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EXPLORING THE INTEGRATION OF WEB 2.0 TOOLS INTO FORMATİVE ASSESSMENT PRACTICES IN SCIENCE EDUCATION: A CASE STUDY

Abstract. The integration of Web 2.0 tools into science education has gained increasing attention because of their potential to enhance student engagement, support interactive learning, and facilitate assessment processes. However, limited research has examined how these tools operate within an explicitly defined formative assessment (FA) framework. Most previous studies have focused primarily on technological affordances or learning outcomes rather than on the pedagogical processes through which these tools support formative assessment. Therefore, this study aims to explore how Web 2.0 tools can be integrated into sixth-grade science classrooms in relation to key formative assessment components.

A qualitative case study design was employed with 13 sixth-grade students during the implementation of the "Sound" unit. Kahoot, Edpuzzle, and Wordwall were integrated into classroom instruction to support the clarification of learning goals and success criteria, the elicitation of evidence of student learning, the provision of timely feedback, and students' active involvement in the assessment process. Data were collected through student reflections, structured classroom observations, and digital activity records generated by the Web 2.0 tools. The data were analyzed using thematic analysis to identify patterns related to formative assessment practices.

The findings indicate that these tools created valuable opportunities for eliciting evidence of learning, providing immediate feedback, increasing student participation, and supporting classroom interaction. However, their formative value depended largely on the pedagogical design of learning activities, the quality of feedback, and students' levels of digital literacy. Rather than demonstrating causal effects on learning outcomes, the findings identify the contextual conditions under which Web 2.0 tools may effectively support formative assessment practices. This study contributes to the literature by providing a practice-oriented perspective on integrating Web 2.0 tools within a formative assessment framework, offering practical implications for science teachers, and suggesting future research using larger samples and mixed-methods designs.

Keywords: Science education; Web 2.0 tools; FA; case study.

1. INTRODUCTION

The problem statement. The rapid rise of digitalization in education has reshaped teaching and learning processes. Particularly in the field of science education, the use of digital tools has become increasingly important to make students' learning processes more effective and interactive. Digitalization in education offers interactive and personalized learning opportunities and may create conditions that support increased classroom participation, depending on pedagogical implementation [1], [2].

The integration of digital tools into instructional practices plays a key role in implementing methods that guide teaching and learning processes, such as FA [3]. FA enables teachers to adapt their instructional strategies in real time by identifying where students stand in relation to learning objectives and success criteria [4]. This process supports students' progress monitoring and teachers' individualized feedback [5]. Web 2.0 tools have the potential to support FA processes when they are pedagogically aligned with learning goals and feedback

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strategies. In particular, tools such as Kahoot, Edpuzzle, and Wordwall offer powerful means of increasing student engagement and supporting teachers in monitoring learning more closely [6], [7].

The integration of Web 2.0 tools into FA processes may facilitate student participation and provide teachers with additional opportunities to monitor learning and deliver feedback, depending on instructional design and classroom context. [8]. Kahoot can be used to enable students to check their understanding, while providing teachers with real-time response data that may inform instructional decisions [9], [10]. Edpuzzle provides real-time data to teachers as students watch video content, making it a valuable tool for identifying misunderstandings and learning gaps [11]. Wordwall supports student learning through interactive games while enabling teachers to detect areas of weakness [12]. The incorporation of such tools into science education holds the potential to make lessons more dynamic and student-centered [13].

Research on the use of Web 2.0 tools in science education, particularly in relation to how they can be integrated with FA practices, remains limited [14], [15]. The integration of Web 2.0 tools with key components of FA—such as clarifying learning goals, collecting evidence of student learning, providing feedback, and encouraging students to take responsibility for their learning and learning from peers [16]—can contribute to improving students' learning experiences in science education. However, more studies are needed to explore how these tools can be effectively implemented within the context of science education.

In particular, the lack of knowledge regarding how Web 2.0 tools interact with the core components of FA and how they support students' learning processes in science classes forms the basis of this study. Understanding how tools used in FA shape student learning can contribute to the development of strategies that help teachers use these tools more effectively. Therefore, this study aims to explore how Web 2.0 tools are enacted within FA practices in a sixth-grade science classroom and to identify the instructional conditions under which these tools may support FA processes.

In this regard, this study seeks to provide a valuable contribution by investigating how digital tools can be integrated with FA in science education, ultimately aiming to enhance the effectiveness of both teaching and learning.

Analysis of recent studies and publications. In recent years, the rapid development of educational technologies has intensified discussions on how learning and assessment processes should be restructured in digitally enriched classrooms. The integration of Web 2.0 tools into instructional practices has influenced teachers' pedagogical decision-making and students' learning experiences, particularly in technology-supported classroom environments. Particularly in FA processes, these tools can support the real-time collection of learning traces and offer opportunities for timely instructional adjustment; however, their contribution depends on how the collected evidence is interpreted and used pedagogically [14].

FA is conceptualized as a process in which teachers clarify learning goals, elicit evidence of student understanding, interpret that evidence, and adapt instruction accordingly [17]. Integrating Web 2.0 tools into this process may create opportunities for more immediate feedback, yet the quality and formative function of feedback depend on pedagogical design and classroom enactment.

The current literature highlights three fundamental components shaping FA, which provide an analytical framework for examining the use of Web 2.0 tools in classroom practice. Gotwals et al. (2015) [11] conceptualized these components as a core structure for FA. The first component involves clarifying and sharing learning goals and success criteria. Clearly communicating the intended goals and criteria enables students to understand what they are expected to achieve. Competition-based tools such as Kahoot allow teachers to quickly share these objectives with students [18], while video-based platforms like Edpuzzle enable teachers to monitor the extent to which these goals are being achieved [19].

The second component focuses on eliciting evidence of student learning during instruction. This process allows teachers to understand students' current learning status and adjust instruction accordingly [17]. Web 2.0 tools can generate rapid response data and participation traces that may support evidence collection, yet evidence becomes formative only when it informs instructional decisions [20]. Kahoot can provide immediate response patterns that help teachers identify potential misconceptions [21], Edpuzzle can indicate where students pause or respond incorrectly during video-based tasks [19], and Wordwall can be used for practice and self-check opportunities depending on task structure [15].

The third component involves closing the gap by using feedback and follow-up actions to guide next steps in learning. This requires teachers to interpret evidence and respond through targeted feedback, task revision, or instructional adjustment when misunderstandings are identified. Gotwals et al. (2015) [11] emphasized that this process helps students take responsibility for their own learning and consolidate it by providing peer feedback. Web 2.0 tools enhance this process by offering teachers the ability to provide real-time feedback and adjust instruction based on students' needs. For example, Kahoot can provide rapid item-level feedback that may help learners recognize gaps [22]; Wordwall can be used for individual practice and peer-supported checking when structured intentionally [23]; and Edpuzzle can support instructional decision-making by showing patterns of incorrect responses across embedded questions [24].

Research on educational technologies has concluded that Web 2.0 tools increase student motivation, promote active engagement in learning, and support the development of self-regulated learning skills [25]. However, the existing literature on the use of Web 2.0 tools in FA processes generally focuses on variables such as student engagement [14], motivation [26], academic achievement [27], and feedback processes [14]. Some comparative studies have examined technology-supported FA practices alongside traditional approaches and reported teacher and student perspectives; yet, fewer have traced how evidence, feedback, and next-step decisions unfold in real-time classroom interactions [22], [28]. Moreover, a substantial portion of this research has focused on higher education settings, whereas process-oriented studies situated in middle school science classrooms remain relatively limited. Although existing studies have examined the effects of Web 2.0 tools on engagement and achievement, fewer studies have explored how tool-generated data are translated into FA actions within real classroom contexts, particularly in middle school science education. This gap underscores the need for context-sensitive and process-oriented studies that examine not only whether Web 2.0 tools are used, but how they function within FA practices through evidence interpretation, feedback quality, and instructional follow-up.

The research goal. The purpose of this study is to explore how Web 2.0 tools are enacted within FA practices in a sixth-grade science classroom, focusing on students' experiences during this process. Specifically, the study examines how Kahoot, Edpuzzle, and Wordwall function in relation to key FA components, including clarifying learning goals, eliciting evidence of student understanding, providing feedback, and supporting student involvement in assessment. Rather than investigating the effectiveness of Web 2.0 tools as independent variables, this study adopts a process-oriented perspective and explores the instructional conditions under which tool-generated data may inform FA actions.

By adopting a qualitative case study design, the research does not seek to establish causal relationships or statistical generalizations. Instead, it aims to provide an in-depth and context-bound understanding of how FA practices are shaped through the pedagogical use of Web 2.0 tools in an authentic middle school science classroom.

Accordingly, the study addresses the following research questions: (1) How do sixth-grade students experience the use of Kahoot, Edpuzzle, and Wordwall when these tools are implemented for FA purposes?

(2) Under what instructional conditions do Web 2.0 tools support key FA components in science lessons?

2. RESEARCH METHODS

2.1. Research design

This study employed a qualitative case study design to explore students' experiences with Web 2.0 tools within FA practices in a real classroom context. Case studies enable an in-depth and multifaceted examination of a bounded system within its natural setting, such as a specific classroom or instructional process [29]. The bounded system of this case study consisted of a single sixth-grade classroom during a four-week instructional unit on "Sound and Its Properties," in which Web 2.0 tools were intentionally integrated into FA practices. This design was considered appropriate because the aim of the study was not to generalize findings, but to gain a detailed understanding of how FA processes are enacted when supported by Web 2.0 tools in a specific educational context. Accordingly, the study prioritizes analytic insights into process and conditions over claims of effectiveness or statistical generalization.

The case study design was selected to provide an in-depth understanding of how FA practices are enacted in a real classroom context. This approach allows for the exploration of context-dependent interactions between digital tools and instructional processes.

2.2. Participants

The study sample consisted of 6th-grade students (n=13) enrolled in a public school during the 2024–2025 academic year. The participants were selected through convenience sampling, as the researchers had access to the classroom. The students were aged 11–12 and represented a mixed socio-economic background typical of public middle schools in the region.

2.3. Data Collection Instruments

Classroom Observation Form: A semi-structured classroom observation form developed by the researchers was used to systematically document the implementation process. The observation form focused specifically on FA components, including (a) elicitation of evidence of learning, (b) immediacy and quality of feedback, (c) student participation in assessment-related activities, and (d) observable indicators of engagement. The form consisted of three tool-specific sections (Kahoot, Wordwall, and Edpuzzle), each containing both structured (e.g., Yes/No; High/Medium/Low scales) and open-ended items. A general evaluation section examined pedagogical contributions, technical challenges, and instructional adjustments made during the process. To ensure content and construct validity, expert feedback was obtained from specialists in science education and educational measurement, and revisions were made accordingly [30].

Interview Form: A semi-structured interview form was developed to explore students' perceptions and experiences regarding the pedagogical use of Web 2.0 tools within FA. The interview protocol was organized into three sections corresponding to Kahoot, Wordwall, and Edpuzzle.

Students were asked open-ended questions addressing:

- perceived contribution to learning,
- clarity of feedback,
- level of involvement in assessment activities,

- ease of use and encountered difficulties,
- perceived impact on participation in classroom assessment processes.

The final section invited students to compare tools, express preferences, and provide suggestions regarding frequency and instructional use. All questions were open-ended to enable in-depth reflection and to capture nuanced experiences related to FA engagement. Content validity was established through expert review and subsequent revision [30].

Student Diaries: Students maintained reflective diaries throughout the four-week implementation. These diaries were intended to capture students' self-assessment experiences, perceptions of feedback, and reflections on how digital tools supported or constrained their learning. As a form of learner-generated evidence, the diaries provided insight into students' metacognitive awareness and their involvement in FA processes.

Digital Documents: Digital artifacts generated during the instructional process were collected from Kahoot, Wordwall, and Edpuzzle. These included quiz results, response patterns, completion rates, and embedded-question analytics. These records served as objective indicators of evidence elicitation and feedback cycles within the FA framework, allowing triangulation with observational and interview data.

In order to strengthen the theoretical grounding of the study, the data collection instruments were aligned with the three guiding questions of FA (Where are we going? Where are we now? How do we close the gap?) as conceptualized in the literature. This alignment ensured coherence between the research purpose, implementation process, and data analysis framework (see Table 1).

Table 1

Alignment of data collection instruments with the three guiding questions of FA (Adapted from Gotwals et al.)

FA Guiding Question	FA Focus	Observation Form	Interviews	Student Diaries	Digital Records
Where are we going?	Clarification of learning goals and success criteria	Documentation of whether learning objectives were explicitly communicated and referenced during tool use	Students' perceptions of goal clarity and task expectations	Reflections on understanding lesson goals	—
Where are we now?	Elicitation of evidence about current understanding	Observation of student responses, participation patterns, and misconceptions during activities	Students' descriptions of how tools revealed their understanding	Reflections on difficulties and conceptual gaps	Quiz scores, response accuracy rates, completion data
How do we close the gap?	Feedback processes and instructional adjustment	Observation of immediacy and type of feedback provided; teacher's instructional modifications	Students' perceptions of feedback usefulness and opportunities for improvement	Reflections on learning improvement over time	Embedded feedback logs (Edpuzzle), comparative performance across sessions

2.4. Implementation process

The implementation was carried out during the "Sound and Its Properties" unit in a sixth-grade science classroom over four weeks (eight class hours; two hours per week). Web 2.0 tools (Kahoot, Edpuzzle, and Wordwall) were integrated into the instructional sequence to support FA cycles guided by three questions: (a) Where are we going? (clarifying learning goals and

expectations), (b) Where are we now? (eliciting evidence of student understanding), and (c) How do we close the gap? (providing feedback and adjusting instruction):

Week 1 – Sound Reflection:

At the beginning of the lesson, a short quiz was administered using Kahoot to determine students' prior knowledge. Then, the teacher explained the fundamental concepts of sound reflection using a mirror-sound analogy. During this process, students watched a video on echo formation via Edpuzzle, which included embedded questions to ensure active participation. Students observed the reflection of sound from different surfaces through a simple classroom experiment and reinforced their learning using a Wordwall matching activity. At the end of the week, students' achievements were assessed through a short Kahoot quiz.

Week 2 – Sound Absorption:

The lesson began with a Wordwall "True/False" activity to review knowledge from the previous week. Subsequently, students conducted experimental observations by applying sound waves to different surfaces to determine which surfaces absorbed sound. To support this process, a topic-related video was presented via Edpuzzle, and questions within the video kept students' attention engaged. Small group discussions followed, focusing on the sound-absorbing properties of different surfaces, and findings were shared in the classroom. At the end of the lesson, a Kahoot mini-test was used to measure students' ability to distinguish between the concepts of "sound reflection" and "sound absorption."

Week 3 – Sound Insulation:

At the beginning of the week, students used a Wordwall "Drag-and-Drop" game to match materials used in sound insulation with their respective functions. Then, students watched a video on sound insulation technologies via Edpuzzle and participated in a classroom discussion on the question, "Is sound insulation necessary in homes?" Students worked in small groups to design a sound-insulated room and presented their designs to the class. A Kahoot quiz at the end of the week reinforced students' understanding of sound insulation concepts.

Week 4 – Acoustic Applications:

At the start of the lesson, a Kahoot survey was administered to engage students, and the question "Why does sound differ in theaters and concert halls?" was discussed. Then, students watched a video on acoustic engineering and sound arrangements via Edpuzzle. Based on the video content, students designed acoustic models and attempted to create an environment with optimal acoustic arrangements. The designs were compared through peer assessment, and the most suitable design was selected. At the end of the lesson, students reviewed key concepts with a Wordwall fill-in-the-blank activity, followed by a Kahoot final test for overall unit evaluation.

Overall Evaluation:

At the conclusion of the implementation, students completed a brief self-assessment to reflect on their learning progress and difficulties (How do we close the gap?). In addition, performance indicators and response patterns obtained from Edpuzzle and Kahoot (e.g., completion rates, response accuracy, item-level trends) were reviewed to provide individualized feedback and to inform instructional adjustments.

2.5. Data collection process and data analysis

In this study, the implementation was conducted over a four-week period within the "Sound and Its Properties" unit of the 6th-grade science course, comprising a total of eight class hours (two hours per week), during which Web 2.0 tools (Kahoot, Edpuzzle, and Wordwall) were systematically integrated into FA practices. Prior to the implementation, all necessary permissions (Ethics Committee Approval, Ministry of National Education approval, and

parental consent) were obtained. A lesson plan was developed to explore how Web 2.0 tools contribute to students' learning processes and how they can be used in FA practices.

During the implementation, students' interactions with the tools were observed, and classroom activities were documented through photographs. In addition, student diaries reflecting their learning experiences were collected. After the completion of the implementation, face-to-face interviews were conducted with the students, and these interviews were audio-recorded. In the interviews, students were asked about their learning experiences, motivation, and assessment processes related to the topic of "Sound" in the Science course through the use of Web 2.0 tools.

All qualitative data (interview transcripts, student diaries, observation notes, and digital artifacts) were transcribed, anonymized, and uploaded to NVivo 12 for data management and analysis. The data were analyzed using thematic analysis, progressing through three stages: (1) open coding, (2) grouping codes into categories, and (3) generating overarching themes to explain how Web 2.0 tools were experienced within FA practices [23].

Digital platform records were used as supporting artifacts to contextualize and triangulate qualitative interpretations [23].

To enhance the credibility and consistency of the coding process, the researchers conducted the coding independently. Inter-coder agreement was calculated using the formula proposed by Miles and Huberman (1994) [Agreement / (Agreement + Disagreement)] and was found to be 0.90, indicating a high level of agreement [22]. Codes on which discrepancies occurred were re-examined, and consensus was reached through discussion among the researchers.

Furthermore, the use of multiple data collection methods (interviews, classroom observations, student diaries, and digital artifacts) enabled data triangulation, which contributed to the trustworthiness of the findings by allowing cross-validation across different data sources.

3. THE RESULTS AND DISCUSSION

The findings of the study are presented under two subheadings.

3.1. Experiences with Web 2.0 tools

3.1.1. Kahoot

In this study, Kahoot was utilized as a FA tool at different stages of instruction through short quizzes administered at both the outset and conclusion of the learning process. In the first week, during the introduction of the topic Reflection of Sound, a brief quiz was implemented to assess students' prior knowledge. At the end of the same lesson, another quiz was administered to check students' understanding of the content addressed in the lesson. In the second and third weeks, a similar approach was adopted: mini-quizzes were conducted via Kahoot at the conclusion of the topics Absorption of Sound and Sound Insulation to monitor students' understanding. In the fourth week, Kahoot functioned not only as a knowledge check but also as a brainstorming tool. Students were posed the question, "Why is sound perceived differently in theaters and concert halls?", which initiated a discussion and invited critical reflection on the topic. At the end of the process, a comprehensive review quiz was administered to summarize patterns of understanding and inform feedback and review activities related to the four-week learning objectives and success criteria.

Findings from classroom observations and student feedback indicated active participation in Kahoot activities. The competitive, game-based format of the questions captured students' attention and appeared to support their engagement during the sessions. Students frequently

described the activity as "enjoyable," "exciting," and "motivating," reflecting positive perceptions of the classroom experience rather than demonstrated effects on learning outcomes. These findings suggest that students perceived Kahoot as a dynamic supportive component of the learning process. Moreover, attention levels were generally observed to remain high; when students experienced difficulties in responding, the platform's timely feedback appeared to help them re-engage with the learning process.

The qualitative data analysis further revealed that students' perspectives on Kahoot were categorized under several themes. The results, derived from the frequency of coded responses, are presented in Figure 1 and are illustrated through representative student statements (see excerpts below).

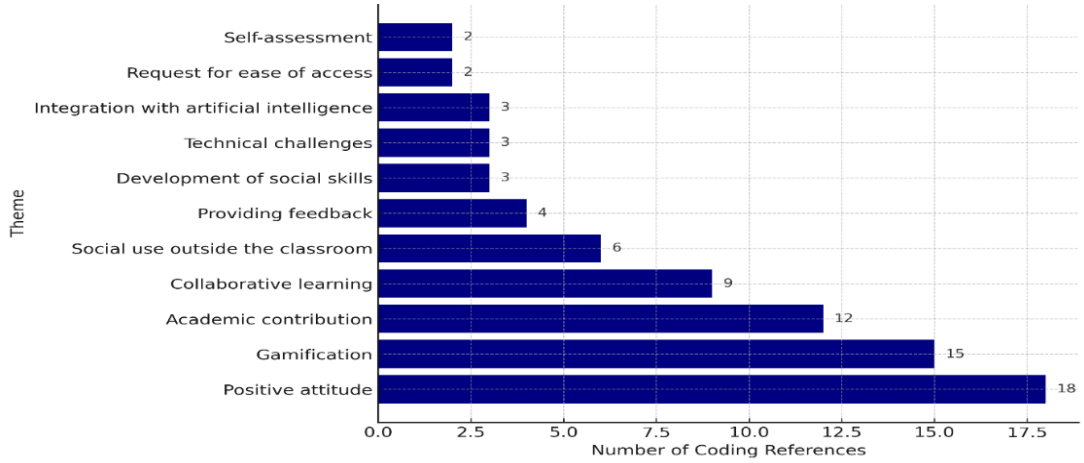


Figure 1. Distribution of students' views on the Kahoot application based on qualitative coding frequencies (N = 13 students)

For example, one student remarked, "The instant results make me curious about whether I understood correctly," while another explained, "Because it's competitive, I pay closer attention." These statements suggest that Kahoot was perceived as engaging due to its competitive format and immediate response feedback, rather than as a direct mechanism for improving conceptual understanding.

Based on the obtained data, the aspect students appreciated most in Kahoot was its gamification-based structure. This preference appears to be related to the interactive and feedback-oriented nature of gamified activities, which incorporate instant feedback, visual elements, and competition. These features may create conditions that capture students' attention and support their willingness to participate in learning activities, particularly when dealing with abstract and structured concepts in science education.

This finding is consistent with previous studies suggesting that gamification-based tools may support students' motivation and participation in classroom activities [24], [10]. However, unlike studies that report direct improvements in learning outcomes, the present study does not provide evidence of such effects. Instead, it indicates that Kahoot may function as a supportive tool within FA processes by making student thinking more visible and by enabling immediate feedback.

From a FA perspective, Kahoot can be interpreted as a tool that contributes to evidence elicitation and feedback cycles, particularly when questions are aligned with learning objectives and followed by instructional responses. In this sense, its effectiveness appears to depend not only on its gamified structure but also on how teachers interpret and act upon the evidence generated during its use.

3.1.2. Edpuzzle

In this study, Edpuzzle was employed to support students' engagement with video-based instruction and to formatively assess their conceptual understanding. Each week, videos enriched with interactive questions, aligned with specific learning outcomes were presented to students. In the first week, during the instruction of the "Reflection of Sound" topic, real-time questions related to echo formation were posed to students, aiming to explore the extent to which they comprehended the video content. In the second week, a video addressing sound absorption supported students in structuring their observations regarding the behavior of sound on different surfaces. During the third week, an Edpuzzle video on sound insulation technologies supported students' opportunities for note-taking and organizing information, while subsequent classroom discussions contributed to deeper reflection on the topic. In the fourth week, through a video on acoustic engineering and sound arrangements, students explored the practical applications of acoustics and connected the video content to prior knowledge and reflected on practical applications.

The use of Edpuzzle throughout this process appeared to be useful both in providing timely feedback to the instructor and in supporting student participation in learning. According to the qualitative data analysis, students' opinions regarding the Edpuzzle application were coded under various themes. The findings derived from the frequency of coding are presented in Figure 2.

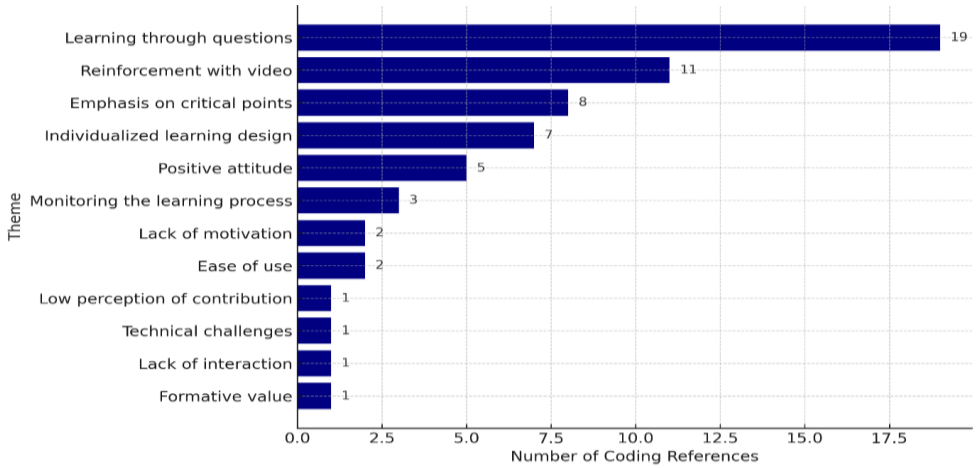


Figure 2. Distribution of students' views on the Edpuzzle application based on qualitative coding frequencies (N = 13 students)

For instance, a student stated, "The questions made me check if I was following the video," highlighting the perceived role of embedded questioning in monitoring understanding. Another student noted, "I paid more attention when the video paused," suggesting that the structured interruptions may have supported attentional focus during the activity.

The most frequently coded theme in students' perceptions of Edpuzzle was "reinforcing learning through questions." This suggests that embedded questions may have helped students maintain focus on key ideas during video-based instruction and may have supported their conceptual understanding. Classroom observations further indicated that students responded to these questions with sustained attention, particularly at moments when questions appeared. This pattern may be associated with the immediate feedback provided during the process, which can support students' regulation of their learning and attention during video-based tasks [19].

This finding is consistent with previous research indicating that interactive video-based learning environments may support sustained attention and more active processing of content [25], [26], [27]. However, rather than demonstrating direct improvements in learning outcomes, the present study suggests that such tools may create conditions that support engagement with content under appropriate instructional design. In this respect, the role of embedded questioning

appears to be particularly important in directing students' attention to critical aspects of the content.

The recurring theme of "reinforcement through video" further indicates that students perceived audiovisual elements as supportive of comprehension, particularly in the context of abstract scientific concepts. Similarly, Zhang et al. (2006) [27] highlight the role of instructional videos in facilitating conceptual understanding. In addition, themes such as "emphasis on critical points" and "individualized learning support" suggest that the ability to pause, reflect, and respond to questions at one's own pace may contribute to more personalized learning experiences, which aligns with previous findings on individualized learning environments [17], [25].

From a FA perspective, Edpuzzle appears to contribute primarily to evidence elicitation and feedback processes. Students' perceptions of receiving feedback while responding to embedded questions suggest that the tool may support ongoing monitoring of learning, particularly when combined with teacher follow-up. This interpretation is consistent with Black and Wiliam's (2009) [12] emphasis on the importance of interaction and feedback within FA practices.

However, less frequently mentioned themes, such as technical difficulties, limited interaction, and decreased motivation, indicate that the effectiveness of such tools is not guaranteed. These findings suggest that the formative potential of Edpuzzle is influenced not only by its design features but also by contextual factors such as technical infrastructure, students' digital competencies, and the nature of instructional implementation [25].

3.1.3. Wordwall

In this study, Wordwall was used as a FA tool through various game-based activities to support students in reviewing the topics and identify areas they did not fully comprehend. At the end of the first week, following the topic "Reflection of Sound", students reviewed key concepts related to sound reflection through an interactive game in which they matched surfaces based on whether they reflected sound or not. In the second week, the "True or False?" game provided opportunities for students to demonstrate their understanding to distinguish between concepts related to sound reflection and absorption. During the third week, students participated in a "Drag-and-Drop" activity in which they matched sound insulation materials with their functions, supporting their engagement with the relationships between concepts. In the fourth week, the "Fill-in-the-Blank" game, covering all topics, provided students with the opportunity to review key concepts and identify gaps or misconceptions in their knowledge. Wordwall activities, by gamifying learning, appeared to make the process more engaging from students' perspectives, while also providing the teacher with immediate feedback on which learning outcomes students found challenging.

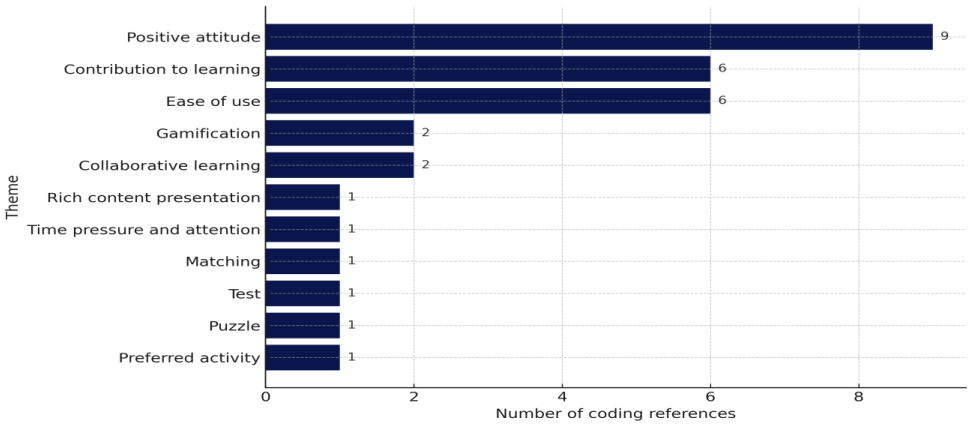


Figure 3. Distribution of students' views on the Wordwall application based on qualitative coding frequencies (N = 13 students)

For example, one student stated, "I like the matching games because I can see immediately if I made a mistake," highlighting the perceived role of instant feedback in monitoring understanding. Another student noted, "We sometimes helped each other when someone didn't know the answer," suggesting that certain Wordwall activities created opportunities for peer-supported review.

Based on the analysis of interview data and in-class observations, students demonstrated active engagement with the Wordwall application. Gamification-based activities, particularly dynamic formats such as matching, puzzle, and quiz games, appeared to capture students' attention and support their participation in the learning process. These findings suggest that the gamified design of Wordwall may create conditions that enhance both cognitive and affective engagement from the students' perspective.

This result is consistent with previous studies indicating that gamification-based digital tools may support students' motivation and help sustain attention during learning activities [24], [29]. However, rather than providing evidence of direct improvements in learning outcomes, the present study suggests that such tools may facilitate engagement under specific instructional conditions.

Frequently emphasized themes, such as "positive attitude," "contribution to learning," and "ease of use," indicate that students perceived Wordwall as an accessible and supportive learning tool. In the context of science education, where abstract concepts are prominent, interactive and visually supported activities may contribute to reinforcing key ideas. In particular, the immediate correct–incorrect feedback structure can be associated with the "Where are we now?" component of FA, as it enables students to monitor their current level of understanding during review tasks.

From a FA perspective, Wordwall appears to contribute to evidence elicitation and self-assessment processes, particularly when feedback is interpreted and followed by instructional action. Students' engagement with content, their processing of information through interactive formats, and their ability to monitor their responses align with this interpretation. This is consistent with Wang's (2015) [28] view that digital tools can support interaction and attention within the learning process.

In addition, observations related to "collaborative learning" suggest that Wordwall may also support peer interaction, as students were seen assisting each other and jointly solving tasks. This indicates that the tool may function not only at an individual level but also within collaborative learning contexts [16].

However, less frequently observed themes, such as time pressure and distraction, indicate that some students may experience difficulties during time-constrained activities. These findings suggest that the effectiveness of Wordwall depends on careful pedagogical design, including task structure, pacing, and classroom management. As with other digital tools, its formative potential appears to be shaped not only by its features but also by contextual and instructional factors [25].

Figures 4–7 present illustrative excerpts from student diaries and selected digital artifacts. These examples demonstrate how students articulated their experiences of feedback, engagement, and perceived learning challenges, thereby increasing transparency in the interpretation of coded themes.

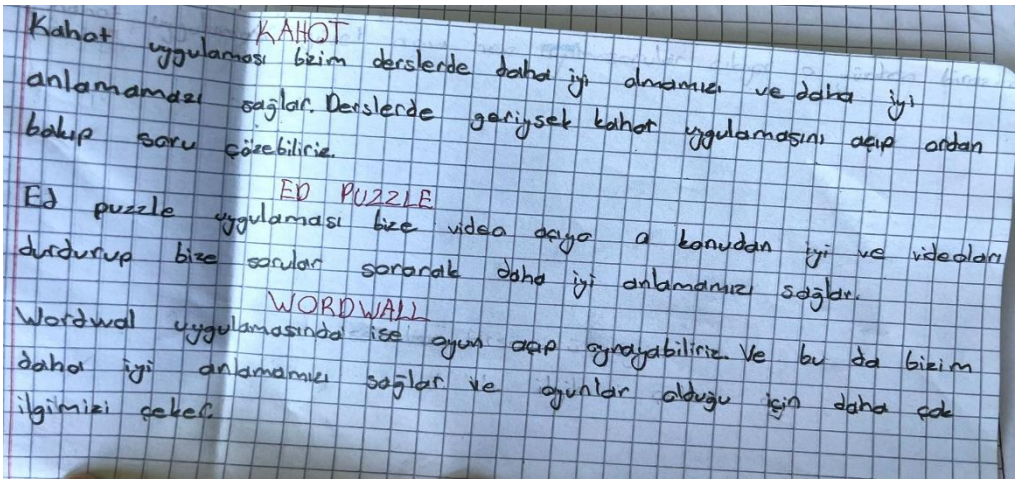


Figure 4. Sample student diary 1

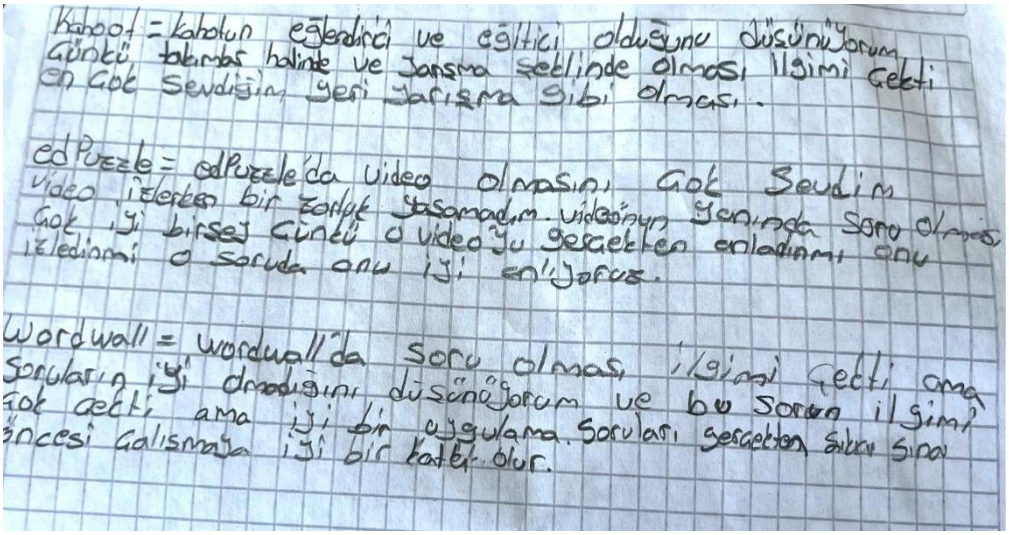


Figure 5. Sample student diary 2



Figure 6. Sample digital document 1

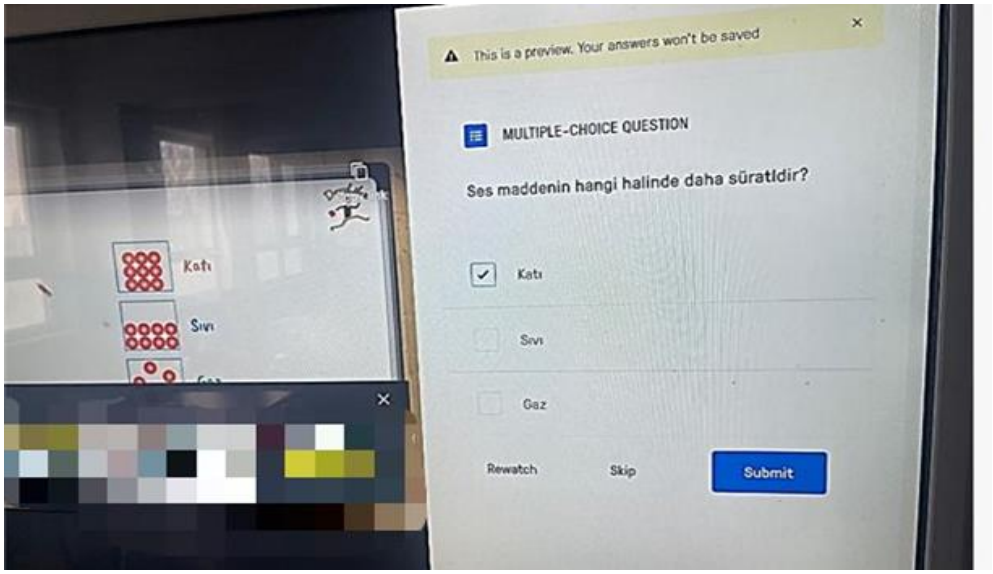


Figure 7. Sample digital document 2

3.2. Use of Web 2.0 tools in FA

Based on the data obtained in the study, a visual co-occurrence mapping based on thematic coding was conducted to visualize the relationship between Web 2.0 tools and FA components (Figure 4). Examination of this network reveals which FA components associated with each Web 2.0 tool.

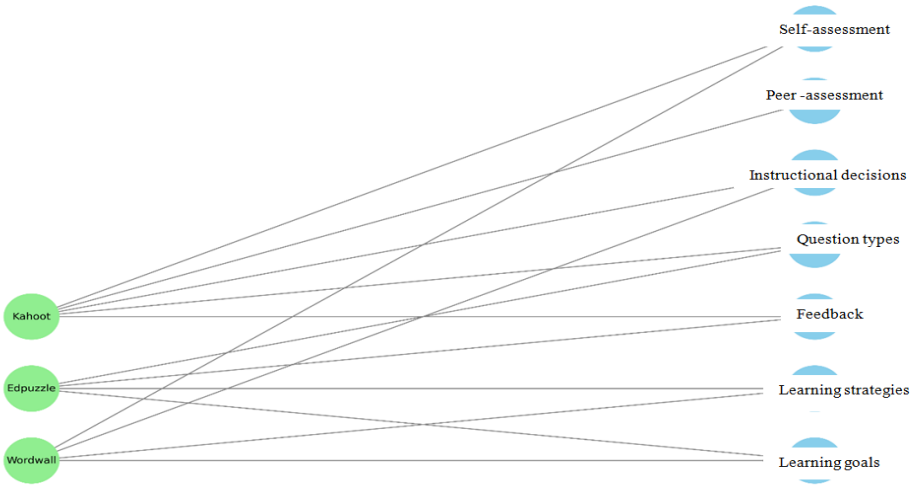


Figure 8. Network analysis illustrating the co-occurrence relationships between Web 2.0 tools and FA components

Figure 8 should be interpreted as a representation of relational patterns rather than causal relationships between tools and FA components.

As illustrated in Figure 8, Kahoot was more frequently co-coded with multiple FA components within the dataset. Its associations with self-assessment, peer assessment, feedback, question types, and instructional decisions suggest that Kahoot was positioned within a multifaceted FA environment. This finding indicates that gamification-based tools may create

conditions that support student engagement and may assist teachers in structuring instructional decisions in a more dynamic manner [9], [28].

Edpuzzle, in contrast, was primarily associated with components such as video-integrated question types, information strategies, and feedback cycles. This pattern appears to be closely related to the design of the tool, which encourages active engagement with instructional content through embedded questions. These features may create opportunities for ongoing assessment and timely feedback within the learning process. Furthermore, the placement of questions at critical points in the video may contribute to making learning objectives and success criteria more explicit. This interpretation aligns with previous research suggesting that interactive video tools can support active participation under appropriate instructional conditions [25], [27], as well as with Black and Wiliam's (2009) [12] emphasis on the role of interaction in FA.

Wordwall was found to be associated with components such as self-assessment, instructional decisions, sharing learning objectives and success criteria, and information strategies. This may be attributed to its game-based formats, which provide immediate feedback and allow students to monitor their own learning processes. In this context, students' repeated attempts during game-based activities may support clearer communication of learning goals and may help sustain attention during the learning process. These findings are consistent with studies indicating that gamified digital tools can offer flexible instructional opportunities and support differentiated FA practices [9], [16], [23].

It is important to emphasize that co-occurrence mapping does not imply causal relationships between specific Web 2.0 tools and FA outcomes. Rather, it illustrates how these tools were positioned within FA cycles during the implementation process. The findings suggest that the formative function of each tool depended largely on pedagogical design, questioning strategies, feedback quality, and subsequent instructional actions.

4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

This study examined how Web 2.0 tools functioned as supportive elements within FA practices in a sixth-grade science classroom, with a particular focus on the instructional conditions under which tool-generated data informed formative actions. The findings indicate that tools such as Kahoot, Edpuzzle, and Wordwall created opportunities for evidence elicitation, feedback provision, and increased visibility of student thinking during classroom interactions.

However, these outcomes should be interpreted as context-dependent conditions rather than direct evidence of improvements in students' skills or learning outcomes. The findings suggest that the formative value of Web 2.0 tools does not stem from the tools themselves, but from how they are pedagogically integrated, particularly in relation to the clarity of learning objectives, the use of success criteria, and the quality of feedback provided during instruction.

Across all tools, their effectiveness was closely linked to instructional design, feedback practices, students' levels of digital competence, and the availability of adequate technical infrastructure. Observed technical challenges and potential distractions further highlight that the integration of digital tools requires both pedagogical and infrastructural support.

This study contributes to the literature by providing a practice-oriented perspective on how Web 2.0 tools can be positioned within FA processes, emphasizing the conditional and context-sensitive nature of their use. Rather than producing direct effects, these tools functioned as mediating instruments within pedagogically structured FA cycles.

The study is limited by its qualitative case study design, small sample size, and short implementation period, which restricts the generalizability of the findings. Future research may benefit from employing mixed-methods designs, larger samples, and comparative analyses of

different tools to further examine how digital technologies interact with FA components across diverse contexts.

Overall, the findings underscore that the effective use of Web 2.0 tools in FA depends on purposeful pedagogical integration, where questioning, feedback, and instructional follow-up remain central to the learning process.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During manuscript preparation, ChatGPT (OpenAI, GPT-5.5) was used solely to improve grammar, language, and readability. All scientific content, analyses, interpretations, and conclusions were developed and verified by the authors, who take full responsibility for the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the preparation, submission, and publication of this article. Furthermore, the authors declare that there are no financial, professional, or personal relationships that could have influenced the research process, the interpretation of the findings, or the conclusions presented in this study.

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ІНТЕГРАЦІЯ ІНСТРУМЕНТІВ WEB 2.0 У ПРАКТИКУ ФОРМУВАЛЬНОГО ОЦІНЮВАННЯ УЧНІВ У НАВЧАННІ ПРИРОДНИЧИХ НАУК

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Анотація. Інтеграція інструментів Web 2.0 у природничу освіту привертає дедалі більшу увагу завдяки їхньому потенціалу щодо підвищення зацікавленості учнів, підтримки інтерактивного навчання та спрощення процесів оцінювання. Однак лише в обмеженій кількості досліджень розглядалось, як ці інструменти функціонують у межах чітко визначеної системи формувального оцінювання (ФО). Більшість попередніх досліджень зосереджувались переважно на технологічних можливостях або результатах навчання, а не на педагогічних процесах, через які ці інструменти сприяють формувальному оцінюванню. Тому метою цього дослідження є вивчення того, як інструменти Web 2.0 можна інтегрувати в уроки природничих наук для учнів 6-го класу з урахуванням ключових компонентів формувального оцінювання.

Було застосовано якісний дизайн дослідження за участю 13 учнів 6-го класу під час вивчення теми «Звук». Kahoot, Edpuzzle та Wordwall були інтегровані в навчальний процес для сприяння уточненню навчальних цілей та критеріїв успішності, виявленню доказів засвоєння матеріалу учнями, наданню своєчасного зворотного зв'язку та активній участі учнів у процесі оцінювання. Дані збирались за допомогою рефлексій учнів, структурованих спостережень за уроками та цифрових записів активності, згенерованих інструментами Web 2.0. Дані було проаналізовано за допомогою тематичного аналізу для виявлення закономірностей, пов'язаних із практиками формувального оцінювання.

Результати дослідження свідчать, що ці інструменти створили цінні можливості для виявлення доказів засвоєння знань, надання миттєвого зворотного зв'язку, підвищення рівня залученості учнів та підтримки взаємодії в класі. Однак їхня формувальна цінність значною мірою залежала від педагогічного оформлення навчальних заходів, якості зворотного зв'язку та рівня цифрової грамотності учнів. Замість того, щоб демонструвати причинно-наслідкові зв'язки з результатами навчання, результати дослідження визначають контекстуальні умови, за яких інструменти Web 2.0 можуть ефективно підтримувати практики формувального оцінювання. Це дослідження робить внесок у наукову літературу, пропонуючи орієнтовану на практику перспективу щодо інтеграції інструментів Web 2.0 у систему формувального оцінювання, надаючи практичні рекомендації для вчителів природничих дисциплін та пропонуючи напрямки подальших досліджень з використанням більших вибірок та змішаних методологічних підходів.

Ключові слова: природнича освіта; інструменти Web 2.0; формувальне оцінювання; кейс-дослідження

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