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SPECIFICATIONS OF E-MENTORING IN EDUCATION FOR SUSTAINABLE DEVELOPMENT: ACTION RESEARCH

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Abstract:
Technological advancements have enabled mentoring relationships to transcend temporal and geographical boundaries through digital platforms. E-mentoring—defined as mentoring facilitated by technology rather than face-to-face interaction—offers asynchronous, flexible, and accessible support, distinguishing it from traditional mentoring formats. This study investigates the characteristics of e-mentoring within the context of Education for Sustainable Development (ESD), employing a meta-analysis of scholarly literature published over the past seven years. Through systematic searches across academic databases (ERIC, Google Scholar, Springer Link, and Taylor & Francis), 18 evidence-based studies on e-mentoring were identified, including 5 directly related to ESD and 3 concerning distance education and sustainability. The methodology followed a structured process of search, screening, and synthesis, aiming to explore how e-mentoring aligns with the principles of sustainability. The findings contribute to a consolidated understanding of e-mentoring as a tool for professional development in ESD, while also revealing existing knowledge gaps and suggesting directions for future research.

Keywords: e-mentoring, Education for Sustainable Development (ESD), professional development, sustainability education

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1. Introduction

In the rapidly evolving landscape of education, mentoring has become a vital mechanism for enhancing teachers' professional growth. E-mentoring—defined as digitally mediated guidance and support—transcends traditional barriers of time and location. Through asynchronous communication tools and online platforms, mentors and mentees engage in flexible, dynamic interactions that foster new modes of learning and collaboration.

Within the framework of Education for Sustainable Development (ESD), e-mentoring assumes heightened importance. ESD emphasizes lifelong learning, critical thinking, cooperation, and the cultivation of values aligned with sustainability and social responsibility. Teachers are central to promoting these principles, making their continuous, reflective professional development essential.

Integrating e-mentoring into teacher education for ESD presents a promising strategy for building communities of practice, encouraging active engagement, and fostering empowerment. Yet, empirical research on the design and implementation of e-mentoring programs within ESD contexts remains scarce—particularly in action-oriented frameworks and during periods of crisis, such as the COVID-19 pandemic.

The COVID-19 pandemic served as a catalyst for transitioning professional learning into digital spaces, rendering e-mentoring not only necessary but central to sustaining teacher support. The crisis underscored the critical importance of adaptability, collaboration, and innovation—qualities that are foundational to sustainable development and integral to Education for Sustainable Development (ESD).

In this context, e-mentoring evolved beyond a logistical solution into a pedagogical strategy that resonates with the core values of ESD. Digital mentoring environments facilitated democratic engagement, reflective practice, and shared responsibility among educators, particularly in remote and under-resourced communities. These virtual spaces enabled inclusive participation and fostered resilience, contributing to the cultivation of sustainability-oriented mindsets.

Despite its increasing relevance, e-mentoring within ESD remains under-theorized and insufficiently explored in empirical research. There is a pressing need for deeper investigation into the structural design of such programs, the lived experiences of participants, and the extent to which e-mentoring supports transformative learning aligned with the Sustainable Development Goals (SDGs). Understanding these dimensions is essential for leveraging e-mentoring as a strategic tool in advancing sustainable education systems.

This study investigates the implementation of an e-mentoring program aimed at supporting primary school teachers in embedding the principles of Education for Sustainable Development (ESD) into their pedagogical practice. Conducted during the 2021–2022 academic year, the program was grounded in a participatory action research methodology, emphasizing collaboration, reflection, and iterative learning.

At the heart of the initiative was the development of a virtual learning community, where mentors and mentees engaged in sustained dialogue, collaborative reflection, and

experiential learning. The program design prioritized both pedagogical guidance and peer support, utilizing digital tools to transcend geographical and temporal limitations. The mentoring approach adopted in this study repositions the teacher not merely as a recipient of expert knowledge, but as a co-creator of sustainable educational practices. It foregrounds the co-construction of knowledge, sensitivity to local contexts, and the transformative potential of technology-mediated professional development. By fostering agency and reflective practice, the program contributes to building capacity for ESD and advancing the broader goals of sustainability in education.

By situating e-mentoring within the broader objectives of sustainability and digital innovation, this study seeks to provide both practical insights and theoretical contributions to the evolving field of teacher professional development. It responds to the pressing need to equip educators with the competencies, dispositions, and collaborative strategies required to navigate increasingly complex and dynamic educational landscapes.

The following sections present a structured analysis of the program's design, implementation, and outcomes. Particular emphasis is placed on the role of e-mentoring in fostering reflective practice, professional empowerment, and alignment with the Sustainable Development Goals (SDGs). In doing so, the study contributes to a deeper understanding of how digitally mediated mentoring can serve as a transformative tool for advancing Education for Sustainable Development.

2. Literature Review

The integration of e-mentoring into teacher professional development has attracted increasing scholarly interest, particularly in response to the global shift toward digital transformation and remote education. Existing research emphasizes e-mentoring's potential to foster individual and collective growth, support networked professional communities, and promote reflective engagement (Bierema & Merriam, 2002; Dawson, 2014; Single & Muller, 1999). In contrast to traditional face-to-face mentoring models, e-mentoring offers flexibility, scalability, and accessibility—qualities that are especially critical in contexts marked by disruption, limited resources, or geographical dispersion. Recent analyses of mentoring software in education (e.g., Pesina, 2025) highlight the rising relevance of digital platforms in supporting teacher development, especially when embedded within structured pedagogical frameworks. These platforms facilitate personalized learning pathways, promote reflective dialogue, and enhance access to professional communities.

Meanwhile, the field of Education for Sustainable Development (ESD) has evolved to foreground not only the transmission of knowledge, but also the cultivation of competencies, values, and attitudes that empower learners to contribute meaningfully to a more sustainable and equitable future. ESD frameworks endorse interdisciplinary approaches, participatory learning, and critical reflection—principles that dovetail

closely with e-mentoring strategies designed to foster active engagement and personal transformation (UNESCO, 2017).

Despite clear theoretical resonance, the intersection between e-mentoring and ESD remains under-explored. Few empirical studies investigate how digitally mediated mentoring can function as a catalyst for sustainable educational change. There is a critical gap in understanding the pedagogical conditions, design strategies, and transformative outcomes that underpin effective e-mentoring within ESD-oriented contexts.

Current scholarship continues to affirm the role of digital platforms in enabling collaborative inquiry, co-construction of knowledge, and the formation of virtual communities of practice (Salmon, 2000; Trust et al., 2016). These spaces provide opportunities for peer learning, shared reflection, and pedagogical innovation—essential features of a dynamic and sustainable learning culture.

Nevertheless, the design and implementation of e-mentoring programs face persistent challenges. Research highlights the need for context-sensitive, ethically grounded frameworks that align with the values of ESD. Key success factors include clearly defined mentoring roles, sustained engagement, structured support mechanisms, and reflective feedback loops (Kochan & Pascarelli, 2012; Louws et al., 2017). Importantly, mentors must demonstrate not only digital fluency but also a robust understanding of sustainability paradigms and transformative pedagogy.

The present study contributes to this growing discourse by examining an e-mentoring program grounded in participatory action research and oriented explicitly toward ESD. By situating the initiative within an authentic educational context, the research offers practical insights and theoretical contributions to an under-researched nexus, advancing knowledge on how digital mentoring can support sustainability education in meaningful and replicable ways.

3. Research Aim and Questions

The primary aim of this study is to investigate the structure, dynamics, and outcomes of an e-mentoring program designed to support primary school teachers in integrating the principles of Education for Sustainable Development (ESD) into their professional practice. Framed within a participatory action research methodology, the study explores how digitally mediated mentoring can foster professional learning, teacher empowerment, and alignment with the Sustainable Development Goals (SDGs).

To guide this inquiry, the following research questions were formulated:

- **RQ1**: What are the specifications of an e-mentoring program on the principles of education for sustainable development?
- **RQ2**: What factors are supportive of an e-mentoring program in education for sustainable development?
- **RQ3**: How should the participation of mentees in an e-mentoring program in sustainable development education be supported and encouraged?

4. Methodology

This study employed a Participatory Action Research (PAR) approach, which is well aligned with the principles of Education for Sustainable Development (ESD), emphasizing collaboration, critical reflection, and transformative learning. PAR facilitates the co-construction of knowledge among stakeholders, positioning participants not as passive subjects but as active contributors in the inquiry process (Kemmis, McTaggart & Nixon, 2014).

The research was carried out during the 2021–2025 academic year and consisted of three iterative action research cycles. Each cycle included the stages of planning, implementation, observation, and reflection. This cyclical process enabled continuous adaptation of the research framework based on participant feedback and contextual dynamics.

A total of 32 in-service primary school teachers participated in the study, representing diverse geographical regions and educational contexts. Selection was based on voluntary enrollment in an online professional development program focused on sustainability education. The cohort comprised both experienced and early-career educators, providing a heterogeneous set of perspectives regarding mentoring needs and experiences.

Ethical considerations were rigorously addressed through procedures of informed consent, anonymization of data, and voluntary participation. No personal data was collected, and participants were fully informed of their right to withdraw from the study at any time without consequence.

The e-mentoring program was strategically designed to foster reciprocal and collaborative learning among participants via digital platforms. The program established three core roles: the e-mentor, the e-mentees, and two critical friends who provided feedback and facilitated meta-reflection throughout each action research cycle.

The e-mentor functioned as a facilitator and guide, tasked with designing and implementing learning activities, moderating online discussions, and supporting the professional growth of the mentees. The e-mentees were actively encouraged to engage in content co-creation, collaborative inquiry, and critical self-reflection on their teaching practices. The critical friends, acting as external observers, offered constructive feedback and upheld the reflective dimension of the process.

Communication occurred asynchronously through platforms such as Slack and Webex, ensuring flexibility, accessibility, and self-paced engagement. Mentoring interactions centered around key themes including the Sustainable Development Goals (SDGs), sustainable pedagogical practices, digital education, and inclusive teaching approaches.

A strong emphasis was placed on transformative learning through methods such as reflective journaling, participatory planning, and collaborative decision-making. The program also underscored the importance of democratizing mentoring relationships,

fostering equitable participation by recognizing and valuing each voice irrespective of level of experience or professional status.

4.1 Research Design and Data Collection

The study was structured around three iterative action research cycles, each spanning approximately two months. During each cycle, participants actively engaged in the planning of collaborative actions, the implementation of pedagogical activities, and the systematic reflection on outcomes, followed by revisions to their approaches. This cyclical and adaptive methodology facilitated a deep engagement with both mentoring practices and the core principles of Education for Sustainable Development (ESD).

- Cycle 1 focused on familiarizing participants with foundational ESD concepts and establishing digital communication protocols.
- Cycle 2 involved the co-creation of classroom activities inspired by the Sustainable Development Goals (SDGs), guided by mentor input and peer feedback.
- Cycle 3 centered on critical reflection and evaluation of practices, emphasizing personal growth and professional development.

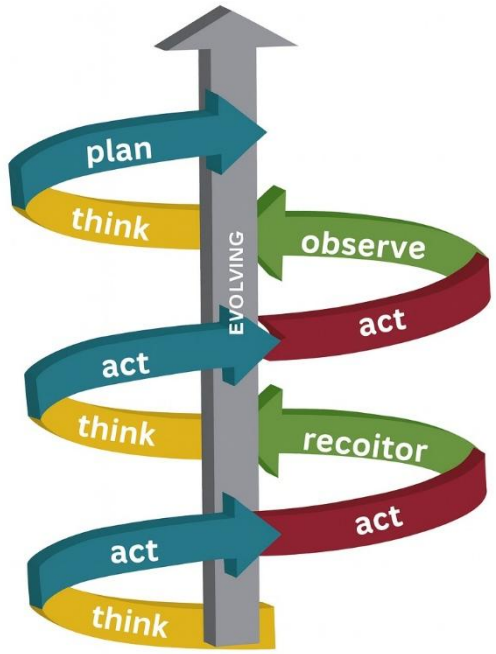

Figure 1: Action research cycles

4.2 Data Collection Methods

A variety of qualitative data sources were employed to ensure triangulation and richness of insight:

- Reflective journals and written participant feedback,
- Transcripts from asynchronous online discussions via Slack,
- Open-ended questionnaires and collaborative digital artefacts (e.g., Padlet boards, Mentimeter responses),

- Observational notes and commentary provided by the critical friends.

4.3 Data Analysis

Thematic analysis was conducted using a recursive coding process. This involved identifying patterns, contradictions, and emergent shifts in understanding throughout the three cycles. Codes were systematically grouped into overarching themes that were aligned with the study's research questions and grounded within the conceptual framework of ESD.

5. Data Collection & Tools

A fundamental component of the e-mentoring program was the strategic integration of digital tools that facilitated interaction, reflection, and collaborative learning, directly supporting the principles of Education for Sustainable Development (ESD). The central communication hub was Slack, which hosted multiple thematic channels (e.g., #focus-group, #discussion-forum, #initial-questionnaire, #video-communication, #world-cafe-method). This asynchronous space enabled continuous dialogue, document sharing, peer feedback, and access to curated ESD-related resources, fostering equitable participation regardless of time constraints or geographical location.

Webex and, occasionally, Zoom, were employed for synchronous e-meetings, particularly at the launch of each action research cycle, during collective reflection sessions, and for mentoring interactions requiring real-time collaboration. These live sessions strengthened the sense of community and supported authentic dialogue across diverse educational contexts (Loepp & Weber, 2021).

To promote engagement, knowledge exchange, and reflective practice, several interactive tools were embedded within the program design:

- Mentimeter: Used to collect real-time feedback and visualize participant responses during live sessions—particularly for expectations mapping at the start and evaluation at the end of each mentoring cycle (Khan, 2025).
- Padlet: Functioned as a collaborative digital noticeboard for posting action plan results, sustainability-related ideas, and educational resources (Rath, 2025).
- Google Docs and Google Drive: Enabled collaborative writing, joint planning, and sharing of sustainability teaching materials among mentors and mentees (Opara et al., 2021).
- Slack Focus Group Channel: Provided a semi-structured space for in-depth thematic discussions beyond live meetings, supporting sustained engagement with ESD topics (Syahputra & Usman, 2025).

Tool selection was guided by principles of accessibility, ease of use, and the capacity to foster active engagement, learner autonomy, and inclusive participation. This digital ecosystem was further enriched by the adoption of learner-centered pedagogical models—notably the World Café method and Flipped Classroom approach—adapted for

online delivery to promote collaborative meaning-making and sustained professional reflection.

Table 1: Digital Tools Used in the E-Mentoring Program

Tool / Platform	Purpose in the Program	Interaction Type	ESD Relevance
Slack (multiple channels)	Asynchronous communication, resource sharing, and peer feedback	Asynchronous	Builds communities of practice; equitable access to ESD resources
Webex / Zoom	Synchronous mentoring sessions, collective reflection	Synchronous	Supports dialogue, collaboration, and shared vision for sustainability
Mentimeter	Real-time feedback and visualization	Synchronous	Encourages reflection and active participation in sustainability topics
Padlet	Collaborative resource and idea sharing	Asynchronous/ Synchronous	Promotes co-creation of ESD materials
Google Docs / Drive	Joint planning, collaborative writing	Synchronous/ Asynchronous	Facilitates shared authorship of sustainability-focused lesson plans
Slack Focus Group Channel	Thematic in-depth discussions	Asynchronous	Encourages thematic exploration of SDGs and ESD practices

5.1 World Café Method

The World Café approach was employed to stimulate rich collaborative dialogue on sustainability-related themes and pedagogical strategies. Virtual "tables" were created using breakout rooms in Webex, where small groups discussed targeted questions over timed rounds. Participants rotated across rooms after each round, exchanging insights and building collective understanding.

This method fostered:

- Inclusive participation and knowledge sharing,
- Cross-pollination of ideas across diverse educational backgrounds,
- Emergent thinking that aligned with the democratic and co-constructive principles of Education for Sustainable Development (ESD).

5.2 Flipped Classroom Model

The Flipped Classroom strategy was used during mentor-led sessions to encourage self-directed learning and deeper interaction:

- Participants first engaged asynchronously with preparatory materials such as short readings, video lectures, and reflective prompts.
- Synchronous sessions focused on collaborative dialogue, interpretation, and application of the material, allowing for higher-order thinking and shared meaning-making.

This approach supported autonomy and enriched the mentoring dynamic by promoting critical reflection and sustained engagement.

5.3 Participant Feedback

Both methodologies received positive evaluations for their contribution to:

- Enhanced reflective capacity and professional self-awareness,
- Increased ownership of the learning process,
- Active peer-to-peer interaction and community-building.

These strategies were instrumental in advancing the program's goals of transformative and sustainable professional development.

6. Results

6.1. Demographic Characteristics of Participants

According to the data in the table below, the teachers of the research group come from the first-grade education, namely 11 teachers from kindergarten, 2 teachers from the first grade, 1 teacher from the second grade, 2 teachers from the third grade, 2 teachers from the fourth grade, 5 teachers from the fifth grade, 8 teachers from the sixth grade and 1 teacher from the Integration Department - Environmental Group.

6.2 Results from the Initial Questionnaire

The first questionnaire asked a series of questions related to Sustainable Development (SD) in order to assess the existing situation and to identify important factors at the context and input level. Participants reported 96.9% that they have heard of the term "17 Sustainable Development Goals (SDGs)" while 40.6% have received sufficient training on the 17 SDGs and believe that they have been sensitized to take action on the major change in our planet by 2030, to a great to maximum extent at 47, 4% and 26.3% respectively. 62.5% of respondents reported that they have taught some or all of the 17 SDGs in their classroom or have participated with their class in some action on the 17 SDGs. While, a total of 20 of the respondents who, as we have seen, 62.5% stated that they have taught some or all of the 17 SDGs within their classroom or have participated with their classroom in an action for the 17 SDGs, in a related question stated that they have taught/have conducted actions for the following:

- Racial stereotypes,
- Climate crisis,
- Peace and cooperation of peoples,
- Zero Hunger (skills workshops through the Healthy Kids - Healthy Planet program),
- Recycling,
- Getting to know the 17 SDGs and engaging with sustainability,
- Climate-environment-peace-humanities,
- Energy saving, water saving, climate change, environmental protection,

- Gender equality, children's rights, racism,
- Poster making - newspaper creation,
- Climate change,
- Zero Poverty - continent - quality education (UNICEF- ACTIONAID),
- Environmentally sound management of school waste, beach cleaning, cooperation with WWF,
- Discussions, video watching, constructions presented throughout the school, and field actions.

In a related question, "How would you rate your level of digital skills?", 37.5% of the subjects stated that they have digital skills to a great extent, and 15.6% to a maximum extent. In another question, subjects stated at 90.6% that they believe that the 17 goals can lead to improved living standards globally.

6.3 Results from the Distance Learning Seminar Entitled: "The 17 Sustainable Development Goals through the World Café technique"

In the second stage of the research, a distance training seminar entitled "The 17 Sustainable Development Goals through the World Café Technique" was designed and implemented. The seminar was addressed to primary school teachers who were interested in participating in the research process. It was attended by 45 teachers and kindergarten teachers serving in schools in Attica and the wider Greece.

6.4 Results of the Formative Evaluation

In the third stage of the research, we proceeded to an evaluation of the process with the ultimate goal of differentiating and directing the process in the desired direction, while "refreshing" the co-researchers' existing knowledge. The main purpose was to make everyone become competent "Ambassadors" of the 17 SBAs, after giving them feedback, in order to effectively transform their initial ideas and conceptions. The corresponding questionnaire included a series of questions and exercises related to the 17 SDGs. The results showed that the participants were largely aware of the individual themes, so that all of them were considered potential "Ambassadors" of the 17 SDGs. In particular, 18,8 % of them answered all the questions correctly. Thus, according to their scores (66 to 85 points), they were congratulated for proving to be excellent "Ambassadors" of the 17 SDGs, having already taken action for the 17 SDGs. Also, 65.6% answered all questions correctly. Therefore, according to their scores (44 to 65 points), they were defined as "Advisors" of the 17 SDGs, since their knowledge is at a very good level. In 12.5% they answered correctly only a few questions. Thus, according to their scores (22 to 43 points) they received a Bravo because they are "Guides" of the 17 SBAs. Finally, only one of the respondents, 3.1%, through his effort, was named as a great "Friend" of the 17 SBAs.

6.5 Results from the Teachers' Meetings for the Design of Educational Practices (action plans)

In the fourth stage of the research, three different synchronous distance meetings were implemented with the teacher-educators of different age groups of students, with the aim of the respective collaborative planning of a classroom teaching practice that would lead to the achievement of effective education of students on the 17 SDGs. The following reflective comments emerge from the transcription of the meetings, and the results obtained from the teachers' participation during the meetings are also presented.

6.5.1 Reflection of a Group Meeting in Grades A, B and C

During the meeting, there was an increased willingness to work together among the group members. The participants exchanged knowledge, opinions, and experiences and came to a conclusion on the structure of the teaching with appropriate adjustments adapted to the specific characteristics of the different student groups, as well as to the previous experience of implementing the 17 SBAs in the respective classroom.

6.5.2 Reflection of a Group Meeting in Grades D, E and F

During the meeting, the following was observed: the group of teachers had different previous experiences of implementing the 17 SBAs in the classroom. In particular, there were teachers who had never taught the 17 SDGs in their classroom before, teachers who had been involved to a lesser extent with the 17 SDGs and others who were systematically involved with them. For this reason, a specific gradation of implementation of the 17 SDGs was proposed, according to the specific characteristics of the student groups.

6.5.3 Reflection of a Meeting of a Kindergarten Group

During the meeting, there was a remarkable cooperative spirit among the members of the group. The participants first discussed time and how more complex cognitive functions are mastered by kindergarten students. Then, they exchanged knowledge, opinions, and experiences and came up with the structure of instruction with adjustments based on the specific characteristics of different student groups, as well as previous experience of implementing the 17 SBAs in the classroom. The group proposed a specific graduation for the implementation of the 17 SDGs, which is aimed at primary school students but can be implemented with some variations for kindergarten students.

6.6 Results of the Educational Practices Applied in the Classrooms

In the fifth stage, teachers proceeded to implement their action plans in the classroom. Through collaborative instructional design, the co-researchers were led to the transformation of new individual action plans suitable for implementation in their own classrooms. During the teachers' meeting (stage four), the flipped classroom was proposed as an illustrative method, which was eventually implemented by several teachers. The co-researchers created an appropriate learning environment in order to

foster both critical thinking and reflection skills of the students on the 17 SDGs. From the collection and critique of the "Educational Practice Plans for the 17 Goals

Sustainable Development", the following data emerge: The co-researchers worked exemplary and submitted to the highly produced educational products, such as: digital books with children's drawings, digital games, digital quizzes, digital jigsaw puzzle with the 17 sustainable goals from children's individual projects, jigsaw puzzle with the 17 sustainable goals from children's individual projects, creation of podcast with pupils in the role of leaders arguing characteristically about whether the 17 goals are a waste of time, posts on Padlet "I know the 17 SDGs", podcast - presentation of the world café by pupils, creation of commercials, board game with questions created by the teacher and pupils, etc.

6.7 Results of the Final Evaluation on e-mentoring

In the sixth stage of the research, we proceeded to the final evaluation of teachers about e-mentoring. The corresponding questionnaire included a series of questions about e-mentoring. The results showed positive attitudes from the participants and are summarized below:

The majority of the subjects stated that they consider the e-mentoring (multimodal guidance) program they participated in necessary for Education for Sustainable Development to a high degree, with respective percentages of 51.7% excellent and 37.9% high. The majority of the subjects stated that they felt that the e-mentoring program helped in implementing the 17 SDGs in the classroom to a high degree, and in respective percentages of 55.2% excellent grade and 34.5% high grade. The majority of the subjects state that this e-mentoring program helped in addressing the difficulties and needs related to the 17 SDGs in high grade, and in corresponding percentages, 58.6% excellent grade and 24.1% high grade. Respondents indicate that the e-mentor was knowledgeable about the 17 SBAs to a high degree, with respective percentages of 93.1% excellent and 6.9% high. Subjects state that the digital media and tools used contributed to their understanding of the 17 SDGs to a high degree and at respective percentages of 69.0% excellent and 27.6% high. Subjects state that the e-mentoring program contributed to the creation of a community of practice to a high degree and at respective percentages of 93.1%. The subjects considered that the way of support and encouragement in the e-mentoring program regarding the 17 SBAs was excellent at 79.3%. Finally, regarding "the factors that worked supportively in the e-mentoring program they participated in", the participants stated that they were:

Table 2: Supportive factors identified by participants in the e-mentoring program

Encouragement, interaction, and the World Café technique	37,9%
The excellent online tutor with her good mood	51,7%
The digital media and tools	10,3%

Similarly, with regard to "the factors that acted as barriers to the e-mentoring program they participated in", subjects state that they were:

Table 3: Barriers encountered by participants during the e-mentoring program

There have been no obstacles
The time
Our increased work commitments, distract us from dealing with this issue.

A final question asked "what they would suggest to change, improve or add to this program". The results showed the following:

Table 4: Suggestions for improvement of the e-mentoring program

They did not answer	20,7%
It was complete	20,7%
Perhaps additional digital media	3,4%
More time for the project	51,7%
School partnerships	3,4

6.8. Results from the Teaching Evaluation on the 17 Sustainable Development Goals

In the seventh stage of the research, we proceeded to an evaluation of teaching for the 17 SDGs. The corresponding questionnaire included a series of questions about the teaching (action plans) that the co-researchers implemented for the 17 SDGs and any difficulties they encountered. The results showed positive attitudes from the participants and are summarized below.

The majority of subjects stated that the training practice was implemented according to their design and objectives to a high degree. The majority of the subjects state that the educational practice aroused the interest of the students to a high degree. Teachers state that the knowledge of students is moderate at 27.6% and high at 3.4%. In contrast, 69.0% declared a low grade. Subjects stated that students understood the 17 SBAs from the educational practice they designed at a high percentage (7 to 10) of the corresponding 5 - 10 scale. Also, to the question, "To what extent do you think your students were made aware of the 17 SDGs by the educational practice you designed", subjects state that students were made aware of the 17 SDGs by the educational practice they designed at a high percentage (7 to 10) of the corresponding 5 -10 scale. In another question, "To what extent did the educational materials (e.g., videos) and media you used contribute?", teachers state that the educational materials contributed at a high percentage (8 to 10) of the corresponding 5 - 10 scale.

6.9 Results from the Interview with Critical Friends Regarding e-mentoring

In order to enable the triangulation of the research process among the initial ideas of the co-researchers, the produced teaching products - action plans and the "critical friends", in the eighth and final stage of the research, we conducted an interview with the latter, aiming to explore their views regarding the effectiveness of the applied e-mentoring program. The critical friends responded that: Given the bidirectional communicative interdependence that was established between the participants and the e-mentor of the program, this initiative is considered to have substantially contributed to the acquisition

of valuable knowledge, the development of skills, and the adoption of attitudes and values related to the 17 Sustainable Development Goals (SDGs). Focusing on the ways that functioned supportively, so that the basic objectives mentioned above were activated and achieved, we will highlight the following key points: The form of program development contributed significantly:

1) to address daily teaching problems,
2) to understand the content of teaching,
3) to provide information on ways to organize the teaching of the 17 SDGs.

After presenting the collected data from the research process, a summary of the results in relation to the research questions posed followed. The analysis and presentation of the data were carried out through triangulation by gathering data from the initial ideas of the co-researchers, the produced teaching products – action plans, and the "critical friends."

6.10 Limitations of the Research

One of the key factors for success in conducting a survey was the representativeness of the sample. In the present study, the participation was quite high and representative, with participants from various regions of the country. This resulted in the researcher taking on a multifaceted, complex, and demanding role, in which she regularly needed to encourage and motivate the co-researchers in order to persuade them to actively participate in the processes. Although some stages could be implemented by distributing specific responsibilities to each participant, thereby achieving the immediate involvement of the entire team in the research process, it was deemed particularly important for the guide to take full responsibility for completing the e-mentoring program processes. Another limitation identified by both the researcher and the other members of the research team was the lack of time, which deprived the open cyclical research process of the opportunity to achieve the desired multiple synthesis and re-synthesis of the spiral action research for the safer conduct of conclusions. However, this was not at all easy, as the available time did not allow for the satisfactory organization and consolidation of the new knowledge and its effective implementation at the classroom level by the teachers. Additionally, several co-researchers initially exhibited skepticism regarding both the usefulness of the research subject and the level of difficulty that such an endeavor might entail in matters related to Education for Sustainable Development. However, following the collaboration that ensued, the attitudes of the team members transformed, prioritizing enthusiasm and the willingness to produce high-quality, effective educational products. Finally, an inherent limitation of multifaceted guidance programs is the inability to transmit visual and auditory cues (Ensher et al., 2003). Simple gestures like a smile or a nod can be lost or misunderstood due to their transmission through digital media. At this point, the e-mentor's experience was particularly decisive, as her example identified appropriate non-verbal behavior methods (Bonnett et al., 2006) in this specific learning environment, such as the use of emoticons that contributed to creating a friendly atmosphere of mutual feedback.

7. Discussion

The findings of this study enrich and extend existing scholarship on the transformative potential of e-mentoring in promoting reflective practice, peer collaboration, and professional empowerment. Prior research (e.g., Bierema & Merriam, 2002; Louws et al., 2017) underscores the importance of psychologically safe and flexible mentoring environments. This study advances the discourse by demonstrating that when such spaces are purposefully grounded in the principles of Education for Sustainable Development (ESD), they can serve as catalysts for values-driven transformation.

The emergence of a community of practice resonates strongly with Wenger's (1998) theory of social learning, framing mentoring as a relational, co-constructive process. Participants transitioned from passive recipients of expertise to active contributors within a democratic, non-hierarchical mentoring culture. This evolution from hierarchical structures to holistic, emotionally intelligent models reflects broader postmodern trends in mentoring (Ben-Amram & Davidovitch, 2024).

The integration of multimodal digital tools supported inclusive participation and differentiated engagement, reflecting current pedagogical models that prioritize learner agency and digital equity (Trust et al., 2016). By combining technological accessibility with thoughtful instructional design, the program enabled personalized, self-paced interaction while accommodating diverse learning preferences and realities.

Crucially, this study contributes a novel, practitioner-informed framework for e-mentoring within ESD—a model rarely detailed in prior literature. Positioned within a participatory action research paradigm, the program offers practical insights into how digitally mediated mentoring can be authentically enacted, especially in periods of uncertainty such as the COVID-19 pandemic.

7.1 Limitations

While the study yielded encouraging results, several limitations must be noted:

- **Sample Size and Selection Bias:** The relatively small and self-selected cohort may limit generalizability. Participants were predisposed toward sustainability-focused development, which could shape engagement levels and outcomes.
- **Asynchronous Participation:** Though flexible, asynchronous formats led to occasional delays and uneven involvement due to external pressures and time constraints.
- **Dual Role of Researcher:** The researcher's role as both e-mentor and investigator raises potential for interpretive bias. Despite mitigation efforts (e.g., triangulation, feedback from critical friends), clearer role separation in future studies would enhance research rigor.

7.2 Contributions and Future Directions

This study affirms the potential of action research as a responsive, ethical methodology for professional learning in digital spaces. It repositions e-mentoring as a transformative

pedagogical strategy, rather than a mere delivery mechanism. In line with recent meta-analyses (Maxwell et al., 2024), the study advocates for multi-level mentor preparation and longitudinal training models that embrace mentors as co-researchers and co-learners within sustainability education systems.

7.3 Directions for Future Research

- Longitudinal impacts on pedagogical practice, curriculum innovation, and educator identity,
- Scalability and adaptation across diverse educational and cultural contexts,
- Empirical inquiry into the intersections between mentoring, sustainability education, and digital inclusion, particularly in initial teacher education and ongoing professional development.

7.4 Connection to Research Questions

RQ1 findings reveal that the e-mentoring program significantly supported educators' professional development in ESD, promoting reflective, student-centred approaches and fostering confidence to embed sustainability themes into everyday practice.

RQ2 is addressed through evidence of robust collaborative instructional design, where teachers co-developed content, adapted strategies, and relied on collective peer input—underscoring the importance of teacher agency and shared ownership in professional learning.

RQ3 is reflected in the participants' strong appreciation for mentoring relationships—not only with the e-mentor but among peers. The formation of a virtual community of practice fostered trust, psychological safety, and shared purpose, enabling self-directed learning and creative exploration. Echoing outcomes found in ecoaching literature, participants valued the personalized, asynchronous support and emphasized the role of reflection in their development (Regan et al., 2025).

Altogether, these findings affirm that e-mentoring, when purposefully designed with ESD principles, can initiate transformative learning, foster sustainable professional networks, and empower educators to lead from within. Far from a reactive digital solution, e-mentoring emerges as a core pedagogical strategy for enabling meaningful, values-based change in education.

Aligned with recent scholarship (e.g., Jung et al., 2024), this study strengthens the case for integrating Sustainable Development Goals (SDGs) into professional development frameworks, ensuring that teacher learning retains both real-world relevance and policy coherence.

8. Conclusion & Future Work

This study illuminates the transformative potential of e-mentoring as a professional development strategy aligned with the core values of Education for Sustainable Development (ESD). Far more than a delivery mechanism, e-mentoring was

conceptualized as a pedagogical ecosystem—a space fostering ethical dialogue, critical reflection, collaborative meaning-making, and emotional connection.

Through sustained interaction, co-construction of knowledge, and shared vulnerability, participating educators began to redefine their professional identities—not merely as implementers of sustainability education, but as agents of change within and beyond their classrooms. While the mentoring structure offered scaffolding, it was ultimately the collective engagement and horizontal trust that enabled learning to become truly transformational.

The findings suggest that authentic professional development in the context of ESD must be relational, participatory, and ethically grounded. It must engage with the complexities of sustainability challenges, acknowledge the emotional dimensions of teaching, and respond to the systemic barriers educators encounter. In this light, e-mentoring—when thoughtfully designed—has the power to disrupt traditional hierarchies and generate counter-spaces for hope, inquiry, and innovation.

The virtual community of practice that emerged was not merely a network of teachers sharing tools and strategies; it evolved into a microcosm of a sustainable learning culture, built upon reciprocity, care, and a shared ethical purpose. This outcome holds important implications for institutional approaches to teacher learning: emphasizing dialogue and community over standardization and assessment.

Looking forward, future research should explore how such mentoring models can be scaled and sustained without compromising their human-centered ethos. Longitudinal studies could illuminate their influence on teaching philosophy, student outcomes, and school culture. There is also fertile ground for further exploration of the intersections between mentoring, digital inclusion, and sustainability pedagogy, particularly within diverse educational landscapes.

Ultimately, the study affirms that educator transformation is foundational to sustainability education—and thoughtfully crafted e-mentoring can offer both the spark and the sanctuary for that transformation to unfold.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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