ATS STEM

Assessment of Transversal Skills in STEM

ATS-STEM Final Executive Report

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This research report has been developed within the framework of work package 5 of the European project "Assessment of Transversal Skills in STEM (ATS-STEM) and has been carried out by the educational technology group of the University of Santiago de Compostela (http://tecnoeduc.es).

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RESEARCH OBJECTIVES

In recent years, the STEM trend has burst onto the education scene and has become fashionable. We are aware that this trend has multiple and very different meanings, some of which may even be contradictory. For some, STEM is an elitist approach linked exclusively to experimental disciplines. For others, it is a sort of "solution" to the existing gender gap in the ICT professions. For others among us, the STEM movement represents an interdisciplinary, globalised, active, social, and fully applied teaching strategy that represents the strategic direction towards which to converge to transform teaching models. Nothing new on the one hand, but a challenge and a methodology that we must build, systematise, and implement across the board in European schools to accompany school-age citizens, and offer them a guarantee of developing the knowledge and core ATS-STEM learning competences they need to succeed in the 21st century. For this reason, we took on the challenges of formulating an ATS-STEM teaching methodology and designing a project-based methodological proposal for its implementation in educational classrooms. The was proposal tested with evidence of learning obtained after a pilot in 7 European countries (Belgium, Cyprus, Finland, Ireland, Slovenia, Spain and Sweden). Our previous experience in the ATS 2020 project demonstrated the motivational and didactic power of digital tools and their possibilities in teaching processes.

We assume that formative assessment is a key element of learning processes and that the digital tools developed to support this strategy are key to the implementation of globalized teaching projects and the transformative methodologies required by European education systems. Accompanying, stimulating, giving feedback, and guiding students in their learning projects is key in the development of the ATS-STEM Teaching Methodology.

The research presented here is part of the European project "Assessment of Transversal Skills in STEM (ATS-STEM), Reference: 606696-EPP-1-2018-2-IE-EPPKA3-PI, and documents the research process followed to evaluate the results obtained in the implementation of the ATS-STEM teaching methodology in primary and secondary schools in 7 European countries.

The research that we have developed pursued a **double objective**. On the one hand, to "know and explain" the implementation process of the ATS-STEM program, and on the other hand, to "understand" how it has worked, after experimentation, in different contexts (schools, classrooms, countries) and to make proposals to "improve" it. The research developed is focused on the evaluation of the effectiveness of the use of tools and digital support in the implementation of ATS-STEM Educational projects. These projects were carried out by students and teachers in multiple learning cycles in primary and secondary education to facilitate their implementation. The aim was for students to be given opportunities to achieve the core ATS-STEM learning competences. Therefore, the main objective of the evaluation is to check how the support of digital tools helps to develop these transversal competences in students.

Our evaluative research's goal focused on analyzing the possibilities of digital assessment in the implementation of "STEM education" practices and in the development of key competences for learning in European schools. The research has allowed us to gather evidence on the use of digital technology to enhance how we assess student learning. We sought to determine the strengthens, weaknesses and impacts on the implementation of ATS-STEM educational projects. Thus, this study provides answers to the following questions:

- How might digital assessment practices support the development of STEM competences?
- What are the challenges to using digital assessment strategies in STEM learning?
- Why apply digital assessment in the development of STEM projects?
- What and how does it contribute for STEM teaching and learning processes?
- "How" and "with what" digital assessment methodologies and digital tools should we apply it to improve STEM teaching-learning processes?

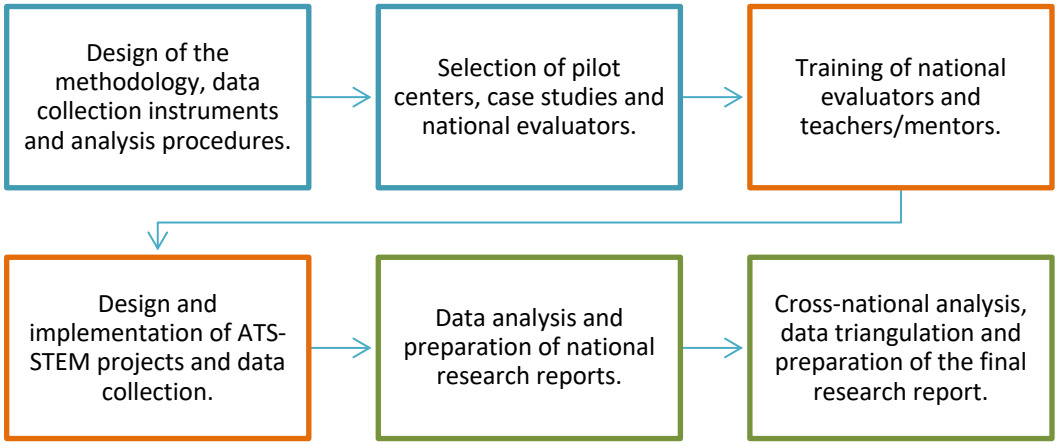
METHODOLOGY AND PHASES OF THE STUDY

In order to find answers to the research objectives, we developed an evaluative research methodology which is one of the most widely used in educational research. All processes and instruments we used are included in the comprehensive research guide developed for the implementation of the research in the 7 pilot countries (Fernández-Morante et al., 2022).

Evaluative research is a rigorous, controlled and systematic process of collecting and analysing valid and reliable information to provide information for planning, implementing and developing educational programmes.

Figure 1

Stages of ATS-STEM Research



The evaluative research of the ATS-STEM project was developed in **three phases**.

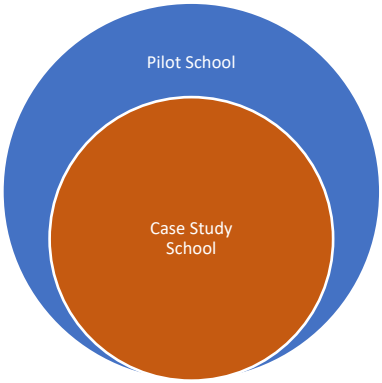
- The first phase was the planning phase in which the research methodology was designed, the data collection instruments were developed, the participating schools and participants (mentors, teachers and students) that made up the study sample were selected, and the national evaluators were recruited.
- A second phase of experimentation during which the participating teachers were trained in the ATS-STEM Teaching Methodology, the national evaluators were trained in the methodology and in the application of the ATS-STEM instruments, the ATS-STEM educational projects (conducted via learning cycles) were implemented in the pilot schools and all the research data were collected.
- Finally, a phase of data analysis and drawing of conclusions was conducted. In parallel the national evaluators in wrote individual national research reports, while the research coordinating team conducted a transnational analysis (of the quantitative and qualitative data) and collated and wrote the final research report.

The ATS-STEM project had a duration of 3 years and 3 months (from February 2019 to May 2022) – including a short extension of three months to the original term to offset the effects of the pandemic on the original plan.

In the educational experimentation and evaluative research developed, two types of participation were established with different levels of commitment and responsibility on the part of the participants: schools participated as pilot schools in a large survey and selected schools became case study schools for more in-depth mixed methods research. Multiple instruments and analysis procedures were designed for the systematic collection of data in these caste study schools. Each type of participation (case study and pilot) was associated with specific instruments and procedures.

Figure 2

Types of participation in the ATS-STEM pilot

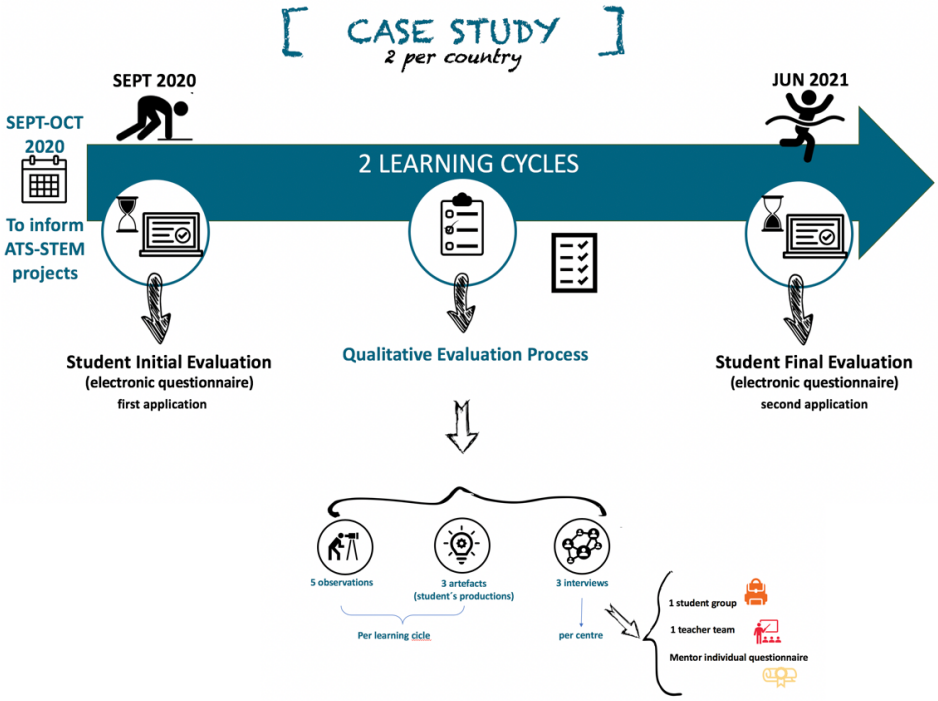


All **pilot schools** committed to implement at least 2 projects (learning cycles) according to the ATS-STEM Teaching Methodology and its educational principles in an integrated manner in the school curriculum of each country (Butler et al., 2020; Reynold et al., 2020; Szendey et al., 2020). In all pilot schools, data were collected at the beginning and at the end of the experimentation by means of the same instrument - "Self-administered core ATS-STEM learning competences online questionnaire" – customed developed for the research.

Among the participating pilot schools, 2 were selected per country in which **case studies** were conducted. In these schools a more complex process of complementary qualitative data collection and in-depth follow-ups were conducted.

Figure 3

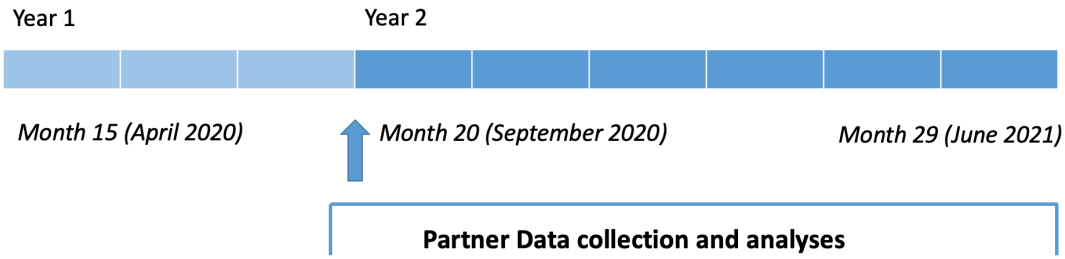
ATS-STEM Case studies



DATA COLLECTION INSTRUMENTS

Figure 4

Timing of the field work of ATS-STEM research



Study for a period of two schoool years (Pilot testing proccess):

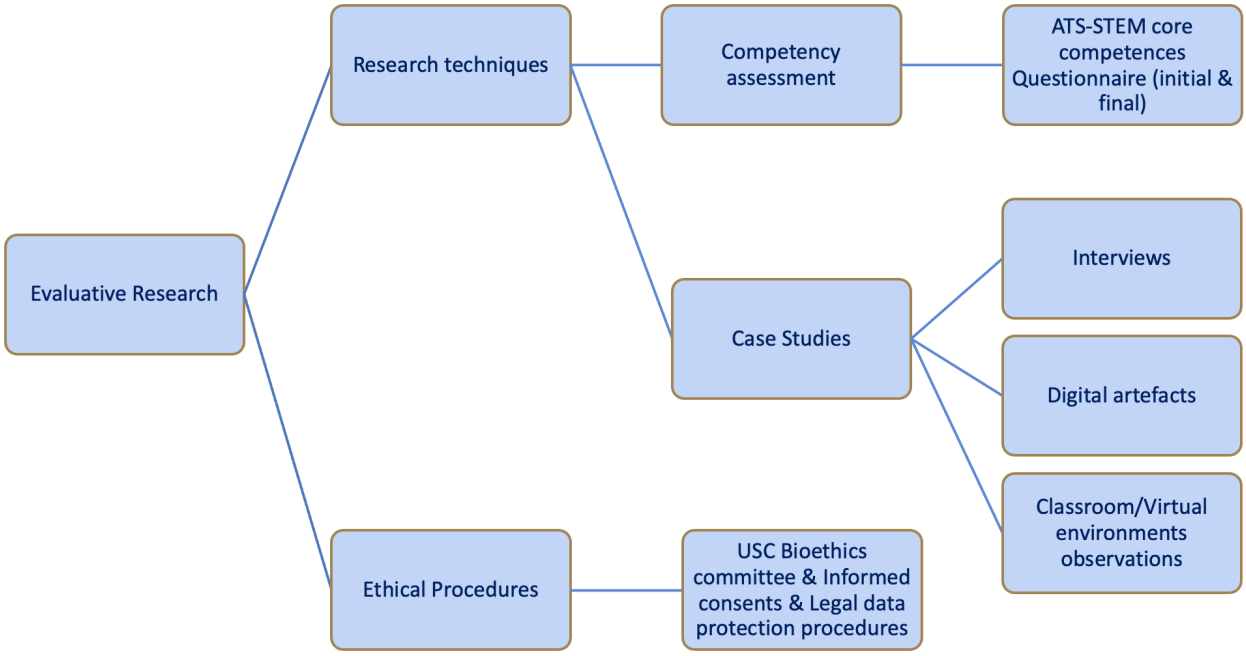
- 1 st year for a preparation with teachers, mentors and national evaluators, and ATS-STEM projects design
- 2nd year a full school year pilot in classrooms and data collection

The field work of the ATS-STEM research was planned to be carried out over two academic years in two phases: A first phase of design and preparation of all the actors involved (between September 2019 and April 2020) and a second phase of implementation and data collection (between March 2020 and June 2021). The months from March 2020 to September 2020 were dedicated to the adaptation of the proposal to the confinement situation of covid and therefore the implementation of the projects and data collection finally took place between September 2020 and June 2021.

To develop the evaluative research**, 4 types of instruments** were developed to collect quantitative and qualitative data: The evaluation test of the 8 core competencies of the ATS-STEM model, the interviews, the digital artifacts produced by the students, and the classroom observations and the activity developed in the virtual learning environments created for teaching. It should be noted that in addition to the digital assessment tools implemented, the situation of the closure of schools due to the pandemic, resulted in the transition to virtual teaching in a much of the pilot. The situations were different in each country regarding lockdown rules and covid phases but educators adopted multiple social communication, collaboration and group work tools by the educational administrations of the 7 countries.

Figure 5

ATS-STEM Research Design



a) *ATS-STEM core competences questionnaire*: An electronic self-administered questionnaire was created for the evaluation of the 8 core competencies for ATS-STEM learning methodology. This teaching methodology, and the conceptualization of the 8 core competencies, are part of the "STEM Conceptual Framework" that was developed and published within Work Package 1 of the ATS-STEM project (Butler et al., 2020).

b) *Case studies*:

- Interviews:
  - With teachers, mentors and participating students
  - Yielded information on three dimensions of analysis:
    - The teaching-learning process carried out during the ATS-STEM pilot.
    - The uses of digital assessment carried out and the difficulties and benefits perceived in its use.
    - The application of the ATS-STEM teaching methodology and the difficulties and perceived benefits of it
- Classroom observations and Virtual environments observations:
  - Five classroom observations was made in each of the learning cycles of the ATS-STEM educational projects (learning cycles) implemented in the case studies, one in each of the

steps of the ATS-STEM educational projects (learning cycles) designed to guide the participating teachers in the design of learning projects.

- Digital artefacts: The teachers participating in the case studies selected digital artifacts created by the students to provide evidence of the learning outcomes. By artifact we mean any elaboration or product created by the student in their learning activity in the ATS-STEM educational projects (learning cycles).

STUDY SAMPLE (PILOT SCHOOLS AND CASE STUDIES)

As for teachers and students, a total of 295 Primary and Secondary School teachers, 3096 students and 88 European schools participated in the **ATS-STEM pilot**.

Table 1

ATS-STEM Transnational Pilot Sample

Country	Number of schools (pilot school + case studie)	Number of pilot schools	Number of case studies	Number of teachers	Number of students
Ireland	13	11	2	14	322
Sweden	9	7	2	13	394
Slovenia	17	15	2	102	519
Belgium	11	9	2	23	341
Cyprus	11	8	3	29	324
Spain	18	16	2	83	986
Finland	9	7	2	31	210
Transnational sample	88	73	15	295	3096

In the ATS-STEM case studies, 89 teachers and 624 students of Primary and Compulsory Secondary Education participated, and 377 class sessions (lessons) of an average duration of 60 minutes were carried out.

Table 2

ATS-STEM Case Studies

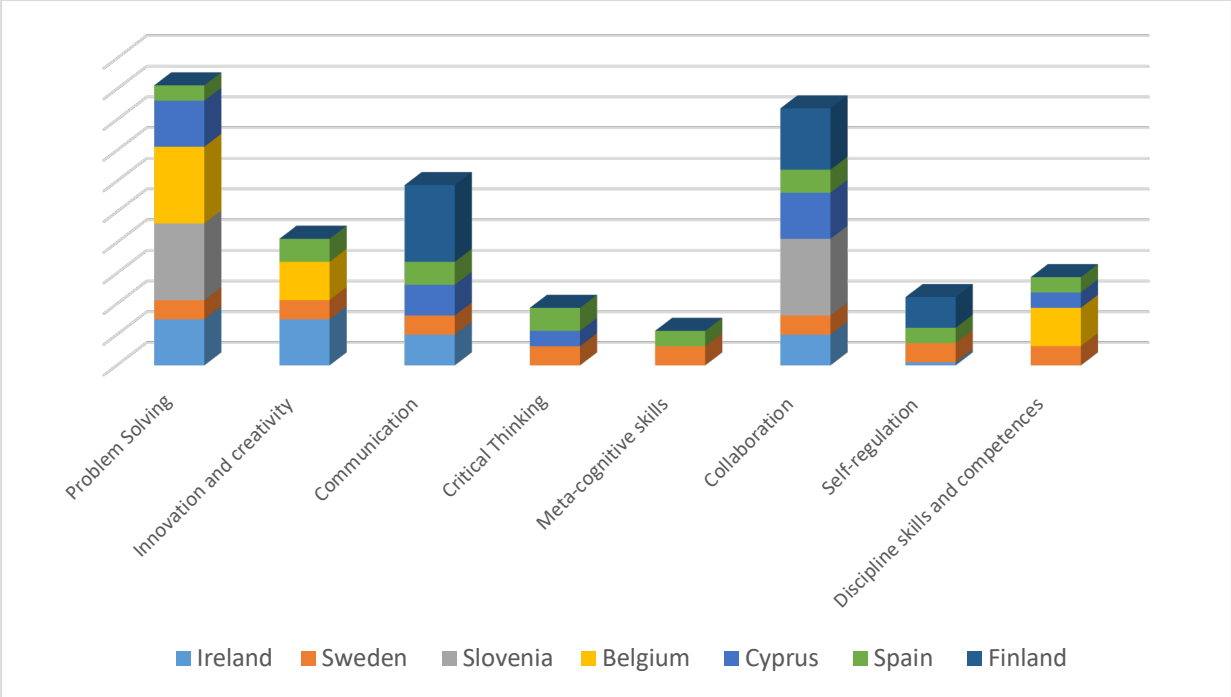
Country	Number of schools case studies	Number of total projects implemented (learning cycles)	Number of teachers	Number of students	Number of lessons	Educative Level
Ireland	2	4	4	82	31	Primary & Secondary
Sweden	2	2	2	129	36	Primary
Slovenia	2	4	44	98	44	Secondary

Belgium	2	4	6	76	84	Primary & Secondary
Cyprus	3	6	16	102	130	Primary
Spain	2	3	13	45	---	Secondary
Finland	2	4	4	92	52	Primary & Secondary
Transnational sample	**15**	**27**	**89**	**624**	**377**	

In the ATS-STEM educational projects (learning cycles) implemented in the case studies, the **8 core ATS-STEM learning competencies defined in the ATS-STEM framework** (Butler et al., 2020) were worked on, although not in the same way or with the same intensity in the different countries. The figure shows which competencies were addressed in each country and with what intensity.

Figure 6

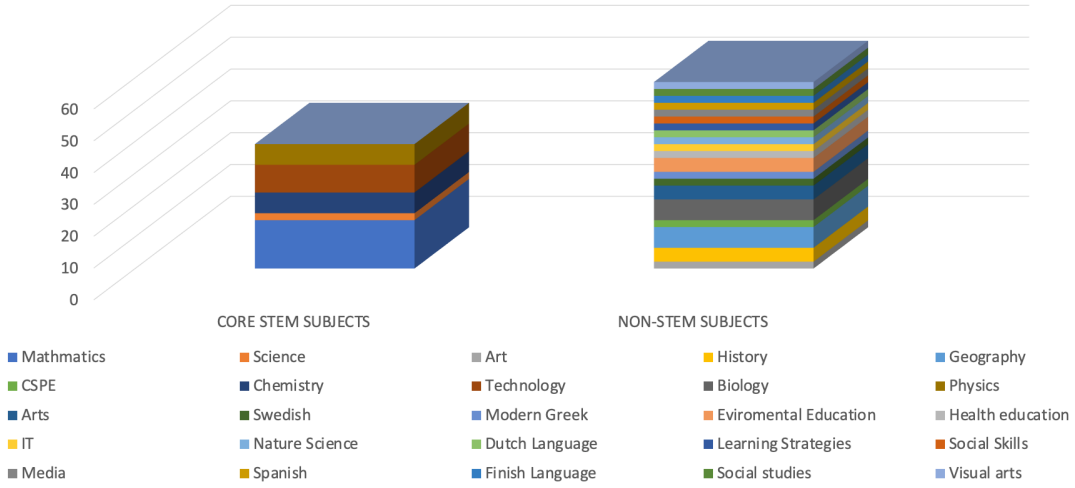
Grouped distribution of core competences for learning by countries



In line with the **interdisciplinary and holistic learning aproach**, ATS-STEM educational projects (learning cycles) were implemented in schools in multiple subjects, both in those traditionally considered STEM (core STEM subjects) and, with greater intensity, in non-STEM subjects in the fields of Humanities, Arts and Social Sciences.

Figure 7

Grouped distribution of core STEM subjects and non-STEM subjects addressed in ATS-STEM projects

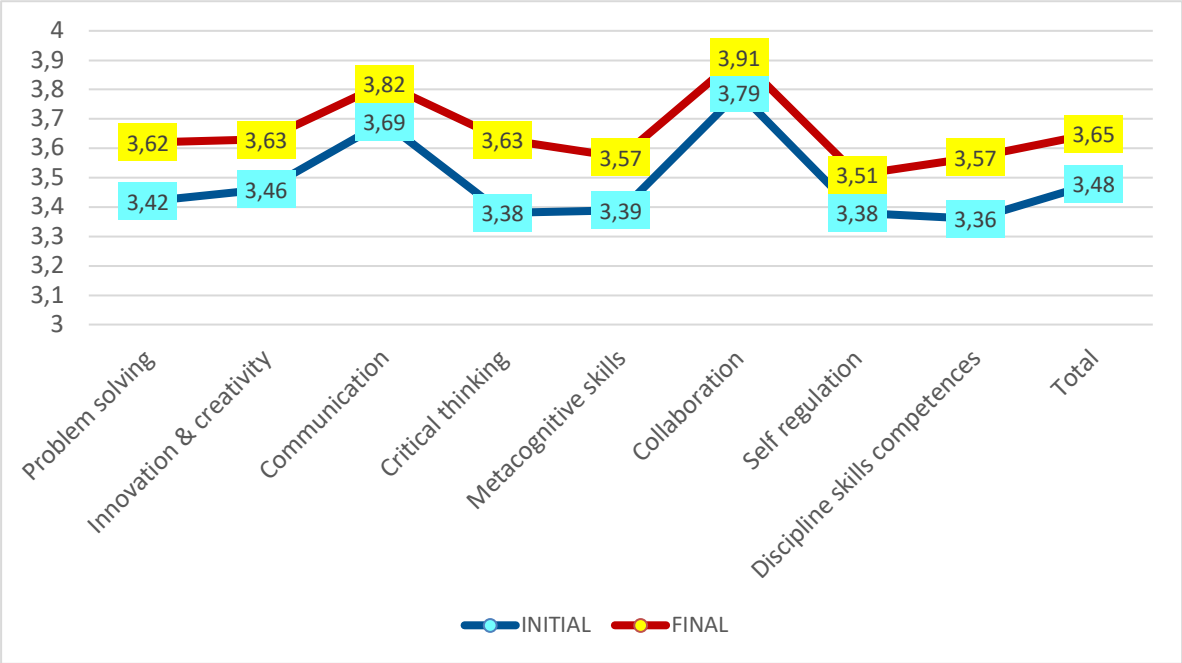


RESULTS OBTAINED IN TERMS OF IMPROVEMENT OF STUDENTS' CORE ATS-STEM LEARNING COMPETENCIES

In terms of learning outcomes, the evolution of the level of competence perceived by the participating students in each of the 8 core ATS-STEM learning competences was evaluated before and at the end of the pilot. The results obtained in global (transnational) terms showed a statistically significant improvement in all 8 competencies.

Figure 8

Means obtained for ATS-STEM learning competences before and at the end of the pilot



CHALLENGES IDENTIFIED FOR IMPLEMENTATION OF DIGITAL ASSESSMENT AND STEM, INTERDISCIPLINARY AND GLOBALIZED EDUCATION IN EUROPEAN EDUCATION SYSTEMS

Many challenges have been identified from the results obtained in the case studies for the widespread implementation of Digital Assessment and STEM, interdisciplinary strategies in European education systems and schools.

The following recommendations to key challenges relating to digital assessment tools have been identified:

We should promote the design of digital assessment tools aligned with active, applied, and collaborative teaching methodologies and formative assessment approaches. These tools must be secure and incorporate functionalities that enable feedback to be given to learners, their constant feedback through all activities and tasks, favouring self-regulation and decision-making throughout the training process.

Digital assessment tools will only be useful if they are used to feed back into teaching processes and if they provide meaningful and quality information to learners and teachers and if this information allows progress to be assessed, needs to be identified and decisions to be made that help to achieve the learning objectives of all learners.

Digital assessment tools need to be flexible. It is essential to spend time defining which tools to use and for what purpose.

Digital assessment tools should be well integrated into the learning process avoiding dispersion and over-stimulation that can distract/disorientate learners from the objective.

It is essential to ensure that learners understand the process and purpose of each activity and digital assessment tool and how to achieve it. This ensures their ability to execute, initiative and autonomy in the process.

The following recommendations to key challenges have been identified in relation to the infrastructures available in the centres:

We must transform school spaces that are insufficient in size for the number of students working in the classrooms and that are generally configured for traditional teaching models, transmissive and not active and collaborative (furniture, environment, means and resources...)

Community/external agents must be involved in educational processes to enhance the applied and contextualised dimensions of education and the impact and achievement of learning. In this way we can bring people together to solve local problems with real world skills.

The following recommendations to key challenges relating to current educational legislation and teachers' working conditions have been identified:

Timetables must incorporate the time required for teachers to introduce digital assessment in an adequate and effective way (selecting the tools, designing the proposals, helping students to understand the meaning and procedure of use, managing all the tasks involved in the feedback...).

Digital assessment and problem-solving approaches in teaching should be incorprated as a relevant resource for learning in all knowledge areas of the curriculum, not only in the traditional or core STEM initiatives or subjects.

We should promote formative assessment and feedback in teaching processes in schools. To this end, it is necessary to include assessment **in school timetables and in school projects**, which should be more flexible and integrated.

The following recommendations to key challenges related to teacher preparation and attitudes have been identified:

We must foster a culture of formative assessment among teachers and an understanding of its strategic value in improving teaching. Although the experimentation provided them with a wealth of data on the process, they did not always use it.

We can help promote **changes in teachers' perception of digital assessment** as a useful strategy and tool for face-to-face teaching. The situation of confinement caused by the pandemic (COVID-19) forced all teachers to make an abrupt and forced introduction of digital technologies in all functions and activities to ensure the continuity of teaching. The immediacy with which it was produced and the lack of time for reflection and analysis has generated **a divide between face-to-face teaching and the use of digital technologies and the linking of digital assessment exclusively to e-learning.** It is necessary to avoid this binary. We can instead harness the positive aspects of the experience during the pandemic, to change embedded teaching cultures so that they perceive the possibilities and benefits of digital assessment in face-to-face teaching. The pandemic forces us to **rethink and reimagine the role of digital technologies in educational practices**.

The following recommendations to key challenges related to students' preparation and attitudes have been identified:

All students enrolled in EU schools must have the necessary digital equipment to develop their educational process. Guarantee the **digital autonomy of students** as a strategy to promote equal opportunities and compensate for the economic and socio-family limitations of students that have a clear impact on school results.

Effective use of digital assessment in teaching requires **time to explain and explore the tools with students** before they understand the proposed use and what it will bring to the teaching-learning process (its benefits).

We can motivate students to engage in formative assessment and active teaching activities. This teaching model requires a **significant involvement of students** in all activities and in assessment.

We should promote a **change in the traditional perception internalised by students regarding assessment**: From being the object of assessment to becoming an active agent of it. It is an indispensable condition for the activation of innovative formative assessment strategies (feedback, self-assessment, co-assessment, etc.).

We can take this opportunity to promote a change in the perception of the value of assessment as a necessary activity for learning and achieving objectives, not just for measuring results.

The following challenges related to the improvement of the ATS-STEM teaching methodology have been identified:

There is a need to Improve assessment rubrics for key competences (to be more focused/concrete and clear) to assist in the design of teaching and learning activities.

Aligning the criteria for the achievement of key competences with the design of teaching-learning activities and formative assessment strategies is crucial.

PROPOSALS AND RECOMENDATIONS FOR THE AGENTS INVOLVED

In the analysis of the case studies, the following agents emerge as having the capacity to intervene in the implementation of Digital Assessment and **interdisciplinary STEM Education** in European schools:

- Regional, National, and European Education Administrations
- Initial and continuing teacher education institutions
- School administrations
- Families
- External agents (associations, companies, municipalities, institutions, professionals, etc.).

The following proposals and recommendations related to digital assessment tools have been identified:

We must guarantee the digital autonomy of all students to deal with the economic and socio-family inequalities present in the system and guarantee equal opportunities. All pupils should have sufficient and relevant (1:1) technology.

We must continue to promote the development and availability in all schools of digital assessment tools aligned with active, applied, and collaborative teaching methodologies and formative assessment approaches.

Institutional digital assessment tools must be designed to pedagogical criteria and educational needs.

The digital assessment tools that will be incorporated should incorporate functionalities that:

- Make explicit the elements to be assessed in the process and the criteria and allow for adaptation/flexibility of these on an individual basis.
- Systematise/organise relevant (individual and group) information (for teachers and students) and present it in a clear and attractive way.
- Guide students on what to do with feedback.
- Remind users of learning tasks and deadlines for progress in the learning process.

The following proposals and recommendations have been identified in relation to current educational legislation and teachers' working conditions:

We should continue to align national curricula with active and collaborative approaches of teaching towards **competency approaches**. It is necessary to challenge over-reliance on transmissive or rote learning models predominant in some countries, which organise knowledge in different subjects without interrelationships between them. These traditional, rote learning models do not allow for collaborative, globalised work and the integration of key competences. The curriculum must be a facilitating tool for globalised teaching, not a straitjacket or brake on contextualised, active and competency-based learning.

We should stive to incorporate in the educational legislation of the Member States **formative assessment, interdisciplinary and globalised teaching** at all educational levels as a structural pedagogical principle and not dependant on teaching styles, educational practices or initiatives linked exclusively to STEM subjects.

We should seek to incorporate **educational innovation** at all levels of educational planning and ensure the necessary structural conditions for its scalability in EU education systems. This would include efforts for:

- Recognition in the teaching workday of the time and work involved.
- Recognition in teacher performance assessments.
- Implementation of flexible school organisation criteria and procedures.

It is crucial that we incorporate, in the educational legislation of the Member States, collaborative teaching between teachers and **"pair work in the learning process"** practices and the organisational conditions necessary for their implementation and generalisation. We must help teachers work together and realise that teaching itself can at times require a team-based activity. Teachers can hence model this for students.

We must further commit to the **transfer and sustainability in the Member States of successful and evidence-based results** derived from publicly funded European educational research and innovation projects. We seek the commitment of local and national administrations to effectively incorporate the new methods, resources and examples of good practice generated.

The following proposals and recommendations related to teacher preparation and attitudes have been identified:

The following methodological models and teaching practices for teacher training plans, should be considered strategically due to their potential for transformation:

- Training in criteria for the selection of educational technologies, in particular tools for digital assessment from an educational perspective and not from a technical-instrumental or fad/trend-based perspective.
- Training for the integration and use of digital assessment tools as a suitable resource to support the teaching-learning process.
- Changing attitudes towards digital assessment tools and practices. Teachers need to perceive their usefulness and the added value they bring to presential educational processes. They need to understand that the correct use of these tools complements and extends interaction, feedback possibilities and enhances rather then replaces traditional approaches.
- Training in collaborative teaching strategies for developing attitudes and skills for co-teaching (pedagogical pairs)
- Training for the implementation of globalised teaching methodologies and project work.
- Training for the implementation of formative assessment approaches: strategies and resources.

We should seek to intensify **educational digitalisation plans and training in digital competence for teachers** as fundamental instruments for modernising education, extending current educational contexts and changing methodological models.

The following proposals and recommendations have been identified in relation to student preparation and attitudes:

Include in **compulsory education curricula the training of students in transversal learning strategies and skills**: collaboration, teamwork, leadership, reflective and critical thinking, oral and written communication skills, active involvement, feedback.

Include **digital competence in compulsory education curricula**: safety, online collaboration, digital communication, digital creation, information search/selection, etc…

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