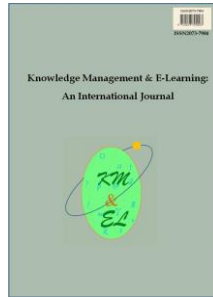

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Integrating experiences of prospective science teachers in developing materials with web 2.0 tools within the context of student-led instructional activities

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Abstract: The purpose of this study is to determine the experiences, opinions, and achievements of prospective science teachers (PST) regarding the process of developing digital instructional materials using Web 2.0 tools based on student-led instruction (SLI) activities. The study was conducted with 24 prospective science teachers who were taking the Instructional Technologies and Material Design course for the first time. In this mixed-methods experimental (or intervention) design, quantitative data were collected using the “Self-Efficacy Scale of Teachers’ Digital Teaching Material Development” (SESTDMD), while qualitative data were obtained through feedback forms, peer and self-assessment reports, and focus group interviews. Quantitative findings indicate a significant increase in digital material design competence and self-efficacy levels following the implementation. Qualitative findings, on the other hand, revealed that prospective teachers achieved multidimensional and rich gains across five themes (deepening their perspectives on technology and pedagogical awareness, and achieving multidimensional and rich gains in professional, personal, social, and emotional domains). When the findings were evaluated together, it was concluded that digital material design activities were effective in gaining awareness of teacher candidates regarding the roles and behaviors of teachers who design and manage the teaching and learning process. Recommendations are presented within this framework.

Keywords: Prospective science teachers; Student-led instruction; Digital teaching material design; Web 2.0 tools

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1. Introduction

The rapid technological and digital transformation of our century has impacted many dimensions of social life and has also led to multifaceted and radical paradigm shifts in education. With this paradigm shift in education, teachers’ roles, teaching–learning processes, student interaction, and assessment practices have been reshaped (Means et al.,

2013); teacher- and subject-centered approaches have been replaced by more flexible, accessible, and student-centered digital learning environments (Selwyn, 2012; Weimer, 2013; Weller, 2020). From this perspective, students are defined as individuals who take responsibility for their learning, fulfill their needs, make decisions, solve problems, and lead, rather than being passive recipients of information. A holistic approach to their development is emphasized (Darling-Hammond et al., 2017).

In this context, the student-centered paradigm places the learner at the heart of the learning process, viewing the flexible structuring of this process according to individual differences—such as students' interests, needs, proficiency levels, and learning styles—as a prerequisite. In such a learning process, students are expected to direct their own learning, lead the process, take responsibility in collaboration with their peers, and fulfill roles related to real-life tasks, collaboration, and problem-solving processes. Meanwhile, the teacher, as a learning partner, is expected to take on a facilitating and guiding role (Bovill, 2020; Kember, 2009; McCombs & Whisler, 1997). In the literature, numerous models, approaches, and roles have been defined for teaching–learning processes that serve these prerequisites of the student-centered paradigm. One such approach is student-led instruction (SLI).

SLI is an approach in which students take active roles in their own learning, participate in decision-making and learning processes, assume responsibility, and guide their peers and the learning environment (Cook-Sather et al., 2014; Mitra, 2004; Andersson & Palm, 2017). Since SLI aims to empower students to be active agents who not only receive information but also direct the learning process, PST are expected to gain experience by assuming leadership roles in the planning, implementation, and evaluation processes related to teaching and learning (Lee & Hannafin, 2016). Some studies in the literature indicate that SLI activities enhance students' ownership of learning and engagement, and support the development of their academic self-confidence and motivation (Bovill, 2020; Felten & Lambert, 2020; Khalil et al., 2022). Additionally, it is emphasized that students' active participation in decision-making processes in learning is effective in creating democratic classroom environments (Mercer-Mapstone et al., 2017; Raudoniute & Beresford-Dey, 2026). Such activities also encourage students to participate in learning processes more consciously and responsibly (Lubicz-Nawrocka, 2018). In addition, these studies show that these practices develop students' critical thinking, leadership, and self-regulation skills (Cook-Sather & Felten, 2017; Kahu & Nelson, 2017). It has also been observed that it contributes to communication skills and increases problem-solving and conceptual understanding skills (Andersson & Palm, 2017; Richardson & Khawaja, 2025).

While education systems are being restructured in parallel with the student-centered paradigm and technological developments, teaching processes have also been transformed by the impact of digitalization (Ahmad et al., 2024; Redecker, 2017). Teaching technologies and digital materials are of particular importance in the effectiveness of this transformation. Digital materials are any visual, auditory, textual, or interactive content created, stored, and presented in a digital environment, intended to present information, facilitate student interaction, and support learning through digital technologies (Aloraini, 2012; Liu et al., 2014; Roblyer & Doering, 2013). These tools enable innovative applications in many dimensions such as access to information, content presentation, student interaction, and assessment in the teaching-learning process, allowing users to produce, share, and learn together (O'Reilly, 2005; Redecker et al., 2011; Clark & Mayer, 2016). Multimedia tools, in particular, provide student-centered experiences by appealing to different learning styles and individual differences (Atalmış & Şimşek, 2022; Fosnot, 2013; Holmes et al., 2019), facilitate the understanding of

complex concepts more easily (Mayer, 2009), encourage student-student and student-teacher interaction and active learning, and offer opportunities for more effective use of evaluation and feedback processes (Domingo & Garganté, 2016; Gikandi et al., 2011). On the other hand, in addition to these features, the easy updateability of the content and their time-space independence make digital materials distinctly different from traditional teaching materials (Clark & Mayer, 2016; Roblyer & Doering, 2013). As a result, digital materials are not only a source of information; they also become a part of the learning process.

In the context of all these features and perspectives, Web 2.0 technologies have constituted a significant turning point in the digitalization of education. Web 2.0-based applications such as blogs, wikis, digital storytelling tools, interactive presentation platforms, and online collaborative tools allow students to become not only information consumers but also information producers and sharers (Hrastinski, 2008). These tools encourage interaction and collaboration between individuals, while also supporting the development of higher-order cognitive skills such as self-regulation, critical thinking, and creativity (Mayer, 2009; Holmes et al., 2019).

In today's world, where student-centered learning environments are particularly encouraged, digital materials have proven to be not only tools that convey content but also dynamic elements that structure, support, and personalize learning (Redecker et al., 2011), gaining a widespread and significant place in our lives, especially with the COVID-19 pandemic (Mahfoodh & AlAtawi, 2020; Şenyurt & Şahin, 2022). However, the effective integration of these materials into teaching processes is directly related not only to technical knowledge but also to pedagogical knowledge. In this context, the digital pedagogical competencies of teachers and PST stand out as one of the most critical factors determining the effectiveness of the use of Web 2.0 tools in education (Koehler & Mishra, 2009; Instefjord & Munthe, 2017; Voogt et al., 2015). While the research conducted shows that teachers and prospective teachers' competence in accessing and using digital materials is generally determined to be at a moderate level, it is found to be weak in terms of producing creative content (designing materials) (Faizi, 2018; Geçim & İmer-Çetin, 2023; Mouza et al., 2017), which provides important clues about eliminating the deficiencies in this area.

Integrating digital technologies into educational environments is no longer a pedagogical luxury but a fundamental necessity in today's environment. However, the effective use of technology in learning environments requires not only technical implementation but also a pedagogical design process (UNESCO, 2021). These requirements apply to all disciplinary fields related to teaching and learning. As one of these disciplinary fields, science teaching, while aiming to help individuals understand nature, scientific thinking, and technology, inherently presents certain challenges and specific requirements. The main challenges include understanding abstract concepts, planning and carrying out experimental activities, integrating technological tools into teaching, and using digital learning materials such as simulations (Bybee, 2013; Gilbert & Justi, 2016; Talanquer, 2009). Ignoring these requirements can lead to students learning scientific concepts superficially or developing misunderstandings. Therefore, instructional materials are needed to improve the quality of students' learning within the scope of science education. Therefore, in all teaching fields—particularly in disciplines such as science education, which, by its nature, relies on experimentation and visualization—the use of digital learning environments enriched with the interactive, collaborative, and multimedia features offered by Web 2.0 tools provides effective learning settings that can help students make sense of abstract concepts (Redecker, 2017; Zawacki-Richter et al., 2019). However, in order for this potential to be effectively

realized, it is not sufficient for preservice teachers merely to be familiar with these digital tools. They must also learn how to use them for pedagogical purposes and take active roles in this process (Trust & Whalen, 2020).

At this point, the integration of SLI and Web 2.0 tools has the potential to offer a profound model of digital pedagogy. The combination of these two approaches creates a complementary unity between pedagogical and technological domains. While Web 2.0 tools provide the technical means to support student autonomy and democratic learning environments—core principles of SLI—the SLI approach guides the pedagogically meaningful use of these tools to foster deep learning, emphasizing student leadership and the reconfiguration of learning processes (Türkben & Alptekin, 2023; Ertmer et al., 2015). Thus, technology-supported learning moves beyond the passive use of digital tools and transforms into a learning ecosystem that strengthens students' roles in the learning process and enhances their higher-order thinking, problem-solving, collaboration, and creativity skills (Chen & Chen, 2024).

Despite these advantages and contributions, a review of the literature reveals that although studies on the development of digital teaching materials by preservice teachers have been increasing, experimental research on the implementation of student-led instructional activities in Web 2.0-supported learning environments remains quite limited (Chai et al., 2016). Moreover, existing studies that examine these variables generally address student leadership and digital material design separately, and research investigating the holistic effect of these two variables together is rather scarce (Geçim & İmer-Çetin, 2023; Türkben & Alptekin, 2023). In this context, there is a need for novel studies that examine the interaction between SLI and Web 2.0-based material design and its impact on preservice teachers' digital creativity, autonomy, and metacognitive regulation skills. Such an integrated approach, situated at the intersection of constructivist and connectivist learning theories, can make significant contributions to the development of student-centered digital pedagogies in the context of teacher education.

In the Turkish context, Bayra (2025) found that science teachers and PST had moderate to low levels of competence in using Web 2.0 tools, noting that overall performance was weak even among those with high computer proficiency. Aki and Ezberci-Çevik (2025) emphasized that although PST were technically familiar with Web 2.0 tools, they lacked substantial experience in applying them; they tended to view these tools in a device-oriented manner and were unable to put them into practice. The study conducted by Bediroğlu and Şahin (2023) showed that self-efficacy in developing digital materials was generally at a moderate level and significant differences were observed between different demographic groups.

Furthermore, Taşkın-Ekici & Dereli (2022) found that prospective science teachers (PST) generally demonstrated inadequate or, at best, moderate competence in using Web 2.0 and other digital tools, highlighting the need for systematic guidance. Beyond these findings, numerous studies have shown that teachers and PT across various subject areas lack sufficient competence in recognizing Web 2.0 tools, integrating them into their lessons, and creating digital materials (Aksoy et al., 2021; Çelik, 2020; Dönmez-Usta et al., 2024; Geçim & İmer-Çetin, 2023; Özer & Albayrak-Özer, 2017; Tünkler, 2021; Ünal, 2019). While some studies in this area recommend providing training for teachers and PST on preparing materials with digital tools (Başaran et al., 2021), others highlight that teachers themselves express both a need and a willingness to receive training on these topics (Avcı & Güven, 2021; Fidan & Cura Yeleğen, 2022; Mtega et al., 2013). These findings highlight the training needs of teachers and PST - especially those in the field of science education- regarding the use of Web 2.0 and other

digital tools. However, studies investigating the nature of digital products created by PST using Web 2.0 technologies, their experiences, and the challenges they encounter when taking on leadership roles in such educational activities remain quite limited in the literature.

In line with the general framework and rationale presented above, this study aimed to determine how PST experienced the process of developing digital instructional materials using Web 2.0 tools based on SLI activities, and to determine their perspectives and learning outcomes related to this process. In this context, prospective teachers' approaches to the digital material development process, the challenges they encountered, the quality of the products they developed, and the impact of this process on their professional development are evaluated from a multidimensional perspective. The research findings are expected to contribute to the structuring of digital material development and SLI practices in teacher education programs. The following questions were addressed in this research process.

1. What are self-efficacy levels of prospective teachers' in developing digital teaching materials?
2. Is there a statistically significant difference between the pre-test and post-test scores of the PST obtained from the SESTDMD?
3. What are the experiences of PT in developing digital instructional materials using Web 2.0 tools based on SLI activities?
 - a) What are the PST' perceptions of their instructional technology literacy and awareness before and after the intervention?
 - b) What are the PST' perceptions of their competence and self-efficacy in designing digital instructional materials (DDIMD) before and after the intervention?
 - c) What are the PST' views on their gains in relation to personal and social development?
 - d) What are the PST' views on their gains in relation to professional experience and teaching practice?
 - e) What are the challenges and suggestions that PSTs face during their experiences in this process?

2. Research Method

In this study, the mixed methods experimental (or intervention) design was employed because it allows for the simultaneous or sequential collection and analysis of quantitative and qualitative data and the integration of data across one or more stages of the study to reveal the effects of SLI activities in an experimental process (Johnson & Christensen, 2014; Creswell, 2014). Since this design allows the researcher to add a qualitative phase to the quantitative process by using the experimental design as a basis (Creswell & Plano-Clark, 2018; Creswell, 2021), the effects of experiences in designing digital instructional materials using WEB 2.0 tools based on SLI activities on PST' gains were measured with quantitative data. These quantitative data were supported by qualitative data collected in the pre-experiment, experimental, and post-experiment stages, aiming to diversify and enrich the research findings (Doyle et al., 2016). The use of this design in the research process is presented in Table 1.

Table 1
Research design

Pre-experiment	Experimental procedure	Post-experiment
Pre-measurements	Implementation of SLI activities (12 weeks)	Post-measurements
-SESTDTMD Scale -Opinion form	Types of materials studied Web 2.0 tools used Ongoing Data Collection: -Peer assessment reports (end of each lesson) -Self-assessment reports (end of each lesson)	-SESTDTMD Scale -Opinion form -Focus group interviews
Data type: Quantitative + qualitative	Data type: Qualitative	Data Type: Quantitative + qualitative

As shown in Table 1, the research process comprised three main stages: *pre-experiment*, *experimental*, and *post-experiment*. The procedures conducted at each stage are described below:

Pre-experiment. In this stage, preliminary measurements were conducted to determine the participants' characteristics before the experimental procedures. Both quantitative and qualitative data were collected. Quantitative data provided information on participants' baseline levels for the variables under investigation, while qualitative data offered deeper insights into their initial perceptions and experiences.

Experimental. This stage involved teaching activities planned and implemented by student groups using Web 2.0 tools, aligned with the weekly topics of the course. Each group designed various types of materials in line with the objectives and content of the Ministry of National Education (MNE) Science Curriculum. These materials included:

- Concept maps (mind, spider, hierarchical, etc.),
- Diagrams (Vee diagram, fishbone, flow chart),
- Posters, banners, wallpaper, charts,
- Worksheets and booklets,
- Tables (meaning analysis table, note-taking table, SWOT analysis),
- Puzzles, cartoons and comics,
- Text types (story, tale, poem, etc.),
- Digital presentation and multimedia tools (PowerPoint presentation, animation, video, digital portfolio).

For each material type, groups selected the most suitable and widely used Web 2.0 tools, such as Canva, Pixton, StoryboardThat, Wordmint, Google Docs, Google Slides, Kahoot, Quizizz, WordArt, Powtoon, Padlet, Mentimeter, MindMaple, Wordwall, Prezi, and artificial intelligence-based tools (e.g., ChatGPT, Gamma). Additionally, qualitative data were gathered weekly through peer- and self-assessment reports completed by each student.

Post-experiment. In the final stage, post-measurements were conducted to determine the participants' levels after the experimental process. As in the pre-experiment, both

quantitative and qualitative data were collected. All data collected before, during, and after the experiment were then analyzed holistically.

The stages of the flow process of teaching activities carried out by student groups are given in Fig. 1.

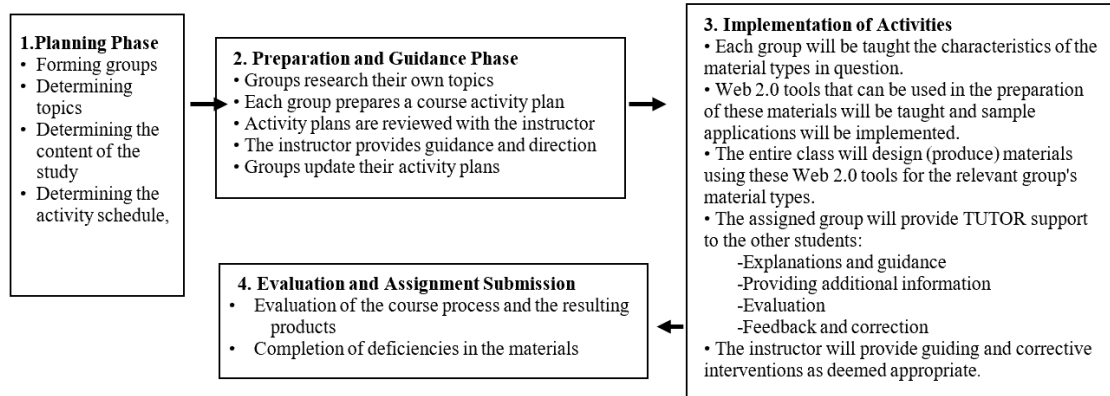


Fig. 1. Stages related to the flow process of teaching activities

As shown in Fig. 1, the process of designing digital teaching materials using Web 2.0 tools based on SLI activities consists of four main stages: planning, preparation and guidance, implementation and evaluation of activities, and submission of assignments. The planning stage was conducted once with the entire class at the beginning of the semester, while the other three stages were conducted in a similar cyclical manner for each group.

1. Planning stage. During the planning stage, conducted at the beginning of the semester, the instructor and the PST formed working groups through a mutual exchange of views. During this process, the teaching materials to be prepared, the Web 2.0 tools to be used, the basic criteria for the teaching activities to be implemented, and the activity schedule were determined. This stage established the basic framework of the research process and laid the groundwork for the systematic execution of the subsequent steps.
2. Preparation and guidance stage. During this stage, student groups investigated the characteristics, types, preparation processes, and purposes of teaching materials within their respective subjects. Then, they identified the Web 2.0 tools that could be used in the preparation of the materials and examined their functions in material production. Each group planned potential teaching activities to generate alternatives and reviewed these plans under the supervision of the instructor. Based on the instructor's suggestions, the activity plans, teaching content to be used, and the application methods of Web 2.0 tools were updated.
3. Implementing the activities. In this phase, each group implemented the teaching activities they had prepared with the entire class. As part of the implementation, information was shared about the types of materials related to their subject and the Web 2.0 tools that could be used in the preparation of these materials, and sample implementations were conducted. Subsequently, all students in the class were asked to develop sample designs of relevant material types using the same Web 2.0 tools. During this process, the group members conducting the activity

provided one-on-one guidance (tutoring) to address any problems encountered by the participating students, provide necessary feedback, and evaluate the designs. The instructor provided guidance and corrective interventions when deemed necessary. This implementation method supports interactive knowledge sharing and peer learning within learning communities (Anderson, 2016).

4. Assessment and assignment submission. In the final phase, the materials designed in class were evaluated in-class with the participation of students and the instructor. The deficiencies and problems identified as a result of this evaluation were expressed from different perspectives. The instructor gave all students one week to address these deficiencies and improve the materials. Following this period, the materials were collected online regularly each week. Such cyclical evaluation processes are considered effective in improving the quality of learning outcomes (Boud & Molloy, 2013).

2.1. Study group

The study involved 24 prospective teachers (16 females and 8 males) who were second-year students in the Science Education Department of a state university and were taking the *Instructional Technologies and Material Design* course for the first time. Since the research was conducted as part of a compulsory course, participants were included automatically, without any selection process.

The participants were between 18 and 20 years old, with a mean age of 19.08. It was determined in the pre-measurement stage, based on both the scale data and qualitative findings from their written responses, that the participants did not possess sufficient experience in preparing digital instructional materials or using Web 2.0 tools, apart from creating PowerPoint presentations that included photographs, videos, and verbal information. In this context, prior to the study, 50% of the group ($f=12$) evaluated themselves as inadequate in preparing digital instructional materials, while only 21% ($f=6$) reported partial familiarity with a limited number of widely known Web 2.0 tools (such as Canva). However, their actual level of proficiency in using these tools was found to be insufficient.

Furthermore, the participants clearly expressed their learning and development needs, as well as their strong motivation and expectations regarding the design of digital instructional materials and the use of Web 2.0 tools. During the study, all participants used their personal notebook and tablet computers to design the digital instructional materials.

Ethical approval for the study was obtained from the Mehmet Akif Ersoy University Non-Interventional Ethics Committee (Decision No: GO 2025/1201). Necessary attention and care were given to ensure the confidentiality of the collected data, and voluntary participation forms were obtained from all participants.

2.2. Data collection tools

Both quantitative and qualitative data were collected in this study. Quantitative data were collected using the “*Self-Efficacy Scale of Teachers’ Digital Teaching Material Development*” (*SESTDMD*) developed by Korkmaz et al. (2019). This scale consists of a total of 38 items in three factors: *preparation sub-dimension* (14 items), *use* (18 items), and *negative view* (6 items) in a five-point Likert-type scale. The KMO value of the scale was determined as 0.939; Barlett’s test was determined as $\chi^2 = (11554.026; df = 946 (p =$

0.000), and it was stated that the items explained 62% of the total variance (Korkmaz et al., 2019). Cronbach's Alpha values for the scale were reported as .97, .94, .86, and .96, respectively. In the current study, the Cronbach's alpha coefficients for the subdimensions were .93, .93, and .82, with a value of .96 for the total score in the pre-test. In the post-test, the coefficients were .86, .93, and .80 for the subdimensions, and .92 for the total score.

Qualitative data were collected through a reflection form, peer and self-evaluation reports, and a focus group interview. The semi-structured reflection form was administered to all participants before and after the experimental implementation in order to reveal their perspectives on technology and Web 2.0 tools. The content validity of this form was ensured based on the evaluations of three experts—two associate professors and one professor—specialized in science education, measurement and evaluation, and educational technologies.

The form consisted of nine items, each rated on a 4-point Likert scale (1 = not appropriate, 4 = very appropriate). Scores of 3 and 4 were considered “appropriate,” and the item-level content validity index (I-CVI) was calculated accordingly. The I-CVI value was found to be 1.00 for five items, 1.00 for three items, and 0.00 for one item. The scale-level content validity index (S-CVI/Ave), calculated as the mean of all item-level values, was 0.89, which was considered acceptable in terms of content validity (Lynn, 1986; Polit & Beck, 2006). One item that was not rated as “appropriate” by any expert was removed from the form.

Peer evaluation forms were completed individually by each student participating in the course activities, while self-evaluation forms were filled out by every member of the groups conducting the activities. These forms were administered and collected weekly over a 12-week period. At the end of the semester, a semi-structured focus group interview was conducted with seven volunteer participants. The interviews were audio-recorded and documented to gain an in-depth understanding of the participants' experiences throughout the process. All data collection instruments were developed by the researcher and were reviewed by at least three field experts to ensure content validity (Yıldırım & Şimşek, 2021).

2.3. Data analysis

The steps followed in analyzing the quantitative and qualitative data obtained during the research process are summarized below.

In the analysis of the quantitative data, the pre- and post-measurement scores from the same participants were first matched. The scores for the items related to “negative view” subdimension were reverse-coded, so that higher scores reflected a positive view. Given the sample size ($n < 50$), the Shapiro–Wilk test was used to assess the normality of the data. The results of the normality test for the scale scores are presented in Table 2.

As shown in Table 2, the scores for all dimensions of the scale at both the pre- and post-measurement stages did not follow a normal distribution ($p > .05$). In addition, since the skewness and kurtosis values in all sub-dimensions of the scale were within the range of (± 1.0), it was accepted that the scores showed a normal distribution (Hair et al., 2013).

In the next stage, descriptive statistics for the scores were calculated, and a dependent samples t-test was conducted to compare the mean scores for all sub-dimensions of the scale between the pre- and post-measurements.

Table 2
Normality test results

Sub-dimension	Pre-measurement			Post-measurement		
	Statistic	df	Sig.	Statistic	df	Sig.
Web 2.0 Development	.964		.516	.963		.495
Design	.965	24	.542	.921	24	.062
Positive View	.923		.067	.934		.122
Total	.970		.662	.930		.100

For the qualitative data analysis, a comprehensive dataset was created by combining the peer- and self-assessment reports collected during the research process, the opinion forms administered in the pre- and post-measurements, and the recordings of the focus group interviews. This dataset was analyzed by two coders: *the researcher* and *an expert in Curriculum and Instruction*. Both coders independently conducted a word-by-word analysis, initially identifying codes and subsequently grouping them into themes. Following this independent analysis, they collaborated to review and reconcile similarities and differences in their codes and themes. Intercoder reliability was calculated using the formula proposed by Miles and Huberman (1994): $\text{Reliability} = \text{Consensus} / (\text{Consensus} + \text{Disagreement}) \times 100$. The first coder identified 170 codes, while the second identified 178 codes. Of these, 167 codes were common, and 14 codes were in disagreement. Based on these values, intercoder agreement was calculated as 92.26%, indicating a high level of reliability in the coding process.

3. Research results

In this section, the findings obtained from the analysis of the data collected during the research process are presented below in sequence, in accordance with the research questions.

Sub-problem 1. Descriptive statistics regarding the SESTDMD scores of PST are given in Table 3.

Table 3
Descriptive statistics for PST' SESTDMD scores

Sub-dimension	Pre-measurement			Post-measurement		
	<i>n</i>	Mean ($\bar{x}$)	SD	<i>n</i>	Mean ($\bar{x}$)	SD
Web 2.0 Development		2.83	1.01		4.41	0.36
Design	24	2.87	0.93	24	4.34	0.38
Positive View		2.26	0.47		4.30	0.42
Total		2.76	0.82		4.36	0.29

As seen in Table 3, the preliminary measurement results indicated that the PST' mean score for the Web 2.0 development sub-dimension was $\bar{x} = 2.83$, and the mean score for the design sub-dimension was $\bar{x} = 2.87$. Based on the scale's scoring range (1.00–2.33 = low; 2.34–3.66 = medium; 3.67–5.00 = high), these values indicate a moderate level of self-efficacy. The mean score for the positive view sub-dimension was

$\bar{x} = 2.26$, indicating a low level. The total mean score obtained from all dimensions of the scale was $\bar{x} = 2.76$, indicating a moderate level of self-efficacy.

According to the final measurement results, the PST' mean score on the Web 2.0 development subdimension was $\bar{x} = 4.41$, the mean e score on the design subdimension was $\bar{x} = 4.34$, and the mean score on the positive view subdimension was $\bar{x} = 4.30$. The total mean score of the scale was $\bar{x} = 4.36$. These values indicate that the PST demonstrated high levels of self-efficacy in all subscales and in terms of total mean score after the intervention.

Sub-problem 2. This sub-problem examined whether there was a statistically significant difference between the pre-test and post-test scores of the PST on the SESTDMD. The findings regarding this sub-problem are presented in Table 4.

Table 4
Dependent groups *t* test results of the SESTDMD scale of PST

Sub-dimension	Measurement	<i>n</i>	($\bar{x}$)	<i>Sd</i>	<i>df</i>	<i>t</i>	<i>p</i> *
Web 2.0 Development	Pre	24	2.83	1.01	23	7.409	.00
	Post		4.41	0.36			
Design	Pre	24	2.87	0.93	23	7.349	.00
	Post		4.34	0.38			
Positive View	Pre	24	2.26	0.47	23	17.697	.00
	Post		4.30	0.42			
Total	Pre	24	2.76	0.82	23	9.162	.00
	Post		4.36	0.29			

Note. * $p < .05$

As shown in Table 4, the mean scores for all sub-dimensions and the total mean score increased markedly from pre-test to post-test. In the subdimensions of Web 2.0 Development ($\bar{x}_{pre} = 2.83 < \bar{x}_{post} = 4.41$); Design ($\bar{x}_{pre} = 2.87 < \bar{x}_{post} = 4.34$) and having positive view about digital materials ($\bar{x}_{pre} = 2.26 < \bar{x}_{post} = 4.30$) differed significantly ($p < 0.05$) in favor of the post-test. Similarly, the total mean score of the scale increased ($\bar{x}_{pre} = 2.76 < \bar{x}_{post} = 4.36$), indicating a significant improvement in favor of the post-test.

Sub-problem 3. The third sub-problem investigates the PST' experiences designing digital teaching materials using Web 2.0 tools based on SLI activities. For this sub-problem, the themes and codes derived from the analysis of participants' opinions—collected during the pre-measurement, post-measurement, and experimental process—are summarized holistically and presented in Fig. 2.

As seen in Fig. 2, five main themes were identified from the prospective teachers' opinions. These are:

- Instructional technology literacy and awareness,
- Competence and self-efficacy in digital instructional material design,
- Gains related to personal and social development,
- Gains related to professional experience and teaching practice,
- Difficulties experienced during the activity process, and the PST' suggestions.

The codes and subcodes related to these themes are discussed in detail under each theme below.

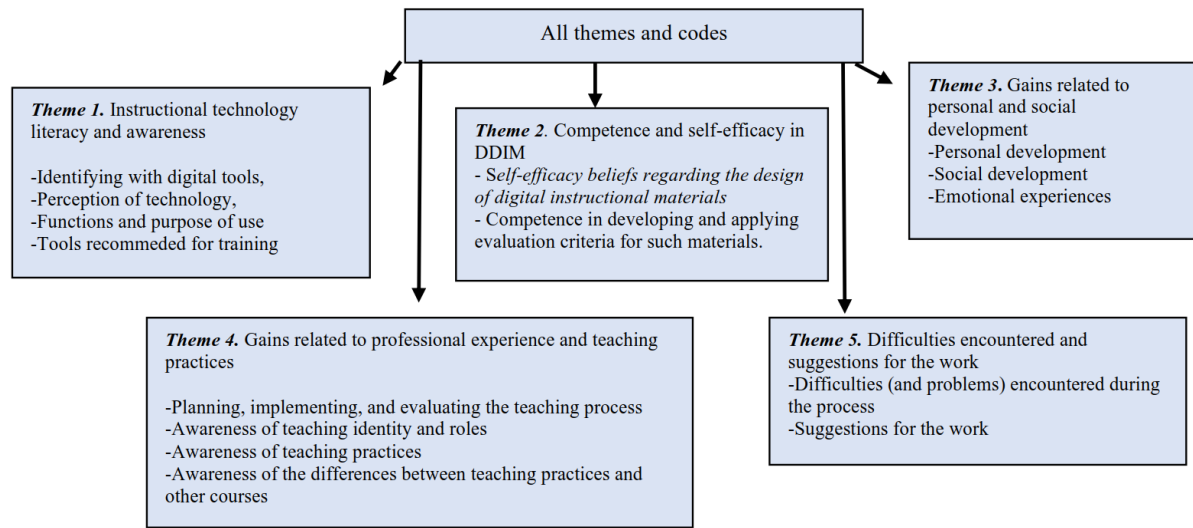


Fig. 2. Themes and codes obtained from PST' opinions

The first. Findings regarding the instructional technology literacy and awareness of PST are given in Table 5.

Table 5

Findings regarding the PST' literacy and awareness of instructional technologies

		Pre-measurement	Post-measurement
Codes		%	%
Theme 1. Instructional technology literacy and awareness	A1. Identifying Digital Tools		
	Educational Technologies in the Classroom	33	63
	WEB 2.0 tools	21	70
	Artificial intelligence applications	8	54
	A2. Perception of Technology		
	The importance of technology and its place in our lives	25	67
	Keeping up with technological developments	16	54
	Digital Ethics and Copyright Awareness	-	67
	A3. Functions and Purpose of Use		
	Ease of access to information	41	63
	Simplifying daily life	33	54
	Saving time	38	83
	Preparing visualizations and presentations	21	79
	Communication and social interaction	33	70
	Enriching and making teaching interactive	-	67
	STM and WEB 2.0 tools	-	79
	A4. Recommended tools for		
	Simulation and Virtual Laboratory Tools	-	50
	AR/VR Applications	-	41

Teaching	Web 2.0 Tools	-	75
	Interactive content creation tools	-	46
	Robotic coding and STEM Tools	-	29
	Animation and visual content production	-	38
	Data collection and analysis tools	-	33

When Table 5 is examined, the PST' literacy and awareness regarding instructional technologies are categorized into four groups: identifying with digital tools, perception of technology, the functions and purpose of use and the tools recommended in the training of PST.

A comparative analysis of the pre-and post-measurement data indicates that PT' literacy and awareness level were low in scope and diversity, but increased substantially by the end of the study. In this regard, the common codes identified in both measurements demonstrated significant improvements in favor of the post-measurement. For instance, familiarity with Web 2.0 tools rose from 21% to 70%, familiarity with artificial intelligence tools from 8% to 54%, visualization skills from 21% to 79%, and awareness of the importance and functions of instructional technology from 25% to 67%.

Moreover, several codes emerged exclusively in the post-measurement phase. Notably, these included the use of Web 2.0 tools to enrich instruction, enhance interactivity, and design teaching materials—one of the primary objectives of the study—as well as digital ethics and copyright awareness, reported by 67% of the participants. In addition, between 29% and 75% of the PST highlighted the need for training in areas such as simulation and virtual laboratory tools, augmented reality (AR), virtual reality (VR) applications, Web 2.0 tools, robotic coding, animation, and visual content production.

Some sample statements of PST regarding the theme of “*literacy and awareness regarding instructional technologies*” are provided below.

“Thanks to this course, I learned how to use technology consciously and creatively not only to present content, but also to engage students, make the learning process more engaging, and appeal to different learning styles” (S4).

“...preparing presentations, developing digital materials, and interacting with students through technology have become a fundamental part of my teaching vision” (S2).

“...now I view technology not only as a tool for accessing information, but also as a tool I can use to effectively convey information, ensure the active participation of my students in the learning process, and make the teaching process more creative” (S7).

“...I realized how effective, creative, and necessary a tool technology is in education” (S19).

“I think interactive content creation tools like Nearpod, Genially, and Edpuzzle should be better learned to produce materials that will make lessons more engaging” (S18).

“After taking this course, I started using teaching technologies, especially digital presentation tools (PowerPoint, Canva), interactive applications (Kahoot, Quizizz), digital content creation tools (Wordwall, Mentimeter), and smart boards. I also use online platforms to increase student interaction” (S8). “I also think that PhET simulations, augmented reality applications, and virtual laboratory tools like Labster should be learned” (S14).

In conclusion, based on the PST' perspectives, notable improvements were observed in their familiarity with digital tools, their attitudes toward technology, and their understanding of its purposes and functions, reflecting enhanced literacy and awareness of instructional technologies. Correspondingly, the participants provided recommendations on the digital design tools that should be incorporated into the training of PST.

The second. The findings of the pre- and post-measurements regarding the competence and self-efficacy of PST in designing digital teaching materials are given in Table 6.

Table 6

Findings regarding PST' competence and self-efficacy in designing digital teaching materials

		Pre-measurement	Post-measurement	
Codes		%	%	
Theme 2. Competence and self-efficacy in DDIM	Self-efficacy beliefs regarding DDTM	- Designing in accordance with pedagogical principles	13	83
		- Using Web 2.0 tools consciously and effectively	21	75
		- Openness to development and desire to learn	16	58
		- Designing basic/simple materials	29	-
		- Increased material design skills	-	83
		- Feelings of inadequacy and shyness	54	-
		- Considering oneself partially competent	25	-
		- Increased self-confidence and perception of competence	16	75
		- Alignment with learning objectives	25	79
		- Alignment with student characteristics	25	54
	Competence in using DDTM and assesment criteria	- Up-to-dateness and scientific nature	16	67
		- Visual layout	8	63
		- Accessibility and usability	13	58
		- Being understandable and simple	38	54
		- Attractiveness	21	75
		- Encouraging student participation	25	63
		- Being fun	21	54
		- Alignment with pedagogical principles	-	70
		- Interactivity and feedback	-	50
		- Font and readability	-	54

An examination of Table 6 indicates that the findings related to prospective teachers' competence and self-efficacy in digital instructional design are grouped into two main categories: (1) *self-efficacy beliefs regarding the design of digital instructional materials*, and (2) *competence in developing and applying evaluation criteria for such materials*.

With respect to competence in designing and applying evaluation criteria for digital instructional materials, participants identified several qualities that a good instructional material should possess prior to the study. These included “*appropriateness to learning objectives and student characteristics*”, “*up-to-dateness*” and “*scientific accuracy*”, “*visual layout*”, “*accessibility and usability*”, “*attractiveness*” and “*ability to encourage student participation*,” with mention rates ranging from 8% to 38%. Following the study, these same criteria were cited at substantially higher rates, ranging from 58% to 79%. Additionally, post-measurement findings revealed new criteria—“*appropriateness to pedagogical principles*, *interactivity* and *feedback*, and *readability*”—reported by 50% to 70% of participants (see Table 6).

In relation to self-efficacy beliefs in designing digital instructional materials, pre-measurement data indicated that 50% of PST reported experiencing feelings of inadequacy and shyness. By the end of the study, this rate had decreased to 0%, while 75% of participants reported increased self-confidence and a heightened sense of competence. Furthermore, prior to the study, self-efficacy levels for “*feeling partially competent*”, “*being able to design basic materials accordance with pedagogical principles*” and “*using Web 2.0 tools consciously and effectively in material design*” ranged from 13% to 30%. Following the study, these rates rose substantially, reaching between 58% and 83% (see Table 6).

Some sample quotations of PST’ views on their competence and self-efficacy in designing digital teaching materials are given below.

“Before the course, I could only prepare basic materials. However, as I used the tools, I started to produce higher-level materials, and I think I improved myself.” (S4).

“Before taking this course, I was prejudiced against using technology because I was less knowledgeable and inexperienced. However, thanks to what I learned during the course, I can now use technology and Web 2.0 resources effectively. This way, I can produce materials that are both fast, practical, and high-quality” (S7).

“...I make sure that the materials are simple, understandable, visually appealing, and appropriate to the teaching objectives and the student’s level.” (S2).

“...I now use Web 2.0 tools more consciously than before, and it’s not difficult to prepare the type of material I want. When I evaluate myself, I wasn’t bad with technology, but I see that I can prepare materials more consciously and successfully during this process.” (S5).

“Looking back, I realize I’m in a better position. I wasn’t good with technological tools, but the skills I gained in this course have increased my professional interest and motivation. Designing materials piqued my interest and I found it fun” (S11).

“...I can now create materials for science education in a digital environment. Although it was challenging at first, over time, both my technical and design skills have improved. Thanks to Canva, in particular, I learned how to create visually appealing, color-coordinated, and relevant content. For example, I prepared worksheets that would capture students’ attention for the topic ‘Classification of Living Things’” (S16).

“I prioritize materials that attract attention, then are educational, entertaining, and appeal to different mindsets” (S9).

In summary, the findings indicate that PST' competences—initially low in the pre-measurement phase—both in designing materials using Web 2.0 tools in a digital environment and in applying the principles and processes of material preparation, improved markedly through the course activities. This progress was accompanied by a corresponding increase in their self-efficacy beliefs.

The third. The findings regarding the gains of PST in personal and social development areas are given in Table 7.

Table 7

Findings regarding gains in personal and social development areas

	Codes	• Codes Subcodes
Theme 3. Gains related to personal and social	1. Personal development	1.1. Self-regulation and awareness
		• Self-regulatory learning skills • Self-awareness • Increased self-confidence • Self-assessment • • Gaining different perspectives
		1.2. Thinking and decision-making skills
		• Decision making, • Problem solving, • Creative thinking, • Reflective thinking, • • Critical thinking
	2. Social development	1.3. Planning and sense of responsibility
		• Taking responsibility and being disciplined • Planning and time management
		2.1. Leadership and communication
		• Leadership skills • Communication skills (fluent speaking, public speaking) • Self-expression
		2.2. Social relationships
		• Strengthening social relationships within the classroom • Getting to know classmates better and fostering connections • Classroom cooperation and solidarity • Group interaction (division of labor, collaboration) • Supportive learning (classroom) environment
	3. Emotional experiences	3.1. Positive emotions
		• Empathy • A sense of accomplishment • Feeling proud of oneself • Increased motivation • Increased curiosity and a desire to learn more • Encouragement and enjoyment • Feeling valued • Remembering childhood (Nostalgia) • Coping with anxiety • Feeling a sense of being a teacher • Feeling a sense of responsibility for teaching and learning
		3.2. Negative emotions
		• Lack of self-confidence • Experiencing excitement, stress, and anxiety • Stage anxiety • Fear of criticism

As presented in Table 7, the findings related to PST' personal and social developmental gains during the study period are classified into three categories: *personal development*, *social development*, and *emotional experiences*.

The findings indicate that, in terms of personal development, PST reported gains in self-regulation and awareness, thinking and decision-making skills, and planning and sense of responsibility during the activities conducted in the study. In relation to social development, participants emphasized improvements in leadership, communication, and social relationships. Additionally, their emotional experiences were categorized into two groups: positive and negative. Positive emotions included a sense of accomplishment, pride, self-worth, teaching efficacy, responsibility for teaching and learning, curiosity, motivation, and a desire for further learning. Negative emotions encompassed lack of self-confidence, excitement, stress and anxiety, stage fright, and fear of criticism.

Some sample statements of PST obtained through various data collection tools regarding gains in the areas of personal and social development are presented below.

"First of all, I had the opportunity to express my creativity and develop my visual thinking skills. Experiencing that I could convey an idea or information not only through words but also through visuals was a source of morale and motivation for my self-improvement" (S11).

"Personally, it helped me develop a more effective learning style. I felt more disciplined and organized. It improved my communication skills in social life. Now I can speak more clearly about a topic and help others understand it. I gained skills such as organizing information better, expressing myself more clearly, collaborating in group work, and being more emotionally balanced." (S13)

"...especially thanks to group work, idea sharing, and discussion environments, I began to express myself more easily." (S5).

"During these activities, we had the opportunity to think, write, and share together. We shared our ideas freely. This process both enhanced our communication skills and helped us build empathy." (S23)

"...first of all, it helped develop my higher-order thinking and reasoning skills, such as creativity and expressiveness. Incorporating literary genres into a field like science, which requires analytical and inquisitive thinking, allowed me to experience a different way of thinking. Trying to transform a science concept into a rhyme or poem revitalized my abilities to express my thoughts more artistically and emotionally." (S17)

"...I reflected on my own learning experiences and realized which methods were most effective for me. In particular, my awareness of the permanence of learning by doing and experiencing increased. I also understood the importance of various methods that meet the needs of individuals with different learning styles." (S11)

"...Creating an animation, even a small one, on my own gave me a sense of accomplishment. This feeling not only boosted my self-confidence but also inspired me to consider what I could do in the teaching profession" (S2)

"...while listening to the lecture, memories of watching cartoons in my childhood came to mind. I especially felt a sense of joy during the cartoon parts. The messages conveyed through the cartoons made me think and reminded me how powerful humor is not only for making people laugh but also for making people think." (S3)

Within the scope of this theme, it was determined that experiences derived from SLI activities contributed to PST' personal, social, and emotional development, yielding positive outcomes in these areas.

The fourth. The findings regarding the PST' professional experience and gains in teaching practice are given in Fig. 3.

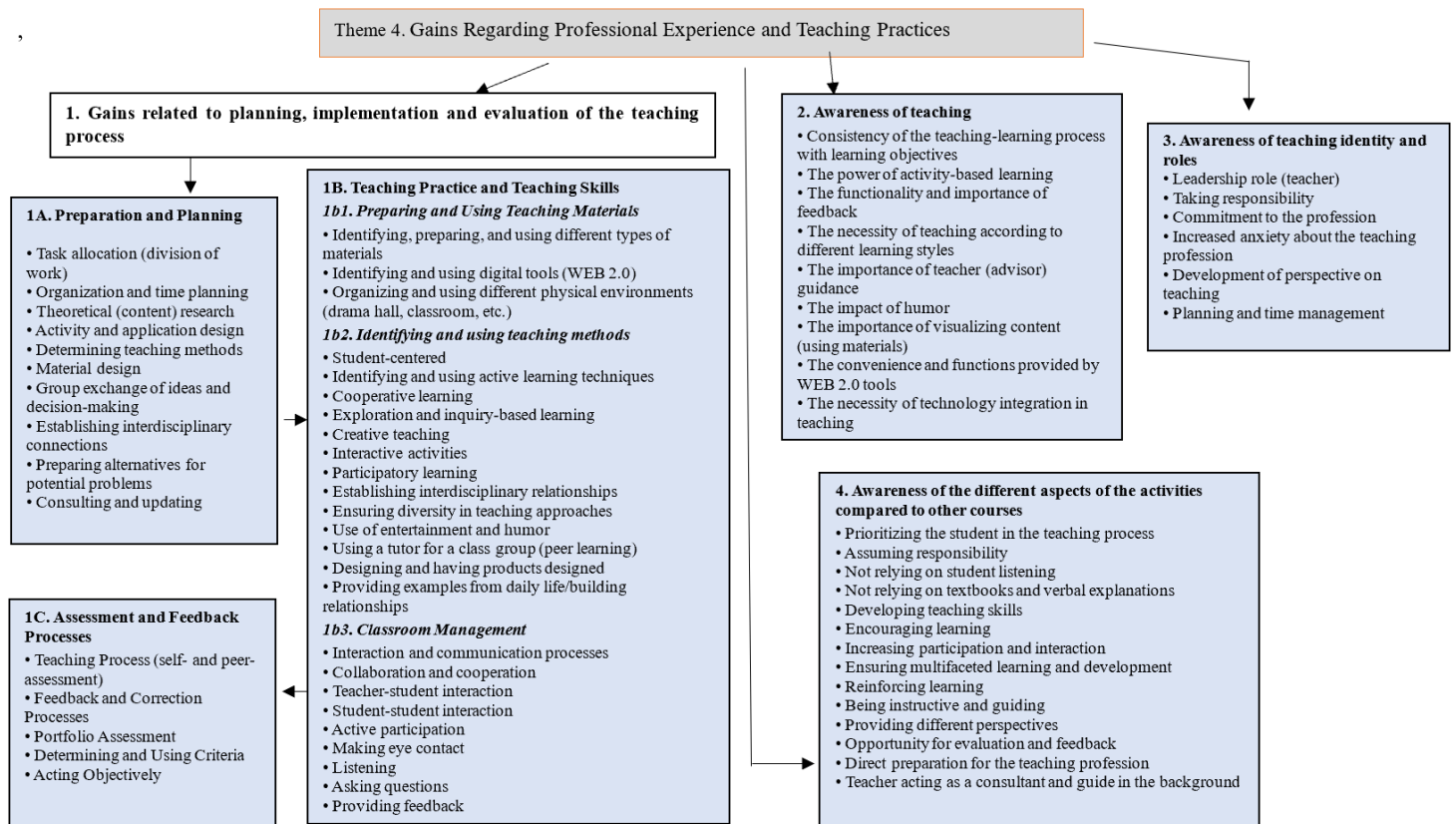


Fig. 3. Findings regarding PT' gains related to professional experience and teaching practices

As shown in Fig. 3, PST also achieved gains related to professional experience and teaching practices. The learning outcomes within this theme can be classified into four categories: (1) planning, implementation, and evaluation of the learning process and its outcomes; (2) awareness of teaching; (3) awareness of teaching identity and roles; and (4) awareness of how the activities differ from those in other courses.

In this study, PST were found to have developed knowledge, skills, and awareness concerning the principles and variables involved in the planning, implementation, and evaluation of the teaching process. During the planning phase, they reported gains in areas such as task distribution (division of labor), organization, conducting theoretical research, designing teaching activities and materials, exchanging ideas and making group decisions, establishing interdisciplinary connections, preparing alternative solutions to potential problems, and seeking guidance from advisors.

During the teaching implementation phase, participants demonstrated improvements in preparing and utilizing instructional materials, recognizing and applying teaching methods, and managing classroom dynamics. Throughout this process, they employed a variety of student-centered active learning techniques, such as creative drama, role-playing, jigsaw, educational games, aquarium, gossip, snowball, stations, and brainstorming activities. These experiences contributed to the development of their awareness and skills in areas including collaboration, interaction, peer learning, creative learning, integrating humor into the learning process, and establishing connections with daily life and interdisciplinary contexts. In terms of classroom management, PST were observed to have acquired behaviors related to collaboration, cooperation, maintaining eye contact, active listening, questioning, and providing feedback within the framework of interaction and communication processes.

Regarding the evaluation and feedback processes, PST demonstrated improvement in assessing both the teaching process and its products, conducting peer- and self-evaluations, evaluating portfolios, providing feedback and corrective guidance, establishing and applying evaluation criteria, and maintaining objectivity in their assessments.

Regarding their awareness of teaching, participants reported increased understanding of the alignment between the teaching–learning process and learning objectives, as well as the importance and functionality of activity-based learning, feedback, humor, content visualization, and the use of materials and technology to enhance learning. They also highlighted the advantages of Web 2.0 tools, the necessity of addressing different learning styles, and the critical role of teacher guidance (see Fig. 3). In terms of awareness of teaching identity and roles, PST noted gains such as developing a sense of belonging—or, in some cases, experiencing anxiety—toward the profession, cultivating unique perspectives on teaching, improving planning and time management, enhancing leadership skills, and assuming responsibility. When comparing the teaching activities in this course with those in other courses, participants emphasized that in this study, students assumed greater responsibility and took a more active role, while the teacher served primarily as a guide. They further noted that the course did not rely solely on textbooks or verbal instruction, but instead incorporated practices that directly contributed to professional skill development, increased participation and interaction, supported multifaceted growth, and provided opportunities for evaluation and feedback. These differences led participants to view the teaching activities as fostering professional readiness, encouraging learning, promoting holistic development, and broadening perspectives (see Fig.3).

Some sample statements of PST' on the theme of professional experience and teaching practices are presented below.

“My groupmates and I first came together to develop our plan and roadmap. We then gathered information about the types of materials we would cover in class and then prepared our activity plan. We discussed which Web 2.0 tools we should use to implement the practical aspects of our topics, and how, and reached a consensus.” (S19)

“...the most challenging thing I had was the seemingly complex nature of the topics and the uncertainty about whether everyone would understand them at the same level.” (S12)

“...I liked that my classmates had us practice using Web 2.0 tools and checked our work.” (S3)

"The way this course was taught gave me a real teaching experience. I had the opportunity to evaluate myself in terms of both mastery of the subject matter, classroom management, and creative presentation." (S8)

"I felt how enjoyable and important it is to communicate one-on-one with students and manage the lesson by observing their reactions in real time. I also experienced the importance of patience and flexibility in teaching." (S5)

"...This experience demonstrated the importance of using creative and visual materials effectively in the teaching profession." (S16)

"Taking teaching responsibility towards our colleagues really contributed to our stepping stone to the teaching profession. Professionally, I gained skills such as guiding students, listening effectively, and responding. Not only conveying information, but also involving students in the process and communicating effectively with them is a crucial skill. Personally, I developed a sense of leadership and responsibility." (S2)

"While I was learning and having fun, I realized that teaching is not just about conveying information, but also about stimulating curiosity and establishing an emotional connection. Thanks to this course. I saw more clearly how my creativity could be integrated into the teaching process." (S8)

"...I saw technology not just as a tool, but as an environment that facilitates learning. I also realized that I needed to be more engaged with technology in my own teaching journey." (S19)

"Learning how concept maps can help students with different learning styles make sense of and organize information will be very helpful for me to implement more student-centered and effective teaching strategies in my future lessons." (S10)

"First of all, I experienced firsthand how effective and fun materials like puzzles and their types, riddles, cartoons, and cartoon characters can be in science teaching. I learned abstract science concepts (cell I can turn these concepts (e.g., organelles, chemical reactions, etc.) into a word puzzle activity to help students learn these concepts in a more fun way." (S1)

"I realized that teaching isn't just about explaining and passing on information; it's about a lot of other things you have to do. That's why I was a little afraid of the profession." (S13)

"This course, unlike other courses, included multifaceted learning techniques. While lectures are usually predominant in classes, this course was supported by social interaction, experiences, group work, and hands-on activities... The course was one-on-one."

Overall, the findings within this theme indicate that SLI activities enhanced PST' skills in planning, implementing, and evaluating the teaching process; increased their awareness of teaching, teacher identity, and roles; and strengthened professional competencies such as classroom management, communication, and collaboration. Moreover, unlike practices in other courses, this process offered a rich learning experience that fostered engagement through multifaceted professional development.

The fifth. The findings regarding the difficulties experienced by PST during their experience and their suggestions for this study are given in Fig. 4.

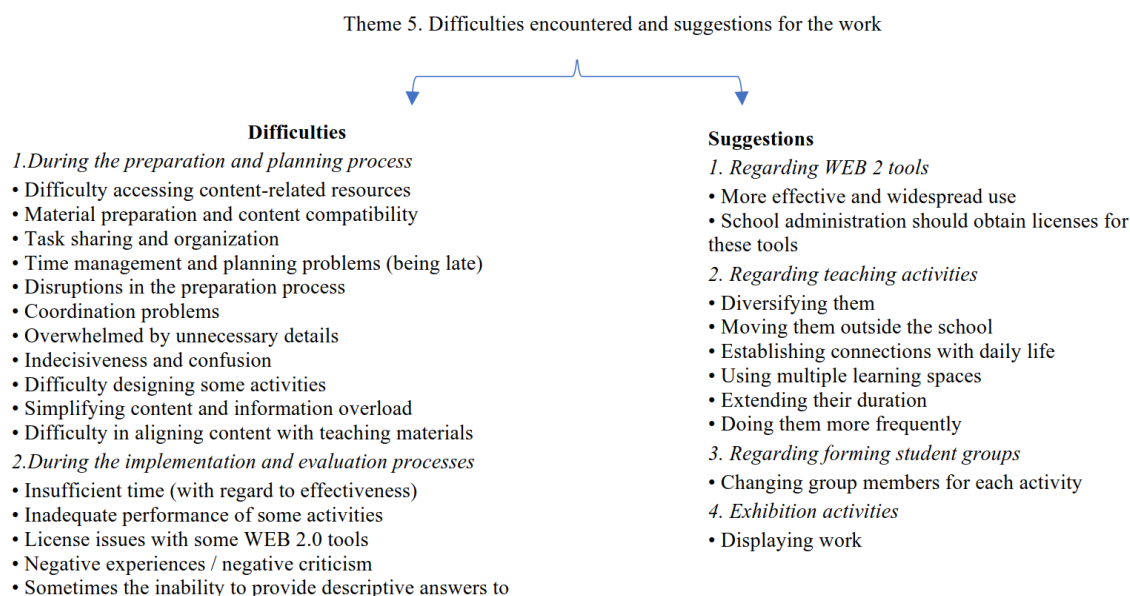


Fig. 4. Difficulties experienced by PST during their experience and their suggestions for the study

This section examines the challenges that preservice teachers encountered during their studies and their recommendations for further study from a multidimensional perspective. As illustrated in Fig. 4, PST encountered a range of challenges while designing digital teaching materials with Web 2.0 tools, both in the preparation and planning stages and in the implementation and evaluation stages. During the preparation and planning phase, the most frequently reported difficulties included limited access to resources, coordination issues within groups, challenges in selecting information aligned with learning outcomes, difficulties in activity and material design, focusing on unnecessary details, and inefficient time management. In the implementation and evaluation phases, participants noted constraints such as insufficient lesson time for certain activities, perceived inadequacies in the quality and scope of some activities, and difficulties in accessing and using Web 2.0 tools due to licensing restrictions. Additionally, they reported that activity facilitators sometimes failed to provide sufficiently descriptive answers to questions, criticism was occasionally perceived negatively, and technical issues arose when using Web 2.0 tools.

Participants' suggestions for the study emphasized the need for more effective and widespread use of Web 2.0 tools in classrooms, including securing licenses for these tools through school administrations. They also recommended conducting similar classroom activities more frequently, diversifying the activities, establishing stronger connections to daily life, and extending the duration of activities. Additional suggestions included utilizing multiple learning spaces, incorporating out-of-school environments, rotating group members between activities, and showcasing the products created during the process.

Selected excerpts from PST' opinions, gathered through various data collection tools within the scope of this theme, are presented below.

"During the planning process, we were unsure whether the visual materials would be suitable for everyone. Some students might not understand the symbols used in the graphics or might interpret them differently. To address this, we decided to design clearer labels and simpler graphics for each activity. (S7)"

"The most significant problem was time management. (S15)"

"We had trouble deciding what kind of presentation to prepare, what it would include, and where we could find the important features of fairy tales, folk songs, stories, acrostics, poems, and tongue twisters." (S9)

"However, due to technical issues and lack of time, the practical part was a bit disappointing. I thought it could have been much more productive if it had been better planned." (S2)

"The main problems we encountered were: We were concerned that the activity time wouldn't be enough. We had difficulty deciding which type of activity would be more appropriate and effective for the classroom environment. We felt the need to clarify the distribution of tasks to balance the flow of the presentation and prevent time loss. To solve these problems, we enlisted the help of our course instructor, tested our time management by rehearsing the presentation, and clearly defined the distribution of tasks and clarified the roles of each group member." (S21)

"...The practical part, however, couldn't be fully realized due to technical issues. Computer and internet access was limited, which reduced the effectiveness of the activities. I think not everyone was able to fully experience the activities. Overall, the content was sound, but there were shortcomings in the teaching process." (S20)

"However, if it were supported by more real-life examples and hands-on activities, it would be easier to put the topics into practice. More case studies could be conducted regarding the teaching materials, and students could be encouraged to design their own materials and participate more actively in the evaluation process. This would give us a better opportunity to apply what we learned in real-life scenarios." (S18)

"...To be honest, this group seemed a bit passive and unprepared to me. The topic could have been quite creative and fun, but unfortunately, they didn't reflect that. They just read from slides throughout their presentations and didn't interact at all. Other groups sometimes had games and hands-on activities, but we didn't see anything like that in this class." (S6)

"...during the activity, the students were reluctant to participate. Because some materials were missing, we had some shortcomings, and we couldn't do it exactly as we wanted." (S5)

"...we were uncertain about the methods we could use when implementing our activity." (S13)

"The biggest uncertainty was not being able to estimate how much the class knew or whether they would understand the topic." (S24)

In summary, the challenges encountered by PST in designing digital teaching materials with Web 2.0 tools were primarily related to technical infrastructure, time management, and content planning. Nevertheless, the suggestions they proposed present

practical and feasible strategies for enhancing the efficiency, accessibility, and interactivity of the process.

4. Discussion

In this section, the study's findings are discussed in relation to the existing literature. Analysis of the quantitative data revealed that PST' positive attitudes toward preparing and using digital teaching materials with Web 2.0 tools were initially at a moderate level but increased significantly following the teaching activities, reaching a high level. These results align with the pre-test and post-test findings reported by Günşen (2023), who employed the same scale with special education teachers. Similarly, studies by Bediroğlu & Şahin (2023) and Erdoğan & Yıldırım (2023), which utilized different measurement instruments, also reported significant increases in post-test scores. This suggests that in all studies, PST' self-efficacy in preparing digital materials began at comparable levels prior to the intervention, and the observed increases reflected the positive impact of the implemented teaching activities. Furthermore, qualitative analysis identified five main themes: instructional technology literacy and awareness; competence and self-efficacy in digital instructional material design; personal and social development; professional experience and teaching practices; and challenges encountered along with recommendations for improvement. The results pertaining to these themes are discussed in detail in the following section.

It was determined that the Web 2.0-based material development activities carried out within the framework of the SLI approach led to a significant improvement in participants' perceptions of instructional technology literacy and their awareness in this area. Before the implementation, participants generally evaluated the concept of instructional technology from a "low" and "limited" literacy perspective, perceiving technology mostly as a supportive tool used merely for accessing information. However, following the experimental intervention, their perceptions of instructional technology shifted significantly toward viewing these tools as a "core component" at the center of the teaching and learning process.

Throughout the implementation process, it was observed that participants developed an awareness of the important role instructional technologies play in supporting pedagogical goals and in designing student-centered, engaging, and meaningful learning experiences. In this context, participants recognized that instructional technologies offer several advantages, such as facilitating time management, reducing lesson preparation time, concretizing abstract concepts, and providing opportunities to reach students through diverse modes of learning. They also expressed that these advantages contribute to their professional practice in multiple and meaningful ways.

The results obtained regarding this development of awareness strongly align with the findings reported by Kuş-Gürbey and Büyük (2024) and Özmen et al. (2021). Moreover, the present findings support previous studies indicating that experiences of producing digital materials through Web 2.0 tools enable preservice teachers to approach technology not merely from an instrumental perspective but also from pedagogical and creative standpoints. Consequently, these experiences have been shown to enhance preservice teachers' pedagogical awareness of technology, their skills in integrating technology into the instructional process, and their overall digital competencies (Baki, 2022; Doğan & Göğüş, 2025; Öztürk et al., 2021; Talan & Batdı, 2022; Yılmaz, 2024).

In addition to these gains, it was found that PST's also developed a sense of sensitivity toward ethical responsibilities. In relation to this sub-problem, it can be concluded that the Web 2.0-based material development activities carried out within the framework of the SLI approach were effective in enhancing participants' instructional technology literacy and awareness.

The comparison of pre- and post-test results regarding participants' competencies in digital instructional material design revealed a notable improvement across the related thematic areas. Before the implementation of the Web 2.0-based material development activities conducted within the framework of the SLI approach, PST's mentioned essential criteria for instructional materials—such as alignment with learning objectives and student characteristics, currency and scientific accuracy, visual design, accessibility and usability, attractiveness, and promotion of student engagement—at relatively low rates. However, after the implementation, their emphasis on these criteria increased significantly, indicating meaningful growth in their awareness and understanding of effective material design principles. In addition, within the same scope, the criteria of “compliance with pedagogical principles,” “interaction and feedback,” and “readability” emerged only in the post-test and were mentioned by the majority of participants. These findings indicate that preservice teachers not only developed their technical competencies in material design but also began to value qualitative aspects such as alignment with learning objectives, accessibility, visual organization, and sensitivity to students' needs.

Preservice teachers' self-efficacy perceptions regarding digital instructional material design were observed to be low in the pre-assessment phase. In this context, participants described their digital competencies as being at a beginner level, emphasizing issues such as technical inadequacy, hesitation, and anxiety. However, in the post-assessment phase, these perceptions shifted toward a high level of self-confidence, greater awareness of Web 2.0 tools, and improved skills in their effective use. Participants reported that they approached the material design and evaluation process from a student-centered and pedagogically grounded perspective, paying particular attention to criteria such as alignment with learning objectives, visual organization, accessibility, and responsiveness to students' needs.

The feelings of inadequacy and hesitation that participants initially held regarding digital material design were replaced, by the end of the study, with increased confidence and motivation in designing materials aligned with pedagogical principles and in using Web 2.0 tools consciously and effectively. This change in self-efficacy beliefs can be interpreted as clear evidence of Bandura's (1997) self-efficacy theory, which posits that individuals' beliefs in their competence within a specific domain are strengthened through mastery experiences and structured learning environments. Moreover, this finding is consistent with studies conducted by Timur et al. (2021) and Bediroğlu and Şahin (2023), which demonstrated that technology-supported material design processes positively influence preservice teachers' self-efficacy perceptions and enhance their motivation, particularly in terms of pedagogical integration. In conclusion, the Web 2.0-based material development activities implemented within the framework of the SLI approach were found to have a positive effect on preservice science teachers' digital pedagogical competencies and self-efficacy beliefs.

On the other hand, when the findings related to participants' instructional technology literacy and awareness are considered together with those concerning their competencies and self-efficacy in digital instructional design, it becomes evident that preservice teachers experienced positive developments in both their Technological Pedagogical Content Knowledge (TPACK) and self-efficacy levels during the digital

material design process. These results are consistent with studies conducted within the framework of the Technological Pedagogical Content Knowledge (TPACK) model developed by Koehler and Mishra (2009), which suggest that teachers' ability to integrate digital tools into pedagogical goals can be developed through systematic training and practice (Koehler & Mishra, 2009; Chai et al., 2010; Tondeur et al., 2012, 2017). Similarly, these studies emphasize that preservice teachers need to integrate pedagogical, technological, and contextual knowledge to use digital tools effectively, and that practice-based activities combined with reflective learning processes are critically important in this regard. In this context, the findings of the present study—which demonstrate preservice teachers' progress in recognizing and effectively using Web 2.0 tools as well as designing student-centered materials—are largely consistent with the existing literature while also offering perspectives that expand upon these theoretical frameworks.

Specifically, the SLI approach enables preservice teachers to take an active role in meaningfully integrating technological tools with pedagogical objectives, thereby transforming the balance among the three core components of the TPACK model—technology, pedagogy, and content knowledge—into a dynamic and practice-oriented process (Mishra & Koehler, 2009). In this context, the SLI approach acts as a catalyst within the TPACK framework, facilitating the integration of theoretical components into teaching practices in a more concrete and sustainable manner. Moreover, participants' active leadership throughout the process led to a notable increase in their self-efficacy perceptions. This finding indicates that preservice teachers not only became familiar with digital tools but also strengthened their belief in their ability to use these tools effectively (Yıldız Durak, 2021). Accordingly, the findings of this study, grounded in TPACK and self-efficacy theories, reveal that the effective use of technology is not solely dependent on technical knowledge but is enhanced through active participation, leadership, and practice-based experiences (Regan et al., 2019). Therefore, it can be concluded that by fostering creativity, autonomy, and a stronger sense of teacher identity in digital instructional design, the present study contributes not only to educational practice but also to the theoretical literature with an innovative perspective. Based on these results, it is suggested that teacher education programs should not be limited to the provision of theoretical knowledge but should also be designed to offer preservice teachers practice-based and interactive learning experiences (Borich, 2017; Damanik & Widodo, 2024).

This study, conducted within the scope of SLI activities, concluded that PST achieved significant gains in personal, social, and emotional development. In the personal development dimension, significant progress was made in teachers' skills such as self-regulation, awareness, thinking, decision-making, planning, and taking responsibility. These findings align with those of (McLoughlin & Lee, 2010; Noorwali & Sabir, 2025) who reported that learning environments integrating Web 2.0 tools enhance planning, problem-solving, and self-management skills. They are also consistent with prior research (Brush & Saye, 2009; Ertmer & Ottenbreit-Leftwich, 2010; Tatlı et al., 2023) demonstrating that the processes involved in digital content production foster improvements in PST' responsibility-taking, time management, decision-making, and problem-solving competencies. Furthermore, in the context of social development, the digital material design process was found to enhance PST' leadership skills, social communication, and intragroup collaboration capacities. This finding is consistent with recent research highlighting the role of Web 2.0 tools in supporting collaborative learning environments. For instance, it aligns with the findings of Chai et al. (2013), which emphasize that collaborative digital design processes contribute to the development of digital leadership, role distribution, and communication skills among PST.

The study found that PST experienced a range of emotions, both positive—such as a sense of achievement, feeling valued, and motivation—and negative—such as lack of self-confidence, stage anxiety, and fear of criticism. These contrasting emotional experiences may be attributed to the inherent complexity of emotional responses and the pressures associated with engaging in new, technology-supported teaching processes. Indeed, previous research (Bediroğlu & Şahin, 2023; Erdoğan & Yıldırım, 2023; Tatlı et al., 2023) has shown that PST often begin material development with Web 2.0 tools experiencing technical anxiety, fear of making mistakes, and time pressure, yet conclude the process with heightened self-efficacy and a stronger sense of accomplishment. Similarly, Korthagen (2004) argues that emotions such as anxiety and insecurity often accompany the learning process, particularly in novel experiences, while Loughran (2006) notes that PST may simultaneously feel positive emotions associated with success and negative emotions linked to fear of error. Taken together, these findings suggest that SLI activities integrating Web 2.0 tools not only enhance prospective teachers' technical competencies but also foster their personal growth, social interaction skills, and emotional resilience. This indicates that technology-supported instructional design processes represent an effective approach for promoting the multidimensional development of professional competencies.

Within the theme of professional experience and teaching practice, the gains related to the planning, implementation, and evaluation of the teaching process were categorized into four groups: awareness of teaching identity and roles, teaching, and teaching activities related to other subjects.

The study concluded that PST engaged in multifaceted experiences encompassing the planning, implementation, and evaluation of the teaching–learning process, resulting in notable professional gains. In the planning phase, their efforts centered on activities such as task allocation, conducting content research, designing instructional activities and materials, and establishing interdisciplinary connections. During the implementation phase, they employed student-centered teaching techniques that emphasized interaction, collaboration, and active learning, including methods such as creative drama, jigsaw, and educational games. Additionally, they demonstrated improvements in organizing the physical learning environment, applying fundamental classroom management and communication skills, and providing tutorial support.

In the evaluation dimension, PST reported gains such as conducting self- and peer assessments, preparing portfolios, and determining and applying objective evaluation criteria. These results are fully consistent with the professional skill gains reported by Erdoğan and Yıldırım (2023) for science pre-service teachers following educational activities conducted with Web 2.0 tools. Similarly, Onbaşılı (2020) found significant improvements in science PST' self-confidence in planning and evaluation processes during teaching practices supported by Web 2.0 tools. Comparable results have also been observed in studies on student activity-based teaching material development with Web 2.0 tools across different fields, including preschool teaching (Doğan & Göğüş, 2025), chemistry teaching (Şen, 2025), and special education teaching (Arslan-Arı & Başer, 2022). In addition, findings from mathematics education research highlight similar outcomes in the dimensions of professional development and contributions to teaching (Özpınar, 2020). These parallels may be attributed to the fact that the principles and variables underpinning the teaching–learning process form a shared foundation across disciplines.

The study also revealed that PST developed greater awareness of behaviors related to their teaching identity and roles, including taking responsibility, demonstrating

leadership, fostering a sense of professional belonging, engaging in planning, and managing time effectively. These findings suggest that digital teaching processes can evoke predominantly positive emotions in relation to the development of professional identity. This result aligns with the findings of Cai et al. (2022), which indicate that teaching practices have a significant impact on professional identity formation and self-efficacy perceptions. Moreover, one underlying factor contributing to PST' concerns about their ability to meet the demands of the profession may be rooted in preconceived notions and perceptions that teaching is an "easy" occupation.

Regarding teaching, PST reported increased awareness of the alignment between instruction and learning objectives, the impact of activity-based learning, the importance and functionality of elements such as humor and visualization, the integration of technological tools, the need to address different learning styles, and the critical role of teacher guidance. They further noted that the teaching activities in this course differed from those in other courses by making students more active and responsible, positioning the teacher as a guide, fostering engagement, and moving away from rote memorization and textbook dependence. Additionally, participants stated that these practices enhanced their teaching skills, prepared them for the profession, supported multifaceted development, and provided valuable opportunities for feedback. These results suggest that SLI activities fostered the active participation of PST by encouraging them to take responsibility for their own learning, enhancing collaboration and interaction with peers, contributing to both material production and knowledge construction (Scardamalia & Bereiter, 2006), and promoting the development of higher-order cognitive skills (Hernández-de-Menéndez et al., 2020). This aligns with findings indicating that such activities enable PST to gain teaching experiences that more closely resemble real classroom contexts and to focus more intently on pedagogical objectives as they plan and manage their own lessons (Banville et al., 2024). Moreover, the present findings are consistent with research showing that providing students with opportunities to design instructional materials using Web 2.0 tools enhances creativity, digital literacy, and interactive learning skills (Uzungöz et al., 2017), as well as increasing their awareness of instructional design (Wang et al., 2014). Consequently, in terms of their awareness of teaching and its distinctions from activities in other courses, PST can be regarded as having internalized the fundamental principles of effective teaching—commonly discussed in the literature—through their own learning experiences, thereby both recognizing their significance and formulating practical approaches for their implementation.

The challenges encountered by PST in this study, along with their recommendations, can be examined under two dimensions. During the preparation and planning phases, the most prominent difficulties included limited access to resources, coordination problems within groups, challenges in selecting information aligned with learning outcomes, difficulties in designing activities and materials, focusing excessively on unnecessary details, and inefficient time management. In the implementation and evaluation phases, notable issues involved insufficient lesson time for certain activities, deficiencies in the scope and quality of some activities, difficulties in accessing and using Web 2.0 tools due to licensing restrictions, inadequate explanatory responses to questions, negative perceptions of criticism, and technical problems. These findings are consistent with previous studies reporting similar challenges in instructional material development processes (Çelik, 2020; Taşlıçay-Arslan & Demirkan, 2019; Turan et al., 2025; Tünkler, 2021). Such similarities are likely attributable to the common requirements inherent in digital material development, students' insufficient prior learning, existing prejudices toward learning, and the lack of active and productive learning experiences in their educational backgrounds.

Analysis of the study's suggestions revealed that PST emphasized the need for more effective and widespread integration of Web 2.0 tools in classrooms, including the provision of licenses for these tools by school administrations. They also recommended increasing the frequency and diversity of similar teaching activities, establishing stronger connections to daily life, and extending activity durations. Additional suggestions included utilizing multiple learning spaces, incorporating out-of-school environments, rotating group members for each activity, and showcasing the products created. These recommendations are largely consistent with the perspectives reported in similar studies across different disciplines (Baki, 2022; Doğan & Göğüş, 2025; Yaşar-Sağlık & Yıldız, 2021).

5. Limitations

This research has several limitations. First, the study was limited to 24 preservice teachers enrolled in the Science Education program at a university. Since all participants were from the same department and grade level, the generalizability of the findings to preservice teachers from other disciplines or different grade levels is limited. Furthermore, because there was only one cohort of second-year students in the Science Education department of the faculty where the research was conducted, it was not possible to form a control group. This situation restricted the opportunity to comparatively evaluate the effects of the intervention.

The implementation of the research was carried out within the scope of a specific course and over the duration of a single academic term. However, this short time frame is considered a major limitation in comprehensively evaluating the long-term development or sustainability of preservice teachers' digital material design skills and pedagogical approaches. In addition, limitations related to licensed access to certain Web 2.0 tools, deficiencies in technical infrastructure (such as internet speed and connectivity), and participants' lack of experience in using these tools can be regarded as factors that constrained both the effectiveness of the process and the participants' overall learning experiences.

In this study, qualitative data were collected through self-evaluation, peer evaluation, and focus group interviews. Since these data were based on participants' subjective and immediate self-perceptions, they carried a potential risk of bias. To minimize this risk and enhance the reliability of the data, evaluation reports (self and peer evaluations) were collected immediately after each activity, thereby attempting to control for variability that might arise due to time intervals.

The teacher-centered and passive learner roles that participants had internalized during their previous years of education also posed certain limitations during their engagement in the activities included in this study. This situation partially constrained preservice teachers' active participation in the planning and research phases of the study, their ability to conduct and manage group work, their effective use of metacognitive thinking processes, and their assumption of leadership and facilitation roles during instruction. Therefore, it is considered that participants' performances in these dimensions may not have fully reflected their actual potential, a finding also evidenced within the scope of this study.

6. Conclusion

In this study, prospective teachers' experiences in designing, implementing, and evaluating digital teaching materials using Web 2.0 tools were comprehensively examined through quantitative and qualitative data. The quantitative findings revealed that the PST' digital material design competence and self-efficacy levels, which were moderate before the study, increased significantly after the teaching activities, reaching a high level. The qualitative findings support this development, indicating that the PST' perspectives on technology and pedagogical awareness deepened, and that they achieved multidimensional and rich gains in professional, personal, social, and emotional areas. The findings of the study were grouped under five main themes: Educational technology literacy and awareness (1), Digital teaching material design competence and self-efficacy (2), Personal, social, and emotional development (3), Professional experience and teaching practices (4), and Challenges and recommendations (5). Overall, this study demonstrates that Web 2.0-based digital material design activities significantly enhance PST' digital pedagogical competencies, professional identity development, and personal and social skills. The findings are highly consistent with similar studies in the literature. In conclusion, this study demonstrates that digital material design activities are a powerful tool in transforming PST into teachers who not only impart knowledge but also design, manage, and transform the learning process. In this context, it is clear that teacher education must be systematically structured in the digitalization process, focusing not only on instrumental but also on pedagogical transformation. In this context, the following recommendations are developed.

- Student-centered and leadership-based teaching activities should be emphasized in teacher training programs, and these activities should be systematically integrated into all teaching processes.
- Educational content focused on the effective pedagogical use of Web 2.0 tools should be offered to PST in all branches; practical, guidance-based, and reflective learning-focused modules should be developed and maintained.
- The impact of such practices on the long-term professional competencies of PST should be monitored through longitudinal research, and teacher training policies should be shaped accordingly.
- Similar studies should be conducted in different branches and at different universities to obtain interdisciplinary comparative findings.
- Teacher training institutions should meet the infrastructure and hardware needs for licensing access to Web 2.0 tools, technical support, and the organization of learning environments.
- Digital teaching materials designed by PST should be displayed online, and alternative assessment tools such as peer and self-assessment should be used to evaluate these products.
- The digital teaching material development process should include content that fosters awareness of not only technical and pedagogical but also ethical responsibilities.
- Learning environments that provide emotional support to PST should be created, particularly to overcome affective barriers such as technological anxiety and lack of self-confidence; peer support, mentoring, and guidance systems should be encouraged.

Author Statement

The author declares that there is no conflict of interest.

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