Id: 1440275

Participatory Educational Research (PER)
Vol.11(3), pp. 126-145, May 2024
Available online at http://www.perjournal.com
ISSN: 2148-6123
http://dx.doi.org/10.17275/per.24.38.11.3

Digital Transformation in Science Education: Teachers' Self-Efficacy of Distance Learning and Blended Learning Experiences

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Article history

Received:
20.02.2024

Received in revised form:
24.03.2024

Accepted:
20.04.2024

Key words:
Blended learning, Blended learning experience, Self-efficacy towards distance education, Science education

Blended learning emerges as an indispensable tool for pioneering science education practices in the 21st century. Studies underscore the efficacy of blended learning applications in science education, particularly in enhancing learners' computer proficiency, fostering positive attitudes and motivation towards science courses, and surmounting learning hurdles. This study aims to assess the levels of self-efficacy among science teachers for blended education within the context of the digital transformation process. It also seeks to investigate the predictive capacity of various factors and analyze teachers' experiences with blended learning. The research adopts a mixed-method approach, integrating both qualitative and quantitative research methodologies. Quantitatively, the study utilizes the "Self-Efficacy Perception of Distance Education Scale" to gauge science teachers' self-efficacy perceptions about distance education. The quantitative segment encompasses a sample of 175 science teachers. On the other hand, for the qualitative aspect, 26 teachers' experiences were examined through an “Open-Ended Question Form” to gain nuanced insights. The results of the quantitative analysis demonstrated that science educators displayed a heightened level of perceived self-efficacy in the domain of distance education. The influencing factors identified included gender, seniority, school type, class size, and usage of laboratory facilities. The qualitative findings indicated that science teachers' engagement with blended learning was characterized by both positive and negative sentiments. These experiences were further categorized into subgroups of positive and negative encounters.

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Introduction

The global Covid-19 pandemic, educators found themselves compelled to acquire proficiency in distance education. This newfound expertise has played a pivotal role in effectively amalgamating in-person instruction with online learning, thereby giving impetus to the emergence of the blended learning paradigm. Blended learning, a dynamic pedagogical approach, stands out as a more adaptable method than conventional face-to-face or exclusively online practices. It not only amplifies opportunities for refining the teaching and learning process but also facilitates valuable feedback and reflective practices (Graham, 2006). As the demand for 21st-century skills escalates in a rapidly evolving world, technology emerges as a pivotal factor. Blended learning, a prominent technology-driven concept, assumes a growing significance in contemporary education (Akgündüz, 2019). The proficiency of teachers plays a pivotal role in determining the impact of 21st-century learner skills. Alongside subject matter expertise within the realm of professional competencies, the ability to adeptly leverage new technologies in the classroom, seamlessly integrate them into lessons, and utilize them for effective teaching and learning, are paramount among the skill sets of 21st-century educators. Furthermore, the incorporation of blended learning experiences by teachers in their respective domains, especially in fundamental subjects such as Science, Mathematics, and Turkish, not only enhances learner skills but also contributes to the integration of the blended learning model in their lessons, as corroborated by evaluations based on assessments like PISA and TIMSS. This integration of technology into scientific experiments in virtual environments not only optimizes time and resources but also heightens learners' curiosity and interest. Virtual experiments facilitated by computer technology present advantages including the exploration of unobservable phenomena, bridging the gap between observable and unobservable phenomena, elucidating key knowledge points, enabling swift and repeated experiments, and providing adaptive online guidance. These benefits culminate in a more effective comprehension of scientific phenomena and enhanced learning outcomes. The amalgamation of virtual and physical laboratories enriches scientific research by affording students a broader spectrum of experimentation, an advantage that standalone laboratories cannot replicate (De Jong et al., 2013).

Blended learning emerges as an indispensable tool for pioneering science education practices in the 21st century (Fazio & Jaipal-Jamani, 2023). In a randomized controlled trial examining blended learning, Stockwell et al. (2015) demonstrated that employing a blended instructional approach, wherein video assignments and in-class problem-solving activities are utilized to stimulate interest and deliver foundational information before the lesson, yields superior outcomes in science education as opposed to conventional pedagogical methods. While video assignments may not directly enhance students' test performance, they do lead to heightened engagement and satisfaction. Additional studies underscore the efficacy of blended learning applications in science education, particularly in enhancing learners' computer proficiency (Hwang et al., 2019), fostering positive attitudes and motivation towards science courses, and surmounting learning hurdles (Akgündüz & Akınoğlu, 2017; Gürdoğan & Bağ, 2020; Korkmaz & Kadirhan, 2020). Furthermore, research demonstrates that blended learning creates an inclusive environment catering to diverse learning needs and interests (Dias et al., 2014). It extends learning experiences beyond the classroom for digitally literate students (Kasraie & Alahmad, 2015) and fosters a collaborative learning atmosphere (Okaz, 2015). Notably, science teachers' perspectives on blended learning witnessed a positive transformation following the implementation of the "Blended Learning Based Professional Development Program" by a teaching association in Canada (Fazio & Jaipal-Jamani, 2023). According to Omeodu and Ekineh (2023), science teachers who did not partake in any professional program on blended

learning encountered difficulties in its adoption due to limited competence in utilizing computer technologies and restricted access to computer facilities. Like these studies, Kahraman and Kaya (2021) advocate for further research to garner the experiences and viewpoints of science teachers. Surprisingly, there exists a dearth of research on the experiences of science teachers in Turkey (Sontay & Karamustafaoğlu, 2022). To comprehensively evaluate the blended learning experience, it is imperative to also gauge teachers' competencies in distance education. After all, blended learning competencies encompass the flexibility and customization of learning, mastery-based learning, adept utilization and interpretation of data, proficiency in learning management systems, facilitation of online discussions, and adeptness in software management (Pulham & Graham, 2018). The research underscores a significant positive correlation between the quality of learning outcomes and teachers' self-efficacy in distance education. It also illuminates areas where teachers need to bolster their self-efficacy in this domain (Corry & Stella, 2018; Kaymak & Titrek, 2021). Notably, during the Covid-19 pandemic, science, physics, chemistry, and biology teachers in Turkey were surveyed on their adeptness in employing technological tools and teaching materials in blended learning environments. Despite virtual laboratories and simulations being highly recommended tools in blended learning environments for scientific applications, their implementation remains insufficient (Kumaş, 2023). Bruggeman et al. (2021) underscore that for blended learning environments to truly flourish, teachers must transform, necessitating a pedagogical shift and a creative approach toward integrating technology into the teaching process.

Scholarly investigation into blended learning has unequivocally demonstrated that within the online realm of this pedagogical approach, students contend with challenges about self-regulation, proficient utilization of instructional technology, accessibility to technology, and the need for adequate teacher training (Rasheed et al., 2020). Among science educators, prevalent challenges in the domain of blended education encompass deficiencies in educational resources provided by governing bodies, the learning environments of students, as well as multifaceted social, psychological, and technological factors (Kumaş & Kan, 2022). The onset of the Covid-19 pandemic has substantially heightened the prominence of the online component within the blended learning paradigm. As expounded upon in the investigation undertaken by Acar and Azaklı (2023), the utilization of online argumentation coupled with reflective thinking as a foundation for science instruction has demonstrated a notably potent impact in augmenting the metacognitive capacities and logical reasoning abilities of sixth-grade students.

This study endeavors to investigate the self-efficacy of teachers with a minimum of five years of teaching experience, who are adept in distance education, and to explore their proficiency in crafting blended learning experiences. To fulfill this objective, the study addresses the following research inquiries:

(1) What is the extent of self-efficacy perceptions regarding distance education among science educators?
(2) To what extent can science teachers' self-efficacy perceptions in distance education be indicative of variables such as gender, seniority, school type, class size, and the utilization of laboratory environments?
(3) How are the experiences of science teachers in the realm of blended learning?

Methods

This study employed a mixed methods approach with a convergent parallel design. The convergent parallel design entails gathering diverse and supplementary data to address a research question. In this design, both quantitative and qualitative data are collected

concurrently but independently in the initial stage, with neither dimension contingent on the outcomes of the other. In the second stage, quantitative and qualitative data are analyzed independently. In the third stage, the results are combined. In this stage, the results are compared or transformed to relate the two types of data with new analyses. In the final stage, the researcher interprets to what extent and in what ways the two results are combined, separated, related, or combined the results to answer the general purpose (Creswell & Clark, 2017). In this study, data on teachers' distance education self-efficacy perceptions in the quantitative dimension and their experiences in designing a blended learning environment in the qualitative dimension were collected and analyzed separately and simultaneously. Both results were combined and interpreted. In the quantitative facet of this research, the survey model was employed to elucidate the self-efficacy of science educators in the context of distance education, following the approach advocated by Karasar (2009). In the qualitative dimension, phenomenological design was used to determine teachers' experiences towards blended learning. This approach seeks to explore and comprehend social phenomena. Within research employing a phenomenological design, the focus lies on investigating phenomena that individuals are cognizant of but may not possess a comprehensive and detailed comprehension of, as expounded by scholars such as Patton (2014).

Study Group

Quantitative Study Group

The study cohort comprised science educators employed in public and state-affiliated secondary schools under the purview of the Ministry of National Education. These educators possessed a tenure of five years or more and actively participated in the implementation of distance education. To ensure a representative sample, a deliberate effort was made to incorporate science teachers from various regions across Turkey into the study cohort. As part of the study's parameters, quantitative data were gathered from a cohort of 175 science teachers. The research participants were selected through the convenience sampling approach, which is a purposeful sampling strategy. Convenience sampling enables a thorough investigation of situations that are thought to contain valuable information. In convenience sampling, a form of purposive sampling, researchers fast-track the research process by choosing a nearby and easily reachable situation, improving efficiency and convenience. Convenience sampling is usually the method of choice when other sampling techniques are not possible. Convenience samples are often a more affordable and feasible option for researchers who are comfortable with the sample. Nevertheless, this sampling technique has lower generalizability and reliability of research findings than other sampling methods (Yıldırım & Şimşek, 2011).

Among the 175 science teachers who partook in the quantitative phase of the study, 62.4% were identified as female, while 37.6% were classified as male. While 32% of the teachers had 10-14 years of seniority, 29.8% had 15-19 years of seniority and 21.9% had 5-9 years of seniority. Teachers with 20 or more years of seniority constitute 16.3% of all teachers. While 84.8% of the teachers work in public schools, 15.2% work in private schools. When the technological infrastructure facilities in the schools where teachers work were examined, it was found that 92% of the schools had smart boards, 81.5% had internet in their classrooms, 64.6% had computer laboratories, 42.1% had audio and camera systems, 27% had projectors and 16.9% had learning management systems. Teachers stated that their students' level of access to technology was high. These data were obtained through the demographic information form contained these criteria.

It is pertinent to highlight that 33.7% of the surveyed teachers are employed in educational institutions where class sizes exceed 31 students. Teachers instructing classes with 10-15 students constitute 6.2% of the study cohort. When queried about the extent of laboratory utilization in face-to-face instruction, findings indicate that 27% of teachers exhibit a very low usage, while 18.7% demonstrate a high level of utilization. Concerning the incorporation of laboratories in online teaching environments, results indicate that 19.1% infrequently employ them, whereas 13.5% make frequent use.

Qualitative Study Group

In the qualitative part of the study, 26 science educators (selected voluntarily among 175 science teachers) took part, comprising 69.23% female and 30.77% male participants. Regarding teaching experience, 38.46% had accumulated 10-14 years, 26.92% had 15-19 years, and 19.23% had 5-9 years. Educators with 20 years or more of experience constituted 15.38% of the total participants. As for institutional affiliation, 80.77% of the teachers were affiliated with public schools, whereas 19.23% were associated with private schools. When asked about the level of laboratory usage in face-to-face lessons, it is remarkable that 26.92% had a very low level of usage, and 19.23% had the highest level of usage. As for the usage of laboratories in online environments, it was determined that 19.23% rarely use them, and 11.54% use them frequently. It is noteworthy that 34.62% of the teachers worked in schools where the class size was 31 or more. Teachers who worked in classes with 10-15 students constituted 7.69% of the study group.

Data Collection Tools

In this research, two instruments were utilized for data collection. The first instrument employed was the Self-Efficacy Perception of Distance Education Scale, while the second instrument utilized was an Open-Ended Question Form specifically designed for the assessment of Blended Learning experiences.

Self-Efficacy Perception of Distance Education Scale

The quantitative data in this study were acquired utilizing the "Self-Efficacy Perception of Distance Education Scale," developed by Çok and Günbatar (2022) to evaluate science teachers' self-efficacy perceptions about distance education. Additionally, a "Personal Information Form" was formulated to obtain demographic particulars of the teachers. This data collection instrument, administered through the online Google Form platform, was shared with willing participants via a link, aligning with the principle of voluntary participation. This scale comprises 36 items and is structured around five sub-dimensions, rated on a 5-point Likert scale, denoted as follows: (1) "Not at all adequate," (2) "Not adequate," (3) "Undecided," (4) "Adequate," and (5) "Very adequate." The overall scale demonstrated a high level of internal consistency, with a coefficient of .966, while the sub-dimensions exhibited values ranging from .828 to .936, encompassing technical (.934), instructional content (.910), technology use in teaching (.936), distance education software (.915), and emotional communication (.828). The examination of the five-factor model's data fit revealed AGFI (.85), GFI (.90), NNFI (.91), CFI (.92), and IFI (.93) values, all of which met acceptable criteria.

Confirmatory Factor Analysis (CFA) was conducted for the validity of the scale for the study group in this research. The values of the fit indices of the model were $\chi 2/sd=2.56$ (p=.000);

AGFI (.85), GFI (.90), NNFI (.90), CFI (.90), IFI (.91). It was found that the obtained model was acceptable for the relevant study group. Cronbach's Alpha internal consistency coefficients regarding the reliability of the scale were also re-examined. The internal consistency coefficient for the whole scale was calculated as (.831), and the values of the sub-dimensions were; encompassing technical (.891), instructional content (.852), technology use in teaching (.904), distance education software (.864), and emotional communication (.783).

Blended Learning Experience Open Ended Question Form

To elucidate comprehensive insights pertinent to the research objective, qualitative data was gathered from a cohort of 26 willing science educators who engaged in the study. The construction of the Open Ended Question Form commenced with a thorough review of pertinent literature (Graham et al., 2019). The ultimate iteration of the protocol was established through the collective consensus of three researchers, each specializing in distinct domains. The qualitative data was elicited through the use of two primary inquiries:

(1) What is your evaluation of the incorporation of traditional face-to-face instruction with online tools?
(2) I do/do not implement the Blended Learning model in my courses because...

Data Analysis

Quantitative Data Analysis

Initially, an assessment of missing and extreme values was conducted to scrutinize the distribution of scores derived from the Self-Efficacy Perception of Distance Education Scale, which constituted the quantitative dataset in this study. It was ascertained that missing values comprised less than 5% of the dataset, and occurred randomly, and the response pattern of three individuals with missing data was subsequently excluded from the dataset. Z values and Mahalanobis coefficients were then computed to identify potential outliers. The threshold value for Z values was established at three (Field, 2009). Upon examination of Mahalanobis distances, no outliers were detected. Subsequently, the dataset underwent necessary preparations for subsequent analyses, including descriptive assessments of the total scale scores of the scale. Measures of central tendency and dispersion were computed accordingly. To address the second research question, a multiple regression analysis was employed. Before the analysis, key assumptions requisite for its application were rigorously tested. Data must meet pivotal assumptions such as normality, linearity, homogeneity, absence of multicollinearity among predictor variables, and absence of autocorrelation for the accurate execution of multiple regression analysis (Kalaycı, 2009).

In this context, normality, linearity, and homogeneity assumptions of the data were examined and these assumptions were met. It was determined that the relationship between the predicted variables and the predictor variables was linear, there was no multicollinearity when the pairwise correlations between the variables were examined, the variance inflation factor (VIF=1.19) value was lower than 10, the tolerance value (0.89) was higher than .20, and the condition index value (CI=14) was lower than 30. In addition, since the Durbin-Watson value (1.6) was between zero-two, it was determined that there was no autocorrelation. The discontinuous variables in the study were recoded as "dummy variables" in the regression analysis, while the continuous variables were taken as they were. In order to determine the

extent to which science teachers' self-efficacy perceptions towards designing distance education environments were predicted according to the determined variables, the standard approach from multiple linear regression analysis was used. Multiple linear regression analysis provides the opportunity to interpret the variance explained in the predicted variable by the predictor variables, whether this explained variance is statistically significant, and the direction of the correlation between the predictor variables and the predicted variables (Alpar, 2003; Tabachnick & Fidell, 2013). In the standard approach, the aim is to jointly examine the relationships of all variables identified as predictor variables on the predicted variable.

Qualitative Data Analysis

To gain insights into teachers' encounters with blended learning designs, two fundamental inquiries were formulated and subsequently subjected to content analysis. The objective of content analysis, employing an inductive approach, is to discern underlying concepts and relationships that elucidate the acquired data. In the process of content analysis, initial scrutiny involves examining the gathered data, segmenting it into distinct sections, and elucidating the meaning conveyed by each section. Following these stages, codes are organized into specific categories, culminating in the development of themes and sub-themes (Yıldırım & Şimşek, 2011).

Within this study, three researchers engaged in concurrent yet independent coding of all collected data. They subsequently convened to reach a consensus on the codes and establish themes and sub-themes by discerning the interrelations among the codes. To fortify internal validity, the identified themes and sub-themes underwent a comprehensive cross-verification process involving all researchers.

Validity and Reliability Analysis of Qualitative Data

The qualitative data collection inquiries, formulated by three researchers, were disseminated to the participating teachers, and subsequently, the data volunteered by the teachers were subjected to analysis. To ensure the validity of the research, the researchers and an expert came together; the researchers explained the data collection process to the expert and they examined the qualitative data collected, the method of data analysis, and the results obtained together. As a result of the examination, the credibility of the researchers's approach in the research process was decided.

Three researchers independently created categories, sub-themes, and themes, and then came together to compare their findings. As coding was performed by more than two researchers, the inter-coder agreement level was calculated using the Kendall W test. The Kendall W coefficient of agreement between coders takes values between 0 and 1, where a value of .80 and above indicates sufficient agreement among the researchers (Howell, 2013). In this study, the value of W=0.84 ($\chi 2$=158.767; p< .05) suggests that coder reliability was achieved. In the analysis of the data, SPSS 21.0 statistical package was used.

In qualitative research, validity is the criterion for measuring the extent to which research participants' experiences are accurately conveyed in the study (Patton, 2014). In this context, to protect the identities of the participants in direct quotations, codes such as T1, T2, T3...T26 were assigned to the teachers. The entire process of the research was provided in detail. Ethical approval and participant consent were obtained. Multiple research designs and data collection methods were used, ensuring the credibility of the study.

Ethics Committee Report

This study strictly adhered to the ethical guidelines stipulated in the "Directive on Scientific Research and Publication Ethics of Higher Education Institutions". No activities inconsistent with the ethical standards of scientific research and publication were undertaken. Before the commencement of the study, approval was obtained from the University Ethics Committee. The approval was granted on October 6, 2022, during the 2022/24 meeting, under decision number 2022/24-10.

Findings

Findings related to science teachers' perceptions of self-efficacy for distance education

Initially, descriptive statistics were computed for the scores derived from the scale administered to the educators.

Table 1. Descriptive Statistics of the Self-Efficacy Perception of Distance Education Scale

Variable	N	Arithmetic Mean	Median	Variance	Standard Deviation	Ranj	Skewness	Kurtosis	KMO (p)
Scale Score	175	140.5	142	794.9	28.2	140	-0.72	1.04	0.80

Upon examination of Table 1, it is evident that the descriptive statistics of the scale, including the arithmetic mean and median values, exhibit a proximity to each other. In a symmetrical distribution, when skewness and kurtosis coefficients fall within the ±1 range, it is construed as an indication that the distribution adheres closely to the symmetry axis (Çokluk et al., 2010). In this context, it can be affirmed that the skewness and kurtosis coefficients of the scores on the scale fall within the ±1 range. These findings corroborate a distribution closely resembling symmetry. Notably, Büyüköztürk (2012) contends that the Kolmogorov-Smirnov test is the preferred normality test for datasets with over 50 data points. The calculated p-value exceeding α =.05 attests that, at this level of significance, the scores do not exhibit a significant departure from a symmetrical distribution. Consequently, as indicated in Table 1, it is established that the variables manifest a normal distribution. Based on the research data, the computed arithmetic mean for science teachers' self-efficacy perception concerning distance education is 140. Given that the scale's potential range of scores spans from 36 to 180, it is evident that the scores attained by the teachers align with a notably high level of self-efficacy.

Findings on Predictors of Science Teachers' Self-Efficacy Perceptions Regarding Distance Education

The findings from the multiple regression analysis about the prediction of self-efficacy perceptions in distance education, a sub-objective of this study, are detailed in Table 2.

Table 2. Multiple Regression Analysis Results on Teachers' Self-Efficacy Perceptions

Predictor	B	Standard Error B	β	t	p	Binary r	Partial r
Constant	159.819	6.462		24.733	0.000		
Gender	-8.868	4.215	-0.153	-2.104	0.037	-0.345	-0.360
Seniority	8.841	5.056	0.130	1.748	0.028	0.156	-0.134
School type	-12.397	6.069	-0.154	-2.043	0.043	-0.720	-0.756
Class size	0.954	5.389	0.113	0.177	0.036	0.379	0.314
Lab. usage	-1.103	4.677	-0.017	-0.236	0.014	-0.099	-0.018
Online lab. usage	-13.840	4.257	-0.237	-3.251	0.001	-0.477	-0.443
$R= 0.62, R^2=0.38, F(6, 168)=4.738, p<.05$							

Based on the findings presented in Table 2, it is evident that gender, professional tenure, school classification, class size, utilization of laboratory environments, and teachers' self-efficacy in designing distance education environments exhibit a statistically meaningful correlation. Collectively, these variables account for 38% of the overall variance observed in teachers' self-efficacy perceptions ($R=0.62$, $R^2=0.38$, $F(6,168)=4.738$, $p<.05$). The mathematical regression model formulated for prognosticating these perceptions is provided below. Distance Education Self-Efficacy Perception = 159.819 – 8.868*gender + 8.841*seniority - 12.397*schooltype + 0.954*classsize - 1.103*face-to-face lab usage - 13.840*online lab usage

According to the obtained model, being male leads to an increase of 8.868 units in perception scores. Teachers with lower seniority, working in private schools, with smaller class sizes, and utilizing laboratories more frequently have higher self-efficacy perceptions. The height of the constant term (159.819) in the equation indicates that even when no variable is present, teachers' self-efficacy perceptions regarding designing distance education environments are at a high level. As indicated by the standardized regression coefficient (β), the hierarchical significance of the predictor variables to the predicted variable is as follows: online laboratory utilization, school classification, gender, professional tenure, class size, and in-person laboratory utilization. Upon scrutinizing the t-test values on the significance of the regression coefficients, it has been ascertained that the variables within the model serve as noteworthy predictors.

Findings Regarding Science Teachers' Blended Learning Experiences

In presenting the findings obtained through the analysis of the data from the open-ended question form, special care has been taken to select statements that best represent similar views expressed by the participants. In direct quotations from the participants, the use of [...] is employed to indicate the continuation of the participants' statements before or after the quoted text. The findings related to this research question have been categorized under two themes named "Perception" and "Experience." The sub-themes under each theme are presented in Table 3 and Table 4.

Table 3. Science Teachers' Perceptions of Self in Blended Learning Models

Thema	Sub-thema	Categories	Frequency
Perception	Positive perceptions	Positive attitude	11
		Openness to development	7
		Effective teaching	3
	Negative perceptions	Resistance to Learning	7
		Negative attitude	5
		Perception of Inadequacy	5

Table 3 shows that science teachers have formed two sub-themes in their perceptions of themselves in the Blended Learning Model (BLM) implementations; positive perception includes the categories of positive attitude (f=11), openness to development (f=7), effective teaching (f=3). Teacher T1 stated having a positive attitude as follows: *"I have been using online tools in my lessons for a long time. I have received various trainings on this topic and prepared eTwinning projects. I am always concerned about how to reach students faster and for longer periods."* Teachers' positive perceptions of BLM implementations also stem from their openness to development. Teacher with the code T11 mentioned, *"During the pandemic process, I conducted studies on how online tools can be used in lessons and presented them as seminars to teachers in various institutions. Therefore, it is an area I am knowledgeable about. I believe that the proportions should be well determined according to the content of the lessons. For example, in a lesson with applications like science, activities such as experiments and applications with students should be enriched with face-to-face lessons, and the theoretical and question-based part of the subject should be supported with online tools."* Effective teaching is also one of the aspects that determine teachers' positive perceptions of themselves in BLM implementations. Teacher with the code T5 mentioned, "*Learning becomes more effective when lessons are supported with online tools...*" expressing their views on this sub-category. The second sub-theme consists of negative perceptions; resistance to learning (f=7), negative attitude (f=5), and perception of inadequacy (f=5). Teacher T14... stated, *"A face-to-face lesson will always be more effective than an online one, and online activities will contribute. I think I don't need it right now. Since students are already addicted to screens, I try not to use it as much as possible..."* emphasizing a general resistance to BLM implementations. Teacher with the code T16 showed negative attitudes towards BLM implementations by stating, *"I don't feel the need for it right now. Since students are already addicted to screens, I try not to use them as much as possible."* Teacher with the code T12 expressed, *"I don't consider myself very competent. I believe that teachers' awareness and equipment in this field need to be further improved..."* indicating their perception of inadequacy in BLM implementations.

Table 4. Science Teachers' Experiences in Implementing BLM

Thema	Sub-thema	Teacher code
Positive Experience	Enrichment of teaching	T1, T2, T4, T5, T8, T10, T11,T12, T13, T14, T15, T16, T18, T24, T25
	Using online assessment and evaluation tools	T1, T4, T5, T6, T9,T11,T12, T13, T14, T18, T20, T21, T25
	Monitoring and evaluating instruction	T4, T6, T9, T11, T12, T13, T14, T18, T20, T21, T25
	Planning instruction	T2, T4, T8, T10, T13,T14, T18, T20, T21, T25
	Student-centered approach	T5, T8, T10, T18, T24, T12, T14,T25
	Feedback	T1,T6, T12, T18, T20, T21, T25
	In-service training recommendation	T5, T6, T8, T12, T26

	Benefiting from experiences	T1, T6, T11, T18, T23
	Reinforcing instruction	T8, T9, T18, T24
Negative Experience	Online infrastructure inadequacy	T2, T4, T7, T8, T9, T10, T12,T13, T14, T17, T21, T23, T24, T25,T26
	Reflection (school, parent, student)	T5, T7, T8, T10, T12, T17,T23
	Classroom management (screen dependency, time management, student attention, class size)	T9, T10, T11, T12, T23, T25
	Using when necessary	T4, T6, T11, T16, T20, T25
	Educational opportunity inequality	T6, T7, T24, T26

When Table 4 is examined, the experiences of science teachers regarding BLM (Blended Learning Model) applications are analyzed under two sub-themes: positive experiences and negative experiences. Positive experiences consist of 9 categories, including enrichment of teaching (f=15), using online assessment and evaluation tools (f=13), monitoring and evaluating instruction (f=11), planning instruction (f=10), student-centered approach (f=8), feedback (f=7), in-service training recommendation (f=6), benefiting from experiences (f=5), and reinforcing instruction (f=4). On the other hand, negative experiences consist of 5 categories, including online infrastructure inadequacy (f=15), reflection (school, parent, student) (f=7), classroom management (screen dependency, time management, student attention, class size) (f=6), using when necessary (f=6), and educational opportunity inequality (f=4).

From the teachers evaluated under the category of enriching teaching, teacher T25 expressed their thoughts as follows: *"In a study related to the moon, I require students to enter the online platform and perform various measurements. I prepare a detailed document about the topic and how to use the online platform, explaining what I expect from them. During the lesson, I provide information about the application and the work they will do on the document. Students enter the online application and perform their calculations and measurements on a selected crater, which they then record on the document I provided during the face-to-face lesson."* T25 exemplified how they integrate face-to-face and online applications in relation to a topic about the moon. Teacher T1, who uses online assessment and evaluation tools, mentioned, *"I conduct end-of-topic tests with tools like Plickers and Quizizz,"* while T6 stated, *"... I use EBA (Educational Informatics Network) and plan to use it for video parts for review purposes during the topic presentation. For the application part, I assign tasks. In the evaluation section, I check the correctness of the answers individually from the reports section."* According to the data from T14, they focused on monitoring and evaluating instruction with an emphasis on process evaluation: *"...In this section, process evaluation should be at the forefront. Face-to-face and online activities can be conducted together in a way that feeds each other, and a summative evaluation can be made. However, the process must be evaluated with formative evaluation methods to support it."* Among the 7 teachers who focused on providing feedback, T11 stated, *"...I check the correctness of the answers individually from the reports section in the evaluation section..."* to emphasize the importance they give to feedback.

T13, who emphasizes planning according to the blended learning model, has described their planning practices step by step: *"I generally pay attention to preparing and implementing project-based lesson plans. I value interdisciplinary learning. I focus on using real-life examples and experiential learning. In the planning phase, I choose the appropriate web2 tool according to the activity of the project or the learning outcome. I mostly use these online-prepared and implemented activities in the evaluation section. As the learning through discovery method is not suitable for class hours and class size, I first present the knowledge through presentation aligned with the learning outcome, and after the introduction and*

development part of the lesson, I use the online application to reinforce the learning and for lesson evaluation...".

Going beyond planning, T18, who uses the blended learning model to reinforce instruction, stated, *"...According to my students' requests and desires, at suitable times, on desired topics, we solve questions using online tools to reinforce the subjects...,"* providing information about the process. Two teachers, T5 and T18, who focus on student-centered approach, shared the following about their student-centered practices: T5: *"...I select an appropriate material and present it to my students in the classroom or through online sharing. In the evaluation stage, I first ask my students for their opinions...".* T18: *"...According to my students' requests and desires, at suitable times, on desired topics, we solve questions using online tools to reinforce the subjects...".* Teachers who want to improve themselves in the blended learning model expressed their willingness to receive in-service training in this regard. T12's comment, *"...Teachers can be informed about online applications and how they can be supported within the curriculum, and in-service trainings can be provided,"* supports this view.

Five teachers who implemented the blended learning model emphasized that they benefited from their experiences during the pandemic. T18's views on this matter are as follows: *"...The general experience we gained from the lessons we conducted through distance education during Covid-19 showed that this is feasible. With proper planning and the full resolution of issues like internet and tablets, we can use this model in the future, taking into account disasters such as earthquakes, floods, and pandemics that our country has experienced."* Teachers utilizing their experiences gained during the pandemic and making connections between those experiences are crucial findings.

Teachers who had negative experiences and were categorized under the "insufficient online infrastructure" expressed their views as follows: T12 stated, "...Our school's technical equipment is not sufficient for this..." T23 mentioned, *"Besides the slight lack of technologies like internet and tablets, students and parents are not accustomed to this type of education and do not consider the assigned tasks as mandatory."*

Among the teachers reflecting on their negative experiences, T10 expressed, *"...Students need to be more active...,"* directing the feedback towards the students; T12 stated, *"...Our school's technical equipment is not sufficient for this...,"* addressing the school; T23 conveyed, *"...Parents are not accustomed to this type of education and do not consider the assigned tasks as mandatory...,"* reflecting the feedback towards the parents.

T9, who had a negative experience in classroom management, stated, *"...some students access other websites during online classes and passively participate in the lesson..."* On the other hand, T12 expressed, *"...It is very challenging to keep the student in front of the screen under control. Because the other side may not be fully engaged in the subject. The student's self-discipline may not be suitable for this..."*

T16 and T20, who had negative experiences, consider using the BLM in necessary situations. T16 expressed, *"...Of course, it cannot replace face-to-face education, but I think it is a lifesaver in compulsory situations. I can easily use it when needed."* T20 stated, *"...In situations where we cannot conduct face-to-face lessons, online education adds richness and provides convenience."*

On the other hand, T7 cited opportunity inequality as the reason for their negative experience,

stating, *"...In the region where I work, not every student has equal access to the internet."* T26 expressed their negative experience related to opportunity inequality as well, suggesting, *"...I support blended learning and believe it will be beneficial, but first, all our students should have access to these opportunities. Additionally, teachers should receive hands-on training on this topic in face-to-face sessions..."*

Conclusion, Discussion and Suggestions

The research underscores that science educators exhibit a notably elevated level of self-efficacy perception in the realm of distance education. Comparable investigations conducted with diverse samples and across various subject domains have yielded congruent outcomes (Aytaç, 2021; Özcan & Saraç, 2020; Uzunboy, 2022). This heightened self-efficacy among teachers in distance education studies may be attributed to their exposure to this mode of instruction during the Covid-19 pandemic. The qualitative insights gleaned from the research indicate that educators who drew upon their pandemic-induced experiences hold favorable attitudes toward blended learning. This observation finds reinforcement in a separate study conducted by Ma, et al. (2021), which noted an enhancement in online teaching competencies among educators in China during the period of Covid-19 school closures. Per the quantitative findings of the study, educators exhibit a heightened level of self-efficacy perceptions in the context of distance education. However, when examining the qualitative data, it is observed that teachers' experiences with blended learning are reflected both positively and negatively. Some teachers expressed that their experiences with blended learning were not yet at a sufficient level.

The infusion of technology into the educational paradigm, coupled with the implementation of distance education, gives rise to a novel challenge in instructional management proficiency (Hung, 2015). Distance education, which encompasses both technology and instructional management dimensions, involves various aspects of teaching, from planning to evaluation, such as online learning tools and virtual classroom management. In this research, when examining the variables that predict science teachers' self-efficacy perceptions, it was found that male teachers, those with lower seniority, those working in private schools, those with smaller class sizes, and those using both face-to-face and online laboratories have higher perceptions of distance education compared to others. The higher perceptions of male teachers towards distance education can be attributed to their feeling more competent in online learning environments and having higher technological literacy skills. Within the literature, there exists a body of research (Horzum, et al., 2012; Kartal Temelli & Şahin, 2018; Kozikoğlu et al., 2021; Yenilmez et al., 2017; Yılmaz, 2012) demonstrating a notable gender-based disparity in teachers' self-efficacy perceptions towards distance education, favoring males. In parallel, other studies (Oğuz, 2013; Plumm, 2008; Schofield, 1995) corroborate this finding with qualitative evidence of the utilization of technology. On the other hand, some studies found no significant difference based on gender in the variables examined in this research and attitudes toward using information technologies (Güney & Mete, 2022; Gorder, 2008; Karaca, et al., 2021; Kurnaz, et al., 2020; Teo & Milutinovic, 2015). When examining the research and other studies in the literature, it is evident that different results have been obtained. However, in the ever-changing knowledge age, it is important to equip teachers with high self-efficacy perceptions towards distance education and an unchanging teacher competence regardless of gender.

The research findings on the influence of professional seniority align with prior studies encompassing educators across various disciplines, as indicated by Güney and Mete (2022), Moçoşoğlu and Kaya (2020), and Horzum et al. (2012). However, contrasting results were

reported by Karaca, et al. (2021) and Kurnaz et al. (2020), suggesting that teachers' perceptions of distance education may not significantly differ based on their tenure in the profession. Given the divergent perspectives in the existing literature regarding the significance of professional seniority as a variable in shaping teachers' perceptions of distance education, further research should be undertaken to enhance the depth of these insights.

Apart from teachers' characteristics, the qualitative aspect of the research includes variables related to classroom management and enrichment of teaching, such as school type, class size, and the use of online and face-to-face laboratories. When examining the literature, it is observed that teachers' perceptions of learning environments are higher for private school teachers compared to others (Koca, 2006; Ulaş & Ozan, 2010). It is known that class sizes are larger in public schools compared to private schools the teachers included in the research sample. The lower student numbers in private school classrooms, the higher socioeconomic status of parents, their involvement in the education process, and the higher performance criteria for teachers in private schools may contribute to the higher perceptions of distance education in this context. In this regard, class size, as a differentiating factor in teachers' perceptions of distance education, is an important variable, and lower class sizes create a more interactive classroom environment and higher teacher self-efficacy perceptions.

In the context of distance education, it is recommended to create classroom environments where the student's learning needs are addressed by prioritizing factors such as enriching teaching methods and using online assessment and evaluation tools (Shyr & Chen, 2017). As seen in the research findings, teachers of important subjects like science have shown a positive increase in their self-efficacy perceptions in both online and face-to-face environments when using laboratory facilities. This finding is supported by the study conducted by Kılıç et al. (2015), where they found that science teachers' self-efficacy perceptions increased with their use of laboratory facilities.

In blended learning environments, which combine virtual and physical laboratories, a wider range of experiments can be offered to students, providing advantages that laboratories alone cannot offer and enhancing the effectiveness of scientific research (De Jong et al. 2013). Yapıcı and Akbayın (2012) investigated the impact of the blended learning model on academic achievement in biology and the attitudes towards the internet among high school students. They determined that teachers' preparation of activities such as videos and animations allowed students to better understand the subject. Through the online quizzes, students could test themselves and identify areas where they were less efficient, leading to an increase in their academic achievements.

Researchers suggest that when teachers use blended learning, they should also enhance their computer and internet literacy. Enriched blended learning environments, employing different methods such as gamification, 5E, and Quantum Learning Cycle, are more effective compared to traditional blended learning at all educational levels and across computer-based and other subjects (Çırak-Kurt et al., 2018).

Within the academic discourse, blended learning is recognized for its capacity to bolster an array of classroom management functions, encompassing tasks like assessment, feedback provision, augmenting learning prospects, furnishing efficacious and streamlined learning encounters, enabling students' access to information and resources, as well as engendering motivation through collaborative and interactive engagements (Bath & Bourke, 2010; Saliba et al., 2013; Smyth et al., 2012). Kashefi et al. (2012) also emphasized that blended learning

contributes to students' communication and teamwork skills. As technology advances, classroom and classroom management approaches change, leading to a shift in the role of teachers (Fegely et al., 2020). Teachers are moving away from being mere intermediaries between knowledge and students. Nowadays, teachers' primary task is to guide students in inquiry-based lessons and help them with technology use (Littleton & Kerawalla, 2012). Blended learning environments, where the roles of learners and teachers are reexamined, involve teachers constantly interacting with and guiding students as coaches and mentors rather than being mere educators. This kind of learning, which can be called competency-based, ensures that students grasp the current lesson and skills before moving on to the next one (Clark, 2020).

Blended learning necessitates proficiency in technology utilization. Nevertheless, a considerable portion of educators may lack the requisite experience in employing technology to support their students (URL-1, 2020). Applications of blended learning may at times demand the utilization of advanced information and communication technologies. Thus, there is a critical need to augment teachers' computer literacy in order to heighten the efficacy of the learning process (Abubakar & Adetimirin, 2015). Within this context, studies emphasizing the limited proportion of pioneering and trailblazing educators who demonstrate a willingness to cultivate innovative pedagogical strategies and digital competencies (Kıymet & Çakır, 2023) underscore the imperative for teachers to enrich their experiences in blended learning.

In the study's qualitative findings, science teachers provided in-service training recommendations related to blended learning. Similarly, the study by Güney and Mete (2022) found that receiving in-service training in distance education and information technologies positively affected teachers' self-efficacy regarding information technologies.

This research is limited to the blended learning experiences of science teachers. It is recommended to conduct similar studies with teachers from different disciplines, make comparisons, and compare the experiences of teachers from different countries. It is also suggested to focus on implementing practices that enrich science teachers' blended learning experiences and create environments where they can share their experiences.

Finally, future research should explore blended learning experiences across diverse disciplines and countries, allowing for comparative analysis and the implementation of practices that enrich teachers' experiences in blended learning environments. Creating platforms for educators to share their experiences can further contribute to enhancing teaching effectiveness in distance education.

Note

A part of this article was presented as an oral presentation at the X. International Congress on Education Programs in 2022.

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