachelor's or master's degree students), and 9 focus groups were conducted with faculty with management and governance positions (such as Head of Department, delegate, coordinator of graduate or postgraduate programs).

In each country, data collection followed a similar procedure. Table 1 synthesises the articulation of the research design and the data collection procedure.

Research Design	Qualitative Exploratory Research (Creswell, 2015)
Research Questions	1. What is adaptive teaching in HEIs? 2. What are the characteristics of an adaptive teacher? 3. What does it mean teaching adaptively? 4. How to adapt digital tools to meet students' educational needs? 5. How to adapt tools for the assessment of the diverse students' learning?
National Desk Analysis* and *Literature Review	Selection of primary and secondary contributions, such as scientific articles and research reports, published between 2002 and 2022, using ERIC, SCOPUS, WoS, SBA, Google Scholar and EMBASE as search databases. *Keywords* for the research were: *Adaptive Teaching; Adaptive Teacher; Learning Methodology for Adaptive Teacher; Adaptive Teaching/Teacher in STEAM*. To be included in the Desk Analysis, contributions had to: (1) be written in one of the languages of the nations involved in the partnership, i.e. Italian, English, German, Spanish, Greek, French, Croatian; (2) present an empirical study or theoretical reflection on *Adaptive Teacher/Adaptive Teaching*; (3) explore the translation of *Adaptive Teaching/Adaptive Teacher* constructs into STEAM disciplines. N=74 contributions were selected. Among these, N=24 concern the Italian national context and N=7 concern the teaching of STEAM disciplines in the Italian context.
Data Collection Procedure and Methods	– 9 focus groups conducted with groups of 3 professors belonging to STEAM degree courses; – 9 focus groups conducted with groups of 3/4 students enrolled in STEAM degree courses; – 9 focus groups conducted with groups of 3 faculty members holding governance positions in STEAM Departments and Degree Courses (Coordinators of Degree Courses; Head of Departments; Teaching Delegates) The focus groups were video-recorded and transcribed ad verbatim.

4 A presentation of the T.E.S.T. project has already been published in several papers (see Romano, 2023; Romano, *et al*., 2023, or Panagiotakopoulos, & Karatrantou, 2023). Nevertheless, to avoid any risk of self-plagiarism, the Co-Authors declare that the structure of this article, the content of the paragraphs and the articulation of the results sections are completely original.

Data Analysis	The text corpus collected: – included the articles identified in the literature review and the transcriptions ad verbatim of the focus groups; – was subjected to thematic analysis with manual coding by the research team (Saldana, 2013).
Criteria for participants' selection	Participants were selected through non-probability and snowball sampling procedures, consistent with the aims of the research (Creswell, 2015).

Table 1: Data collection procedure (Romano, 2023)

As co-researchers, we carried out the focus groups according to a validated protocol. The protocol included the critical incident technique (CIT) to collect vivid depictions about a key incident that professors or students faced in online and hybrid learning. Informed consent was requested for each participant. Each focus group was approximately 45-min long, and was videorecorded and subsequently transcribed. We agreed on a common data analysis procedure: in order to emphasise the richness of the data collected, an iterative process of thematic content analysis was carried out manually from each research group (Saldana, 2013). We inductively analysed our data to describe what adaptivity looks like for professors and students facing the complexity and the uncertainty associated with post-digital teaching and learning. Each team had to produce two formats; the first one for presenting the results of the national desk analysis and the second one for the results of the thematic analysis based on the transcripts of the focus groups[5].

In the second phase of the research, all partners were involved in defining the content of the Open Educational Resources (OER) in the form of interactive educational videos. One of the OERs was «Diversity and adaptive teaching in STEAM laboratories - Focus on the classroom context and student needs», which focuses on the relationship between diversity, accessibility and adaptive teaching in laboratory settings in STEAM disciplines. The core curriculum - defined as a learning programme for faculty members in HEIs - has the pragmatic aim of providing an educational framework for developing the digital, methodological, designing teaching skills necessary to facilitate the learning processes of students in classroom and in laboratory settings. The last phase of the research project (PR3) was to design a methodological toolkit for the creation of adaptive learning experiences in online laboratories. The conceptual and methodological frameworks of this toolkit include the constructs of Inquiry Based Science Learning (IBSL), Online Problem-Based Learning (Giampaolo, 2021) and Learning Design (Dalziel, 2013).

The Learning Programme for faculty and the methodological toolkit developed were tested with groups of faculty members and cohorts of students in the universities involved in the consortium.

3. Results and Discussions

The pragmatic scope of the qualitative phase was to build a research-grounded profile of the adaptive teacher and a core curriculum for developing competencies in adaptive teaching, with a repertoire of learner-centred digital devices, techniques and assessment tools to facilitate adaptive learning. In line with this scope, the thematic analysis revealed themes that were classified into three main categories:

5 Methodological note. The article is a collective narrative that takes place within a network of interviews, stories, anecdotes, critical incidents, and examples, drawn from the empirical research material collected during the qualitative steps. These rich materials have been reworked to keep participants' confidentiality and anonymity. In the paper, we insert in italics the transcripts extracted from the interview, and adopt descriptive labels and progressive numbering to name the participants. All ethical aspects of the study were in compliance with the requirements of the Italian National Agency, which had approved the original research project.

1. *The profile of the adaptive teacher;*
2. *The adaptive tools;*
3. *The adaptive assessment.*

The following paragraphs discuss these three categories. The results are not offered as concepts to be understood, but as a framework of "becoming questions" that could provide an incitement to open up possibilities of inquiry to what has been previously foreclosed (Jackson & Mazzei, 2023). The paragraphs follow the intention to produce an "assemblage" of "becoming-questions" that could provoke new lines of inquiry about the unthought aspects of teaching adaptively for inclusion.

3.1 The Profile of the Adaptive Teacher

Research Questions: What is adaptive teaching? *What does it mean to teach adaptively?*

As co-researchers, we moved our first steps searching for a scientific definition of the constructs of adaptive teaching. The definitions of "adaptive teaching" available in the literature are multiple and often contradictory to each other. We rapidly came to the conclusion that any attempt to reconstruct the contributions that have delved into adaptive teaching and its implications for inclusive design is partial and reductive (Garavaglia, 2021; Marchisio, et al., 2019). It is a topic that gathers a plurality of disciplinary perspectives, from which numerous insights can be drawn, both theoretically and empirically. Our effort was to build "an assemblage" of definitions, which could provide readers with insights about its characteristics and declinations, taking into account the specific domains of the STEAM disciplines as exemplar cases. In Europe, in fact, teaching training courses addressing adaptive learning technologies and methodologies for student inclusion are lacking both in general and in the STEAM field (Pfeifer et al., 2020).

In this regard, STEAM professors are facing a wide range of difficulties and challenges concerning both pedagogical and technical issues as well as classroom and learning activities management. Often it is difficult to shape collaboration and teamwork culture among students and at the same time there is lack of adequate training in STEAM education and classroom management as well as lack of support from institutions. At university level studies in the areas of STEAM, professors are not sufficiently prepared to address classroom diversity (Torres-Coronas & Vidal-Blasco, 2019).

Research Questions: How can STEAM professors address student diversity in an adaptive and inclusive perspective?

Adaptive teaching emerges as an approach aiming at achieving a common learning goal with students whose prior knowledge, experiences, soft and hard skills, specific abilities or learning styles differ from the mainstream (Loughland, 2019). In such a procedure, different teaching strategies are applied to different groups of students so that any diversity in the classroom does not prevent any student from achieving the learning outcomes and succeeding.

Our empirical basis was offered by the analysis of the focus groups. According to them, a dynamic combination of practical and effective competences enables professors to face and handle difficulties and challenges in STEAM disciplines education. This combination embraces digital competences, modern approaches in designing and implementing educational activities, online tools and teaching approaches, as well as competences related to handling accessibility and adaptability in any situation and dimension, putting principles of active learning in a certain role. Participants in the focus groups outlined a profile of the "adaptive teacher" in HEIs in our continuously changing world as

"Circumstances and tools are constantly changing, so a teacher must learn to adapt to new conditions, new tools and the new needs of his/her students each time" (STEAM Professor n. 1).

At the same time "*a teacher must be 'as adaptable as possible', meaning that he/she should be so flexible that he/she needs to make the minimum adjustments to his/her teaching"* (STEAM Student, n. 1), and *"the teacher should have not only a deep knowledge of the subject he/she is called to teach, but a deep knowledge of the characteristics and needs of his/her students as well"* (STEAM Student n. 2). Today,

many efforts are made to support the multicultural, open, and constantly changing environment of our life at all levels. Professors to be inclusive in this world should be able *to "diagnose students' thinking, decide whether to pursue an unexpected tangent, to make on the spot decisions, to continuous monitoring of various events in class and deciding where to focus, to compromise a positive attitude towards diversity, to adopt educational mediation approaches, and formative evaluation"* (STEAM Professor n. 2).

To achieve these, they need "*knowledge and experience on models and concepts of individualization and differentiation in the classroom, perspectives on heterogeneity, diversity, multiculturalism, and gender* as well as *competences to develop instructional design dealing with diversity with a focus on co-teaching and research-based learning"* (STEAM Professor n. 3).

Allen, Webb, & Matthews (2016) explain that the human-centred constructivist paradigm of teaching and learning supports the process of adaptive teaching. This methodological choice foregrounds the relevance of how professors and students positioned themselves in an entanglement of bodies, artefacts, repertories of actions, and social practices of interactions. According to this constructivist vision of teaching and learning:

(a) students' learning is a result of the meanings they make of their experiences;
(b) the personalization of teaching involves connection to students' experiences and then providing physical and material spaces for students where they feel they can belong, express ideas, propose solutions, create new projects;
(c) the processes that learners practise in pursuit of knowledge and understanding are more important than simply accumulating facts.

Based on the focus groups, the functions and competencies of an adaptive professor derive from:

"*Two concepts are important: adaptability and flexibility. An adaptive teacher is one who is willing to get used to new situations and has a lot of patience. He/she must be willing to adapt*" (STEAM Professor n. 4).

"*Every teacher must recognise the need to be able to adapt to each situation, to apply alternative ways of teaching each time and to choose the appropriate methods to teach and assess his/her students, based on their needs and abilities*" (STEAM Professor n.5).

A professor in STEAM education should act as a *Facilitator* with competences related to pedagogy, content knowledge, use of content and tools, feedback and assessment and learner empowerment (see at this regard the TPACK-Framework, Koehler & Mishra, 2009). At the same time, he/she should work as a *Learning designer* being able to design course/curriculum/activities, as well as content and tools, and as a *Manager* managing the educational procedure and resources. He/she should be a *Community member* able to build and handle a community as well as to implement policies. He/she should be characterised by *Professional* competences related to transferable skills, digital skills and professional development. It is very important for him/her to be an *effective user of digital tools* in the classroom and laboratory (Spyropoulou & Kameas, 2021).

An adaptive professor should additionally be able to *Handle Diversity* (due to individuals' time of learning, self-paced learning, capacity, personality, sex, age, religion, culture, nationality, special needs, special abilities), *Handle and Support Accessibility* (for special needs, special abilities, disabilities, learning difficulties, emergency situations) and *Cultivate Adaptability* (to face complex problems, navigate ambiguity and unknown circumstances, adapt in new, difficult, and emergency situations).

Important strategies that contribute to the definition of adaptive teaching include integration of "*multiple discipline-based contents*, *focus on real-world problems and scenarios*, *use of collaborative methodologies to enhance students' participation*, *adoption of student-directed work*, *designing project-based instruction*, and *implementing problem-based inquiry learning"* (personal elaboration of the authors from the focus groups analysis). Tools technologically sophisticated as *Virtual* and *Augmented reality* as well as digital platforms and tools suitable to adapt to student progress are necessary to support adaptive teaching implementations (Allen, Webb & Matthews, 2016).

3.2 Adapting tools and devices

Research Questions:How can adaptive teaching benefit from the use of digital tools? How to adapt digital tools to students' educational needs?

Digital resources empower professors to tailor their lessons according to each student's needs, interests, and learning styles (Mead et al., 2020). This is especially significant as HEI faculty members in the pandemic perceived that they "*can't tell if the student is understanding, is paying attention, or is lost*" (STEAM Professor n. 6). Digital simulations, for instance, offer real-time feedback, aiding students in recognizing areas for improvement. Digital tools can also promote co-learning and mutual assistance during challenging learning situations. professors interviewed in the project were particularly in favour of adapting tools, as they emphasised that they "*have to be able to understand certain situations, to understand above all how to act, [and] to provide information and training in that sense*" (STEAM Professor n. 7).

In order to realise these benefits in the adaptive STEAM classroom, it is essential to align the provided tools with the subject-specific didactic designs and learners' collaboration necessities. Such decisions require robust theoretical foundations. Starting from the results of the project and searching for a robust theoretical apparatus that could enhance them, we consider relevant to make a link to Bloom's taxonomy (Bloom, 1956), which informs didactical design decisions, and Media Synchronicity theory (Dennis *et al.*, 2008), which can explain the technical support requirements in different collaboration settings.

Bloom's taxonomy provides a structure for thinking about the different levels of learning, from lower-order thinking skills to higher-order thinking skills, and guides the development of learning outcomes, personalised instructional strategies, and assessments (Bloom, 1956). The hierarchical framework consists of six cognitive levels:

1. Remembering: Recalling past knowledge;
2. Understanding: Interpreting information;
3. Applying: Utilising information in novel scenarios;
4. Analysing: Deconstructing information to discern relationships;
5. Evaluating: Judging information's value;
6. Creating: Innovating using information.

These levels, especially from "Applying" upwards, resonate with STEAM settings (Madhuri et al, 2012). HEI faculty members can utilise Bloom's taxonomy to ensure digital tools match the intended learning outcomes:

1. Higher-order skills can be honed using digital tools, such as machine learning, data analysis software or virtual simulations, which can help students apply, analyse, and evaluate information. These tools provide an immersive and interactive learning experience that supports the development of critical thinking and problem-solving skills.
2. Bloom's taxonomy can guide the selection of digital tools that support collaboration and communication among students and with other educators and experts. For example, online discussion boards or video conferencing tools can provide opportunities for students to share their ideas, insights, and perspectives with others.
3. The taxonomy can guide the selection of digital tools that offer immediate feedback to students on their progress and performance. This feedback can help students identify areas where they need additional support and practice and adjust their learning strategies accordingly. For example, online quizzes or interactive games can provide immediate feedback on student performance and help them reinforce their understanding of key concepts.

Faculty members participating in the Focus Groups said that they "s*hould be prepared with the proper tools and techniques above all others to adapt [their] course to emergency situations*" (STEAM Professor

n. 8). They need training "*both in the tools, as they are dynamic and constantly evolving, and in the ways in which professors will use these tools in education*" (STEAM Student n. 4).

To address the issue of selecting tools that not only fit the didactical requirements of an adaptive teaching setting, but also the communication and interactions setting in place, Media synchronicity theory (Dennis et al., 2008) can be used as an explanatory and guiding framework. Media synchronicity theory sheds light on selecting and adjusting digital tools for collaboration in adaptive learning settings. This theory underscores that communication technologies differ in synchronicity levels—how communication can be coordinated among learners. For optimal collaboration, tools should be chosen based on the learners' communication demands, granular learning objectives, and necessary synchronicity.

For example, video calls, providing high synchronicity and real-time communication, are apt for group deliberations and brainstorming. Conversely, discussion forums, which support time-lagged communication and thus have low synchronicity, suit reflection and peer reviews. So, a student explained what tool was useful in a particular subject: *"I also experienced videos as really helpful, especially in mathematics lessons, because I could repeat them. And for me, this was really helpful"* (STEAM Student n. 5).

It is also important to consider the affordances and limitations of digital tools when selecting them for an adaptive setting. For instance, some tools, in particular in the field of Augmented or Virtual Reality, may offer a high level of synchronicity but require a stable and high-bandwidth internet connection. Other tools may offer a lower level of synchronicity but may be accessible on a wider range of devices, such as smartphones or tablets. professors have to carefully evaluate the trade-offs between different tools and select the ones that best align with the communication and educational needs of the students. In accordance with this argumentation, a STEAM professor thinks that it is important to *"make clear what students are needing in this new way of learning"* (STEAM Professor n. 9).

Together, Bloom's taxonomy and media synchronicity theory are instrumental for constructing learner-centric adaptive courses. The former assists in shaping activities and evaluations targeting social and cognitive processes, while the latter aids in selecting communication tools, bolstering collaboration (Blaschitz et al., 2022).

In relation to the future of digital teaching, one professor emphasises the positive effects it could have: *"In general, I think we should stop thinking that digital environments and their utilisation is only related to special circumstances like pandemic and then we forget about them. For better or worse we should realise that they are part of our everyday life and our lives. I see and consider it a mistake that the use of such software and tools is reduced to a minimum when we return to teaching. I believe that we should keep their positives and continue to utilise them, as we can gain quite a bit from them"* (STEAM Professor n. 10).

So, by cohesively applying these frameworks, educators can engineer adaptive lessons and experiences, which engage students, stimulate critical thinking, and foster collaborative and inclusive mindset. Through deliberate alignment of activities with Bloom's levels and the right tool selection grounded in synchronicity requirements, professors can prepare the materialisation of a setting that allows for adapting to individual students' needs while at the same time facilitating collaborative work towards the intended growth outcomes.

3.3 Adapting evaluation

Research Questions: What is adaptive assessment? How to adapt assessment tools to students' diverse needs?

Traditional evaluation is facing a systematic transformation from the assessment of learning to assessment for learning, and to assessment as learning (Schellekens *et al*., 2021; Yang & Xin, 2022). Adaptive evaluation is closely linked to the last two concepts. It involves monitoring progress toward specific learning goals (assessment of learning) and encouraging students to take an active role in evaluating their own learning through dialogue and self-assessment (assessment for and as learning). In both cases, students

and professors need to be literate in assessment (Schellekens et al., 2021). Students should become self-regulated learners, and professors should have "*strong control over the learning environment (...) and be highly focused on student engagement and learning outcomes. Of course, all of this is part of the transformation of what assessment means*" (STEAM Professor n. 11). As students with special needs face disadvantages with traditional assessment systems (Hanafin et al., 2007), adaptive assessment offers adequate tools to create this inclusive learning environment that accommodates diversity.

Consequently, adaptive assessment exposes students' areas of weakness and enables professors to develop suitable strategies to assist the students in enhancing academic performance. It provides personalised assessments that cater to individual needs. Adaptive assessment is built on the fundamental principle of tailoring assessments to students' knowledge and skills while anticipating their evolving needs. It is a departure from the one-size-fits-all approach, allowing educators to adapt the evaluation process based on individual progress. This approach aligns perfectly with the core tenets of adaptive teaching, which emphasise critical thinking, problem-solving, and mastery of foundational concepts.

In adaptive evaluation, students acquire knowledge and develop the ability to apply it in real-world scenarios. By leveraging adaptive evaluation, professors can fine-tune their assessment strategies to estimate whether students are not only grasping course content but also cultivating the complex problem-solving skills. However, adaptive evaluation is not uniform for all students. There can be a significant variation in students' ability to acquire skills and succeed in using them for science learning (VanLehn, Chung, Grover, Madni & Wetzel, 2016). For that reason, "paying attention to the impact of assessment emphasis on whose success may provide one avenue to advancing equity in college-level science courses" (Raph *et al.*, 2022, p.1871).

From a student perspective, the learning process can be more important than the result. "*It is not just the result that counts, the whole process does*" (STEAM Student n. 7). In adaptive evaluation, the assessment evolves based on students' responses, gradually adapting to their skill levels. This dynamic approach is particularly effective in STEAM. It aligns with students' demands for "*dynamism and interaction in the learning process*" (STEAM Student n. 8) and with professors who can "*first identify the students' needs and then offer a course that accommodates varying levels of knowledge*" (STEAM Teacher n. 12) In this context, online-based formative assessment interfaces are appropriate tools for enhancing valuable interactions among instructors and learners (Pachler, Daly, Mor & Mellar, 2010) and learning performance and motivation (Jeong, González-Gómez & Prieto, 2020).

Some tools to put theory into practice

To choose tools that yield effective results, Sikora *et al.* (2020) recommend four criteria: functional compliance, compatibility, practicality and support. Some of the tools analysed in the *T.E.S.T.* project and that meet these criteria are:

1. *Computerised Adaptive Testing* (CAT). CAT tailors the assessments to each student's skill level, providing more challenging questions as they progress. This approach ensures that students are continually challenged at an appropriate level, stimulating learning. SIETTE and CONCERTO are versatile tools for assessment.
2. *Intelligent Tutoring Systems*. These systems employ artificial intelligence to simulate the role of a human tutor. Intelligent tutors guide students through complex problem-solving scenarios, adapting their instruction to individual needs.
3. *Tools for Constructing Models*. Hands-on experience and critical thinking are crucial skills in STEAM disciplines. DRAGOON helps students grasp complex concepts and improve problem-solving skills.

In the evolving landscape of inclusive education, adaptive evaluation is a dynamic approach that aligns with the core principles of personalised learning and mastery. By adopting adaptive evaluation methods, professors can nurture the problem solvers, the innovators, and the critical thinkers required to tackle the challenges of tomorrow's world.

4. Conclusions. *Why adaptive teaching matters for inclusive learning in HEIs*

The article addresses the topic of adaptive teaching: it intends to promote an emerging framework for teaching adaptively and accessible with much promise in terms of inclusive practices but not without its fair share of theoretical and methodological challenges. As co-researchers directly involved in the investigation processes, we tried to address these challenges with humility to invite journal readers critique. The exploratory study hereby described did not provide any "tokenism" or "magic formula" to promote and realise inclusive practices in HE through adaptive teaching: its objective was to contribute to the outstanding of the international scientific debate around how to develop adaptive approaches to teaching keeping in mind students' intersectional diversity and educational needs.

The purpose of the profile of adaptive professors and the framework for adaptive teaching is to provide a practical scaffold for those professors wishing to refine their practices and attitudes, so that they would be able to be critical with the excluding practices that still happen in online and in person classrooms. Adaptive teaching, indeed, has resulted more concretely as a practice-based endeavour than as a research construct (Loughland, 2019). Adaptive approaches translate into practice principles of the Universal Design for All perspective in HEIs, with the recommendation that *all* students, students with learning disorders, disabilities or espoused to marginality, get the opportunity to actively be engaged in their academic path and supported to make connections and overcome difficulties (Vaughn et al., 2016). The interactions of the factors that support adaptive teaching is visually summarised in Figure 1.

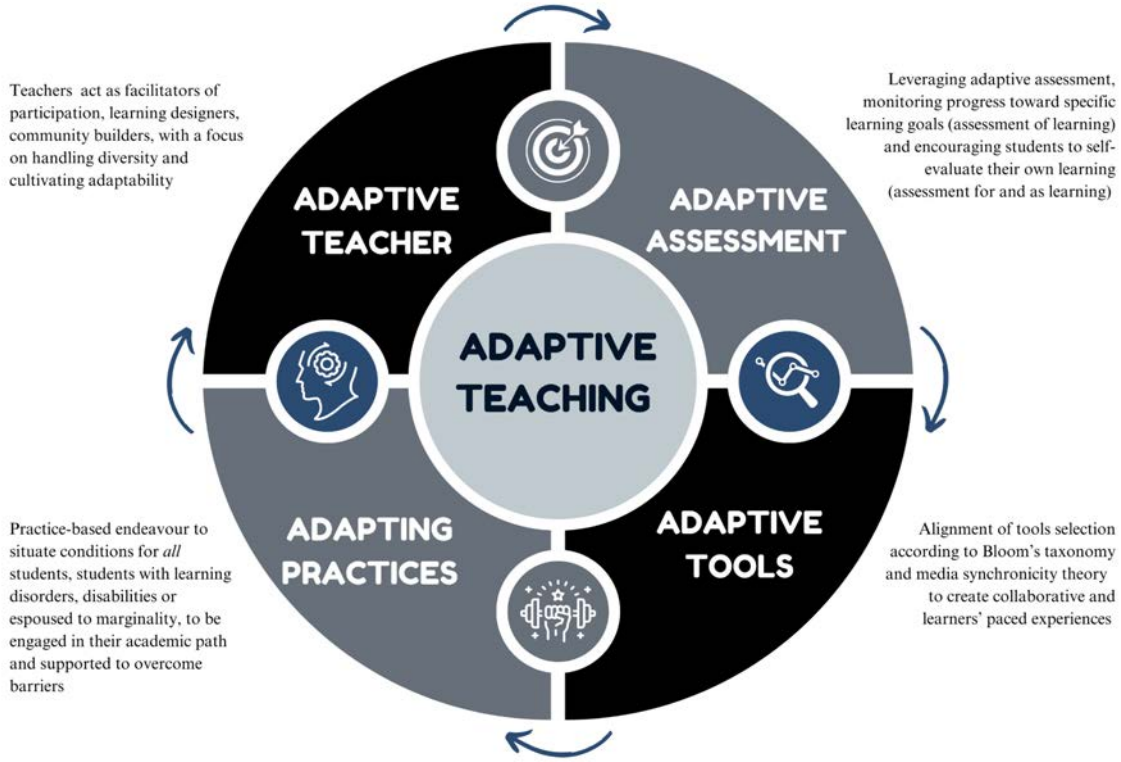

Figure 2. Visual representation of results of thematic analysis (Source: personal elaboration of the authors)

Limitations and Future Research

Epistemologically and methodologically, this article has some limitations. First, based on the *T.E.S.T.* project, we consider the definition emerging from the project as reductivist. Adaptive teaching aligns with student learning pace, helping them confront uncertain situations, imagine things done differently, and feel comfortable to try and make mistakes. Nevertheless, we recognize that the definition we provided

is rooted in humanistic, person-centred and dualistic (human and machine placed at two opposite poles) philosophy of learning. The anchor to the most recent scientific literature on situated transformative learning (Nicolaides, 2023; Marsick, & Faller, 2023; Fabbri & Melacarne, 2023) and intersectionality research (Glover-Reed *et al*., 2021), invites us to trouble the theoretical perspective with which we have carried out our research project and to recognize our blindspots as researchers in approaching the topic.

In our investigation, we kept a *humanistic* perspective which still perpetrates the dichotomy between human and not human, human and technology, human and artificial intelligence (Koro, 2022). We did not take into account the relational epistemology of humans in relation to not-human technological devices (Fabbri, & Melacarne, 2023). We assume that student learning can be fostered through the construction of an adaptive ecosystem, technologically advanced, highly personalised and flexible. We considered students as a *homogeneous* category of people: we did not deepen the implications of a situated perspective on student positionality, taking into account the effects of vulnerability and disadvantages produced by the intersections of such characteristics.

As researchers, our reflexivity guides us toward a more complex and intra-action attunement to a *post-humanistic* perspective (Fabbri, & Melacarne, 2023) on adaptive teaching, where subjects inquire and unfold the *unknown* and *not fore-known* implications of socio-technical complexity in teaching and learning processes (Koro, 2022; Nicolaides, 2023)[6]. Speaking about adaptive teaching recalls an ontological perspective on adaptivity, where learners and professors are not agentic subjects separated by their embodiment, their intercorporeality, and technologies are not neutral artefacts (Marsick, & Faller, 2023; Gherardi, 2023; Rautio *et al*.., 2021). The "*interrelation*" among people, both professors and students, artefacts, environment, materials, physical settings, human bodies should be at the core of teaching and learning adaptively. Examined through this lens, adaptive teaching practices are socio-technologically situated, with their materiality differentially marked by individual gender, race, class, age, sexual orientations, culture, and all other possible power signifiers (Rautio *et al*., 2022). A future trajectory of adaptation is to move beyond these critiques, searching for a more comprehensive and well-substantiated investigation of the enactment of adaptive teaching practices for inclusion of students with a complex and *not-a priori known* range of diversities.

Unforeseen challenges

Looking forward, we would offer insights for discussing unforeseen challenges for HEIs. In the actual post-digital scenario, as university professors we are daily confronted with expansions of datafication of knowledge exchange, which require adaptability to technologization and algorithmization (Marsick, & Faller, 2023). In January 2023, the introduction of sophisticated programs of open artificial intelligence brought a huge revolution in the consolidated ways of learning and searching for information. What is the impact of artificial intelligence on student learning? How and to what extent is artificial intelligence affecting the explicit and implicit curriculum in HEIs? How and to what extent does AI-pervasive learning impact curriculum accessibility and adaptation? Those open-ended questions affect all the academic disciplines and require deeper investigation processes with intersectional and intersectorial research approaches.

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