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Research Article

Dialogic teaching in out of school environments through technology and thought experiment

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This study addresses a notable gap in the literature by exploring the integration of innovative strategies—specifically Web 2.0-based dialogic teaching—into out-of-school learning environments. The research investigated 7th-grade students' awareness of Web 2.0 tools, their performance on a thought experiment (the Sugar Cube), their cognitive engagement, and reflections on the activity, all facilitated through Web 2.0 platforms. Employing a mixed-methods approach, the study involved 20 volunteer students and utilized a Web 2.0 tools awareness scale, a thought experiment task, and semi-structured interviews. Findings indicate that dialogic teaching in an out-of-school context enhanced students' awareness of Web 2.0 tools, deepened their engagement in scientific thought experiments, and supported higher-order thinking. Originally designed for seventh graders, the activity demonstrates potential adaptability across different grade levels, curricular goals, and informal learning settings. The study contributes practical strategies for fostering student engagement, guidance for improving technological access in underserved areas, and theoretical insights into the digital integration of dialogic teaching and thought experiments in science education.

Keywords: Dialogic teaching; Out of school environment; Science education; Thought experiment; Web 2.0 tools

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1. Introduction

The importance of learning styles has become increasingly prominent due to the rapid changes experienced in recent years, particularly following the COVID-19 pandemic (Zhao et al., 2021). A lack of education and expertise can hinder the adoption of new technologies, making it difficult to stay up to date with innovations and adapt to change (Amhag et al., 2019). Digital tools are playing an increasingly significant and evolving role in education. Technology advancements have become commonplace in modern learning environments, impacting not only education but also every other field, thus making technology an essential component (Alsuwaida, 2022). It has been shown that information is now predominantly disseminated via the internet, fundamentally reshaping educational practices, access to knowledge, and cultural literacy in both blended learning environments (Alkursheh, 2024). With this shift, learning styles that do not align with the demands and expectations of Generation Z and Generation Alpha have come into focus. Traditional, passive, and one-size-fits-all approaches are no longer suitable for these generations, as they fail to

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meet their expectations for interactivity, personalization, and digital engagement (Seemiller & Grace, 2016).

Recent studies have increasingly highlighted the significant role of Web 2.0 tools in enhancing various educational outcomes, including student motivation, critical thinking, collaboration, and digital competencies across diverse learning contexts. Kızıltaş and Kultaş (2025) compared students' writing motivation and creative writing skills in traditional education environments using Storyboard and Story-jumper, both Web 2.0 tools. Their findings demonstrated that these tools significantly improved students' creative writing abilities and led to a notable increase in motivation compared to the pre-test results. Pausé and McCarroll (2019) examined the use of Tumblr, a Web 2.0 tool, with student cohorts across two countries. Their findings showed that Tumblr's multimedia format enhanced student engagement with course content and peers, while also strengthening digital competencies for both students and instructors. Based on qualitative data collected from student reflections, instructor observations, and interaction analysis, a thematic analysis revealed that Tumblr supported personalized, self-directed learning and fostered a dynamic online learning community. Hinchcliff and Mehmet (2023) provided a pedagogical and theoretically grounded rationale for the staged integration of Canva, designed to enhance students' critical thinking, communication, and collaboration skills promoting more creative and high-quality assessments. Korukluoğlu et al. (2022) conducted a mixed-methods study to evaluate the effectiveness of a Web 2.0-based critical thinking curriculum for secondary school students. Quantitative data from pre- and post-tests indicated significant improvements in critical thinking skills. Meanwhile, thematic analysis of qualitative data from student journals and feedback revealed enhanced critical engagement and positive attitudes toward the curriculum. These results underscore the potential of Web 2.0 tools in fostering critical thinking and boosting student motivation.

Among the technology advancements that align with these expectations are Web 2.0 tools, which are inherently collaborative, enabling users to generate and share original ideas, create content and actively participate. Through Web 2.0 technologies, learning can be made more permanent, diverse learning environments can be developed, cognitive growth can be supported, and learners can shift from passive information consumption to active content creation and inquiry (Yoldaş et al., 2023). These technologies also facilitate a transition from teacher-centered to student-centered approaches and from individual to community-based learning (Kompen et al., 2019). According to Teo et al. (2018), Web 2.0 technologies support creative, peer and personalized learning across both academic and non-academic contexts. By moving beyond traditional classroom environments, these tools empower students to engage, share, take risks, and self-evaluate in digital environments (Ledger & Fischetti, 2020). Using Web 2.0 tools in out-of-school environments allows learners to study in a more flexible and unrestricted settings; these include online environments, which are a form of out-of-school environments (Aslan & Arabacı, 2023). Online dialogic teaching became widespread following the COVID-19 pandemic. Studies in this area have focused on topics such as student identity and agency (Bearman et al., 2022), emotions and experiences during video conferencing (Okabe-Miyamoto et al., 2022), the influence of class size on dialogic processes in virtual classrooms (Goldenson et al., 2022), teachers' innovative strategies for fostering dialogic teaching (Yu et al., 2021), and online feedback practices (Fine et al., 2022).

2. Literature Review

A comprehensive review of the literature on dialogic teaching, out-of-school environment, Web 2.0 tools, and thought experiments helps to contextualize the study, identify research gaps, and support the development of hypotheses regarding the impact of dialogic teaching in out-of-school environments through technology and thought experiments.

2.1. The Correlation between Dialogic Teaching and Out-of-school Environments

Although dialogical teaching is grounded in the works of Bakhtin (1984), its origins can be traced back to Socratic traditions. This approach emphasizes learning through dialogue, encouraging the co-construction of knowledge. According to Piaget (1936), knowledge and understanding are actively constructed by learners, influenced by their present awareness, prior experiences, cultural background and environmental factors. Dialogic teaching builds on this view by encouraging students to question, challenge and reflect on concepts and perspectives, thereby deepening their understanding (Alexander, 2018; Teo, 2019). In progressive educational settings, dialogue is used as a tool for students to test their own theories and refine their thinking (Marjanovic-Shane, 2023). The teacher plays a crucial role in this process by encouraging learners to question not only what they know but also the assumptions underlying that knowledge. Dialogic teaching creates an inclusive classroom environment where even typically quiet students can find the confidence to speak up. This contributes to greater student engagement, self-confidence, independence, and a sense of responsibility (Alexander, 2018).

The learning environment is a key component of education, encompassing the physical, mental, emotional, and social conditions in which teaching and learning take place (Kelly et al., 2022). Dialogic teaching is considered a fundamental cultural tool for mediating learning and plays an important role in both in-school and out-of-school contexts by fostering active engagement and interaction (Lehesvuori et al., 2018). Out-of-school settings, in particular, have been shown to promote collaborative and fluid communication, idea exchange, and participation (Willard et al., 2019). Dialogic discussions in these contexts often emphasize problem-solving and logical reasoning, competencies that are especially relevant to science education (Wei et al., 2024). Furthermore, students' use of computers outside school has been found to positively impact their academic performance (Gu & Xu, 2019), contributing to overall educational success (Wei et al., 2024).

2.2. The Correlation between Web 2.0 Tools and Out-of-school environments

The increasing accessibility and affordability of digital technology has made it necessary to consider its role as a learning facilitator in out-of-school programs. Devices commonly used in these settings include digital cameras, drones, tablets, laptops, and augmented reality tools (Bolliger & Shepherd, 2017). Web 2.0 technologies, in particular, empower users to communicate, personalize content, engage through dynamic interfaces, create and share resources, and integrate learning across platforms, making them increasingly integral to modern educational contexts (Oni et al., 2018). Technology is no longer limited to content delivery; it also fosters communication skills, teamwork, and emotional connection among learners (Elma et al., 2024). As a result, digital learning can now take place anytime, anywhere, even in remote locations (Bolliger & Shepherd, 2017).

Web 2.0 tools have become essential in transforming traditional educational models. They allow students to engage, share, and self-assess in virtual environments, offering flexibility beyond the physical classroom (Hinchcliff & Mehmet, 2023; Ledger & Fischetti, 2020).These tools also enable teachers to optimize time, deliver more content efficiently and allocate time to alternative learning activities (Yoldaş et al., 2023). However, despite their benefits, Web 2.0 tools come with limitations. Students may use them superficially, prioritizing sharing over meaningful learning (Greenhow & Askari, 2021). Moreover, challenges such as digital distractions, misinformation, unequal access to devices and internet, and concerns regarding data privacy remain critical issues in many learning contexts (OECD, 2021; Zhang et al., 2022). These issues emphasize the need for a well-planned and critical integration of technology in education.

Out-of-school learning [OSL] settings vary from informal environments, such as homes, mobile apps, and playgrounds, to non-formal venues like science centers, museums, national parks, and planetariums (Eshach, 2007). The use of ICT in these contexts supports peer collaboration and student accountability (Gu & Xu, 2019; Naveh et al., 2012). Notably, while many studies have explored science centers, parks, and museums, there is a gap in research regarding youth centers affiliated with the Ministry of Youth and Sports (Yıldırım-Polat & Gürsoy, 2023). Instructors have successfully adapted Web 2.0 tools, such as Canva, Kahoot, Mentimeter, Edmodo and Google Drive, to these environments, reporting enhanced teaching effectiveness (Bugawa & Mirzal, 2018; Jena et al., 2020; Johnson et al., 2019; Karvounidis et al., 2018; Walter, 2013).

2.3. The Correlation between Thought Experiment and Dialogic Teaching

One of the core principles of dialogic teaching is that meaning is co-constructed through dialogue and active engagement. Through structured conversations, students collaboratively build understanding and generate new knowledge (Tadesse et al., 2023). Such interaction not only captures students' attention and promotes engagement but also raises academic expectations and accelerates learning (Alexander, 2018). Dialogic teaching thus supports the development of cognitive skills such as problem-solving, creative thinking, mental flexibility, and adaptability (Ritter & Mostert, 2017).

Open-ended questions, informed by learners' shared experiences, play a significant role in memory retention and recall (Callanan et al., 2017; Haden et al., 2014). Conversations with teachers and peers shape how students interpret experiences, which in turn influences what they remember and how they apply knowledge later on (Garcia-Carrion et al., 2020; Teo, 2019).These interactions foster critical thinking and communication skills by encouraging students to articulate, revise and expand their ideas.

Thought experiments are powerful pedagogical tools that bring abstract or neglected ideas into focus, enhancing imagination and conceptual clarity (Bascandziew & Harris, 2018; Sartori, 2023).They promote in-depth exploration and complex thinking by offering a broader intellectual space than direct instruction (Yu et al., 2019). From a social constructivist perspective, learning occurs through shared ideas, interactions and cooperative meaning-making (Barak, 2017). Thought experiments are considered useful for developing high-level cognitive skills (Krieglstein et al., 2022), supporting mental processes and enhancing learning through imaginative reasoning (Bascandziew, 2024; Sartori, 2023; Meier, 2022). Dialogic teaching aligns with this view, using conservation to spark student curiosity, deepen comprehension and promote autonomy and creativity (Alexander, 2020; Tadesse et al., 2023). High self-confidence enables students to participate actively and influence classroom discussions (Sedova, 2017).

Despite their benefits, dialogic teaching and the use of thought experiments have not yet been widely implemented at the secondary school level, highlighting a significant gap in the literature (Rapanta, 2021). Making connections between scientific concepts and daily life enhances students' ability to understand themselves and their environment, fostering enjoyment and deeper engagement in learning science (Irish & Kang, 2018). However, certain topics like the force of friction remain difficult to teach and are commonly misunderstood (Chiou et al., 2013; Develi & Namdar, 2019).

2.4. Current Research

Grounded in Vygotsky's (1978) sociocultural theory and drawing on Alexander's (2018) dialogic teaching framework as well as Siemens' (2005) connectivism theory, this study explores how dialogic teaching, supported by Web 2.0 tools in an out-of-school environment, can influence students' thinking processes by fostering increased awareness and active participation. Today's educational systems are undergoing rapid transformation due to the influence of Industry 4.0 technologies- such as artificial intelligence, big data, the internet of things- alongside the Society 5.0 vision of a human-centered, digitally integrated future (Schwab, 2017). In this evolving context, students are expected to use digital technologies critically and collaboratively, demonstrating skills such as problem solving and reflective thinking (Redecker, 2017).

However, studies conducted during the COVID-19 pandemic revealed that students often engaged with digital tools passively, showing limited interaction and minimal awareness of their cognitive processes (UNESCO, 2021). Additionally, the prevalence of uncritical digital consumption and restricted dialogic interaction with peers and teachers has underscored the urgent need for pedagogies that promote critical digital literacy. The shift to online learning further exposed significant gaps in students' ability to use digital tools for meaningful learning rather than mere information retrieval (OECD, 2021).

This study aims to implement dialogic teaching using Web 2.0 tools (including Picker Wheel, Canva, Mentimeter, LearningApps, Prezi, and PhET) in an out-of-school environment to enhance students' awareness and observing changes in their thinking. It is original in its dual focus: implementing dialogic teaching in an out-of-school environment and simultaneously raising students' awareness of Web 2.0 tools as a means of fostering cognitive change. By doing so, the study contributes to the development of 21st-century skills and aligns with the Society 5.0 vision of cultivating responsible, reflective, and digitally literate individuals. Despite growing interest in digital pedagogies, there remains a significant gap in the literature regarding how dialogic teaching combined with Web 2.0 tools affects students' cognitive processes in out-of-school environments. The findings of this research are expected to guide educators in designing more interactive, awareness-based digital learning experiences.

In line with these aims, the study addressed the following research questions.

RQ1) Did the awareness levels of students towards Web 2.0 tools create a significant difference before and after the activity?

RQ2) Did the students' scores in the thought experiment show a significant difference before and after the activity?

RQ3) What are the students' thinking processes in the thought experiment before and after the activity?

RQ4) What are the students' positive and negative opinions about dialogic teaching based on out-of-school dialogic teaching?

3. Method

3.1. Participants

The study was conducted in the 2023-2024 academic year with 20 volunteer 7th-grade students attending a secondary school in Şırnak, a middle-income city in the southeastern part of the country. All necessary permits have been obtained. The ethical approval number is E-30640013-108.01-167168. The students in the study were coded as S1, S2, S3. ... Participants took part in this study voluntarily. Participants were identified using the voluntary participation form. The intervention was carried out at a youth center connected to the Republic of Turkey's Ministry of Youth and Sports. This center was chosen because there was a lack of a computerized environment for the students who wished to engage freely in the study, this center was chosen. Students might break out of tradition and exhibit greater desire when they practice outside of the classroom. This experience is enhanced by a computerized environment, which provides a framework for digital out-of-school learning and more interactivity. Substantial supplementary learning possibilities for out-of-school experimental learning may be generated through digital technology (Bolliger & Shepherd, 2017).

3.2. Research Design

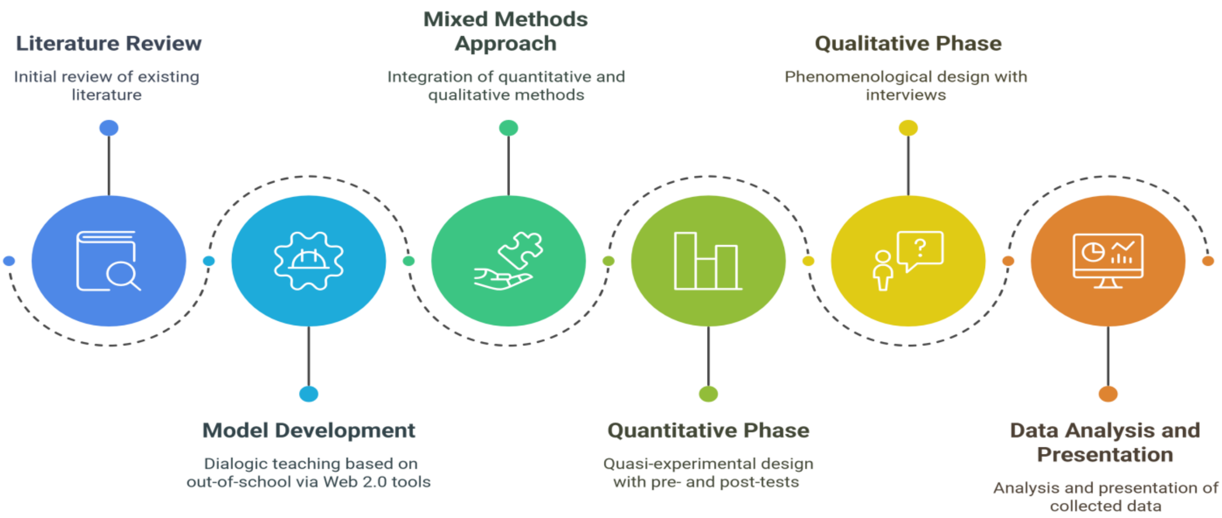
This study adopts a mixed methods approach within the framework of an exploratory sequential design to comprehensively and holistically investigate the research questions. The study consists of two main phases: quantitative and qualitative.

In the quantitative phase, a quasi-experimental design was employed. The instruments used for both pre-test and post-test measurements included the "Awareness Scale for Web 2.0 Tools" developed by Arslan and Görgülü-Arı (2021) and "The Sugar Cube Thought Experiment" developed by Uyar (2021). Although simple experimental designs are often regarded as having lower internal validity compared to more complex models, they are considered suitable for exploratory research involving novel educational interventions (Creswell & Creswell, 2018).

In the qualitative phase, a phenomenological design was adopted to explore students' experiences with dialogic teaching in an out-of-school environment (Patton, 2002). Individual semi-structured interviews, each lasting 10-15 minutes, were conducted in a quiet setting to facilitate open and reflective responses. The interview developed by the researchers and validated by experts included open-ended questions related to students' perceptions of dialogic teaching and Web 2.0 tools. All interviews were audio-recorded and transcribed verbatim. Data were analyzed using content analysis by two independent researchers. Inter-coder reliability was calculated with Miles and Huberman's (1994) formula, resulting in a high agreement coefficient of 0.90, ensuring the credibility and trustworthiness of the qualitative findings.

The overall research design is illustrated in Figure 1.

Figure 1
Research design procedure



3.3. Model Development

Following the literature review, a noticeable gap was identified concerning the use of out-of-school dialogic teaching to investigate changes in students' thinking processes through the integration of Web 2.0 tools. To address this gap, an out-of-school dialogic teaching program incorporating Web 2.0 tools was developed.

The intervention consisted of a ten-week program in which Web 2.0-based dialogic instruction was delivered in 40-minute sessions. Pre-test data were collected two weeks prior to the beginning of the implementation. The core intervention was carried out over six weeks, with each stage implemented once a week for two hours. Two weeks after the final session, semi-structured interviews and post-test data were collected to evaluate students' experiences and cognitive development.

The detailed structure of the program is presented in Table 1. Alexander (2018) stated the applicability of dialogic teaching in six stages, which are interactive settings, everyday talk, learning talk, teaching talk, questioning and extending.

3.3.1. Stage 1: Interactive settings

This stage emphasizes interactive class discussions involving both student-teacher and student-student exchanges. Rather than adopting a didactic approach, encouraging informal conversations creates a space for ideas to flow freely and organically (Rogoff et al., 2016). When students engage in dialogic activities that ensure the participation of all members, they tend to construct stronger arguments and show greater willingness to support their peers (Teo, 2019). Active student involvement in such interactive settings contributes to a more meaningful and authentic learning

Table 1
The stages of model and activities

The stages of model	*Activities*
Stage 1: Interactive settings	Students are randomly paired using the **"Picker Wheel"** and assigned to computers. Two posters created by the teacher in Canva (see Appendix) are uploaded to each computer. After examining the posters, students log in to **Mentimeter** to engage in online discussions prompted by the teacher's guiding questions. This stage serves to activate prior knowledge and foster initial dialogue.
Stage 2: Everyday talk	Students watch context-based videos featuring real-life examples. After viewing, they respond to reflective questions via Mentimeter using varied discourse modes: procedural, explanatory, expressive and evaluative. All responses are visible to peers, promoting dialogic interaction.
Stage 3: Learning talk	Following teacher-student interaction, students engage in inter-group discussions. They review responses from other groups and generate related questions using **Mentimeter.** Emphasis is placed on higher-order thinking skills such as analyzing, evaluating, questioning, and defending positions. Students are also encouraged to actively listen, reflect, and respect diverse viewpoints during discussions.
Stage 4: Teaching talk	The teacher delivers a structured lecture using **Prezi,** supplemented with audiovisual materials and conceptual explanations. Misconceptions or incomplete answers from earlier stages are addressed. To deepen conceptual understanding, a simulation aligned with learning objectives is conducted using **PhET.**
Stage 5: Questioning	Students ask questions related to the previous stage. The teacher uses reflective questioning strategies to promote deeper analysis. Peers are encouraged to respond collaboratively. Additionally, each group formulates a question and directs it to another group, fostering peer-led dialogue and broader engagement.
Stage 6: Extending	Using **LearningApps**, students collaboratively design instructional games aligned with learning objectives. Each group presents their game and explains its structure. Other groups play and evaluate each game, promoting peer feedback, knowledge consolidation, and diverse perspective sharing.

experience (Jensen, 2011). Dialogic teaching also values the co-creation of resources, promoting social learning by incorporating real-life experiences into the educational context (Garcia-Carrion et al., 2020).

3.3.2. Stage 2: Everyday talk

This stage encourages students to manage social interactions, narrate experiences, explain concepts, ask various types of questions, explore ideas, and express their emotions and reactions. It emphasizes the development of key 21st-century competencies—particularly communication, collaboration, creativity, and critical thinking— which are considered essential for effective learning and active citizenship (Griffin & Care, 2014; Van Laar et al., 2017). In this context, students engage in discussions that aim to identify best practices for integrating these skills at the subject level. Collaboration, as defined in this stage, involves students working together toward a common goal, such as completing an assessment task or engaging in a group-based activity (Rochmawati et al., 2019).

3.3.3. Stage 3: Learning talk

This stage focuses on helping students develop the ability to respect diverse perspectives, actively listen to others, and allow time for thoughtful reflection. It provides opportunities for students to demonstrate key competencies such as communication, problem-solving, analytical thinking, critical reasoning, and collaborative work (Lim et al., 2016). To further promote collaborative and critical thinking, students are assigned tasks that emphasize problem-solving strategies and require them to solutions in innovative and contextually relevant ways (Chidiac & Ajaka, 2018).

3.3.4. Stage 4: Teaching talk

This stage engages students in various learning activities such as reading, instruction, demonstrations, discussions, dialogues, questioning, responding to peer groups, short question-and-answer sessions, feedback exchange, and defending their viewpoints with a clear purpose. These tasks are designed to enhance students' ability to articulate their ideas effectively and engage in purposeful academic discourse. To successfully convey their thoughts, students are encouraged to utilize diverse media formats and technological platforms, promoting digital fluency and multimodal communication skills (Rios et al., 2020).

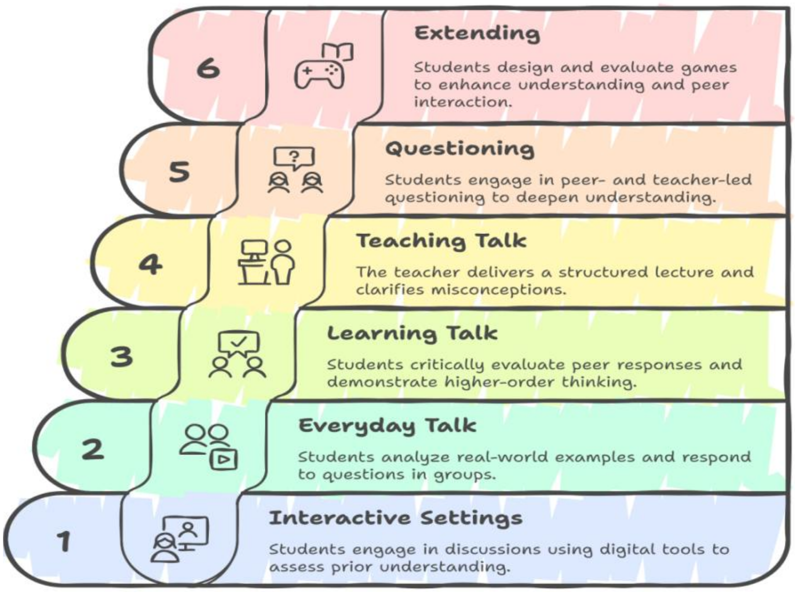
3.3.5. Stage 5: Questioning

This stage involves responding to other groups through short questions and answers, actively listening, allowing time to think, providing feedback, setting learning goals, and defending one's ideas. As educational redesign is a construct of creativity and innovation, it also involves increasing accessibility to group work (Yu et al., 2024).

3.3.6. Stage 6: Extending

This is the part where students expand their thoughts, rephrase them, reason logically and produce a product. Equal access to the platform and readily available information are crucial when introducing new technologies to students (Jahnke & Liebscher, 2020). In the classroom, preparation before the lesson can open up more time for collaborative and creative learning (Delozier & Rhodes, 2017). All stages are summarized in Figure 2.

Figure 2
Dialogic teaching stages



3.4. Web 2.0 Tools

3.4.1. Picker Wheel

Picker Wheel is a Web 2.0 tool used to make random choices. It enables fair and impartial choices in education (name, task, group, etc.). With its interactive structure, it increases student participation and enhances the learning process. It saves time and facilitates decision-making processes. It is a fun, fair and practical selection tool (pickerwheel.com).

3.4.2. Mentimeter

Mentimeter is a Web 2.0 tool that allows users to create interactive content during presentations, lectures, or meetings. Content such as word clouds, rating questions, quizzes, and interactive polls can be made. Participants can respond instantly from their phones or computers. This approach increases participation and attention level, especially in lectures, creating a discussion environment. The data are instantly reflected in visual graphics so that the teacher can receive feedback. Mentimeter is a fun and data-driven interaction platform where participants are active (mentimeter.com).

3.4.3. Canva

Canva is a Web 2.0 tool that makes it easy to create graphic designs for both professional and daily use. The drag-and-drop technique makes it simple to build a variety of styles, including presentations, infographics, posters, social media postings, and videos. It is often used in education for creative projects, students' presentations, and course materials. It contributes to the development of students' creativity, communication and collaboration skills. Simultaneous work can be done on the same project, it is a collaborative platform. Canva is a Web 2.0 tool that enables easy, aesthetic, and collaborative design for both teachers and students (canva.com).

3.4.4. Prezi

Prezi is a Web 2.0 presentation tool developed as an alternative to traditional slide-based presentations, allowing interactive and dynamic presentations. Its zooming feature provides a holistic transition between subjects. Linking information together like a conceptual map makes the narration more memorable and visual. It is ideal for teachers and students who wish to prepare interactive presentations. It contributes to students' conceptual thinking and presentation skills. Prezi is a Web 2.0 tool that facilitates learning and attention by delivering presentations in a visual, interactive and story-based format (prezi.com).

3.4.5. PhET

PhET is a Web 2.0 tool that provides interactive simulations, especially for use in science and mathematics. It is used to model science and mathematics concepts. It allows students to learn through experimentation, exploration and observation. Simulations are interactive; students can observe results by changing variables. It can be easily accessed via web browsers or mobile devices. It is especially effective in terms of solidifying concepts and encouraging experimental thinking. PhET enables students to learn through active participation and experiences by concretizing abstract scientific concepts (phet.colorado.edu/tr).

3.4.6. Learning Apps

Learning Apps is a Web 2.0 tool that allows teachers and students to create interactive digital activities and make the learning process fun. It offers different types of activities such as matching, multiple choice tests, sorting, gap filling, and group formation. It supports game-based learning and increases students' motivation. Teachers can use ready-made activities specific to subjects or easily create their own content. It works on all devices such as tablets, phones, and computers. Learning-Apps is a practical Web 2.0 tool that supports students' active learning by adding interactivity, versatility and fun to the teaching process (learningapps.org).

3.5. Data Collection Tools and Data Analysis

3.5.1. Awareness scale for Web 2.0 tools

The 5-point Likert-type scale was developed by Arslan and Görgülü-Arı (2021) to measure individuals' awareness of Web 2.0 tools. Based on exploratory factor analysis, the scale consists of 27 items categorized under three sub-factors: knowledge, perception, and emotion. These dimensions collectively assess individuals' familiarity with Web 2.0 tools, their perceptions of usefulness in educational environments, and their emotional attitudes toward their use. This multidimensional structure enables a comprehensive evaluation of cognitive, perceptual and emotional dimensions related to Web 2.0 awareness. Table 2 shows the values of the validity and reliability studies of the scale.

Table 2
Validity and Reliability Values of the Awareness Scale for Web 2.0 Tools

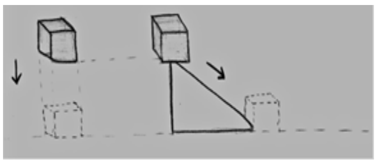
	χ^2/df	*RMSEA*	*GFI*	*CFI*	*NFI*	*NNFI*	*CFI*	*Variance*	*Cronbach's alpha*
Scale	3.15	0.080	0.82	0.90	0.85	.88	0.90	%57.142	0.929

The Cronbach's alpha internal consistency coefficient of the entire scale was calculated as α = .93. The reliability of the scale, indicated by a Cronbach's alpha coefficient above .90, suggests a very high level of internal consistency, meaning that the items in the scale are highly correlated and measure the same underlying construct (Taber, 2018). While preparing the scale items, item pooling and expert opinion were applied, which ensured the content validity This scale was applied as a pre/post-test in the study. The data obtained were analyzed with SPSS 22.0 package program.

3.5.2. Sugar cube thought experiment

The Sugar Cube thought experiment developed by Uyar (2021) was used in this study to help students acquire the concept of explaining the effect of friction force on kinetic energy with examples. In this experiment, the aim was to examine the effect of friction force on kinetic energy by considering factors such as air and water resistance.

Table 3
Sugar Cube Thought Experiment



Imagine an environment where air friction is neglected. Two identical sugar cubes are released from the same height: one falls freely, while the other slides on an inclined plane made of ice. What can you say about the speed of each sugar cube until they reach the ground? Explain.

The thought experiment shown in Table 3 was applied as a pre/posttest and analyzed in two stages. In the first stage, students' answers were scored as "full understanding, 5 points," "partial understanding, 4 points," "did not understand, 3 points," "misunderstanding, 2 points," and "no answer or blank answer, 1 point" (Abraham et al., 1992). The scores were analyzed by means of SPSS 22.0 package program. In the second stage, students' thinking processes were analyzed under three main headings (secondary effects, purpose of conducting thought experiment, and sources of thought) and twelve subheadings by content analysis.

3.5.3. Semi-structured interview form

To determine the positive and negative thoughts of the students on the Web 2.0-based dialogic teaching in an out-of-school environment, individual interviews were conducted with them for 10-15 minutes. In the interviews, a semi-structured interview form, developed by the researchers and whose reliability was ensured through expert opinions, was used. The questions in the form are: (1) What are the positive and negative aspects of the out-of-school activity? How? (2) How did your out-of-school activity affect your use of Web 2.0 tools? Explain. (3) What are the positive and negative aspects of the dialogic teaching you have carried out? (4) What do you think about the out-of-school activity you have carried out? The data obtained were analyzed through content analysis, with codes and themes determined by two independent researchers. The consistency between the two researchers was calculated as 0.90 with Miles and Huberman's (1994) formula, and the result was found to be reliable.

4. Results

4.1. Impact of Dialogic Model on Students' Web 2.0 Awareness

The findings related to students' awareness of Web 2.0 tools in dialogic teaching in an out-of-school environment are given in Table 2. Statistically, their awareness of Web 2.0 tools was statistically significant in favor of the post-test $t(38) = -8.304$ ($p < .001$). Similar significant improvements were found across all sub-factors: knowledge ($t(38) = -6.564$, $p < .001$), perception ($t(38) = -6.897$, $p < .001$), and emotion ($t(38) = -6.932$, $p < .001$)). The effect sizes (Cohen's *d*) for total scale, and sub-factors were 0.72, 0.73, 0.73 and 0.79, respectively, indicating large effects according to Cohen's (1988) guidelines. These results demonstrate a statistically significant and practically meaningful increase in students' awareness of Web 2.0 tools following the intervention. The detailed *t*-test results for the Web 2.0 tools scale are shown in Table 4.

Table 4
T-test Results of the Sub-factors of the Scale for Web 2.0 Tools

Sub-factors	*N*	*Mean*	*SD*	*df*	*t*	*p*	*Cohen's d*
Knowledge							
Pre	20	3.75	.786	38	−6.564	<.001	0.72
Post	20	4.95	.224				
Perception							
Pre	20	3.65	.813	38	−6.897	<.001	0.73
Post	20	4.95	.224				
Emotion							
Pre	20	3.45	.826	38	−6.932	<.001	0.73
Post	20	4.85	.366				
Total							
Pre	20	3.60	.754	38	−8.304	<.001	0.79
Post	20	5.00	.000				

4.2. Change in Students' Performance on the Thought Experiment

Table 5 presents the findings on students' scores in the sugar cube thought experiment following dialogic teaching conducted in an out-of-school environment. Statistically, a significant improvement was observed in post-test scores, with $t(38) = -3.063$ ($p < .005$). The effect size (Cohen's *d*) was calculated as 0.44, which corresponds to a medium effect according to Cohen (1988) criterion. These results indicate that the intervention had a statistically significant and practically meaningful impact on students' performance in the thought experiment.

Table 5
T-test Results of the Sugar Cube Thought Experiment

Test	*N*	*Mean*	*SD*	*df*	*t*	*p*	*Cohen's d*
Pre	20	3.30	1.081	38	−3.063	.004	0.44
Post	20	4.47	1.307				

4.3. Analyzing Cognitive Change in Students' Thought Experimentation

The study involved 20 7th–grade students (11 females and 9 males) attending a public school. Participants were selected through convenience sampling and took part voluntarily. Data were collected through both pre-test and post-test following the implementation of the model. Answering the related research question, three main themes were identified: secondary effect, thinking purposes, and sources of thought. The establishment of a new quantitative relationship resulting from secondary effects increased from 17.3% in the pre-test to 26% in the post-test. While guessing decreased from 23.1% to 2.8%, presenting evidence increased from 1.4% to 14.4%.Symmetry in sources of thought rose from 2.8% to 10.1%. Scientific concepts, which were absent in the pre-test, appeared in 23.1% of post-test responses. The findings indicate a positive shift in students' thinking processes following the intervention. Detailed percentages and themes are presented in Table 6.

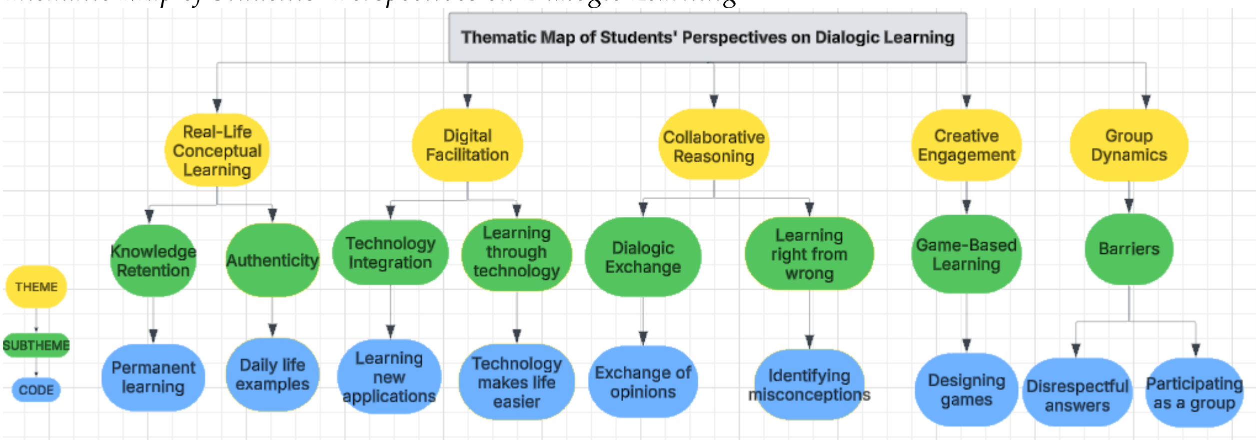
Table 6
Thinking Processes of Sugar Cube Thought Experiment

Thinking Processes	*Pre-test*		*Post-test*	
	n	%	*n*	%
Secondary effect				
Establishing a new amount relationship	12	17.3	18	26.0
Establishing a new conflict relationship	8	11.5	0	0.0
Activation of new schema or schemes	1	1.4	0	0.0
Thinking goals				
Prediction	16	23.1	2	2.8
Providing evidence	1	1.4	10	14.4
Explanation	6	8.6	4	5.7
Sources of thought				
Spatial reasoning	5	7.2	3	4.3
Symmetry	2	2.8	7	10.1
Compound simulation	6	8.6	9	13.0
Experience	4	5.7	0	0.0
Intuitive principles	8	11.5	0	0.0
Scientific concepts	0	0.0	16	23.1

4.4. Perspectives from the Field: Students' Views on Dialogic Learning

To answer the research question related to this field, a systematic qualitative analysis was conducted, in which codes were derived from student responses and organized into subthemes and overarching themes. A thematic map was developed to visually represent students' perspectives in Figure 3.

Figure 3
Thematic Map of Students' Perspectives on Dialogic Learning



In this map, yellow nodes indicate the main themes: Real-Life Conceptual Learning, Digital Facilitation, Collaborative Reasoning, Creative Engagement, and Group Dynamics. Green nodes denote subthemes such as Knowledge Retention, Authenticity, Technology Integration, Learning Through Technology, Dialogic Exchange, Learning Right from Wrong, Game-Based Learning, and Barriers. Blue nodes represent specific codes derived from student responses.

The most dominant theme, *Real-Life Conceptual Learning* (*f* = 20, 100%), was shaped by students' emphasis on long-term conceptual understanding supported by real-life connections and peer discussions. As illustrated by Student 1 (S1):

> We learned new applications. We learned friction force quickly and permanently in a computerized environment by using technology effectively. We had discussions with our friends via Mentimeter. We designed a game about friction force using LearningApps.

This statement reflects how contextualized tasks, combined with peer interaction and digital tools, contributed to meaningful learning. The theme Digital Facilitation (*f* = 18, 90%) was shaped by the subthemes Technology Integration and Learning Through Technology. Students consistently mentioned how digital tools enhanced engagement and made learning more efficient and accessible. Student 6 (S6) remarked:

> I learned that there are new applications. We designed games related to our subject by using the LearningApps on the computer. We also played the games designed by our friends. I think we learned to use technology effectively. I think our lives became easier with technology.

This comment emphasizes students' perception of technology as both a facilitator of learning and a source of practical convenience. Collaborative Reasoning (*f* = 17, 85%), with its subthemes Dialogic Exchange and Learning Right from Wrong, highlighted the value students placed on structured peer discussions that allowed them to refine their ideas and distinguish between correct and incorrect information. Student 14 (S14) stated that, "We learned the ideas of our friends through Mentimeter... We asked questions and learned which were the right ones by exploring many ideas". This illustrates how dialogic engagement supports reflective thinking and conceptual clarification.

The theme Creative Engagement (*f* = 13, 65%) emerged primarily from students' experiences with game-based learning activities, which were seen as enjoyable and motivating. As Student 18 (S18) described:

> We designed a game on LearningApps. It was more enjoyable than the class. We learned the relationship between kinetic energy and the force of friction in the science lesson. While learning, we saw the ideas of our friends in the examples we encountered in daily life, commented on them, asked questions, and got answers. We exchanged ideas; therefore, we learned more about each other's ideas quickly. We made our lives easier by using technology.

This quote demonstrates how combining scientific content with creative, digital, and peer-based activities enhanced both engagement and conceptual understanding. Finally, the theme Group Dynamics (*f* = 5, 25%) addressed challenges faced in collaborative settings, particularly through the subtheme Barriers. Although most students appreciated working in groups, a few highlighted difficulties with peer behavior. Student 5 (S5) noted, "...our friends sometimes deliberately disagreed with our ideas during the Mentimeter and discussion and gave answers as if they were making fun of us, but our teacher warned us". This underscores the importance of teacher scaffolding to ensure respectful and inclusive group interaction.

In sum, the findings indicate that dialogic learning, when integrated with digital tools and collaborative structures, fosters meaningful gains in students' conceptual understanding, digital competence, and creative thinking. Yet, the teacher's role remains crucial in guiding digital use, supporting productive dialogue, and managing social dynamics within the classroom. The revised structure of themes and subthemes enhances both analytical depth and alignment with student voices.

5. Discussion

The aim was to adapt dialogic teaching to an out-of-school environment. It was determined that the first sub-problem, the level of students' awareness of Web 2.0 tools, was statistically significant.

The quantitative findings showed a statistical increase in the dimensions of knowing, perception, and emotional awareness towards Web 2.0 tools. To personalize instruction, manage materials and grades, offer feedback and assistance, extend lessons to out-of-school environments, and provide extra activities, K-12 educators utilize Web 2.0 tools and mobile devices (Liu et al., 2014). Web 2.0 tools and mobile devices create a playground where knowledge production is redefined and people are able to interact, communicate, and reveal themselves (Jones, 2008). These practices foster communication and collaboration, two key components of 21st-century learning, by encouraging students to share ideas, give feedback, and engage in digital dialogue (OECD, 2018).Web 2.0 tools are used similarly to how they are used in other environments to support the physical environment in out-of-school education (Bolliger & Shepherd, 2017). Hsiao et al. (2010) showed that the group using mobile devices and Web 2.0 tools performed well in the subsequent assessment. According to Dyment et al. (2011), Web 2.0 tools facilitate the out-of-school education process. In out-of-school educational environments, Web 2.0 tools have been integrated to support education and develop rich and meaningful learning (Walter, 2013). The convenience of computer technologies can be effectively leveraged in out-of-school learning environments (Mueller et al., 2008). Web 2.0 tools have a valuable place in out-of-school environments (Bolliger & Shepherd, 2017). Collaboration dynamics in dialogic education can result in a variety of behaviors, including the capacity to watch, explain, direct, and participate more actively in the inter subjective meaning-making process (Beraldo et al., 2022). These dynamics reflect the development of communication and collaboration skills that are essential for building shared understanding and fostering active engagement in learning communities (Robin, 2008). Güder et al. (2024) investigated how middle school students' academic performance, motivation, and knowledge of Web 2.0 tools, such as Nearpod, Canva, and Quizizz, were affected when they were integrated into science classes. The results of the study showed that students' awareness of Web 2.0 technologies was positively impacted by Web 2.0 tool-based education.

According to the second sub-findings, dialogic teaching based on an out-of-school environment showed a statistically significant improvement in students' scores in the thought experiment. There was an increase in the students' post-test data. Think, work, and apply are the three steps in the creative process (Rios et al., 2020). Students must solve problems and learn how to apply their answers, in order to think creatively (Soderlund, 2020). Web 2.0 tools help students develop their creativity and critical thinking skills (Hew et al., 2021). The use of Web 2.0 tools helps students develop a deep understanding of the content, increase academic achievement (Aslan & Arabacı, 2023), and facilitate peer social contact as a component of the educational process (Hsu et al., 2014). Dialogic learning serves as a seed for meaning making in science education (Scott et al., 2006). In dialogic learning, meaning making is fundamental as ideas are reshaped, emphasized, and reorganized (Teo, 2019). Conducting thought experiments enables learners to demonstrate their creative problem-solving abilities (Uyar & Karamustafaoğlu, 2023). These thought experiments also improve students' critical thinking by challenging them to question assumptions, analyze inconsistencies and build logical arguments (Lucas & Spencer, 2021). Individuals' inconsistent explicit beliefs can be activated through thought experiments; when relational reasoning and argumentation are specifically prompted, the likelihood of identifying and resolving the inconsistency revealed by the thought experiments increases. The type of model that is manipulated in a thought experiment also affects the outcome and its ability to influence belief revision (Bascandziev, 2024). Thought experiments are a helpful tool for theory development and testing, and they should be used more frequently and rigorously (Gardner, 2023).

According to the third sub-findings, it was determined that dialogic teaching based on an out-of-school environment improved students' thinking processes in establishing new quantitative relationships in secondary effects, in presenting evidence for cognitive purposes, and towards scientific concepts in thought sources. According to Shuttleworth (2023), the practice of applying both mental and physical skills to solve an issue is known as problem solving, a fundamental aspect of critical thinking. Participants define the problem situation; it is generalized by reconsidering it with the examples in the problem (Clement, 2008). When they start to think about a system, they activate the information schemes in long-term memory and make a prediction (Clement, 2008). Using scientific concepts as sources of thought not only enables them to think logically but also to communicate their thoughts (Tuyakova et al., 2022). Analytical thinking concepts, which involve assessing options before concentrating on the best one, can complement divergent thinking approaches (Nuroso et al., 2018). The ability to pose problems is linked to the capacity for creative thought (Elgrably & Leikin, 2021). When individuals use their experiences as the purpose of conducting thought experiments, it shows that they have high analytical thinking skills; when they use compound simulations, they have high creative thinking skills; and when they use symmetry, they can filter their emotions (Uyar & Karamustafaoğlu, 2023). Thought experiments explain the results of physical theories and serve as a bridge to abstract concepts (Uyar & Karamustafaoğlu, 2022; Uyar & Karamustafaoğlu, 2023). Thought experiments are conceptual challenges that might prompt a deliberate attempt to address them at an explanatory level (Bascandziev, 2022). In the teaching-learning process, it can be claimed that e-formative assessment technologies have a favorable impact on students' cognitive and affective domains (Yılmaz & Yaşar, 2023). The students felt that there was freedom of thinking and an awareness of the potential for free action in a conversational setting during the discussion (Albano et al., 2022). These discussions helped develop communication and collaborative problem-solving skills through peer interaction (Weng et al., 2022).A Web 2.0-based instructional curriculum was implemented with secondary school students, and the results indicated that the curriculum had a positive impact on students' thinking processes (Korukluoğlu et al., 2022). Technology enhances these cognitive processes and raises the caliber of ideas (Ang, 2020).

According to the fourth sub-findings of the study, it was seen that the students had positive views towards this activity, which involved dialogic teaching based on out-of-school learning. Students realized that dialogic teaching based on an out-of-school environment improved permanent learning. Dialogic teaching carried out by educators for the purpose of learning together in science provides enduring understanding in the learner (Alexander, 2018; Teo, 2019). For this reason, dialogic teaching makes the learner aware of the intended learning during instruction, to support formative assessment (Black & Atkin, 2014). Teachers' perspectives on learning itself as well as their own role in fostering and evaluating it must change for dialogic teaching to be sustainable (Evagorou & Dillon, 2011). When this finding of the study, was evaluated, it was concluded that web 2.0-based out-of-school dialogic teaching created lasting learning in students. This shows that when students are actively involved in communicative and collaborative learning environments enriched by technology, long-term retention of learning is enhanced (Dede et al., 2020). It was observed, that the students had negative views towards this dialogic teaching-based activity outside the school. Students realized the negative impact of dialogic teaching due to students' disrespectful speech and behavior in groups in out-of-school environments. Dialogic teaching presents a number of difficulties, including students' unwillingness to engage in conversation, cultural disparities, technical limitations, and speech anxiety (Teo, 2019). For these reasons, encouraging active participation, providing a safe and respectful space for communication, and ensuring equal access to technology are essential (Goldenson et al., 2022). Digital technology integration is becoming more widespread in the quickly changing educational landscape, offering cutting-edge resources to improve a range of learning outcomes (Kızıltaş & Kultas, 2025).These technological opportunities not only support content learning but also nurture essential 21st-century skills, especially the 4Cs—critical thinking, creativity, communication, and collaboration—which are indispensable for student success in contemporary learning environments (National Education Association [NEA], 2022).

6. Conclusions

Integrating the Web 2.0 based dialoging teaching model into out-of-school environments was comprehensively examined, with the aim of understanding its multifaceted impact on students' educational experiences. Specifically, the study focused on evaluating students' levels of awareness regarding the use and functionality of Web 2.0 tools, their ability to engage in and carry out thought experiments, the nature and quality of their cognitive processes during these activities, and their overall perceptions and attitudes toward the learning experience facilitated via Web 2.0 tools. To ensure a robust analysis, a mixed-methods research design was employed, combining both qualitative and quantitative data collection techniques. Qualitative data gathered through semi-structured interviews and student reflections revealed that the model was perceived as engaging, innovative, and supportive of active participation and collaboration. More than half of the students expressed that the out-of-school environment provided lasting learning by enabling them to explore new applications, exchange ideas, design games, distinguish right from wrong, use computers and technology effectively, avoid traditional note-taking, relate concepts to daily life and simplify everyday tasks. Taken together, the findings of the study suggest that integrating Web 2.0 tools within dialogic teaching approaches beyond the boundaries of the traditional classroom can have a profound impact on students' digital literacy, critical and creative thinking skills, and overall engagement with learning. This approach not only prepares students for the demands of the digital age but also fosters a learner-centered environment that values dialogue, exploration and active knowledge construction.

7. Limitations and Future Lines of Research

This study is limited to 20 volunteer 7th-grade students, and therefore its findings cannot be generalized to larger populations. The instructional activity was specifically designed for seventh-grade students; however, it holds potential for adaptation to different grade levels. Similarly, while the activity was developed in line with a particular learning outcome in science education, it can be redesigned to align with various other outcomes across different units.

A contextual limitation of the study stems from it was conducted in an economically disadvantaged region, where access to computers was made possible only through a center affiliated with the Ministry of Youth and Sports. In regions with better economic resources, similar dialogic teaching practices based on out-of-school environments can be implemented remotely through the creation of virtual classrooms.

Additionally, while this study was limited to four lesson hours and focused on the use of Web 2.0 tools and thought experiments, future studies could extend the duration and scope by incorporating a wider range of data collection tools, such as reflective journals, interviews or focus groups. This would allow for a more in-depth understanding of students' learning experiences. Moreover, the model can be replicated and adapted for various out-of-school environments, such as museums, science centers, or natural environments, thereby broadening its applicability and educational impact.

Future research should explore the long-term effects of the developed dialogic teaching model across different learning outcomes and grade levels. Comparative studies involving larger sample sizes, diverse socioeconomic regions and interdisciplinary content areas may further validate the model's effectiveness and scalability. Additionally, integrating this model with formal assessment strategies could reveal its impact on students' higher-order thinking skills, conceptual understanding, and sustained engagement with science learning.

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Data availability: The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request.

Ethical declaration: This study was approved by the Scientific Research and Publication the Ethics Committee of Amasya University on 4 December 2023 with the approval number: E-30640013-108.01-167168. During the research process, participants were provided with detailed information about the purpose, procedures, and potential risks of the study, and their informed consent was obtained. Participants were informed that their participation was voluntary.

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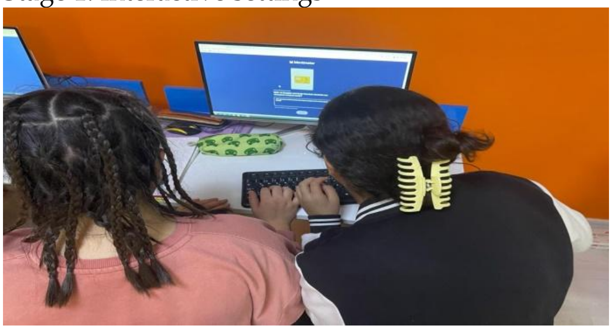
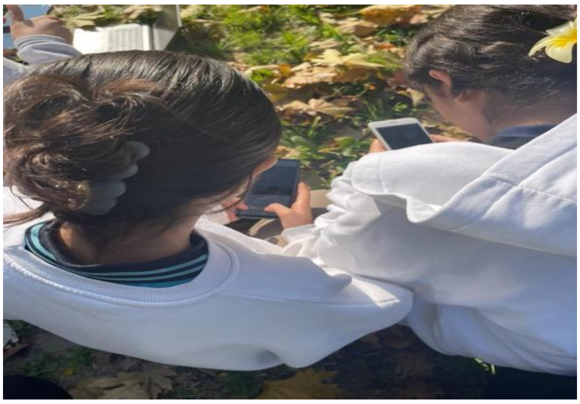
Appendix 1. Implementing dialogic teaching based on out-of-school via Web 2.0 tools model pictures

Stage 1: Interactive settings

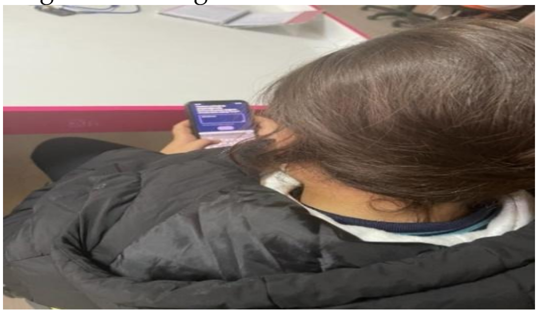


Stage 2: Everyday talk

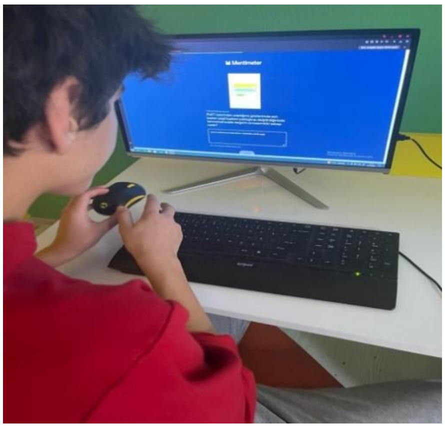


Stage 3: Learning talk

Stage 4: Teaching talk



Stage 5: Questioning



Stage 6: Extending