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Exploring Classroom Learning Environment in a Technology-Enriched Differentiated Instruction Course: Evidence from Pre-Service Teachers

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Abstract

The increasing integration of digital technologies in education has highlighted the need to better understand how technology-enriched instructional environments influence classroom environment, particularly within differentiated instruction (DI). While prior research has focused mainly on instructional strategies and learning outcomes, less attention has been given to learners' perceptions of classroom learning environments in technology-supported DI, especially in teacher education contexts. This study examined pre-service teachers' (PSTs') perceptions of the classroom learning environment in a technology-enriched DI course and explored relationships among key classroom environment dimensions. A triangulation mixed-method design was employed with 53 PSTs enrolled in an undergraduate elective course at a Turkish public university. Quantitative data were collected using the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI), and qualitative data were obtained through a focus group interview. Descriptive statistics and Pearson correlation analyses were used for quantitative data, while qualitative data were analyzed using content analysis. PSTs reported generally positive perceptions of their learning environment. Equity received the highest mean score, whereas differentiation had the lowest. Several classroom environment dimensions were positively associated, with the strongest relationship observed between teacher support and equity. Teacher support was consistently associated with multiple aspects of classroom climate, whereas differentiation showed weak associations with other dimensions, suggesting that individualized instructional adjustments were not always strongly perceived. Qualitative findings supported these patterns, highlighting the importance of feedback, collaboration, and technology-supported activities in shaping classroom environment, while also revealing concerns about workload and variability in group interaction. Technology-enriched DI can foster supportive and equitable learning environments in teacher education; however, the comparatively lower perception of differentiation indicates a need to strengthen the visibility and individualized nature of differentiated practices. The findings suggest that technology enhances participation and access to learning opportunities, but purposeful pedagogical integration is necessary to ensure that differentiation is experienced as personalized.

Keywords: Classroom environment; curriculum design; differentiated instruction; pre-service teachers; technology-enhanced learning; teacher support

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1. Introduction

Education systems worldwide are undergoing substantial transformations to respond to increasing diversity in student populations, including differences in language, ethnicity, gender, learning preferences, educational aspirations, technological proficiency, and learning needs (Coleman-Ali, 2022; Kamarulzaman et al., 2021; Melesse & Belay, 2022; Smets & Struyven, 2020; Sun, 2021; Wen & Cai, 2024; Wong et al., 2023). In response, many countries have promoted reforms that emphasize inclusive curricula, equity-oriented classroom practices, and learner-centered approaches (Feng et al., 2024). One approach frequently recommended for addressing learner variability is differentiated instruction (DI), which is conceptualized both as a teaching philosophy and an instructional framework (Bi et al., 2023; Gheyssens et al., 2022; Melesse & Belay, 2022; Wong et al., 2023). As shown in Figure 1, DI aims to support learners by adjusting instruction according to students' readiness, interests, and learning profiles, with the expectation that appropriately challenging and personally meaningful learning tasks promote deeper engagement and learning (Bi et al., 2023; Hu, 2024; Melesse & Belay, 2022; Tomlinson & Moon, 2013; Xie et al., 2025).

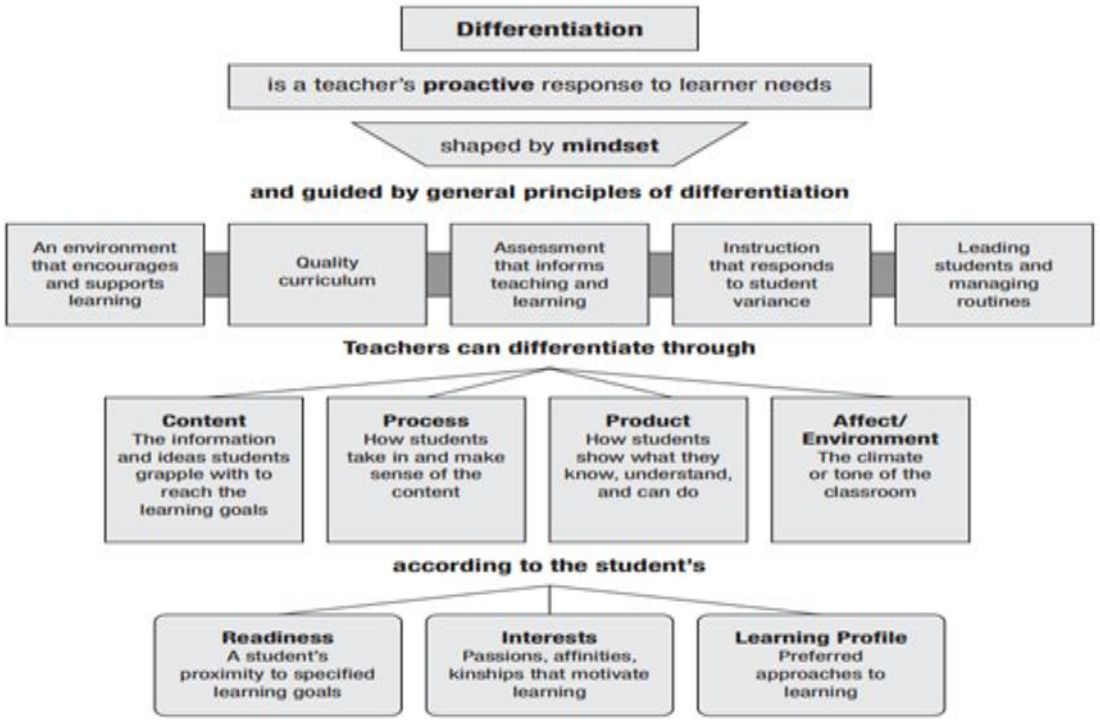

Figure 1. Key Elements of Effective Differentiated Instruction (Tomlinson & Moon, 2013, p. 2).

Although DI has been widely discussed in the literature, research has tended to emphasize differentiation through content, process, and product, while the learning environment dimension has received comparatively less attention (Tomlinson & Moon, 2013). This omission is critical because students' academic and motivational functioning is shaped not only by instructional design, but also by their day-to-day classroom experiences, including perceived support, peer relationships, opportunities for participation, and fairness. Tomlinson and Moon (2013) emphasized that learners' initial concerns often focused less on what would be taught and more on what it would feel like to learn in that classroom. Accordingly, investigating classroom learning environments within DI contexts can provide evidence about whether differentiated instruction is experienced as supportive, engaging, and equitable in practice. Therefore, this study examines pre-service teachers' (PSTs') perceptions of the classroom learning environment in a technology-enriched DI course.

The classroom learning environment is commonly defined as including both physical conditions and psychosocial dimensions such as teacher support, peer collaboration, student involvement, equity, and task orientation (Aldridge et al., 2024; Aldridge & Rowntree, 2022; Bondie et al., 2019; Cai & Lombaerts, 2024; Geitz et al., 2024; Ong & Quek, 2023). Prior research indicates that perceptions of supportive and well-structured classroom environments are associated with favorable cognitive and affective outcomes, including achievement, engagement, and motivation (Aldridge et al., 2024; Cai & Lombaerts, 2024; Cho et al., 2023; Denfeld et al., 2023; Leblebicier, 2020; Lu et al., 2022; Miao et al., 2022; Wong et al., 2023). Classrooms perceived as supportive and non-threatening, especially in terms of teacher-student interactions, lead to higher achievement and increased enjoyment of courses (Aldridge et al., 2024; Xie et al., 2025). For instance, Aldridge and Rowntree (2022) reported that teacher support, cooperation, and involvement were positively associated with students' perceived task value, suggesting that relational and participatory classroom experiences may strengthen students' engagement with learning tasks. Moreover, strong peer relationships involving familiarity, assistance when needed, and mutual support, is essential in DI classes, which is related to student cohesiveness dimension of the classroom environment (Yeflach-Wishkerman, 2024). Similarly, Cai and Lombaerts (2024) found significant associations between multiple classroom environment dimensions including task orientation, continuous assessment, teacher support, cooperation, equity, student involvement, and differentiation and student motivation among learners aged 10 to 16. However, findings across learning environment research are not always uniform, and differences have been observed depending on learner characteristics, learning design, and contextual conditions (Ibrahem et al., 2023; Rijken & Fraser, 2024). These inconsistencies suggest that a positive classroom environment may not automatically emerge from innovative pedagogy, and that specific implementation conditions may shape how learners experience support, equity, and participation.

Technology-enhanced instruction introduces further considerations for DI implementation. Digital tools can support differentiation by enabling self-paced learning, flexible access to content, interactive learning activities, and collaborative knowledge construction (Hu, 2024; Ibrahem et al., 2023; Kamarulzaman et al., 2021). Studies conducted in technology-rich environments have often reported more favorable perceptions of classroom environment dimensions such as task orientation, cooperation, and computer usage (Chipangura & Aldridge, 2017; Pramathevan & Fraser, 2019). Moreover, digital technologies may contribute to learners' motivation by encouraging exploration, problem solving, and collaboration (Hillmayr et al., 2020; Rijken & Fraser, 2024; Stilin et al., 2024). Nevertheless, evidence remains mixed regarding whether technology-enhanced instruction consistently improves classroom perceptions and achievement. Some studies report null or inconsistent effects depending on the instructional design and learner experiences (Earle & Fraser, 2017; Rijken & Fraser, 2024). These mixed findings indicate a need for more context-specific research examining how learners experience the classroom environment within technology-enriched DI settings, especially in teacher education contexts.

From a theoretical perspective, DI is grounded in social constructivist assumptions that learning is shaped through interaction, dialogue, and shared meaning-making, and that classroom environment plays a key role in supporting engagement and understanding (Melesse & Belay, 2022). DI is also consistent with self-determination theory (SDT), which emphasizes the importance of satisfying learners' needs for autonomy, competence, and relatedness to promote motivation and engagement (Ryan & Deci, 2020; Vansteenkiste et al., 2020). In DI classes, support for autonomy can be demonstrated by providing students with opportunities to express their ideas and make choices, competence can be fostered through suitably challenging tasks and constructive feedback, and relatedness can be promoted through supportive peer collaboration and trusting teacher-student relationships (Hornstra et al., 2023; Vansteenkiste et al., 2020). However, these theoretical mechanisms imply that classroom environment dimensions are not independent. Rather, supportive teacher practices, peer collaboration, engagement opportunities, and perceptions of fairness may develop together as interconnected features of classroom environment. Examining correlations among classroom learning environment dimensions can therefore provide insight into how these perceptions co-occur within a technology-enriched DI context and whether the learning environment functions as a coherent motivational environment.

The significance of this study lies in addressing gaps in both differentiated instruction and in technology-enriched learning environment research. Although DI is frequently recommended as an inclusive pedagogical approach, teachers often report limited experience and confidence in applying it effectively (Estaiteyeh, 2022; Kokkinos, 2020; Smets & Struyven, 2020), and large-scale evidence suggests that DI is among the least frequently implemented effective teaching strategies (Maulana et al., 2023). Because

PSTs' initial training shapes future instructional beliefs and practices, examining their experiences in a DI-based learning environment is particularly important (Kokkinos, 2020). At the same time, while technology may support DI, its contribution to classroom environment remains uncertain across contexts (Earle & Fraser, 2017; Sun, 2021; Zens, 2021). These results suggest that technology may play a visible role in fostering inclusive and supportive learning environments by enhancing communication, facilitating feedback, and increasing opportunities for participation. Therefore, the purpose of this study was to examine PSTs' perceptions of the classroom learning environment in a technology-enriched DI course and to explore the relationships among classroom learning environment dimensions.

Furthermore, this study contributes to the literature by providing evidence from a teacher education context, where pre-service teachers experience technology not only as learners but also as future educators. Understanding how technology shapes perceptions of classroom environment, equity, participation, and engagement in differentiated settings may inform the design of technology-enriched instructional practices that better support both inclusion and personalization. Overall, this study extends research on in technology-enriched differentiated instruction by demonstrating how digital tools influence the social and pedagogical dynamics of differentiated learning environments beyond traditional achievement-based perspectives.

The classroom learning environment is a central component of DI, as students' engagement, collaboration, and motivation are shaped not only by instructional adaptations but also by how supportive, equitable, and participatory the classroom environment is perceived to be (Tomlinson & Moon, 2013). Although prior research has examined learning environment perceptions in technology-rich classrooms and has documented links between classroom environment and learning-related outcomes (Aldridge et al., 2024; Cai & Lombaerts, 2024; Chen et al., 2020; Chipangura & Aldridge, 2017; Pramathevan & Fraser, 2019; Rijken & Fraser, 2024), less is known about how classroom learning environments are perceived specifically in technology-enriched DI contexts, particularly in teacher education. This gap is important because PSTs' experiences during their initial preparation may influence their future instructional beliefs and their readiness to implement DI in diverse classrooms (Kokkinos, 2020; Maulana et al., 2023; Smets & Struyven, 2020).

In addition, because DI is theorized to operate as an integrated instructional and motivational system in which teacher support, collaboration, task orientation, equity, and student engagement are expected to mutually reinforce one another, this study also aimed to explore the relationships among perceived classroom learning environment dimensions. By doing so, the study contributes to learning environment research by clarifying whether a coherent and supportive classroom environment emerges in DI-

based instruction and by providing evidence relevant to teacher education practice. Therefore, the study addressed the following research questions:

1. How do PSTs perceive the classroom environment in a technology-enriched differentiated instruction course?

2. What are the relationships among PSTs' perceived classroom environment dimensions in a technology-enriched differentiated instruction course?

3. What are pre-service teachers' opinions about the differentiated classroom environment?

2. Method

This study employed triangulation mixed-method research design. The qualitative component employed a case study approach (Yin, 2009), while the quantitative component used a survey research design (Cohen et al, 2018). The case was bounded to a single technology-enriched DI course offered to PSTs in a faculty of education in Türkiye during the 2022–2023 academic year. Quantitative and qualitative data were collected from the same case to provide complementary evidence about PSTs' perceptions of the differentiated classroom learning environment. Quantitative survey data were used to describe PSTs' perceived classroom learning environment and examine relationships among classroom environment dimensions. Qualitative focus group data were used to explore PSTs' opinions and interpretations of their experiences in the differentiated classroom environment and to contextualize the survey findings.

2.1. Context and Setting

The study was conducted at a state university located in Türkiye's Aegean Region. The case context was an undergraduate elective course (2 hours per week) open to PSTs from different teacher education departments. The course content covered instructional planning, basic curriculum development concepts, needs assessment, content organization, effective teaching-learning processes, and curriculum evaluation. The course followed the framework program established by the Higher Education Council of Türkiye (Yüksek Öğretim Kurumu, 2007). Prior to data collection, ethical approval was obtained from the university where the research was conducted.

2.2. Participants and Sampling

2.2.1. Quantitative Sampling (Survey Participants)

The quantitative sample consisted of PSTs enrolled in the elective course who voluntarily agreed to participate in the study. Because the study was bounded to an intact course group and participants were accessible during the semester, a convenience sampling

approach was used for the survey component (Cohen et al., 2018; Fraenkel, Wallen, & Hyun, 2023). In total, 53 PSTs filled in the TROFLEI. Of these participants, 43 (81.13%) were female and 10 (18.87%) were male. Regarding grade level, 8 (15.1%) were sophomores, 20 (37.7%) were juniors, and 25 (47.2%) were seniors.

2.2.2. Qualitative Sampling (Focus Group Participants)

For the qualitative component, purposeful maximum variation sampling was used to select a subsample of PSTs from the survey participants (Creswell & Guetterman, 2019; Fraenkel, Wallen & Hyun, 2023). This strategy was applied to represent diverse perspectives based on department, gender, grade level, and academic achievement indicators. A total of 15 PSTs participated in the focus group interview. Their demographic and academic characteristics were presented in Table 1. GPA values were obtained through participant self-report, and course grades were obtained from course assessment records. These academic indicators were used only to support variation in qualitative sampling, not as variables in statistical analyses.

Table 1. The Characteristics of Focus Group Participants

Student Code	Department	Grade	Gender	GPA	Course Grade
STD1	Turkish Language Teaching	Junior	F	3.55	BA
STD2	Turkish Language Teaching	Junior	M	3.23	CC
STD3	Turkish Language Teaching	Senior	F	3.66	AA
STD4	Elementary School Mathematics Teaching	Junior	F	3.84	AA
STD5	Elementary School Mathematics Teaching	Sophomore	M	3.43	BA
STD6	Elementary School Mathematics Teaching	Junior	F	3.14	BB
STD7	Science Teaching	Senior	F	3.57	AA
STD8	Science Teaching	Sophomore	M	2.73	CC
STD9	Social Studies Teaching	Senior	M	2.72	CC
STD10	Social Studies Teaching	Junior	F	2.69	CC
STD11	Social Studies Teaching	Sophomore	F	3.49	AA
STD12	Psychological Counselling and Guidance	Senior	F	3.73	AA
STD13	Classroom Teaching	Senior	F	2.87	CC
STD14	Classroom Teaching	Sophomore	M	3.31	BA
STD15	Classroom Teaching	Junior	F	3.72	AA

2.3. Data Collection Procedures and Instruments

In this study, data were collected through a classroom environment instrument and a semi-structured interview schedule.

2.3.1. Classroom Learning Environment Questionnaire (TROFLEI)

Quantitative data were collected using the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) developed by Welch et al. (2012). The instrument measures students' perceptions of the psychosocial classroom environment in technology-supported learning contexts across eight dimensions: student cohesiveness, teacher support, involvement, task orientation, cooperation, equity, differentiation, and computer usage. In the present study, the "actual" form of the TROFLEI was administered to assess PSTs' perceptions of the classroom environment in the DI course.

The Turkish version of the instrument was prepared through a multistep translation and back-translation procedure to support linguistic and conceptual equivalence. First, the instrument was translated from English into Turkish. A draft version was created through comparison of translations and reviewed by bilingual experts holding doctoral degrees in education from English-speaking universities. After revisions, the Turkish version was back-translated into English by independent bilingual translators unfamiliar with the original form. The back-translated items were compared with the original instrument to ensure conceptual alignment.

In addition, Cronbach's alpha reliability coefficients indicated satisfactory internal consistency, ranging from 0.82-0.92. These indicates that all scales have satisfactory internal consistency. CFA results demonstrated adequate model fit across with $\chi 2/df$ ratios were less than 3, the comparative fit indexes (CFI) were greater than 0.90 and the root mean square error of approximation values (RMSEA) were less than 0.06, indicating strong construct validity according to Tabachnick and Fidell (2019).

2.3.2. Focus Group Interview Schedule

Qualitative data were collected through a semi-structured focus group interview designed to explore PSTs' opinions about the differentiated classroom learning environment. The interview questions were adapted from relevant literature focusing on differentiated instruction and classroom learning environments (Cho et al., 2023; Coleman-Ali, 2022; Gheyssens et al., 2022; Kokkinos, 2020). To enhance content relevance and clarity, the interview schedule was reviewed by two associate professors in Curriculum and Instruction. Based on expert feedback, several questions were simplified, and prompts were revised to avoid leading participants and to elicit broader descriptions of experiences. One expert suggested rephrasing questions about positive and negative aspects to avoid leading participants, proposing instead a broader question about general

experiences. The second expert recommended shortening and simplifying questions, suggesting that one question be divided into two. In accordance with expert feedback, the questions were revised to ensure credibility, content and face validity of the study (Fraenkel, Wallen & Hyun, 2023). Sample interview questions included: “Can you describe your overall learning experience in this differentiated course?”, “Which course activities influenced your learning and engagement most?”, “How did the course materials and technology tools support or challenge your learning?”, “How was your communication with your friends / instructor?”, "Can you share a specific example of how communication influenced your learning or collaboration in the course?", “What aspects of the differentiated classroom environment could be improved to better address diverse learner needs?” please explain. The focus group interview was audio-recorded with participants’ consent and lasted approximately 30 minutes.

2.3.3. Implementation of Technology-Enriched Differentiated Instruction

The DI course was designed to address learner variability through differentiated content, process, and product. Content differentiation was supported through the provision of reading materials at different levels of complexity and through multimodal resources (e.g., written texts, audio podcasts, YouTube videos, and infographics) so that PSTs could select materials aligned with their readiness and preferences. Additional supports such as guided reading questions, key point summaries, and highlighted texts were provided for participants who preferred structured guidance.

Process differentiation was implemented by offering varied learning activities allowing PSTs to engage with course concepts through collaborative, individual, and interactive formats. Activities included station rotation, online research tasks, peer teaching, debates, poster creation, and role-play exercises. Technology tools (e.g., Mentimeter, Nearpod, Padlet) were used to facilitate participation, collaborative discussion, and feedback during classroom sessions. Additional academic support was available outside class hours through online communication platforms (e.g., Zoom, Microsoft Teams, Google Meet).

Product differentiation was supported by allowing PSTs to demonstrate learning through different assessment formats. Formative assessment practices were implemented using interactive tools (e.g., clickers, Kahoot, Socrative) to monitor understanding and provide feedback. Course assessment consisted of weekly reading reflections (20%), formative evaluations conducted during class (20%), and a final assessment (60%). In line with this approach, PST were given the opportunity to select the final assessment format that best aligned with their preferences, such that those favoring multiple-choice exams completed a test in class, whereas those preferring research-based work completed a take-home exam with more complex questions, which was evaluated using a common rubric.

2.4. Administration of Quantitative and Qualitative Data Collection

The TROFLEI questionnaire was administered near the end of the semester to ensure that participants had sufficient experience with the differentiated and technology-enriched course environment to provide informed perceptions. The survey was completed voluntarily and anonymously. After completion of the survey, focus group participants were selected using maximum variation sampling from among survey respondents. The focus group interview was conducted following the completion of the course implementation phase to allow participants to reflect on the overall learning environment and instructional practices.

2.5. Data Analysis

In this part, quantitative and qualitative data analysis procedures were explained.

2.5.1. Quantitative Analysis

Quantitative data were analyzed using Statistical Package for Social Sciences (SPSS, 22.0). To address the first research question, descriptive statistics (means and standard deviations) were calculated for the TROFLEI subscales to summarize PSTs' perceptions of the classroom learning environment (Tabachnick & Fidell, 2019). To address the second research question, Pearson product–moment correlation analyses were conducted to examine relationships among classroom learning environment dimensions. Correlation coefficients were interpreted using Cohen's (1988) widely used guidelines where values around .10 indicate small, .30 indicate moderate, and .50 indicate large associations (cited in Field, 2024).

2.5.2. Qualitative Analysis

Qualitative data were analyzed using content analysis procedures (Miles, Huberman, & Saldaña, 2014). The interview recording was transcribed verbatim prior to analysis. Coding was conducted in stages: initial codes were developed from the transcript, and codes were subsequently organized into broader categories and themes through iterative comparison. For instance, codes such as *active involvement, working on articles, permanent learning, enjoyable activities, group studies, individual activities, paired activities, flexible learning, heavy workload, many assignments, reducing the number of assignments, and long course duration* were grouped under the "activities". Similarly, codes such as, clickers, podcasts, YouTube videos, infographics, using Web 2.0 technologies, games, fun learning environment, Kahoot, Padlet, etc. were grouped under the "technology". Finally, codes such as *not knowing classmates*, *group study*, *improved communication*, *asking for peer support*, *working together*, *participation in group studies*, and *limited communication* were grouped under the "communication". To enhance

analytical credibility, coding decisions were reviewed through peer debriefing, and consensus on categories was reached through discussion. To protect confidentiality, participant codes such as S1, S2, etc. were used during reporting and interpretation of qualitative findings.

2.6. Trustworthiness of the Study

Several strategies were used to enhance the trustworthiness of the qualitative findings, including methodological triangulation, member checking, and peer debriefing (Creswell & Guetterman, 2019). Triangulation was supported by using both survey and focus group data to examine PSTs' perceptions of the differentiated classroom learning environment (Fraenkel, Wallen & Hyun, 2023). Member checking was conducted by allowing participants to review summaries of the focus group responses for accuracy. Peer debriefing was conducted through consultation with academic colleagues to review coding decisions and theme development (Creswell & Guetterman, 2019). To ensure objectivity and external reliability, the methods and procedures were thoroughly described, allowing other researchers to replicate the process, analyze data, and assess alternative conclusions (Miles, Huberman & Saldana, 2014).

3. Results

To address the first research question and unveil PST' perceptions of the classroom environment, descriptive statistics were displayed in Table 2. Also, for the second research question, Pearson correlation coefficients were provided to demonstrate the relationships among PST' classroom environment perceptions (Field, 2024; Tabachnick & Fidell, 2019).

Table 2. The Descriptive Statistics and Correlations between TROFLEI Scales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Student Cohesiveness (1)	1							
Teacher Support (2)	.46**	1						
Involvement (3)	.45**	.46**	1					
Task Orientation (4)	.23	.44**	.49**	1				
Cooperation (5)	.56**	.46**	.45**	.30*	1			
Equity (6)	.37**	.63**	.36**	.32*	.32*	1		
Differentiation (7)	.07	.02	-.04	.02	.16	.06	1	
Computer Usage (8)	.25	.39**	.42**	.25	.34*	.46**	.11	1
M	3.88	4.32	3.59	4.18	3.68	4.62	3.06	4.11
SD	.55	.65	.69	.57	.75	.42	.48	.74

*p<.05, **p<.01

According to Table 2, PST's perceptions of differentiated environments were positive. While PST obtained the highest mean from the equity dimension of the differentiated classroom environment (M = 4.62, SD = .42), the lowest mean from the differentiation dimension of the differentiated classroom environment (M = 3.06, SD = .48). In addition, the second highest mean score was obtained by the teacher support dimension (M = 4.32, SD = .65).

The strongest association was found between teacher support and equity dimensions of the classroom environment (r = .63). Teacher support showed moderate positive associations with student cohesiveness (r = .46, p < .01), involvement (r = .46, p < .01), task orientation (r = .44, p < .01), cooperation (r = .46, p < .01), and computer usage (r = .39, p < .01). In addition, involvement was moderately and positively associated with task orientation (r = .49, p < .01), student cohesiveness (r = .45, p < .01), cooperation (r = .45, p < .01), equity (r = .36, p < .01), and computer usage (r = .42, p < .01). These patterns suggest that PSTs who reported more supportive and participatory classroom experiences also tended to report higher levels of peer connectedness, cooperation, and perceived equity in the technology-enriched differentiated instruction environment. In addition, in this technology-enriched DI course, computer usage has a medium association with equity dimensions (r = .46, p < .01) of the classroom environment which was slightly stronger than its associations with the other variables. This pattern indicates that higher perceptions of equity tended to co-occur with higher reported use of technology among PSTs.

To address the third research question and explore PSTs' opinions about the differentiated classroom environment, focus group data were analyzed thematically. Three main themes were identified: "activities", "technology", and "communication".

Activities

PSTs commonly described the course as requiring active participation through varied learning activities, which reflected the involvement dimension of the classroom environment. Several PSTs reported that completing preparatory readings and participating in in-class tasks supported their learning and made the lessons more engaging. For instance, participants noted that "*Preparing for lessons by working on assigned articles helped reinforce learning, and the in-class activities made the experience more enjoyable"* (S1-S7-S13). Participants also emphasized the simultaneous use of multiple activity formats and contrasted this experience with other courses: "*We engaged in group, individual, or paired activities at the same time…even not one of them is done in other courses"* (S3-S11-S15). Participants also highlighted having options in learning and assessment activities, which they associated with fairness and responsiveness to student preferences. For instance, one participant stated, "*The advantage of evaluation is that the*

choice between exams and assignments is left to the students" (S5-S9-S13). Similarly, others noted that "*the activities and course process were good as the aim was to take into consideration the students' preferences, and the main goal was to ensure that the students learn actually*" (S5-S14-S15). These comments align with perceptions of equity within the differentiated classroom environment.

At the same time, PSTs described the course as demanding in terms of workload and sustained effort, which related to task orientation dimension of the classroom environment. PSTs stated that "*… our homework load was heavier, and we received grades for it, unlike the other classes"* (S1-S4-S6). Others commented that the workload affected time available for other courses: "*I focused more on this course, I couldn't study much for my other classes due to the amount of homework, which affected my performance in others*" (S3-S5-S8-S10-S11). In addition, some PSTs noted that the expectation of continuous activity was challenging, as reflected in the statement: "*…the downside was the constant need to be active*" (S15). PSTs also expressed mixed opinions about extended activity time, with one noting that "…sometimes the long class hours were exhausting" (STD13).

Technology

Moreover, in this differentiated course, PSTs learned the content in multiple formats, including text, audio podcasts, YouTube videos, infographics and using Web 2.0 technologies to accommodate different learning styles, which is related to the computer usage dimension of the classroom environment. In this way, they could engage in a more engaging and fun learning environment. According to perceptions of PSTs, "*I like using technology, this encouraged me to learn the topic. For instance, I found clickers more enjoyable than traditional question-and-answer sessions. I can also play these games in my future classes"* (S2-S4-S8-S11-S12-S15). When technology was integrated into the teaching–learning process, learners tended to understand the material more effectively and developed greater interest in the subject, which contributed to a more engaging and enjoyable learning experience.

Communication

PSTs' opinions about communication reflected both positive and mixed experiences, particularly regarding peer interaction and collaboration. Several participants explained that group-based activities supported social connection and helped them communicate with classmates from different departments, which related to student cohesiveness dimension of the classroom environment. PSTs stated, ""*I didn't know most of my classmates, but through group activities we did in class, I improved my communication with them*" (S4-S5-S7). Another participant emphasized peer assistance: "*My classmates were very helpful in class and supported me in areas where I didn't understand*" (S14).

These views suggest that differentiated tasks contributed to peer support and interaction during the course. Also, as PST studied in groups, they cooperated to complete some tasks, which is related to the cooperation and involvement properties of the differentiated classroom environment.

On the other hand, there were also PST who had negative communication experiences despite being exposed to the same teaching approach. Although PST had the option to work on tasks individually, sometimes they wanted to be in groups. For this reason, they mentioned that their communication was very limited and they only spoke to complete course activities. "*My communication with my classmates was not very good, I didn't know most of them, and we only bonded during activities*" (S6). "*We only communicated enough to complete the task when it was a group activity*" (S8). In addition, there were some who shared their both positive and negative experiences, such as S11 stated that "*I couldn't hear our teacher well in one activity because two group members talked a lot, so I didn't get much out of it. However, in other classes, I met classmates from other departments and gained different perspectives*". In other words, based on PSTs' perceptions, communication at times remained minimal and primarily centered on completing tasks, suggesting that the quality of collaboration differed across groups even within the same instructional approach.

In addition, participants frequently emphasized the role of the instructor in creating a supportive classroom environment. PSTs described receiving timely feedback and assistance when needed, consistent with the teacher support dimension. For instance, PSTs stated, "*The instructor helped me with great dedication and provided feedback whenever I needed*" (S2-S5-S12). Another remarked, "*My issues were resolved at every point I needed, and the feedback was sufficient*" (S3). A further comment highlighted the non-threatening nature of classroom interaction: "*In this course, I could express myself more comfortably and openly compared to other classes, and instead of being judged for my answers, I received constructive feedback*" (S8). Overall, the qualitative findings suggest that PSTs experienced the course as participatory and supportive, while also describing challenges related to workload and variability in peer collaboration. These perceptions provide context for understanding how PSTs evaluated the differentiated classroom environment.

The qualitative findings help contextualize the quantitative pattern observed in Table 2. Participants' emphasis on feedback, accessibility of the instructor, and a non-threatening environment aligns with the high mean score for teacher support and its strong association with equity. Similarly, frequent references to group activities and peer assistance help explain student cohesiveness and cooperation ratings. At the same time, reports of heavy workload and sustained activity expectations provide insight into task orientation perceptions. Variability in collaboration experiences across groups may also

help explain why some dimensions were perceived positively while others were more mixed.

4. Discussion

This study examined PST' perceptions of the classroom learning environment in a technology-enriched DI course and explored relationships among perceived classroom environment dimensions. In addition, qualitative findings were used to capture PSTs' opinions and to provide contextual explanations for the quantitative patterns. Addressing a gap in the literature where DI has often been investigated through instructional components (content, process, product) rather than through the learning environment dimension, the present study contributes evidence from a Turkish teacher education context.

4.1. Perceptions of Equity and Teacher Support in a Technology-Enriched DI Course

Regarding the first research question, PST reported the most positive perceptions for equity and teacher support, while differentiation received the lowest mean score. The high equity score is consistent with previous learning environment studies reporting that students often perceive fairness-related classroom features positively (Cai & Lombaerts, 2024; Leblebicier, 2020; Oksuz-Zerey, 2017; Pramathevan & Fraser, 2019). Equity reflects students' perceptions of fair treatment and comparable opportunities for participation and success (Cai & Lombaerts, 2024). In a context of increasing learner diversity, equity becomes particularly important because it represents how students experience inclusion and fairness in everyday classroom practice rather than only as a policy aim (Feng et al., 2024).

Qualitative findings offer important insight into how PST interpreted equity in this course. Participants frequently described fairness in terms of having options and flexibility, such as being able to choose activity formats and assessment types (Beck & Beasley, 2021; Bondie et al., 2019; Estaiteyeh, 2022). These accounts suggest that visible responsiveness to learner preferences may have been experienced primarily as fairness and inclusion. This interpretation is meaningful because DI can be implemented in ways that emphasize both individual responsiveness and equitable opportunity. In practice, participants may interpret differentiation strategies such as offering varied tasks, flexible pacing, and alternative assessment modes as indicators of equitable treatment, particularly when the course environment is supportive and non-threatening. Therefore, equity may become the most salient and easily recognizable outcome of DI for learners, even when differentiation is present in the instructional design.

4.2. The Level of Perceived Differentiation

Although PST evaluated the classroom environment positively overall, the differentiation subscale received the lowest mean score. This pattern suggests that instructional differentiation may not have been consistently perceived as individualized tailoring based on readiness, interest, or learning profile. This is consistent with the broader DI literature showing that implementing differentiation in a way that is pedagogically sound and also visible and meaningful to learners can be challenging (Wong et al., 2023). Learners may recognize supportive practices (e.g., feedback, encouragement, flexible assessment) as fairness, yet still feel that instruction is not strongly adapted to their individual level or learning needs. In addition, PSTs' prior learning experiences, preferences, and expectations may influence how they define "differentiation", potentially leading them to view DI mainly as variety in tasks rather than as systematic adjustment of instruction to learner readiness (Gheyssens et al., 2020).

The low differentiation score also aligns with the correlational pattern in which differentiation demonstrated weak relationships with other classroom environment dimensions. This suggests that perceived differentiation functioned relatively independently from perceptions of support, peer relations, or technology use. An important implication is that instructors may create supportive and equitable environments through DI-oriented teaching, but learners may still not experience differentiation as a strong or consistent feature unless individualized adjustments are explicitly structured and communicated.

4.3. Relationships among Classroom Learning Environment Dimensions

The second research question focused on relationships among classroom environment dimensions. The strongest association was observed between teacher support and equity, indicating that PSTs who reported higher teacher support also tended to report higher perceived equity. Teacher support also showed moderate positive associations with student cohesiveness, involvement, task orientation, cooperation, and computer usage. These findings are consistent with research emphasizing that teacher-student relationships, supportive feedback, and respectful classroom interaction co-occur with students' positive perceptions of classroom environment (Aldridge & Rowntree, 2022; Cho et al., 2023; Xie et al., 2025). Importantly, these results should be interpreted as co-occurring perceptions rather than directional effects due to the correlational design. However, the pattern is still theoretically meaningful because learning environment dimensions are expected to form a coherent system in student-centered instruction, where supportive teacher behaviors are closely intertwined with participation, collaboration, and fairness.

In addition, involvement was moderately associated with several classroom environment dimensions, indicating that perceptions of active participation tended to appear alongside perceptions of peer connection, instructor support, task focus, and technology use (Lu et al., 2022; Stingo, 2024; Cai & Lombaerts, 2024). This pattern reinforces the view that participatory learning environments are not defined by a single element but by a network of interrelated perceptions. In DI contexts, active engagement often depends simultaneously on the quality of teacher guidance, opportunities for collaboration, and instructional clarity (Lu et al., 2022; Stingo, 2024). Therefore, the observed associations can be interpreted as evidence of a relatively integrated classroom environment within the technology-enriched DI course.

4.4. Qualitative Findings as Contextual Explanation of Classroom Environment

The third research question explored PSTs' opinions about the differentiated classroom environment through focus group interviews. The qualitative findings aligned with quantitative results in several ways. First, participants frequently emphasized timely feedback, approachability of the instructor, and a classroom atmosphere where they could express ideas comfortably. These views correspond closely to teacher support and are consistent with literature showing that supportive teacher behaviors enhance students' comfort, engagement, and willingness to participate (Denfeld et al., 2023; Leblebicier, 2020; Lu et al., 2022; Tomlinson & Moon, 2013). Second, participants described peer interaction and collaboration as a meaningful part of their learning experience, which helps explain perceptions of student cohesiveness and cooperation. Similar findings have been reported in learning environment studies, where familiarity and supportive peer relations tend to coincide with increased collaboration and classroom participation (Cai & Lombaerts, 2024; Oksuz-Zerey, 2017).

At the same time, the qualitative data also revealed variability in collaboration experiences (Cai & Lombaerts, 2024; Cho et al., 2023; Oksuz-Zerey, 2017). While some PST reported that group activities strengthened communication and peer support, others described limited interaction and task-focused communication. This diversity is important because it highlights that cooperative learning structures do not automatically result in equally positive collaboration experiences for all learners. Group dynamics, communication habits, and familiarity among students may shape whether cooperation enhances learning or remains superficial. Such variation may partly explain why some classroom environment dimensions were perceived more positively than others within the same instructional context.

4.5. Technology Integration and Its Role in Perceived Classroom Environment

PST reported relatively high computer usage perceptions, and computer usage was positively associated with several dimensions of classroom environment, particularly

equity, teacher support, involvement, cooperation, and task orientation. Although this study did not find a strong association between technology use and the differentiation dimension, technology support differentiation by enabling instructional flexibility, which is also stressed in the meta analysis study of Hillmayr et al. (2020). Qualitative findings showed that PST experienced technology-supported activities such as Web 2.0 technologies and interactive quizzes as motivating and enjoyable, and many participants noted that such tools supported their participation and interaction during class sessions. These results align with studies suggesting that technology can support participation, collaboration, and engagement when integrated meaningfully into instruction (Cai & Lombaerts, 2024; Hu, 2024; Miao et al., 2022; Ong & Quek, 2023; Yeflach-Wishkerman, 2024).

Notably, computer usage was more strongly associated with equity than with differentiation. This pattern suggests that PST may experience technology primarily as a way to increase access to materials, participation opportunities, and classroom interaction, rather than as a clear mechanism for individualized instructional adjustments. In other words, technology may contribute more visibly to fairness and inclusion than to perceived personalization. This interpretation is consistent with the view that technology integration does not automatically produce differentiation unless digital tools are explicitly used for adaptive pathways, readiness-based supports, or structured personalization (Hillmayr et al., 2020). Therefore, the present findings suggest that technology-enriched DI may strengthen perceptions of equity and engagement, while the perception of differentiation may require more explicit visibility and individualized design features.

4.6. Task Orientation and Perceived Workload: A Mixed Pattern

According to quantitative results, task orientation was rated positively, indicating that PST perceived the class as relatively focused on completing learning activities and achieving instructional goals. However, qualitative findings revealed concerns about workload intensity, sustained activity demands, and the impact of coursework on time available for other classes. This mixed pattern suggests that PST may have experienced the course as academically structured and goal-directed while also perceiving it as demanding. Moreover, the self-directed learning component of this differentiated course may not have been suitable for some PSTs, as they likely needed more support and guidance to complete tasks, engage in computer-based activities, or use platforms like Microsoft Teams. This lack of support may have resulted in lower task orientation scores. Abuhassna et al. (2020) similarly noted that students who struggle with the technical skills required to navigate digital platforms can become frustrated when technology complicates their learning experience. These students may have needed more reassurance regarding their progress, particularly during tasks that required working

independently, such as creating podcasts, YouTube videos, or writing reflection reports, and sharing them on Microsoft Teams. Similar tensions have been reported in research on active learning environments, where students may value engagement and collaboration yet express concerns about workload and effort requirements (Strayer, 2012). Therefore, it is recommended that instructors anticipate the challenges students may face during the DI process and provide appropriate support to meet their needs. Also, this finding implies that maintaining active participation and varied tasks should be balanced with workload feasibility to prevent motivation costs or perceived overload.

4.7. Implications and Suggestions

The findings of this study provide several practical implications for designing technology-enriched DI courses in teacher education. First, the strong and consistent co-occurrence of teacher support with multiple classroom environment dimensions suggests that supportive instructor behaviors are central to shaping positive classroom environment in DI settings. Similarly, Ibrahem et al. (2023) emphasized that while technology and infrastructure are important, the core of effective instruction lies in well-trained teachers. Instructors implementing DI may benefit from maintaining visible availability, offering timely and constructive feedback, and ensuring a non-threatening environment where PST can share ideas openly. These practices seems closely tied to PSTs' perceptions of equity and participation.

Also, the comparatively lower perceived differentiation score suggests that DI practices may need to be made more explicit and visible to learners. Although participants described flexibility and choice, they did not consistently interpret these experiences as individualized differentiation. Teacher educators could strengthen perceived differentiation by communicating the rationale for tiered tasks, explicitly linking learning options to readiness and learning needs, and offering structured pathways that help students recognize how instruction is being tailored. Such clarity may help learners distinguish between general fairness and true individualized differentiation.

In addition, since collaboration experiences varied across participants, instructors may need to support group work more systematically. This includes clarifying roles, monitoring contribution balance, and providing guidance for productive communication, especially in mixed-department classes where familiarity may initially be low. Structured collaboration may enhance student cohesiveness and cooperation more consistently across learners.

Furthermore, technology integration appeared to support engagement and perceptions of equity, yet its link to perceived differentiation was weaker. Therefore, teacher educators may consider using technology not only for interaction and motivation such as quizzes, discussion tools, but also for personalization features such as differentiated resource sets, adaptive learning tasks, individualized feedback channels, and readiness-

sensitive supports. This may help technology function as an instrument of differentiation rather than only as a participation enhancer.

Finally, qualitative findings indicated workload concerns despite generally positive task orientation perceptions. For sustainable DI implementation, instructors may consider balancing activity variety with manageable workload, coordinating assignment demands across weeks, and designing differentiated tasks that maintain challenge without creating excessive pressure. Transparent workload expectations and step by step implementation of DI strategies such as first adjusting the content, then changing the way students learn (process), and finally varying how students show what they've learned (product) may reduce perceptions of overload while preserving the benefits of student-centered instruction.

4.8. Limitations and Future Research

This study has several limitations. First, the quantitative sample included 53 PST from a single elective course within one university context. Although the study provides valuable insights into technology-enriched DI in Turkish teacher education, the sample size and single-case context limit generalizability. Future studies should include larger samples across multiple universities and departments to strengthen transferability and statistical robustness.

Also, the study used a correlational design for the quantitative component; therefore, no causal conclusions can be drawn regarding relationships among classroom learning environment dimensions. Future research could employ experimental or quasi-experimental designs to compare perceptions of learning environment across instructional approaches such as DI versus non-DI, technology-enriched DI versus DI without technology integration. Longitudinal designs may also be useful to examine how PST perceptions evolve over time and whether early DI experiences influence later teaching beliefs and practices.

Third, the study relied on self-reported perceptions through surveys and focus group interviews. While these data capture learners' experiences directly, they may be influenced by social desirability or group interaction dynamics in focus group settings. Future research could incorporate additional data sources such as classroom observations, reflective journals, learning analytics, or open-ended questionnaires to triangulate findings and strengthen interpretive credibility.

Fourth, the study focused on face-to-face DI implementation. Further research could examine whether similar classroom environment patterns emerge in online or blended learning contexts where differentiation and technology use may function differently. Additionally, future studies may investigate how factors such as disability status, linguistic diversity, and cultural background shape perceptions of differentiated

classroom environments, thereby offering a more comprehensive understanding of equity and personalization in diverse teacher education settings.

This study emphasizes the dynamics of a differentiated teacher training classroom environment, offering valuable insights for practical improvements in classrooms. Future research could also investigate whether students' perceptions of the current differentiated classroom environment (actual environment) differ from their expectations of an ideal one (preferred environment). Identifying gaps between PSTs' actual and preferred classroom settings could help implement targeted strategies to address these discrepancies and enhance the overall learning experience.

5. Conclusions

This study investigated PSTs' perceptions of the classroom learning environment in a technology-enriched differentiated instruction course and examined relationships among classroom environment dimensions, supported by qualitative insights. The findings indicated that PST perceived the classroom environment as highly equitable and strongly supportive, and these dimensions tended to co-occur with positive perceptions of involvement, cooperation, cohesiveness, and computer usage. In contrast, perceived differentiation was comparatively lower and was weakly connected to other learning environment dimensions, suggesting that differentiation may not have been consistently recognized as individualized tailoring in this course context. Overall, this study contributes to the DI and technology-enriched instructional environment literature by highlighting how supportive and equitable classroom environment can emerge in technology-enriched DI within teacher education, while also emphasizing the need to strengthen the visibility and perceived individualization of differentiation practices.

Also, this study contributes to the literature by examining how technology-enriched instructional environments shape learners' perceptions of classroom environment within a DI context in teacher education. The study shows that digital tools and interactive platforms supported participation, collaboration, and access to learning opportunities, and were moderately associated with key classroom environment dimensions, particularly equity, teacher support, and involvement. The findings suggest that technology was experienced by PSTs primarily as a facilitator of inclusive and engaging learning rather than as a strong driver of perceived differentiation. Qualitative findings further indicated that technology-supported formative assessment, multimodal resources, and interactive tools enhanced engagement and communication, but also revealed challenges related to workload and variability in collaboration. By highlighting how technology shapes perceptions of fairness, participation, and classroom interaction in a differentiated learning environment, this study extends existing research on technology-supported learning environments beyond achievement-focused outcomes and provides

evidence from a teacher education context, where the pedagogical use of digital tools plays a central role in shaping future teaching practices.

Conflict of Interest

No potential conflicts of interest, the criteria for authorship as explained in the "Authorship" section have been met.

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