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Investigating the Effect of Differentiated Instruction on Academic Achievement and Self-Directed Learning Readiness in an Online Teaching Profession Course

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Abstract

This study investigated the effect of differentiated instruction on Turkish preservice teachers' academic achievement and self-directed learning readiness in an online teaching profession course. The study utilized a pretest-posttest control group design. Data were collected through an achievement test and a self-directed learning readiness scale. The independent samples t-test, paired samples t-test, and analysis of covariance were used to analyze the data. The findings revealed that online differentiated instruction had a significant impact on the academic achievement of preservice teachers, while it did not create a significant difference in terms of total self-directed learning readiness, self-management, desire for learning, or self-control. As a result, it is seen as essential for teacher educators to conduct differentiated instruction in order to enhance preservice teachers' academic achievement and motivate them to use this approach in their future classes. It is also suggested that teacher educators provide preservice teachers with sufficient support to improve their self-directed learning readiness.

Keywords: Online differentiated instruction, online instruction, academic achievement, self-directed learning readiness, preservice teachers

Introduction

It is critical for a country to develop academically responsive classrooms by creating heterogeneous learning communities with high-quality curriculum and instruction in order to optimize each learner's learning ability (Tomlinson, 1999). Students that are in the same class because they are the same or similar ages do not necessarily have the same learning rate or readiness level (Sousa & Tomlinson, 2011). However, in traditional instruction, teachers "teach to the middle" (Haager & Klingner, 2005, p.

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19), which means that the majority of the students' needs are not met. Teachers should value students' learning preferences, needs, profiles, types of intelligence, genders, or cultures of origin in classrooms with students whose learning paces, interests, and needs, as well as readiness levels, differ (Tomlinson, 2004, 2014). In other words, teachers must acknowledge that each student is unique and differentiate content, learning processes, and products based on student readiness (Sousa & Tomlinson, 2011). Instruction designed around students' needs has the potential to boost student engagement and academic success (Asim et al., 2020).

As the demand for online learning has increased, especially with the outbreak of the COVID-19 pandemic, it has become necessary to support students in achieving their academic goals in online classes. Despite this increase, the related literature has highlighted some weaknesses in online learning, such as lack of interactivity (Stefanovic & Klochkova, 2021), lack of variety in teaching methods and activities (Ozudogru, 2021), social isolation (Sharma, 2021), and loss of hands-on activities (Ramlo, 2021). In this sense, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) has recently launched an initiative that demands more research about how to design online learning in a complex and uncertain world (Huang et al., 2021). One suggestion is that differentiated instruction may cater to different learning needs, interests, and readiness levels in online classes.

Review of Related Literature

Differentiated classes are learning environments in which teachers provide students with multiple options for taking in information, making sense of ideas, and showing what they have learned (Tomlinson, 2004). Teachers who differentiate believe that different students have different needs, so they plan a variety of ways to manage all students' learning (Tomlinson, 2004). Furthermore, differentiated instruction provides multiple approaches to the content being taught, the learning process, and assessment (Anderson, 2007; Tomlinson, 2004, 2014). Differentiating content refers to adapting how students will reach the desired knowledge or skills. Teachers may adapt their plan by using texts, novels, or short stories at different levels. Also, teachers may provide flexibility to the students by letting them work in similar groups with books or the internet to develop their understanding of the topic. Differentiating the learning process refers to how students are processing concepts and skills. Differentiated instruction—as opposed to traditional instruction, which requires students to complete the same type and amount of practice regardless of prior knowledge, abilities, or learning styles—allows teachers to differentiate based on students' readiness levels, resulting in clustering students in similar circles. Differentiating the learning process may also include individualized homework, learning centers, and autonomous work activities. Differentiating assessment means affording students different ways to demonstrate what they have learned through varied products. This may be accomplished by using choice boards or open-ended lists of potential product options that students can choose from (Anderson, 2007; Tomlinson, 2004, 2014). Boelens et al. (2018) investigated instructors' differentiated teaching strategies and beliefs in blended learning, finding that the most frequently used strategy was differentiating products by offering additional support throughout product development.

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Pham (2012) also suggested three ideas that teachers might use as a guide when differentiating instruction: (a) appropriate challenging activities—learning assignments for students should be fairly difficult; (b) flexible groups and classroom arrangements—individual, pair, or group work allows students to take on varied responsibilities, and physical settings must allow for student interaction; (c) ongoing assessment and appropriate scaffolding—teachers should use a variety of assessment techniques to determine students' actual development levels in order to prepare learning activities that are appropriate for their readiness levels.

There have also been some concerns raised about the use of differentiated instruction. For instance, Wan (2016) revealed that preservice teachers in Hong Kong were concerned about classroom management and fairness in evaluation after undertaking a course about differentiated instruction. During the design and implementation of a two-hour differentiated teaching in schools within the scope of a practical course, preservice teachers encountered difficulty in planning activities relevant to the students' readiness and in classroom management, according to Kokkinos (2020). According to Gaitas and Alves Martins (2017), the realm of "activities and materials" was the hardest to identify among Portuguese primary school teachers. They also perceived difficulty in assessment, management, planning, and preparation. Courtney (2021) examined the challenges and supports of a teacher while differentiating mathematics instruction in blended and online learning and found that digital resources both were helpful and hindered differentiated learning practices.

In addition to presenting teachers with these challenges, differentiated classrooms also necessitate a different role for teachers: rather than dispensers of knowledge, teachers become mentors or coaches (Tomlinson, 2004). In these classes, teachers assign students as much responsibility for learning as they can handle and work to enhance their self-directed learning readiness. Knowles (1975) defines self-directed learning (SDL) as "a process in which an individual with or without the assistance of others, diagnoses their learning needs, formulates and implements appropriate learning strategies, and evaluates learning outcomes" (p. 18). In the SDL process, students are encouraged to take responsibility for their own learning, identify their learning needs, and investigate available resources for accomplishing their learning goals and improving learning outcomes (Yang, 2016). In other words, learners control their own learning, which leads to increased autonomy. According to Fisher et al. (2001), SDL requires self-management, self-control, and desire for learning. Khiat (2017) adds some other properties of SDL, such as goal setting, time management, procrastination management, stress management, note-taking, research ability, exam and assignment preparation, seminar class readiness, online class readiness, and technical readiness.

All students are expected to be lifelong self-directed learners to fulfill the demands of today's educational environments, so teachers need to know how to empower students' development as self-directed learners (du Toit-Brits, 2020; Van Deur, 2021). According to Silen and Uhlin (2008), students need challenge, support, and feedback in the process of becoming self-directed learners and thus require attention from teachers. A teacher's role is that of a guide for students in this process. Du Toit-Brits (2020) highlights that educators should seek students' educational background and contextual factors that may block this process, identify students' SDL readiness and willingness, and promote it by using cooperative learning. Furthermore, it is vital to identify possible learning goals, monitor students' learning contracts, and make provisions for self-assessment (du Toit-Brits, 2020). SDL

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readiness is also linked to academic performance. Khiat (2017) reveals that students' perceived competence in 11 SDL indicators such as goal setting, time management, and procrastination management had a direct or indirect effect on their academic performance. As a result, it is critical for educators to assist students in becoming self-directed learners.

SDL is vital not only in traditional classes but also in online courses (Rohs & Ganz, 2015) because of the shift from teacher control to student control (Fournier et al., 2014). Relevant literature highlights that online learning environments aid in the development of SDL skills (Kim et al., 2014; Laine et al., 2021; Rashid & Asghar, 2016) because the unrestricted "anywhere and anytime" learning environment provided by online learning allows students to take control of their learning process by providing flexibility and choice (Liaw et al., 2007). In both online courses and differentiated classes, teachers have comparable responsibilities as guides or mentors in the learning process. As a result, it is necessary to further inquire whether differentiated classes conducted online aid students' SDL readiness.

In the past decade, an increasing number of researchers have undertaken studies on differentiated instruction in face-to-face learning situations in both Turkish and international contexts. In comparison to traditional classes, differentiated instruction enhanced students' academic achievement significantly in different grade levels and courses, according to relevant literature (Al-Shehri, 2020; Antonios et al., 2020; Bal, 2016; Clark et al., 2021; Demir, 2013; Eissa & Mostafa, 2013; Jørgensen & Brogaard, 2021; Joseph et al., 2013; Karadayı-Evyapan, 2021; Ozer, 2016; Senturk, 2017; Suleiman et al., 2021; Valiandes & Neophytou, 2018; Yabas & Altun, 2009). Despite this, there are few studies on differentiated instruction in teacher education (Joseph et al., 2013; Tulbure, 2011). Joseph et al. (2013) sought to determine the effect of differentiated instruction on second grade preservice teachers' academic achievement in a curriculum studies course. The findings revealed that preservice teachers in a differentiated teaching group received higher grades than their counterparts in the traditional instruction group. Similarly, Tulbure (2011) revealed that preservice teachers who received differentiated instruction had statistically higher academic achievement.

There is also an increasing number of studies regarding the implementation of differentiated instruction in an online or blended learning setting (Attard & Holmes, 2020; Gulsen, 2018; Karadayı-Evyapan, 2021; Kim et al., 2011; Osifo, 2019; Rosen & Beck-Hill, 2012; Sun, 2021; Wilkinson, 2013). Attard and Holmes (2020) investigated blended learning experiences of teachers and students in secondary mathematics courses and found that blended learning provided differentiation and personalized learning approaches, alternative methods for feedback and communication, and visualization of mathematics concepts. Students also improved in self-confidence and self-efficacy because of differentiation. Gulsen (2018) sought the effect of online differentiated reading instruction on fifth grade students' English language reading comprehension skills and learner autonomy. The study found that students improved their reading comprehension skills as well as their ability to read independently. Karadayı-Evyapan (2021) investigated an online differentiated instruction process in a primary mathematics lesson. The findings indicated that students showed academic success. Moreover, students developed transfer skills, yet their use of reflective thinking was not at a meaningful level. The study also demonstrated that students had a positive attitude toward activities and the process. Kim et al. (2011) investigated the effect of a blended reading intervention program,

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differentiated according to students' needs, on elementary school students' reading achievement. They found that the differentiated program had significant positive effects on students' reading comprehension skills and vocabulary, whereas it had no significant effects on reading fluency and spelling. Osifo (2019) investigated the effect of differentiated academic English courses that included web 2.0 tools and mobile-assisted language learning and found that such classes provided feedback, motivation, collaboration, research, and multimodality skills and pace as well as the freedom to choose the type of activity and assessment. Rosen and Beck-Hill (2012) investigated the impact of a blended learning one-to-one computing program on student achievement, finding that the program increased learning achievement and motivation, improved discipline, and reduced absences by promoting differentiated learning and teaching through the use of technology and a constructivist approach. Sun (2021) investigated two online reading programs applied in secondary schools to find out how differentiated instruction was reflected in them. The findings revealed that differentiated instruction was not fully reflected in the dimensions of affect and learning environment because of the online mode and that differences in engagement were found between higher- and lower-achieving students because of a lack of self-regulation and self-learning ability. Wilkinson (2013) investigated the effects of differentiated use of a specific online learning environment on knowledge levels of students, when an online module was utilized either at home or in class. The research results revealed that both types of instruction were effective in increasing students' knowledge base, with no significant differences between the two methods.

Scholars have argued for the critical role of providing preservice teachers with online learning environments that cater to all students' needs, interests, and preferences, as well as investigating the effectiveness of such classes on academic attainment. Because of the lack of variety in teaching approaches reported in online classes (Ozudogru, 2021) and the difficulty in creating engaging and dynamic learning environments (Herbold, 2011), online differentiated instruction may cater to all students' learning demands. However, investigating academic achievement and online differentiated instruction in a teacher education setting to cater to learner diversity has received little attention. To fill this critical gap in the literature, this study aims to further explore academic achievement in online differentiated teacher education settings. As a result of this study, it will be feasible to determine if an online teacher education class built on differentiated instruction principles has a substantial impact on preservice teachers' academic achievement.

In addition to academic achievement, studies have found that differentiated instruction improved attitudes toward courses (Eissa & Mostafa, 2013; Ozer, 2016; Senturk, 2017), retention levels (Demir, 2013; Ozer, 2016), self-efficacy beliefs (Yabas & Altun, 2009), metacognitive skills (Yabas & Altun, 2009), critical thinking skills (Al-Shehri, 2020), and problem-solving skills (Eissa & Mostafa, 2013) significantly. However, there are limited research studies on the impact of differentiated instruction on SDL readiness (Gencel & Saracaloglu, 2018). More specifically, Gencel and Saracaloglu (2018) examined the effect of a layered curriculum, in which teachers offer task options for learners ranging from easy to difficult, on preservice teachers' SDL readiness. To address this need, this study aimed to investigate the effect of online differentiated instruction on preservice teachers' academic achievement and SDL readiness. Based on the main aim of the study, I proposed four research questions:

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1. Is there a significant difference between the pretest and posttest academic achievement scores of the control and treatment groups?
2. Is there a significant difference between the pretest and posttest SDL readiness scores of the control and treatment groups?
3. After controlling for academic achievement pretest scores, is there a significant difference between the academic achievement posttest scores of the treatment and control groups?
4. After controlling for SDL readiness total, self-management, desire for learning, and self-control pretest scores, is there a significant difference between the SDL readiness total, self-management, desire for learning, and self-control posttest scores of the treatment and control groups?

Method

Research Design

The current study used a pretest-posttest control group experimental design to investigate the effects of online differentiated instruction on preservice teachers' academic achievement and SDL readiness. In accordance with the research design, I formed a treatment and a control group randomly. In order to address the first and second research questions, I investigated the pretest and posttest academic achievement and SDL readiness scores of preservice teachers in the treatment and control groups.

Participants

The participants of the study were sophomores studying in two different programs of an education department at a Turkish university. I chose the programs randomly. The treatment group consisted of 67 preservice teachers studying in the elementary mathematics teaching program, while the control group consisted of 58 preservice teachers studying in the social sciences teaching program. As a result, the study included a total of 125 preservice teachers. Furthermore, the treatment group included 12 males and 55 females, while the control group included 23 males and 35 females. I compared the groups to see if they were equivalent in terms of academic achievement and SDL readiness before the treatment. Table 1 and 2 show the results of the independent samples t-test.

Table 1. *Results of the Independent Samples T-Test to Compare the Academic Achievement of the Groups*

Group	M	SD	*t*	df
Control	45.03	11.49	4.05	123
Treatment	52.32	8.56		

$p < 0.05$

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As Table 1 shows, the pretest achievement mean score of the treatment group was $M = 52.32$, and the pretest achievement mean score of the control group was $M = 45.03$. I conducted an independent samples t-test to reveal whether the treatment and control groups were equal in terms of academic achievement. The results revealed statistically significant differences between the treatment and the control groups ($p < 0.05$). Hence, it can be said that they were not equal in terms of academic achievement before the treatment.

Table 2. *Results of the Independent Samples T-Test to Compare the SDL Readiness of the Groups*

Group	M	SD	t	df
Control	128.67	18.49	.94	123
Treatment	125.35	20.31		

$p > 0.05$

As Table 2 shows, the pretest SDL readiness mean score of the treatment group was $M = 125.35$, and the pretest SDL readiness mean score of the control group was M = 128.67. The independent samples t-test results showed no statistically significant differences between the treatment and the control group ($p > 0.05$). Thus, it is seen that the groups were equivalent in terms of SDL readiness.

Data Collection Procedure and Tools

I gathered the research data during the fall semester of the 2020–2021 academic year. I implemented the study, which lasted 12 weeks, in the Principles and Methods of Instruction course, a two-hour mandatory course taken in the second year of the preservice teacher education program by all preservice teachers. The same instructor taught the course for both departments and implemented it online because of the COVID-19 pandemic.

The instructor conducted traditional instruction in the control group. The traditional class used online lectures with PowerPoint slides, four assignments, and two examinations (one midterm and one final). The class lasted about 90 minutes each week and comprised lectures and discussions. Course syllabus and related course documents were posted on Moodle. Students prepared four lesson plans by using different approaches, methods, and techniques of instruction. In addition, students had a midterm examination consisting of open-ended and multiple-choice questions. The final examination included the questions in the academic achievement test, which was used as the posttest.

The instructor conducted online differentiated instruction in the treatment group. This class included differentiated instruction lesson plans and activities based on Tomlinson (2004). First, students' readiness levels, interests, and learning profiles were identified through a learner analysis form adapted from Senturk (2017) according to the aims of the current study. The learner analysis form included questions regarding demographic characteristics, individual characteristics (being a leader, shy, etc.), likes and dislikes about the implementation of the course (individual work, groupwork,

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stories, etc.), content students know and would like to learn about the relevant topic, ways students prefer when learning (verbal, oral, visual learning, etc.), materials they would rather be used (visual, audial, books, etc.), activities they want to implement during class (discussion, groupwork, projects, etc.) and evaluation types they would prefer (multiple-choice, open-ended questions). Then, the draft course curriculum was differentiated by considering individual differences between students in line with the principles of differentiated instruction. In this sense, the new curriculum included differentiated content, learning-teaching processes, and learning products. Appendix 1 shows sample differentiated lesson plans.

I used two data collection tools, an achievement test and a SDL readiness scale. I administered both tools to the preservice teachers in the first week of the semester as a pretest and in the last week of the semester as a posttest.

Achievement Test

I used the achievement test for the Principles and Methods of Instruction course developed by Ozudogru and Aksu (2019) to assess preservice teachers' academic achievement in both groups. The achievement test included a total of 40 questions, 39 of which were multiple-choice questions, and one of which was a matching-type question with five items. The test has a mean item difficulty index of 0.51, a mean item discrimination index of 0.37, and a Kr-20 reliability coefficient of 0.78. The maximum score to get from the achievement test is 100.

Self-Directed Learning Readiness Scale

I utilized the SDL readiness scale, developed by Fisher et al. (2001) and adapted to Turkish by Sahin and Erden (2009), to find out preservice teachers' SDL readiness. It is also a 5-point Likert-type scale ranging from 1 = completely disagree to 5 = completely agree. It consisted of 40 items with three sub-dimensions: self-management with 13 items, desire for learning with 12 items, and self-control with 15 items. The Cronbach's alpha internal consistency coefficients for the sub-dimensions were 0.87, 0.86 and 0.79, respectively. The Cronbach's alpha internal consistency coefficient was verified again in this study, and it was found to be 0.84 for the overall scale, 0.85 for self-management, 0.70 for desire for learning, and 0.83 for self-control, indicating that the scale is reliable. The minimum score to get from the SDL readiness scale is 40 and the maximum score is 200.

Data Analysis

First, I examined the data to see if they had a normal distribution. Since the sample was more than 50, I conducted a Kolmogorov-Smirnov test. The results indicated that the data exhibited a normal distribution ($p > 0.05$). In addition, I used skewness and kurtosis in order to assess the normality of the data. According to Field (2013), skewness and kurtosis values should be equal to zero to assure normal distribution; however, according to George and Mallery (2010), skewness and kurtosis values between -2 and +2 are also acceptable. As a result of the analysis, the data were in acceptable ranges for normal distribution and basic assumptions for parametric tests were fulfilled. Hence, I employed an

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independent samples t-test to compare the academic achievement and the SDL readiness of the control and treatment groups. I also utilized a paired samples t-test to explore if there was any significant difference between the pretest and posttest academic achievement and SDL readiness scores within the control and treatment groups.

In addition, I employed analysis of covariance (ANCOVA) to compare the posttest mean scores of the treatment and control groups. ANCOVA controls the effect of a covariate, which is a variable linked with a dependent variable other than the independent variable being investigated (Field, 2013).The pretest academic achievement mean scores are defined as covariates, since they were not equivalent before the treatment. I also used ANCOVA to compare the SDL readiness of the treatment and the control groups since, as Frigon and Laurencelle (1993) state, it is erroneous to conduct ANCOVA only when there are preexisting significant differences between the groups on potential covariates due to reduction in error variance, and it can be performed when no significant differences exist between groups.

Before running ANCOVA, I checked assumptions of homogeneity of variance and homogeneity of regression slopes both for academic achievement and SDL readiness scores. The findings of the Levene's test for academic achievement ($F(1,123) = 0.06$, $p = 0.80$) indicated that the variance was homogeneous, as was the homogeneity of regression slopes (FGroup*Pre$(1,121) = 0.00$, $p = 0.98$). Furthermore, the Levene's test results for SDL readiness ($F(1,123) = 0.99$, $p = 0.32$) revealed the homogeneity of variance and homogeneity of regression slopes (FGroup*Pre$(1,121) = 0.30$, $p = 0.58$).

Findings

I present the findings in line with the research questions. Table 3 shows the results regarding the pretest and posttest academic achievement scores of the control group.

Table 3. *Paired Samples T-Test Results Regarding the Pretest and Posttest Academic Achievement Scores of the Control Group*

Control Group	M	SD	*t*	Df
Pretest	45.03	11.49	-9.699	57
Posttest	66.20	13.44		

$p < 0.05$

Data in Table 3 show that the pretest mean score of the control group is M = 45.03 and the posttest mean score of the control group is M = 66.20. Also, the paired samples t-test results ($p < 0.05$) showed that the academic achievement of preservice teachers who were in the control group and received online instruction increased significantly. Thus, in partial response to research question number one, for the control group, online instruction was effective in enhancing preservice teachers' academic

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achievement. Table 4 presents the results regarding the pretest and posttest academic achievement scores of the treatment group.

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Table 4. *Paired Samples T-Test Results Regarding the Pretest and Posttest Academic Achievement Scores of the Treatment Group*

Treatment Group	M	SD	*t*	df
Pretest	52.32	8.56	-11.743	66
Posttest	74.35	13.83		

$p < 0.05$

Table 4 shows that the pretest mean score of the treatment group was M = 52.32, and the posttest mean score of the treatment group was M = 74.35. Paired samples t-test results revealed that the academic achievement of preservice teachers in the treatment group increased significantly ($p < 0.05$). Hence, in partial response to research question number one, for the treatment group, online differentiated instruction had a positive impact on the academic achievement of preservice teachers. Table 5 shows the results regarding the pretest and posttest SDL readiness scores of the control group.

Table 5. *Paired Samples T-Test Results Regarding the Pretest and Posttest SDL Readiness Scores of the Control Group*

Control Group	M	SD	*t*	df
SDL pretest total	128.67	18.49	-5.000	57
SDL posttest total	144.87	15.14		
Self-management pretest	41.79	9.00	-4.126	57
Self-management posttest	48.65	8.57		
Desire for learning pretest	38.31	6.43	-5.121	57
Desire for learning posttest	44.55	5.99		
Self-control pretest	48.56	10.39	.1.920	57
Self-control posttest	51.81	8.25		

$p < 0.05$

Table 5 indicates that the SDL readiness pretest total score of the control group was 128.67, and the SDL readiness posttest total score was 144.87. Paired samples t-test results also revealed that there was a statistically significant difference between the pretest and posttest SDL readiness scores of the control group. In partial response to research question number two, for the control group, this result showed that online instruction helped preservice teachers to improve their SDL readiness.

Addressing research question number two for the control group, Table 5 also shows that the control group's self-management pretest score was 41.79, while the self-management posttest score was 48.65, and this difference is statistically significant ($p < 0.05$). Furthermore, the control group's pretest score for the desire for learning sub-dimension was 38.31, while their posttest score was 44.55. Paired samples t-test results revealed that there were statistically significant differences between the pretest and posttest desire for learning scores of the control group ($p < 0.05$). Last, the self-control pretest score of the control group was 48.56, while their posttest score for self-control was 51.81; however, the results revealed no statistically significant differences between the pretest and posttest self-

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control scores of the control group (p > 0.05). Table 6 presents the results regarding the pretest and posttest SDL readiness scores of the treatment group.

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Table 6. *Paired Samples T-Test Results Regarding the Pretest and Posttest SDL Readiness Scores of the Treatment Group*

Treatment Group	M	SD	*t*	df
SDL pretest total	125.35	20.31	-7.886	66
SDL posttest total	148.28	12.96		
Self-management pretest	39.80	8.42	-7.209	66
Self-management posttest	49.62	5.96		
Desire for learning pretest	38.17	6.16	-10.748	66
Desire for learning posttest	49.62	5.96		
Self-control pretest	39.80	8.42	-10.382	66
Self-control posttest	53.38	8.00		

p < 0.05

As Table 6 reveals, the pretest SDL readiness score of the treatment group was 125.35, and the posttest SDL readiness score was 148.28. In partial response to research question number two for the treatment group, a paired samples t-test also found that the SDL readiness of the preservice teachers in the treatment group increased significantly, which indicated that online differentiated instruction had a significant impact on preservice teachers' SDL readiness.

The results regarding the sub-dimensions of the SDL readiness scale (research question number two) from Table 6 show that the self-management pretest score of the treatment group was 39.80, and the posttest score for self-management was 49.62. Paired samples t-test results indicated that there were statistically significant differences between the pretest and posttest self-management scores of the treatment group (p < 0.05). The desire for learning pretest score of the treatment group was 38.17, and the posttest score was 49.62, and the results revealed statistically significant differences between the pretest and posttest desire for learning scores of the treatment group (p < 0.05). Analyzing self-control scores from Table 6 revealed that the self-control pretest score of the treatment group was 39.80, while the posttest score was 53.38, and statistically significant differences existed between the self-control pretest and posttest scores of the treatment group (p < 0.05). Table 7 summarizes the results regarding the academic achievement posttest scores of the treatment and control groups.

Table 7. *ANCOVA Result for the Academic Achievement Posttest Scores of the Treatment and the Control Groups*

Source	SS	df	MS	F	η^2
Pretest	229.634	1	229.634	1.233	0.01
Group	1,586.295	1	1,586.295	8.518	0.06
Error	22,720.361	122	186.232		
Corrected Total	25,248.768	124			

*p < 0.01

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Addressing research question number three, the results of the ANCOVA analysis shown in Table 7 indicate that the treatment and control groups differed significantly in terms of their academic achievement ($F(1,122) = 8.518$, $p = 0.00$). After controlling for the pretest scores as covariate, ANCOVA results demonstrated that the posttest scores of the treatment group ($M = 74.35$, $SD = 13.83$) were significantly higher than those of the control group ($M = 66.20$, $SD = 13.44$). Hence, being in the differentiated instruction group had a significant impact on the academic achievement of the treatment group. Table 8 presents the results of ANCOVA in relation to the SDL readiness total posttest scores of the treatment and control groups.

Table 8. *ANCOVA Results for the SDL Readiness Posttest Total Scores of the Treatment and Control Groups*

	Source	SS	df	MS	F	η 2
SDL readiness posttest total scores	Pretest	7.474	1	7.474	0.03	0.00
	Group	348.917	1	348.917	1.761	0.01
	Error	24,168.293	122	198.101		
	Corrected Total	24,536.0480	124			
Self-management posttest scores	Pretest	60.753	1	60.753	1.145	0.00
	Group	20.189	1	20.189	0.380	0.00
	Error	6,476.022	122	53.082		
	Corrected Total	6,566.128	124			
Desire for learning posttest scores	Pretest	6.891	1	6.891	0.218	0.00
	Group	15.758	1	15.758	0.499	0.00
	Error	3,852.618	122	31.579		
	Corrected Total	3,875.488	124			
Self-control posttest scores	Pretest	14.998	1	14.998	0.226	0.00
	Group	80.768	1	80.768	1.217	0.01
	Error	8,095.826	122	66.359		
	Corrected Total	8,188.208	124			

*$p < 0.01$

The ANCOVA results presented in Table 8 show that the treatment and control groups did not differ significantly in terms of total SDL readiness ($F(1,122) = 1.761$, $p = 0.18$). Controlling the pretest scores as covariate, the results revealed that the posttest total scores of the treatment group ($M = 148.28$, $SD = 12.96$) were higher than those of the control group ($M = 144.87$, $SD = 15.14$), yet this difference was not significant. Thus, in response to research question number four, being in the differentiated instruction group had no significant impact on the SDL readiness posttest total scores of the treatment group.

As Table 8 shows, ANCOVA results indicate that no statistically significant differences existed between the treatment and control groups in terms of self-management posttest scores ($F(1,122) = 0.380$, $p = 0.53$). Controlling the pretest scores as covariate, the results determined that the self-management posttest scores of the treatment group ($M = 49.62$, $SD = 5.96$) were higher than those of the control group ($M = 48.65$, $SD = 8.57$); however, this difference was not significant. Hence, in

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response to research question number four, being exposed to differentiated instruction had no significant effect on the self-management posttest scores of the treatment group.

Table 8 shows that there were no statistically significant changes between the treatment and control groups in the desire for learning sub-dimension (F(1,122) = 0.499, p = 0.48), according to the ANCOVA results (F(1,122) = 0.499, p = 0.48). With pretest scores as a covariate, the treatment group's desire-for-learning posttest scores (M = 49.62, SD = 5.96) were higher than the control group's (M = 44.55, SD = 5.99), but the difference was not significant. Therefore, in response to research question number four, receiving differentiated instruction did not create a significant effect on desire-for-learning posttest scores in the treatment group.

Table 8 shows that no statistically significant differences existed between the treatment and control groups in self-control posttest scores (F(1,122) = 1.217, p = 0.272). When the pretest scores were controlled as covariate, the results determined that the self-control posttest scores of the treatment group (M = 53.38, SD = 8.00) were higher than those of the control group (M = 51.81, SD = 8.25), yet this was not statistically significant. As a result, in response to research question number four, differentiated instruction did not have a meaningful impact on the self-control posttest scores of the treatment group.

Conclusion and Discussion

The goal of this study was to see how online differentiated instruction affected preservice teachers' academic achievement and SDL readiness. As a consequence, the control group's mean on the pretest was 45.03, while the mean on the posttest was 66.20. There was a statistically significant difference between the pretest and posttest academic achievement scores. This improvement could be attributed to the use of appropriate strategies, methods, and procedures when teaching the course and providing effective feedback on course assignments in order to achieve the course objectives. The results also showed that the treatment group's mean on the pretest was 52.32, and the mean on the posttest was 74.35 following treatment. This difference was statistically significant as well. As a result, improving the online learning environment by differentiating in a teaching profession course contributed to preservice teachers' academic progress.

Although academic achievement increased in both groups, there was a statistically significant difference in favor of the treatment group when the posttest scores of the treatment and control groups were compared to determine if the treatment was more effective than traditional instruction. As a result, courses delivered through online differentiated education were more effective than those delivered through traditional online instruction. Supporting this finding, in various studies, differentiated instruction had a significant impact on learners' academic achievement (Al-Shehri, 2020; Antonios et al., 2020; Bal, 2016; Demir, 2013; Eissa & Mostafa, 2013; Jørgensen & Brogaard, 2021; Joseph et al., 2013; Kadum-Bošnjak & Buršić-Križanac, 2012; Karadayı-Evyapan, 2021; Muthomi & Mbugua, 2014; Ozer, 2016; Senturk, 2017; Tambaoan & Gaylo, 2019; Uzum & Pesen, 2019; Yabas & Altun, 2009). For instance, Tambaoan and Gaylo (2019) found a statistically significant difference

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between the treatment and control groups in favor of the treatment group in terms of academic achievement and engagement in a basic calculus course. In addition, Uzum and Pesen (2019) indicated that ninth grade students in the treatment group had statistically significant higher academic achievement compared to those in the control group in their English course.

The literature review uncovered no direct experimental investigation on the influence of online differentiated instruction on preservice teachers' academic achievement. As a result, this work will add to the literature by filling this essential gap. Differentiated instruction, according to Tomlinson (2014), is a response to the needs of children who learn in different ways and at varying rates rather than in "one-size-fits-all" settings, which could have led to much higher academic attainment in the current study. Taking preservice teachers' readiness levels and learner profiles into consideration, letting them work with peers at the same level, exposing them to more materials during instruction, and giving them responsibility appropriate to their level (Demir, 2013) might have all contributed to this outcome. This outcome can also be attributed to differentiated instruction since it fosters a learning environment in which students engage in more cognitive processes and establish stronger connections across curriculum topics (Kadum- Bošnjak & Buršić-Križanac, 2012). However, there are studies that do not match the results of this study. For example, Johnson (2010) found no statistically significant difference in terms of academic achievement between the treatment and control groups formed from eighth grade students. Similarly, Ucarkus (2020) revealed that there was no significant difference between the post-test scores of the treatment group exposed to differentiated instruction and control group in a social sciences course.

The research results also revealed that the control group's SDL readiness mean on the pretest was 128.67, while the mean on posttest was 144.87. The difference between the pretest and posttest SDL readiness scores was statistically significant. Giving students responsibility for their own learning, providing frequent feedback on their assignments, and supporting them throughout instruction may have contributed to this increase. Also, the SDL readiness mean of the treatment group increased from 125.35 to 148.28, which was statistically significant. Online differentiated instruction was effective in enhancing the SDL readiness of preservice teachers. This result may be due to the flexible learning environment that differentiated instruction provides because improving SDL requires providing a flexible learning environment to students (Gencel & Saracaloglu, 2018). The results also revealed statistically significant differences between the control group's self-management and desire for learning pretest and posttest scores but no significant differences between the control group's self-control pretest and posttest scores. In contrast to the control group, the study found significant differences between the self-management, desire for learning, and self-control pretest and posttest scores of the treatment group. The fact that preservice teachers in the treatment group had the option to control their learning during differentiated classrooms may have contributed to significant disparities in self-control on their behalf. As Anderson (2007) also states, critical elements of choice and flexibility in differentiated instruction consequently lead to increased control over students' own learning, which also improves student responsibility and accountability with regard to their learning.

However, the research results demonstrated that online differentiated instruction did not create a significant difference between the treatment and control groups in terms of SDL readiness total scores and the sub-dimensions of self-management, desire for learning, and self-control when the posttest

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scores were compared. This result may be due to the fact that online instruction itself might have enhanced the SDL readiness of the preservice teachers in both groups. The literature indicates that online instruction is strongly linked to SDL readiness and enhances SDL (Baptista et al., 2020; Kim et al., 2014; Laine et al., 2021; Ozudogru, 2021; Rashid & Asghar, 2016). As a result, I suggest providing preservice teachers with sufficient support in online learning environments to improve their SDL readiness. In line with this suggestion, Zhu (2021) discusses how students' self-management skills for SDL in online courses can be supported through the implementation of learning goals (e.g., explanations and appreciation of students' learning goals); time management (e.g., providing time frames, progress indicators, and short learning units); resource and support management (e.g., flexible learning resources, peer assessments, and accessibility); and navigation (e.g., clear organization and video tutorials on navigating the online system). Asim et al. (2020) suggest that e-portfolios, e-pals, social media, and virtual field trips may help to differentiate online instruction since these play an important role by allowing students to increase self-directed learning skills, meaningful written interactions, and experiences while meeting their needs. The results of some studies do not match those of the current study. For instance, Gencel and Saracaloglu (2018) investigated the effect of a layered curriculum, in which the teacher presents task options for the same learning attainment ranging from easy to difficult, on preservice teachers' SDL readiness and found that a layered curriculum had a significant impact on the SDL readiness of preservice teachers.

As a result of the research findings, it is considered essential for teacher educators to conduct differentiated instruction in both online and face-to-face classes in order to enhance preservice teachers' academic achievement and SDL readiness. Teacher educators can also serve as role models for preservice teachers by using differentiated instruction in their own classes.

In addition, teacher education programs should provide explicit instruction on how to implement differentiated instruction. Preservice teachers may be asked to plan and implement differentiated classes in their teaching practicums to bridge the gap between theory and practice. A differentiated instruction course could also be designed in which preservice teachers are introduced to the concepts of differentiation and strategies to implement effective differentiated instruction, such as a tiered approach to learning, as well as practical experiences and opportunity for reflection (D'Intino & Wang, 2021; Wan, 2016). Furthermore, it is also essential to support in-service teachers through professional development programs so that they may differentiate their instruction to meet the needs of all students. According to Valiandes and Neophytou (2018), quality professional development programs can help teachers alter their instructional approaches while also improving student achievement levels. Differentiated instruction, while creating a dynamic and effective learning environment, is also a difficult teaching strategy that necessitates training, practice, and resources (D'Intino & Wang, 2021).

Limitations and Suggestions for Further Research

There were some limitations in this study. This study was limited to data produced from preservice teachers in two programs departments of an education department at a Turkish university. Hence, the findings of the present study may not be applicable to preservice teachers at other universities. Further

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research on the impact of online differentiated instruction on preservice teachers' academic achievement and SDL readiness could be conducted on a larger sample of preservice teachers.

Moreover, this quantitative study was limited to data regarding academic achievement and SDL readiness. Further studies might examine the effect of online differentiated instruction on preservice teachers' retention levels or higher-order thinking skills, as well as their self-efficacy in delivering differentiated instruction in their future classes. New research may also explore preservice teachers' attitudes about online differentiated instruction, as well as the factors that influenced their academic accomplishment and SDL readiness through interviews. Longitudinal studies could also find out how preservice teachers apply differentiated instruction in their teaching practicums.

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Appendix 1. Sample Differentiated Lesson Plan

Name of the Course	Principles and Methods of Instruction
Topic	Teaching Methods (narration, case, discussion, demonstration, problem-solving)
Duration	45 min. + 45 min.
Aims	1. Students can explain the characteristics of teaching techniques. 2. Students can answer questions regarding teaching techniques. 3. Students can design lesson plans using different teaching techniques. 4. Students can prepare micro-teaching videos showing the use of teaching methods. 5. Students can evaluate lesson plans based on different teaching methods.
Strategies, methods, and techniques	Cooperative learning, discussion, question-answer through Kahoot application, Buzz66
Lesson materials and teaching technologies	Internet, computer, PowerPoint slides
Learning-teaching activities (61 min.)	The instructor first informs the students about the aims of the class. Then, the instructor presents the basic characteristics of each teaching method, which needs to be known by every student, via PowerPoint slide (15 min.). Then, the instructor gives some choices for the students to work on teaching methods in depth (15 min). The alternatives are: - Searching for detailed information regarding the advantages and limitations of each method from internet sources and summarizing them. - Searching for sample implementation videos of teaching methods on YouTube and discussing how they are conducted. - Searching for an article about the effects of teaching methods on academic achievement and other variables and summarizing the results. After that, a whole-class discussion is conducted about the advantages and limitations, implementation details and effects of teaching methods (10 min.). Students are then asked to choose a teaching method and think how they would implement it in a mathematics class. Students can discuss this either individually or in groups of six. For students who would like to discuss in groups, the Buzz 66 technique is used. Discussion rooms are formed, each of which consists of six students, and they discuss for six minutes (6 min.). Then, students share their opinions to the whole class (5 min.) Later, the instructor uses the Kahoot application. Students answer six multiple-choice questions regarding the characteristics of teaching methods from Kahoot. (10 min.)
Measurement and evaluation (29 min.)	Then, students are provided with some choices to show what they have learned. Students may work either individually or in groups. The tasks are: -First, prepare a lesson plan by using different teaching methods. -Second, prepare questions about teaching strategies on the Kahoot application.

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| | -Third, prepare a micro-teaching video showing teaching of a mathematics topic by using different teaching methods.
-Forth, search for sample lesson plans on the internet and evaluate them about the correct/wrong use of teaching methods.
-Fifth, discuss the results of an article regarding the use of teaching methods and present the findings of the article to the class.

Preservice teachers start working on the tasks until the end of the class and are asked to present their work in the following week. |