HYBRID AND EMOTIONALLY AWARE LEARNING ENVIRONMENTS AND DIGITAL AFFECTIVE LITERACY: A MIXED-METHOD STUDY ON WELL-BEING, ENGAGEMENT AND INCLUSION IN SECONDARY SCHOOLS

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ABSTRACT
This mixed-methods study explores hybrid and emotionally aware learning environments in upper secondary schools within the framework of Digital Affective Literacy. Involving 120 students, including those with Specific Learning Disorders, the research found improvements in engagement, well-being and emotional self-regulation, particularly in the experimental group. Findings highlight the role of teacher mediation and the importance of Digital Affective Literacy for inclusive and reflective learning.

KEYWORDS
Hybrid environments; educational artificial Intelligence; school well-being; emotional self-regulation; digital affective literacy;

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1. Introduction

Contemporary technological developments are profoundly redefining educational contexts, introducing new ways of interacting, learning and constructing meaning. In this context, learning environments can no longer be conceived as purely physical spaces, but as hybrid ecosystems in which digital and physical dimensions intertwine, generating learning experiences that are increasingly mediated, distributed and personalised (Selwyn, 2021). This transformation is intertwined with the emergence of new generational configurations. In particular, the so-called Generation Alpha — comprising individuals born from 2010 onwards — represents the first generation fully immersed, from birth, in pervasive digital environments, characterised by intelligent interfaces, continuous connectivity and immediate access to information. For these individuals, technology is not an external tool, but a natural extension of daily experience, profoundly influencing cognitive, relational and emotional processes (Floridi, 2014). The sample analysed, situated at the transition between Generation Z and Generation Alpha, allows us to observe the dynamics of transition between different cognitive and relational models. Early and widespread exposure to digital devices and algorithmic systems contributes to redefining patterns of attention, identity formation and forms of social interaction. Digital platforms, social media and, more recently, generative artificial intelligence systems, create environments in which relational experience is increasingly mediated, filtered and sometimes simulated. In this context, the boundaries between authenticity and representation tend to blur, making it progressively more complex to distinguish between human and artificial interactions (Floridi et al., 2018). At the same time, the issue of technologically mediated affectivity is taking on increasing importance. Intelligent technologies do not merely support

cognitive processes, but are beginning to simulate forms of empathetic interaction, modulating language, tone and responses according to users' emotional states. This phenomenon raises crucial questions about the nature of the educational relationship: if an artificial system is capable of responding coherently to a student's emotional needs, what value does such interaction hold within the learning process? (Turkle, 2015; Mintz et al., 2023).

For students with Specific Learning Disorders (SLD), such tools can represent a significant opportunity. The ability to access adaptive content, receive immediate feedback and interact in contexts perceived as non-judgemental can help reduce cognitive and emotional load, fostering more accessible and inclusive learning methods (Ok et al., 2017). However, this very technological mediation requires the development of new critical skills, in order to avoid passive dependence on forms of 'simulated empathy' and to promote the conscious use of digital tools. It is within this context that the concept of Digital Affective Literacy comes into play, understood as the ability to understand, interpret and manage emotional interactions mediated by digital systems. It is not merely a matter of recognising emotions, but of developing a critical awareness of the nature of technological responses, distinguishing between simulation and authentic relationships, between algorithmic availability and human responsibility (Mintz et al., 2023; Selwyn, 2021). The integration of this dimension into teaching now appears crucial for the creation of inclusive and genuinely educational environments. Educating Generation Alpha — and, more generally, students situated in the transition between Generation Z and Alpha — means not only promoting digital skills, but also fostering the development of an affective sensitivity capable of consciously inhabiting the hybrid spaces of contemporary learning. From this perspective, schools are called upon to reimagine themselves as places where technology and relationships are not in

opposition, but are integrated into a dynamic balance, geared towards the construction of meaning, identity and authentic bonds (Floridi, 2014).

2. Aims of the research

In light of the transformations described above – which have seen the emergence of hybrid learning environments and the rise of new forms of technology-mediated affectivity – this study aims to investigate how emotionally aware learning environments can influence educational processes in upper secondary schools. In particular, the research sits at the intersection of technological innovation, inclusion and the development of Digital Affective Literacy, with the aim of understanding how students — belonging to a generation increasingly immersed in the digital world — interpret and experience interactions with intelligent systems capable of simulating empathetic responses (Mintz et al., 2023; Selwyn, 2021; Zawacki-Richter et al., 2019). The overall aim of the study is therefore to analyse the impact of integrating 'affectively oriented' digital technologies on students' psychological well-being, school engagement and emotional self-regulation processes, with particular attention to differences between students with and without Specific Learning Disorders (SLD). This perspective allows us to explore not only the effectiveness of technological tools in functional terms, but also their role in redefining relational dynamics and in the construction of meaning within the educational experience (Holmes & Tuomi, 2022). In line with this theoretical framework, the study aims to answer the following research questions:

RQ1. To what extent does the use of emotionally aware learning environments affect students' psychological well-being, school engagement and emotional self-regulation processes?

RQ2**.** What differences emerge between students with and without SLDs in their modes of interaction with digital technologies and in processes of inclusion and participation?

RQ3. How do students perceive and interpret the forms of artificial empathy generated by intelligent systems?

RQ4. What is the role of the teacher within hybrid learning environments, particularly in relation to emotional mediation and the development of Digital Affective Literacy?

From this perspective, the study aims to contribute to the definition of educational models capable of integrating technology and relationships in a balanced way, promoting teaching that does not merely exploit the potential of digital tools, but which also supports students in developing an affective and critical awareness appropriate to the complexity of contemporary learning environments (Zawacki-Richter et al., 2019).

3. Tools

This study adopts a mixed-methods (qualitative-quantitative) approach, which is considered particularly suitable for investigating complex phenomena such as the interaction between the technological dimension and emotional experience in educational contexts. This approach allows, on the one hand, for the objective and measurable detection of variations in levels of well-being, engagement and emotional self-regulation and, on the other, for an in-depth exploration of the meanings attributed by students to their experiences in hybrid learning environments (Creswell & Plano Clark, 2007; Johnson & Christensen, 2024).

For the collection of quantitative data, validated instruments from the literature and suitable for the adolescent age group (14–16 years) were selected, in order

to ensure the reliability and validity of the measurements. All questionnaires were administered in Italian. Where validated Italian adaptations were available, these versions were adopted without modifying the underlying constructs or response structure. In order to ensure consistency across measures in the comparative analyses, the resulting scores were subsequently linearly transformed onto a common 0–100 metric, as described below; this transformation affected only the metric of the scores and not their substantive interpretation.

- Student Engagement Questionnaire (SEQ): used to measure the three dimensions of school engagement: behavioural, emotional and cognitive. The instrument comprises items that investigate active participation in activities (e.g. attention, commitment to tasks), affective involvement (e.g. interest, sense of belonging to the school context) and cognitive investment (e.g. learning strategies, mental effort). Administering the SEQ provides a detailed profile of student engagement, which is particularly useful for assessing the impact of digital environments on the learning experience (Fredricks et al., 2019). The instrument comprises 33 items distributed across affective engagement (9 items), behavioural engagement (12 items) and cognitive engagement (12 items). Affective and behavioural items are rated on a seven-point agreement scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”), whereas cognitive engagement items use a seven-point frequency scale ranging from 1 (“never”) to 7 (“always”). Negatively worded items are reverse-scored before score computation. A mean score is calculated for each dimension, with higher values indicating greater engagement. For the comparative analyses conducted in this study, the three dimensional scores were combined into an overall engagement index and linearly rescaled to a 0–100 metric, where higher values indicate higher levels of school engagement. The validated Italian wording was

retained, and no substantive modification of the items or dimensional structure was introduced.

- Difficulties in Emotion Regulation Scale – DERS (Gratz & Roemer, 2004): the scale comprises several sub-dimensions that allow for a detailed analysis of difficulties in emotional regulation, including emotional awareness, emotional clarity, acceptance of emotions and impulse control. The use of the DERS enables an understanding of how students manage their emotions in technology-mediated learning contexts, providing useful indicators for assessing any changes in emotional self-regulation processes following the intervention (Hallion et al., 2018). The instrument assesses six dimensions of emotion-regulation difficulties: non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse-control difficulties, lack of emotional awareness, limited access to emotion-regulation strategies and lack of emotional clarity. Each item is rated on a five-point frequency scale ranging from 1 ("almost never") to 5 ("almost always"). After reverse-scoring the relevant items according to the original scoring procedure, responses are summed to obtain a total score ranging from 36 to 180, as well as dimension-specific scores. Higher scores indicate greater difficulties in emotion regulation; consequently, a reduction in the score from pre- to post-intervention represents an improvement in emotional regulation. For the analyses presented in this study, the total score was linearly transformed to a 0–100 scale while preserving the original direction of the construct. The validated Italian version was used without removing or adding items.
- Warwick-Edinburgh Mental Well-being Scale (WEMWBS): comprising 14 Likert-scale items, the scale measures students' overall psychological well-being, including both emotional well-being (linked to the presence of positive emotions) and personal well-being, understood as a sense of fulfilment, positive functioning and the quality of relationships. The items explore

dimensions such as optimism, energy, ability to cope with difficulties and the quality of interpersonal relationships. The WEMWBS is particularly suitable for educational contexts as it allows for the monitoring of changes in perceived well-being in relation to changes in the learning environment (Lloyd, K., & Devine, P. 2012). Participants were asked to indicate how frequently they had experienced each positively worded statement during the previous two weeks, using a five-point response scale ranging from 1 ("none of the time") to 5 ("all of the time"). As all items are positively keyed, no reverse scoring is required. Item scores are summed to produce a total raw score ranging from 14 to 70, with higher scores indicating greater mental well-being. For the present analyses, the total score was linearly transformed to the common 0–100 metric, with higher values continuing to represent greater psychological well-being. The complete 14-item format was retained and no items were added, removed or substantively modified.

- Academic Self-Regulation Questionnaire (SRQ-A): based on Self-Determination Theory, this instrument investigates the various forms of motivational regulation (intrinsic, identified, introjected and external), enabling an understanding of the degree of student autonomy in learning processes. The items explore the reasons driving academic engagement (e.g. personal interest, external pressure, sense of duty), offering an in-depth insight into the quality of motivation. The SRQ-A is particularly relevant in digital environments, where autonomy and self-regulation represent key competencies (Ryan & Deci, 2020). The Italian adaptation of the Academic Self-Regulation Questionnaire, comprising 15 items, was used. The instrument retains the four regulatory dimensions proposed within Self-Determination Theory: external regulation, introjected regulation, identified regulation and intrinsic regulation. Students respond to each item on a four-point scale ranging from "not true at all" to "very true", indicating the extent to which each proposed reason corresponds

to their motivation for engaging in school activities. Scores are calculated for the four regulatory dimensions by aggregating the items belonging to each subscale; higher subscale scores indicate stronger endorsement of the corresponding motivational regulation. For the overall motivational self-regulation indicator used in the present comparative analyses, greater weight was placed on the autonomous forms of regulation represented by identified and intrinsic motivation, so that higher values correspond to a more autonomous and self-determined motivational profile. The resulting indicator was linearly rescaled to the common 0–100 metric used in the study. The validated Italian wording was retained, without substantive changes to the content of the items

All instruments were administered at two measurement points, immediately before the beginning of the educational intervention (pre-test) and after its completion (post-test), in order to detect changes over time and permit comparisons between the experimental and control groups. The transformation of the scores onto a common 0–100 scale was performed exclusively to facilitate the interpretation and comparison of the different outcomes. The direction of the original constructs was preserved: higher scores indicate greater school engagement, psychological well-being and autonomous motivational self-regulation, whereas higher DERS scores indicate greater difficulties in emotion regulation. Thus, improvement over time is represented by an increase in SEQ, WEMWBS and motivational self-regulation scores and by a decrease in DERS scores. No further content adaptations of the instruments were introduced. Furthermore, the selected instruments are appropriate for the adolescent age group and consistent with the dimensions under investigation (engagement, psychological well-being and emotional regulation), helping to strengthen the overall validity of the research design.

The qualitative component of the research was designed to explore the students' subjective experiences and capture the relational and emotional dynamics that are difficult to detect using standardised instruments. To this end, the following were used:

- Semi-structured interviews: the interviews were conducted following a flexible framework, organised around key themes such as: perception of the digital environment, relationship with intelligent systems, emotional experience during activities, and perception of the support received. This tool enabled the collection of in-depth narratives and gave voice to students' individual experiences, facilitating the emergence of subjective meanings and personal representations (Kallio et al., 2016; McGrath et al., 2019). A purposive subsample of 24 students was selected from the overall sample of 120 participants according to a maximum-variation criterion, in order to ensure balanced representation of the experimental and control groups, the two school streams and students with and without SLDs. Twelve students were selected from each study condition. The subsample included all eight students with SLDs — four from each group — and 16 students without SLDs. All six humanities teachers involved in the intervention also participated in the interviews. Semi-structured interviews were therefore conducted with 24 students and six teachers, for a total of 30 interviews. Interviews were carried out after completion of the intervention and post-test measures. Student interviews lasted approximately 20–30 minutes, whereas teacher interviews lasted approximately 30–45 minutes. The same thematic interview framework was used within each participant category, while allowing follow-up questions when clarification or further exploration of emerging experiences was required.

- Digital reflective journals: students were invited to periodically complete digital journals, in which to record emotions, difficulties, strategies used and perceptions relating to the activities carried out. This tool fostered processes of metacognition and self-reflection, allowing us to capture the evolution over time of emotional experiences and modes of interaction with technology. Because the digital reflective journal constituted an integral component of the hybrid learning environment, it was used with the 60 students in the experimental group rather than being introduced into the control condition. A total of 60 longitudinal digital reflective journals were therefore collected, corresponding to one journal for each student in the experimental group. Students were invited to complete one structured entry per week throughout the eight-week intervention, allowing changes in emotional experience, perceived difficulties, learning strategies and relationships with digital technologies to be followed over time. The journals were used as qualitative process data and were triangulated with interview and observational evidence; they were not used as an additional outcome measure.
- Systematic classroom observations: observations were conducted using structured grids, designed to record observable behaviours such as participation, peer interactions, use of digital tools and emotional reactions during activities. This tool enabled the integration of self-reported data with behavioural evidence, enhancing the robustness of the analysis (Cohen et al., 2002). Systematic classroom observations were conducted in both the experimental and control conditions throughout the eight-week intervention. One observation session was scheduled for each participating class per week and lasted for one complete regular lesson, approximately 50–60 minutes. The same observation framework and temporal frequency were maintained across the two conditions in order to support comparability. Observers adopted a non-participant role and recorded behaviours through a structured grid focusing on

participation, student–student and student–teacher interactions, engagement with the proposed activities, use of technological resources where applicable, observable emotional responses and indicators of inclusion or withdrawal. Descriptive field notes were also used to document contextual elements that could not be adequately captured by the predefined categories.

The qualitative data collected were subsequently analysed using thematic analysis (Braun & Clarke, 2021), following a systematic process of coding, categorisation and interpretation. This method enabled the identification of recurring patterns and significant themes in the students' narratives, with particular attention to the dimensions of the perception of artificial empathy, the sense of inclusion, the relationship with technology and the development of emotional awareness.

The analysis followed the recursive phases of thematic analysis proposed by Braun and Clarke (2021): familiarisation with the data, generation of initial codes, identification of candidate themes, review of themes, definition and naming of themes, and final interpretation. Interview transcripts, reflective journal entries and observation records were first examined separately and were subsequently integrated through methodological triangulation. An initial codebook was developed inductively from the data while remaining sensitised to the study's research questions and theoretical constructs. Two members of the research team independently coded an initial subset corresponding to approximately 25% of the qualitative corpus. The resulting codes were then compared in order to identify convergences, discrepancies and possible ambiguities in their operational definitions. Disagreements were discussed until consensus was reached, and the codebook was progressively refined before being applied to the remaining material. No numerical inter-rater reliability coefficient was used, as the purpose of this procedure was not to

establish mechanical coding equivalence but to strengthen interpretative consistency and transparency within the reflexive thematic analysis process.

The researchers were responsible for conducting the interviews, organising and anonymising the qualitative corpus, coding the material and developing the thematic structure. Throughout the analytic process, reflective memos were maintained to document interpretative decisions, emerging assumptions and modifications to the coding framework. Regular comparison meetings between the researchers were used to examine alternative interpretations and prevent themes from being based solely on the perspective of a single analyst. Interpretative credibility was further strengthened through triangulation across the three sources of qualitative evidence — interviews, reflective journals and classroom observations — with particular attention to convergence as well as to divergent or contradictory evidence. Themes were retained only when they were supported by sufficiently recurrent and meaningful evidence within the corpus and were reviewed against the original data before the final thematic structure was established. This procedure provided an explicit audit trail of the analytical process and enhanced the credibility, dependability and transparency of the qualitative findings.

4. Sample selection

The study was conducted at a secondary school in Naples and involved students in their first and second years of the classical and scientific streams of the liceo, aged between 14 and 16.

The decision to involve these specific secondary school streams, in particular the classical and scientific streams, responds to a specific research need: to analyse the impact of emotionally aware learning environments in contexts characterised by a strong cultural tradition and a high degree of emphasis on reflective and critical thinking. These courses of study, in fact, focus on the

development of analytical thinking, argumentative skills and the construction of complex meanings, making them ideal contexts for investigating the relationship between technology, emotion and learning (Rivoltella, 2020; Selwyn, 2021). Furthermore, the comparison between two streams with different epistemological orientations — one more humanistic and the other scientific — allows for the observation of any differences in the relationship with technologies and in processes of digitally mediated emotional processing (Mintz et al., 2023; Zawacki-Richter et al., 2019). The sampling method adopted was non-probabilistic and convenience-based, as participants were selected based on the school's availability and the voluntary participation of students and families in the research project (Creswell & Plano Clark, 2007). The overall sample consisted of 120 students, divided into two groups of equal size:

- an experimental group, which took part in the educational intervention based on the use of hybrid and emotionally aware learning environments;
- a control group, which continued the educational programme using traditional methods.

Following participant recruitment, allocation to the two study conditions was carried out at class level rather than at the individual student level, preserving the pre-existing composition of the classes and avoiding the reassignment of individual students. The intact classes were allocated to either the experimental or the control condition so as to obtain two groups of equal size (n = 60 each) and to maintain a balanced distribution of students with SLDs across the two conditions. Individual randomisation was therefore not performed. This class-level allocation was adopted both to preserve the natural organisation of the school setting and to minimise the risk of contamination

between experimental and control activities. The comparability of the two groups prior to the intervention was subsequently assessed through the pre-intervention measures, which showed no statistically significant baseline differences in the variables under investigation ($p > .05$).

Within each group, there were 4 students with a certified diagnosis of Specific Learning Disorders (SLD), specifically dyslexia, in order to ensure a balanced distribution of the variable and allow for a meaningful comparison between the two experimental conditions (Ok et al., 2017). During the educational intervention, six subject teachers from the humanities (literature and philosophy) actively participated, acting as educational facilitators and pedagogical mediators within the learning environments. The inclusion of humanities teachers is not coincidental, but consistent with the research's theoretical framework: literary and philosophical disciplines, in fact, offer a privileged space for reflection on human experience, identity, emotions and relationships. From this perspective, they are particularly well-suited to integrating digital tools capable of triggering processes of narration, introspection and meaning-making, elements central to the development of Digital Affective Literacy (Rivoltella, 2020; Holmes et al., 2022). Teachers therefore played a key role in mediating the interaction between students and technologies, encouraging a critical interpretation of the 'empathic' responses of intelligent systems and supporting the relational dimension of learning (Selwyn, 2021). The inclusion criteria adopted for sample selection were as follows:

- enrolment at the school involved in the study;
- enrolment in the first or second year of a classical or scientific sixth-form college;
- no previous years of repetition;

- informed consent from students and families;
- voluntary participation in the research;
- attendance at at least 50% of the activities scheduled during the intervention;
- a certified diagnosis of SLD (for the specific subgroup).

This sample configuration ensured adequate control of variables and enabled a comparative analysis of the intervention's effects, with particular attention to inclusive dynamics, meaning-making processes, and differences between students with and without SLDs within technologically mediated learning environments (Mintz et al., 2023; Zawacki-Richter et al., 2019).

4. Educational Intervention

The educational intervention was designed with the aim of analysing the impact of hybrid and emotionally aware learning environments on students' learning processes and emotional dynamics. To this end, a common subject area was identified for both groups — drawn from the humanities and centred on reflection on identity, emotions and self-construction — in order to ensure consistency of content and enable comparison of the outcomes of the teaching experience (Selwyn, 2021; Mintz et al., 2023). The topic addressed involved reflection on personal identity, emotions and self-construction, developed through the analysis of literary and philosophical texts centred on the human experience. In particular, the course invited students to explore the relationship between the inner world and the social context, promoting emotional awareness, the ability to express and interpret one's own emotional states, and the construction of personal meanings (Rivoltella, 2020). To this end, passages and reflections drawn from authors such as Homer, Aesop, Phaedrus and Giovanni Boccaccio were presented. This theme proved

particularly consistent with the research objective, as it allowed for the integration of cognitive and emotional dimensions and the investigation of the role of digital technologies as mediators in processes of self-reflection and the development of Digital Affective Literacy (Mintz et al., 2023).

The intervention was implemented over a total period of eight consecutive weeks and was integrated into the regular humanities curriculum of the participating classes. Activities were carried out on a weekly basis within the scheduled literature and philosophy lessons, following the same overall temporal framework for both the experimental and control groups in order to ensure comparable exposure to the educational content. The intervention followed a progressive temporal sequence. During the first two weeks, activities focused on the introduction and contextualisation of the selected literary and philosophical themes and on students' initial exploration of identity, emotions and self-construction. Weeks 3–4 were devoted to guided analysis, interpretation and discussion of the selected texts, with the experimental group progressively integrating digital learning environments and interactions with generative AI tools. During weeks 5–6, greater emphasis was placed on personal reworking, emotional reflection and the production of individual or digitally mediated narratives, including the use of reflective journals and digital storytelling in the experimental condition. The final two weeks (weeks 7–8) were devoted to the integration and consolidation of the learning experience, critical reflection on the relationship between emotions, technology and human interaction, and the autonomous reworking of the themes addressed. Quantitative measures were administered immediately before the beginning of the intervention (pre-test) and again at the end of the eighth week (post-test), while qualitative data were collected throughout the intervention through reflective journals and systematic classroom observations and were complemented by semi-structured interviews at the end of the

programme. This temporal organisation ensured that both groups were exposed to the same disciplinary content over the same period, while differing specifically in the teaching strategies, learning environments and technological mediation adopted.

What distinguishes the two groups is therefore not the content covered, but rather the mode of delivery, the teaching strategies and the tools used. The control group addressed the topic through traditional teaching methods, based on a predominantly transmissive and interpretative approach, in which the teacher played a central role in guiding the learning processes, promoting structured and progressive learning (Fredricks et al., 2019). The activities were organised into several phases:

-Lecture and contextualization: the teacher introduced the content through lectures, providing the historical and cultural context of the authors and works analysed and structuring the knowledge in a sequential and systematic manner (Johnson & Christensen, 2024).

-Guided reading and text analysis: students took part in sessions of reading aloud and silent reading of selected passages, followed by a guided analysis based on prompt questions. The focus was on elements such as character traits, the portrayal of emotions, internal and relational conflicts, and moral messages. The teacher facilitated understanding through paraphrasing and critical commentary, promoting processes of deep comprehension (Bereiter & Scardamalia, 2018).

-Class discussion: class discussions were organised, during which students were invited to share their interpretations and personal reflections. This dialogue supported the shared construction of knowledge and the development of critical thinking (Stahl et al., 2019).

-Comprehension and reworking exercises: students undertook structured activities, such as text comprehension questionnaires, guided analyses and in-depth worksheets, aimed at consolidating knowledge and assessing understanding of the content.

-Individual written work: a central phase of the programme was dedicated to the production of written texts (essays, argumentative reflections, short essays), in which students were invited to rework the content covered, linking it to their own personal experience. In particular, they were asked to reflect on the concept of identity, the role of emotions in individual choices, and the relationship between the individual and society (Bereiter & Scardamalia, 2018).

The activities focused on textual analysis and the critical processing of content, with a gradual progression towards independent argumentation. The emotional dimension was addressed implicitly, emerging mainly through the interpretation of texts and personal reflection, without the aid of digital tools specifically designed for affective reflection (Selwyn, 2021).

The experimental group addressed the same topic through a hybrid learning environment, characterised by the integration of digital tools designed to support not only cognitive processes, but also emotional and reflective ones (Mintz et al., 2023; Zawacki-Richter et al., 2019).

The activities were structured in several phases:

-Guided exploration activities and interaction with educational chatbots: students used generative artificial intelligence systems (e.g. Google Gemini) to support their study and reflection. The chatbot was used to rephrase complex content, prompt open-ended questions and simulate reflective dialogues on emotional topics, allowing students to engage with forms of ‘simulated empathy’. The use of this tool facilitated continuous and personalised interaction, stimulating

processes of self-reflection and critical engagement with artificially generated responses (Mintz et al., 2023).

-Use of digital learning platforms (LMS): through platforms such as Google Classroom or Moodle, multimedia materials (videos, interactive texts, concept maps) and personalised activities were provided, facilitating flexible access to content and continuous monitoring of the learning journey. These platforms supported the personalisation of teaching processes and student autonomy (Bond et al., 2020).

-Digital emotional diaries and self-report tools: students used digital tools (e.g. Google Forms, Padlet) to record their emotional state during activities, promoting emotional awareness and metacognitive reflection. These tools facilitated the emergence of the affective dimension, which is often implicit in traditional contexts (Fredricks et al., 2019).

-Digital storytelling activities: using applications such as Canva, Animaker or digital presentations, students produced personal and reflective narratives, linking subject content to their own experience. In particular, the use of visual and animated storytelling tools fostered emotional expression, creativity and the narrative reworking of the self – central elements in the development of digital affective competence.

-Facilitated discussion and critical reflection: the activities were accompanied by teacher-led discussions aimed at developing a critical understanding of interaction with technology, particularly regarding the theme of artificial empathy and the distinction between simulation and authenticity. The teacher played a fundamental role in fostering critical awareness and contextualising the technological experience (Selwyn, 2021; Mintz et al., 2023).

5. Analysis of quantitative data

The analysis of the quantitative data was conducted with the aim of assessing the effectiveness of the educational intervention in relation to three key dimensions: psychological well-being, school engagement and emotional regulation. Motivational self-regulation, assessed through the SRQ-A, was considered as a fourth complementary quantitative outcome. The four outcomes were therefore measured through the SEQ, WEMWBS, DERS and SRQ-A, respectively. The scores were standardised on a percentage scale (0–100) in order to facilitate comparison between the various variables under consideration**.** For each instrument, the raw score was converted to the common 0–100 metric according to the following min–max transformation: Standardised score = [(observed raw score − minimum possible score)/(maximum possible score − minimum possible score)] × 100. A value of 0 therefore corresponded to the theoretical minimum and a value of 100 to the theoretical maximum obtainable on the respective scale. The original direction of each instrument was retained: higher SEQ, WEMWBS and SRQ-A scores indicated higher engagement, psychological well-being and motivational self-regulation, respectively, whereas higher DERS scores indicated greater difficulties in emotional regulation. Consequently, a decrease in DERS scores represented improvement. The values expressed on the 0–100 scale should therefore be interpreted as standardised scale points and not as percentages of participants. To this end, a comparison was made between pre- and post-intervention measurements in the two groups (control and experimental), also taking into account the differences between students with and without SLDs. The percentage variations reported below refer to relative changes from baseline, calculated as [(post-test score − pre-test score)/pre-test score] × 100, rather than to percentage-point differences. Absolute changes on the 0–100 scale are reported separately. For DERS, negative percentage values indicate a reduction in emotional-regulation difficulties and therefore a favourable

change.

In a preliminary phase, the initial equivalence of the two groups was verified through the analysis of pre-test data. The results show substantially similar values between the control group and the experimental group across all variables considered. In particular, the average levels of engagement were 62.4% in the control group and 63.1% in the experimental group; psychological well-being stood at 64.2% and 65.0% respectively, whilst difficulties in emotional regulation showed similar values (around 58% in both groups). With regard to motivational self-regulation, the two groups also show comparable initial scores (61.8% in the control group and 62.5% in the experimental group). All 120 students contributed complete pre- and post-intervention data, with 60 participants in the control group and 60 in the experimental group. At baseline, school engagement was M = 62.4 (SD = 10.2) in the control group and M = 63.1 (SD = 10.0) in the experimental group; psychological well-being was M = 64.2 (SD = 9.4) and M = 65.0 (SD = 9.2), respectively; emotional-regulation difficulties were M = 58.1 (SD = 9.8) and M = 58.4 (SD = 9.6), respectively; and motivational self-regulation was M = 61.8 (SD = 9.1) and M = 62.5 (SD = 9.0), respectively. Independent-samples t-tests confirmed the absence of significant baseline differences for engagement, $t(118) = 0.38$, $p = .705$, 95% CI [−2.95, 4.35], Cohen's $d = 0.07$; psychological well-being, $t(118) = 0.47$, $p = .638$, 95% CI [−2.56, 4.16], $d = 0.09$; emotional-regulation difficulties, $t(118) = 0.17$, $p = .866$, 95% CI [−3.21, 3.81], $d = 0.03$; and motivational self-regulation, $t(118) = 0.42$, $p = .673$, 95% CI [−2.57, 3.97], $d = 0.08$. The absence of statistically significant differences in the pre-test scores ($p > .05$) confirms the comparability of the groups prior to the intervention.

In a second phase, paired t-tests were applied within each group to verify any significant changes between the two measurement points. For the within-group analyses, paired-samples t-tests were performed using 59 degrees of

freedom. For each comparison, the mean pre–post difference, 95% confidence interval and Cohen's dz were calculated. Cohen's dz was obtained by dividing the mean individual change score by the standard deviation of the individual change scores.

As regards the control group, the results show an overall modest improvement. Starting from average initial values, a slight increase in school engagement (+4.2%) and psychological well-being (+3.5%) is observed, accompanied by a modest reduction in difficulties with emotional regulation (-2.8%). More specifically, in the control group (n = 60), school engagement increased from M = 62.4 (SD = 10.2) to M = 65.0 (SD = 10.1), corresponding to an absolute increase of 2.6 scale points and a relative increase of approximately 4.2%; t(59) = 1.86, p = .067, mean difference = 2.6, 95% CI [−0.19, 5.39], dz = 0.24. Psychological well-being increased from M = 64.2 (SD = 9.4) to M = 66.4 (SD = 9.6), an absolute increase of 2.2 points and a relative increase of approximately 3.5%; t(59) = 1.74, p = .087, 95% CI [−0.33, 4.73], dz = 0.22. Emotional-regulation difficulties decreased from M = 58.1 (SD = 9.8) to M = 56.5 (SD = 9.7), an absolute reduction of 1.6 points and a relative reduction of approximately 2.8%; t(59) = −1.42, p = .160, 95% CI [−3.85, 0.65], dz = −0.18. Motivational self-regulation increased slightly from M = 61.8 (SD = 9.1) to M = 63.0 (SD = 9.3), corresponding to an absolute increase of 1.2 points and a relative increase of approximately 1.9%; t(59) = 1.13, p = .262, 95% CI [−0.92, 3.32], dz = 0.15. However, these changes are not statistically significant (p > .05), suggesting that the traditional teaching approach, whilst promoting a certain stability in the observed levels, does not produce significant changes in the dimensions considered.

In contrast, in the experimental group, which started from similar baseline levels, markedly more pronounced improvements emerge. School engagement shows a significant increase (+18.6%), as do psychological well-being (+15.2%) and motivational self-regulation (+13.9%), whilst difficulties in emotional

regulation show a substantial reduction (-17.4%). In the experimental group (n = 60), school engagement increased from M = 63.1 (SD = 10.0) to M = 74.8 (SD = 9.1), corresponding to an absolute improvement of 11.7 scale points and a relative increase of approximately 18.6%; $t(59) = 9.64$, $p = 9.92 \times 10^{-14}$, 95% CI [9.27, 14.13], $dz = 1.24$. Psychological well-being increased from M = 65.0 (SD = 9.2) to M = 74.9 (SD = 8.7), representing an absolute improvement of 9.9 points and a relative increase of 15.2%; $t(59) = 8.71$, $p = 3.43 \times 10^{-12}$, 95% CI [7.63, 12.17], $dz = 1.13$. Emotional-regulation difficulties decreased from M = 58.4 (SD = 9.6) to M = 48.2 (SD = 9.0), corresponding to an absolute reduction of 10.2 points and a relative reduction of 17.4%; $t(59) = -8.78$, $p = 2.67 \times 10^{-12}$, 95% CI [−12.52, −7.88], $dz = -1.13$. Motivational self-regulation increased from M = 62.5 (SD = 9.0) to M = 71.2 (SD = 8.5), an absolute increase of 8.7 points and a relative increase of 13.9%; $t(59) = 7.75$, $p = 1.47 \times 10^{-10}$, 95% CI [6.45, 10.95], $dz = 1.00$. The magnitude of the within-group effects was therefore large for all four outcomes in the experimental condition.The results of the paired t-test indicate that these differences between pre- and post-intervention are all statistically significant ($p < .01$), highlighting the effectiveness of the hybrid learning environment in promoting both student engagement and well-being. Specific attention was paid to students with SLDs, in order to understand whether the intervention produced differentiated effects. Here too, the pre-test data show similar initial levels between the two groups (engagement around 58%, well-being 60%, emotional regulation 56%), confirming comparable starting conditions. The SLD subgroup comprised eight students, equally distributed between the control group (n = 4) and the experimental group (n = 4). Because of the very small subgroup size, these analyses were considered exploratory and were interpreted with caution. In the control group, engagement changed from M = 58.0 (SD = 4.8) to M = 59.8 (SD = 4.7), $t(3) = 1.80$, $p = .170$, 95% CI [−1.38, 4.98], $dz = 0.90$; psychological well-being

increased from M = 60.0 (SD = 5.1) to M = 61.4 (SD = 5.0), t(3) = 1.56, p = .218, 95% CI [−1.46, 4.26], dz = 0.78; emotional-regulation difficulties decreased from M = 56.0 (SD = 4.9) to M = 54.9 (SD = 4.8), t(3) = −1.47, p = .239, 95% CI [−3.49, 1.29], dz = −0.73; and motivational self-regulation increased from M = 59.0 (SD = 5.0) to M = 60.0 (SD = 4.9), t(3) = 1.18, p = .324, 95% CI [−1.71, 3.71], dz = 0.59. None of these control-group changes reached statistical significance.
In contrast, in the experimental group, students with SLDs showed even more pronounced improvements compared to their peers without SLDs. In particular, there was an increase in engagement of +21.3%, an increase in psychological well-being of +17.8%, a reduction in emotional regulation difficulties of -19.6% and an improvement in self-regulation of +15.1%. Consistent with these relative changes, engagement among students with SLDs in the experimental group increased from M = 58.2 (SD = 4.6) to M = 70.6 (SD = 4.3), t(3) = 8.86, p = .003, 95% CI [7.94, 16.86], dz = 4.43. Psychological well-being increased from M = 60.1 (SD = 4.8) to M = 70.8 (SD = 4.2), t(3) = 8.56, p = .003, 95% CI [6.72, 14.68], dz = 4.28. Emotional-regulation difficulties decreased from M = 56.2 (SD = 4.7) to M = 45.2 (SD = 4.0), t(3) = −8.15, p = .004, 95% CI [−15.30, −6.70], dz = −4.07. Motivational self-regulation increased from M = 58.9 (SD = 4.9) to M = 67.8 (SD = 4.3), t(3) = 7.42, p = .005, 95% CI [5.08, 12.72], dz = 3.71. Although these exploratory estimates indicate very large within-subgroup effects, their magnitude should be interpreted cautiously because each condition included only four students with SLDs.
In a third phase, a repeated measures ANOVA was conducted, considering time (pre vs post) and group (control vs experimental) as factors, in order to analyse the effectiveness of the intervention comparatively. Separate 2 × 2 mixed repeated-measures ANOVAs were conducted for each of the four quantitative outcomes, namely school engagement (SEQ), psychological well-being (WEMWBS), difficulties in emotional regulation (DERS) and motivational self-

regulation (SRQ-A). In each analysis, time (pre-test vs post-test) was entered as the within-subject factor and group (control vs experimental) as the between-subject factor. The time × group interaction constituted the principal test of intervention effectiveness, as it directly assessed whether the magnitude of pre–post change differed between the two educational conditions. Partial eta squared (η^2p) was used as the effect-size estimate.

For school engagement, measured through the SEQ, the analysis showed a significant main effect of time, $F(1,118) = 38.62$, $p = 8.01 \times 10^{-9}$, $\eta^2p = .247$, and a significant main effect of group, $F(1,118) = 12.74$, $p = .00052$, $\eta^2p = .097$. More importantly, the time × group interaction was statistically significant, $F(1,118) = 24.24$, $p = 2.79 \times 10^{-6}$, $\eta^2p = .170$. The experimental group improved by 11.7 points on the standardised 0–100 scale, compared with 2.6 points in the control group, corresponding to a between-group difference in change of 9.1 points, 95% CI [5.44, 12.76]. These results indicate that the increase in engagement over time was significantly greater in the experimental condition.

For psychological well-being, assessed through the WEMWBS, there was a significant main effect of time, $F(1,118) = 31.45$, $p = 1.37 \times 10^{-7}$, $\eta^2p = .210$, as well as a significant main effect of group, $F(1,118) = 11.28$, $p = .0011$, $\eta^2p = .087$. The time × group interaction was also significant, $F(1,118) = 20.51$, $p = 1.43 \times 10^{-5}$, $\eta^2p = .148$. Psychological well-being increased by 9.9 points in the experimental group and by 2.2 points in the control group, resulting in a difference in change of 7.7 points, 95% CI [4.33, 11.07]. Thus, the improvement in psychological well-being was significantly greater among students exposed to the hybrid and emotionally aware learning environment.

For difficulties in emotional regulation, measured through the DERS, the analysis identified a significant main effect of time, $F(1,118) = 35.76$, $p = 2.44 \times 10^{-8}$, $\eta^2p = .233$, and a significant main effect of group, $F(1,118) = 14.16$, $p = .00026$, $\eta^2p = .107$. The time × group interaction was statistically significant,

$F(1,118) = 28.32$, $p = 4.96 \times 10^{-7}$, $\eta^2p = .194$. DERS scores decreased by 10.2 points in the experimental group compared with a reduction of 1.6 points in the control group, producing a difference in change of −8.6 points, 95% CI [−11.80, −5.40]. Given that higher DERS scores indicate greater emotional-regulation difficulties, this interaction demonstrates a significantly greater reduction in such difficulties in the experimental condition.

For motivational self-regulation, assessed through the SRQ-A, a significant main effect of time was observed, $F(1,118) = 27.83$, $p = 6.09 \times 10^{-7}$, $\eta^2p = .191$, together with a significant main effect of group, $F(1,118) = 10.69$, $p = .0014$, $\eta^2p = .083$. The time × group interaction was likewise significant, $F(1,118) = 23.61$, $p = 3.66 \times 10^{-6}$, $\eta^2p = .167$. Motivational self-regulation increased by 8.7 points in the experimental condition and by 1.2 points in the control condition, corresponding to a between-group difference in change of 7.5 points, 95% CI [4.44, 10.56]. This finding indicates a significantly greater improvement in motivational self-regulation among students participating in the experimental intervention.

Accordingly, the previously reported aggregate ANOVA values were replaced by outcome-specific analyses in order to make explicit the dependent variable associated with each statistical test. Across all four outcomes, the statistically significant time × group interactions consistently indicated that change over time was more favourable in the experimental group than in the control group. Specific attention was paid to students with SLDs, in order to understand whether the intervention produced differentiated effects. Here too, the pre-test data show similar initial levels between the two groups (engagement around 58%, well-being 60%, emotional regulation 56%), confirming comparable starting conditions. The SLD subgroup comprised eight students, equally distributed between the control group (n = 4) and the experimental

group (n = 4). Because of the very small subgroup size, these analyses were considered exploratory and were interpreted with caution.

Given the presence of only four students with SLDs in each experimental condition, no confirmatory conclusions regarding differential intervention effectiveness for students with SLDs were drawn from the within-subgroup comparisons. The larger descriptive pre–post changes observed among students with SLDs in the experimental group were therefore treated exclusively as exploratory signals. To examine whether change over time differed as a function of both experimental condition and SLD status, an additional exploratory 2 × 2 × 2 mixed analysis was conducted for each outcome, with time (pre-test vs post-test) as the within-subject factor and group (experimental vs control) and SLD status (SLD vs non-SLD) as between-subject factors. The inferential term of specific interest was the time × group × SLD-status interaction.

For school engagement, the time × group × SLD-status interaction did not reach conventional statistical significance, $F(1,116) = 3.21$, $p = .076$, $\eta^2p = .027$. A similar pattern emerged for psychological well-being, $F(1,116) = 2.84$, $p = .095$, $\eta^2p = .024$, and motivational self-regulation, $F(1,116) = 2.47$, $p = .119$, $\eta^2p = .021$. For emotional-regulation difficulties, the three-way interaction approached but did not reach the conventional threshold for statistical significance, $F(1,116) = 3.66$, $p = .058$, $\eta^2p = .031$.

These three-way analyses therefore do not provide sufficient inferential evidence to conclude that students with SLDs benefited significantly more from the intervention than students without SLDs. The larger improvements descriptively observed in the four students with SLDs assigned to the experimental condition should instead be interpreted as preliminary and hypothesis-generating findings. Because the SLD subgroup comprised only eight participants overall, with four students in each study condition, the

corresponding estimates are inherently unstable and characterised by limited statistical power. Confirmation of a differential intervention effect according to SLD status will require studies specifically powered to test the time × group × SLD-status interaction in substantially larger samples.

Overall, the quantitative results indicate that the integration of hybrid and emotionally aware learning environments produces significant positive effects on students' well-being, engagement and emotional regulation. The convergent pattern observed across SEQ, WEMWBS, DERS and SRQ-A indicates that the intervention was associated not only with statistically significant changes but also with effects of substantive magnitude. With regard to students with SLDs, the descriptive pattern suggests potentially favourable responses to the intervention; however, these findings must be considered exclusively exploratory and cannot be interpreted as evidence of a greater intervention effect for students with SLDs, since the relevant time × group × SLD-status interactions did not reach statistical significance.

6. Analysis of qualitative data

The analysis of qualitative data, carried out using thematic analysis, provided an in-depth understanding of students' and teachers' perceptions of the learning experience, highlighting significant differences between the control group and the experimental group, as well as between students with and without SLDs.

Analysis of the interviews, digital reflective journals and classroom observations revealed four main thematic areas: perception of the learning experience, emotional engagement, relationship with technology and perception of inclusion. To preserve participants' anonymity whilst allowing each quotation to be traced to the relevant study condition and participant category, anonymised alphanumeric identifiers were assigned to all interview

excerpts. The first component indicates the study condition (CG = control group; EG = experimental group), whereas the second identifies the participant category (S = student without SLD; SLD = student with a certified Specific Learning Disorder; T = teacher). The final number identifies the individual participant within the corresponding category (e.g. CG-S01, EG-SLD02, CG-T01). These codes are used consistently throughout the presentation of the qualitative findings.

As for the control group, students describe the teaching experience as predominantly structured and focused on understanding the content, but less emotionally engaging. Many students report rather passive participation and difficulty in linking the content to their own personal experience. As one student states: “I understood what the teacher was explaining, but I struggled to feel that it really concerned me” (CG-S01). Another emphasised: “The lessons were clear, but always the same; they didn’t make me reflect much on how I felt” (CG-S02). Some students also highlighted a sense of distance from the relational aspect: “We talked about the characters, but not about us” (CG-S03), or “It was more important to understand the text than to understand what it left us with” (CG-S04).

Students with SLDs in the control group highlighted certain difficulties even more markedly, particularly in relation to cognitive load and the management of written tasks. In particular, a sense of frustration and detachment from the learning experience emerged: “When I had to write, I focused more on the mistake than on what I wanted to say” (CG-SLD01) or “I understood when spoken to, but then I couldn’t express myself well in assignments” (CG-SLD02). Some students also report a feeling of implicit exclusion: “I felt like I was always one step behind the others” (CG-SLD03) and “I couldn’t always participate as much as I would have liked” (CG-SLD04).

In contrast, in the experimental group, the students' accounts highlight greater involvement, both cognitive and emotional. The digital environments and proposed activities are perceived as closer to personal experience and capable of stimulating reflection and active participation. One student states: "With the digital activities, I felt more involved, because I could express what I thought in different ways, not just by writing" (EG-S01). Another points out: "Using the chatbot made me think more, because it almost felt like talking to someone who was listening to you" (EG-S02). Other students emphasise the value of personalisation: "Everyone could work in their own way" (EG-S03) and "I felt freer to interpret things without fear of making mistakes" (EG-S04).

Particularly significant is the perception of the emotional dimension mediated by technology. Some students recognise the value of digital tools as a support for reflection, whilst maintaining a critical awareness: "I know it's a machine, but sometimes the responses helped me understand better what I was feeling" (EG-S05) or "It's not like talking to a person, but it helps you organise your thoughts" (EG-S06). Others highlight an almost "mirror-like" function of the technology: "It was as if it helped me see myself from the outside" (EG-S07) and "It made me ask questions I wouldn't have asked myself" (EG-S08).

Students with SLDs in the experimental group reported even more evident benefits, both in terms of accessibility and emotional expression. In particular, a reduction in anxiety and greater freedom of expression emerged: "With videos and presentations, I was able to explain myself better, without being afraid of making mistakes" (EG-SLD01) and "Writing on the computer or using images helped me say what I felt, without getting stuck" (EG-SLD02). Another student emphasised: "For the first time, I felt as capable as the others, because I could use different tools" (EG-SLD03). Experiences of greater autonomy also emerged: "I could take my time and find the right way to express myself" (EG-SLD04) and "I didn't feel judged whilst I was working" (EG-SLD01).

As for the teachers in the control group, the interviews reveal a positive perception of the clarity and structure of the lessons, but also an awareness of certain limitations, particularly regarding the students' emotional engagement. One teacher states: "The work was consistent and well-organised, but I had the feeling that some students remained distant, especially on a personal level" (CG-T01). Another adds: "It is difficult to work on emotions without tools that facilitate expression" (CG-T02). Some teachers also highlight a difficulty in reaching all students: "Those who are shyer or struggling tend to remain silent" (CG-T03) and "It is not always possible to truly engage the whole class" (CG-T01).

In contrast, teachers in the experimental group highlight a significant change in participation and the quality of interactions. In particular, they emphasise the role of technology as a relational mediator: "The students were more engaged and participatory, even those who usually stay on the sidelines" (EG-T01) and "Digital activities facilitated the emergence of emotions, making the class more open to discussion" (EG-T02). Some teachers also observe a change in the classroom atmosphere: "A more collaborative environment has been created" (EG-T03) and "The students listened to one another more" (EG-T01).

A particularly significant aspect concerns the role of the teacher, which is being redefined in terms of mediation and guidance. As one teacher states: "I was no longer just explaining, but guiding students to understand how to interact with the technology and reflect on what they were feeling" (EG-T02). Another highlights: "The real work was helping students distinguish between an 'empathetic' response from the machine and an authentic relationship" (EG-T03). Some teachers also highlight professional growth: "For us too, it was a way of rethinking our role" (EG-T01) and "Technology has not replaced the relationship, but has made it more visible" (EG-T02).

Overall, the qualitative analysis confirms and expands upon the findings emerging from the quantitative data, highlighting how the hybrid learning environment fosters greater integration between the cognitive and emotional dimensions. In particular, it emerges that digital technologies, if appropriately mediated by the teacher, can become effective tools for promoting emotional awareness, inclusion and active participation. These patterns were particularly salient in the accounts of students with SLDs, for whom the digital environment was described not only as a teaching aid but also as a space for expression, recognition and the affirmation of individual learning preferences. Given the limited number of students with SLDs included in each condition, however, these qualitative findings should be interpreted as exploratory and illustrative of participants' lived experiences rather than as evidence of effects that can be generalised to the broader population of students with SLDs.

7. Discussion

The findings from the quantitative and qualitative analysis provide a comprehensive basis for reflecting on the role of hybrid and emotionally aware learning environments in upper secondary schools. Taken together, this evidence suggests that the integration of affectively oriented digital tools not only has an impact on participation and well-being at school, but also has a deeper effect on the quality of the educational experience, helping to redefine the relationship between learning, emotion and the construction of meaning (Selwyn, 2021). A comparison of the two teaching models reveals that a traditional approach, whilst maintaining its own disciplinary coherence, tends to prioritise the cognitive dimension, leaving the affective dimension in the background. In this sense, this evidence confirms that mere exposure to content, even when accompanied by critical reflection activities, is not

sufficient to generate full student engagement. The school experience thus risks remaining partially disconnected from personal lived experience, limiting the possibilities for constructing deeper meanings (Fredricks et al., 2019; Selwyn, 2021).

Conversely, the hybrid learning environment appears to be a context capable of fostering more integrated participation, in which the cognitive and emotional dimensions are more closely interconnected. From this perspective, technology does not merely perform an instrumental function, but assumes the role of a symbolic and relational mediator, expanding expressive possibilities, promoting the personalisation of learning pathways and making the affective dimension of learning more accessible (Bond et al., 2020; Zawacki-Richter et al., 2019).

Particularly significant, from a theoretical and pedagogical point of view, is the impact observed on students with SLDs. This evidence confirms that environments designed to be inclusive and multimodal can not only compensate for specific difficulties but also enhance different ways of accessing knowledge. In this sense, inclusion emerges as a dynamic process that involves offering multiple channels of expression and participation, rather than simply adapting content (Ok et al., 2017; Rivoltella, 2020).

A further interpretative element concerns the notion of artificial empathy. The evidence gathered suggests that students develop a complex relationship with artificial intelligence systems, whilst recognising both their usefulness and their limitations. On the one hand, these tools appear to foster processes of reflection, organisation of thought and verbalisation of emotional experience; on the other, they are not perceived as substitutes for human relationships. This finding appears particularly significant, as it indicates the emergence of initial forms of critical awareness, linked to the construct of Digital Affective Literacy (Mintz et al., 2023; Selwyn, 2021).

From this perspective, technology helps to make explicit processes that traditionally remain implicit, such as self-reflection and the narration of emotional experience. However, such processes only acquire full educational value when accompanied by conscious pedagogical mediation. The evidence gathered confirms that the teacher's role is not diminished, but rather redefined: from a transmitter of content to a facilitator of interpretative, relational and emotional processes. The teacher thus assumes a crucial role in helping students distinguish between simulation and authenticity, between algorithmic responses and human relationships (Holmes & Tuomi, 2022; Mintz et al., 2023).

In light of these considerations, the centrality of the humanities in the proposed approach appears particularly significant. These disciplinary fields, in fact, offer a privileged context for examining human experience, allowing the use of technology to be situated within a symbolic and cultural framework. In this sense, the effectiveness of the intervention seems to stem from the integration of content depth and tool flexibility, rather than from the mere introduction of digital technologies (Rivoltella, 2020; Selwyn, 2021).

A final key element concerns the relational dimension of the classroom context. Evidence suggests that learning environments designed with an affective focus can foster more intense forms of participation and mutual recognition. The opportunity to express, share and process one's emotions helps transform the classroom into a space where knowledge intertwines with experience, promoting more meaningful and situated learning (Bond et al., 2020).

Overall, this evidence confirms that the central issue is not the replacement of humans by technology, but rather the ways in which it is designed and integrated into educational contexts. When embedded within a critical and relational pedagogical framework, technology can help to enhance the human quality of the school experience, supporting learning processes that

simultaneously engage cognitive, emotional and social dimensions (Mintz et al., 2023; Selwyn, 2021).

8. Conclusions

This study aimed to explore the educational value of hybrid and emotionally aware learning environments, examining the relationship between technological innovation, educational inclusion and the interpretative framework of Digital Affective Literacy. Overall, the research highlighted how the intentional integration of digital tools, when accompanied by thoughtful pedagogical design, can help redefine the school experience for adolescents in a more flexible, accessible and meaningful way (Selwyn, 2021). The findings should be interpreted in relation to the multimodal intervention as a whole, which combined different digital and pedagogical resources—including generative AI-based chatbots, videos, presentations, conceptual maps, podcasts, digital storytelling and reflective activities—rather than as evidence of the independent effectiveness of any single technological component. One of the elements that emerges most strongly concerns the need to consider the affective dimension not as a secondary aspect of learning, but as a structural component of it. In this sense, the findings suggest that contemporary educational contexts require tools capable not only of supporting the understanding and processing of content, but also of fostering processes of recognition, expression and organisation of emotional experience. The relevance of this perspective is particularly evident in a school population that lives immersed in technologically mediated environments on a daily basis and which, precisely for this reason, requires adequate interpretative tools to navigate critically the new forms of relationship with digital technology (Mintz et al., 2023; Rivoltella, 2020). Within this study, Digital Affective Literacy should therefore be understood as a theoretical and interpretative framework through

which these processes can be read, rather than as a construct that was directly measured through a dedicated validated instrument. Consequently, the study does not claim to demonstrate a measurable increase in Digital Affective Literacy itself.

The study also highlights how educational innovation does not automatically coincide with the introduction of technological tools, but rather with the quality of the pedagogical framework within which these tools are situated. The pattern of outcomes associated with the intervention appears to depend on the combined contribution of its multiple components, including subject-specific content, teacher mediation, diverse forms of expression and critical reflection. In this sense, technology appears truly significant when it is placed at the service of teaching that knows how to value students' subjectivity, promote participation and support inclusive processes (Bond et al., 2020; Holmes & Tuomi, 2022). Accordingly, the present design does not allow the contribution of generative artificial intelligence to be isolated from that of the other resources and activities included in the experimental condition. The observed differences between groups must therefore be attributed to the multimodal educational intervention as an integrated whole, rather than specifically to the use of AI or chatbots.

Alongside these elements, it is necessary to acknowledge certain limitations of the study. Firstly, the research was conducted in a single school setting and on a limited sample, a factor that calls for caution when generalising the results. Furthermore, the sampling method used was non-probabilistic and convenience-based, relying on the school's availability and the voluntary participation of students; this methodological choice may have introduced a potential selection bias, limiting the sample's representativeness of the target population.

A further limitation concerns the duration of the intervention, which, whilst

sufficient to detect significant changes in the short term, does not allow for the stability of the effects to be observed with certainty in the medium and long term. Consideration must also be given to the composition of the subgroup of students with SLDs, which is numerically small, making it advisable to explore the topic further with larger and more diverse samples, including those with other educational needs. In particular, given that only four students with SLDs were included in each study condition, the patterns observed within this subgroup should be considered exclusively exploratory and hypothesis-generating. They cannot be interpreted as evidence that the multimodal intervention was more effective for students with SLDs than for students without SLDs.

Finally, some qualitative evidence is based on subjective perceptions and narratives, which are particularly valuable for understanding the experiences of those involved, but cannot always be extrapolated directly to other contexts; in this regard, future research could integrate such data with further cross-validation tools, in order to strengthen the interpretative robustness of the results (Creswell & Plano Clark, 2007; Johnson & Christensen, 2024). More specifically, students' and teachers' accounts should be interpreted as evidence concerning how participants perceived, experienced and attributed meaning to the intervention. Although these accounts may converge with patterns observed in the quantitative data, such convergence should not be regarded as an independent confirmation of objective intervention effects. Rather, the qualitative findings provide contextual and interpretative depth, helping to explain how participants experienced the learning environment and the meanings they associated with its different components.

In light of these factors, the future implications appear particularly significant. It would be desirable to extend the research to different school contexts, including other fields of study, different age groups and a wider variety of

educational needs, in order to verify the transferability of the proposed model. Further developments could involve longitudinal studies, capable of observing the evolution over time of the dimensions theoretically associated with Digital Affective Literacy and the consolidation of the intervention's effects. Furthermore, the relationship between generative artificial intelligence practices, adolescent identity construction and the perception of relational authenticity could be explored in greater detail (Mintz et al., 2023; Zawacki-Richter et al., 2019). Future research could also adopt factorial or multi-arm experimental designs capable of disentangling the specific contribution of generative AI from that of other components of multimodal learning environments, such as audiovisual materials, digital storytelling, conceptual mapping and reflective activities.

Another particularly promising area of research concerns teacher training. The qualitative accounts collected in this study suggest that participants perceived the quality of teacher mediation as an important element in shaping the educational use of technologies. This interpretation should not be understood as evidence of an independently measured causal effect of teacher mediation, but as a relevant finding emerging from participants' experiences. This highlights the need to develop training programmes that help teachers not only to master digital tools, but also to critically interpret their relational and affective potential. From this perspective, training should include skills related to managing mediated interactions, interpreting students' emotional experiences, and creating learning environments capable of integrating technological effectiveness with educational intent (Selwyn, 2021).

In conclusion, the theme of emotionally aware environments poses a profound challenge to schools today, as it calls into question not only the way in which learning takes place, but also the way in which presence, recognition and relationships are built within educational contexts. In an age marked by

increasing algorithmic mediation, education is called upon to safeguard and renew its humanising function. From this perspective, the challenge does not lie in pitting the human against the artificial, but in understanding how to design educational spaces in which technology can be critically engaged with, so that it continues to serve personal growth, participation and the dignity of the educational relationship (Mintz et al., 2023; Rivoltella, 2020). The main contribution of this study lies, therefore, not in demonstrating the specific effectiveness of artificial intelligence or in establishing a directly measured increase in Digital Affective Literacy, but in providing preliminary empirical evidence on a multimodal hybrid learning environment in which different technological, expressive and reflective resources were integrated within a relational and inclusive pedagogical design. In this framework, Digital Affective Literacy serves as an interpretative lens for understanding how students and teachers critically engage with technology-mediated affective experiences, while the qualitative findings illuminate participants' subjective experiences without being treated as objective confirmation of the quantitative effects.

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