

Determining Preservice Science Teachers' Levels of Competence in 21st-Century Skills

Hilal Aktamış^a, Emrah Hiğde^{b*}, & Ekin Dalgıç^c

a Prof. Dr., Aydın Adnan Menderes University, <https://orcid.org/0000-0003-0717-5770>

b Assoc. Prof. Dr., Aydın Adnan Menderes University, <https://orcid.org/0000-0002-4692-5119> *emrah.higde@adu.edu.tr

c Master's Degree Student., Aydın Adnan Menderes University, <https://orcid.org/0000-0002-3414-9765>

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Abstract

The purpose of this research was to identify the 21st-century skills of preservice science teachers (PSTs) and compare their skills in terms of gender, year of study, and university. For this purpose, a cross-sectional survey was used to collect data from eight state universities in the Aegean region. The sample consisted of 799 first-, second-, third-, and fourth-year PSTs studying in the 2019-2020 academic year. For data collection, a 21st-century skills scale was developed based on the sub-sets of 21st-century skills existing in the scale development and adaptation studies. According to the research results, female PSTs had statistically significantly higher scores than male PSTs in the communication sub-scale of the 21st-century skills scale. Additionally, PSTs' communication and creativity scores differed significantly according to their year of study. Third-year and second-year PSTs had higher creativity scores than first-year and fourth-year PSTs. Third-year PSTs also had higher communication scores than first-year and fourth-year PSTs. PSTs' communication and cooperation scores also differed significantly according to their university. PSTs studying at universities that accept students scoring lower on the university entrance exam had higher communication and cooperation scores. In line with these results, future work might help PSTs acquire and develop 21st-century skills.

Keywords: 21st century skills, gender, year of study, pre-service science teachers.

Fen Bilgisi Öğretmen Adaylarının 21. Yüzyıl Becerilerine Yönelik Yeterlik Düzeylerinin Belirlenmesi

Öz

Bu araştırmanın amacı, fen bilgisi öğretmen adaylarının 21. yy becerilerini belirlemek ve cinsiyetlerine, sınıf düzeylerine ve üniversitelerine göre 21. yy becerilerini karşılaştırmaktır. Bu amaçla Ege bölgesindeki sekiz devlet üniversitesinden veri toplamak için kesitsel tarama kullanılmıştır. Araştırmanın örneklemini 2019-2020 eğitim öğretim yılında 1., 2., 3. ve 4. sınıfta öğrenim gören toplam 799 fen bilimleri öğretmen adayı oluşturmaktadır. Veri toplamak amacıyla literatürde yer alan ölçek geliştirme ve uyarlama çalışmalarından 21. yüzyıl becerilerinin alt boyutları toplanarak 21. yüzyıl becerileri ölçeği geliştirilmiştir. Araştırma sonucunda, kadın fen bilgisi öğretmen adayları, 21. yy becerileri iletişim alt boyutunda erkek katılımcılara göre istatistiksel olarak anlamlı düzeyde daha yüksek puan almıştır. Ayrıca katılımcıların iletişim ve yaratıcılık becerileri puan ortalamaları sınıf düzeyine göre anlamlı farklılık göstermiştir. Üçüncü ve ikinci sınıftaki öğretmen adayları birinci ve dördüncü sınıftaki öğretmen adaylarından daha yüksek yaratıcılık puanına sahiptir. Üçüncü sınıftaki öğretmen adayları birinci ve dördüncü sınıftaki öğretmen adaylarından daha yüksek iletişim puanına sahiptir. Katılımcıların iletişim ve işbirliği becerileri puan ortalamaları üniversitelerine göre anlamlı farklılık göstermiştir. ÖSYM puan sıralaması daha düşük olan üniversitelerdeki öğretmen adaylarının iletişim ve işbirliği puanları daha yüksektir. Bu bulgular ışığında 21. yy becerilerinin katılımcılara kazandırılması ve geliştirilmesine yönelik çalışmalar yapılabilir.

Anahtar kelimeler: 21. yüzyıl becerileri, cinsiyet, sınıf düzeyi, fen bilgisi öğretmen adayları.

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INTRODUCTION

In recent years, rapid technological, scientific, and economic changes have led governments and societies to search for a new approach to education in terms of skills to raise people who can meet the needs and expectations of the 21st century (Stewart, 2010; Wilmarth, 2010). People need 21st-century skills in their daily life including education and work settings within the requirements of the current century. In other words, 21st-century skills are the most needed skills for 21st-century people (Griffin et al., 2012). People need these skills for their jobs and careers. In addition, the skills for self-actualization are different in the 21st century compared to the 20th century. The most important reason for this difference is the development of new information and communication technologies. National and international research institutes work hard to determine skills and competences that are valued in the 21st century and have evolved in tandem with the fast expansion of communication and information as well as the rapid growth of global economy (Karakaş, 2015; Reimers & Chung, 2016). A broad set of cognitive and affective skills that promote achievement are now referred to as 21st-century skills and are divided into several categories (Greenhill & Petroff, 2010). The major three categories are as follows: Information, Media and Technology Skills, Learning and Innovation Skills, and Life and Career Skills. They have been given a fresh viewpoint in light of current historical events, globalization, and the digital era. Higher education institutions and private organizations have proposed extensive definitions. Partnership for 21st Century Skills (2009) divided these skills into three main themes and seventeen subthemes:

- Information, media, and technology skills: Media literacy, technology literacy, information literacy
- Learning and innovation skills: Innovation, creativity, problem solving, critical thinking, collaboration, and communication
- Life and career skills: Adaptability, flexibility, self-direction, initiative, leadership, social and cross-cultural skills, responsibility, productivity (Partnership for 21st Century Skills, 2009).

Teachers have a key role in helping students acquire these skills because teachers are the key actors of today's education system in terms of upskilling. Designing, implementing and evaluating creative ideas, having learning experiences to engage students and enhance learning, enriching professional practice, and presenting positive models are the main characteristics of 21st-century teachers. The International Society for Technology in Education (ISTE) emphasized that teachers should have five standards to ensure efficient and effective education and training in the digital world (Crompton, 2017). These standards are listed as follows:

- Developing and designing digital-age assessment tools and learning experiences
- Facilitating and encouraging student's creativity and learning
- Learning about modeling and digital age
- Modeling and supporting digital responsibility and citizenship
- Participating in leadership and professional development

In today's rapidly developing technology-driven society, students need to specialize in new areas of knowledge and skills, have analysis and decision-making skills, and learn to navigate in large masses of information (Tufan, 2003). In this process, educators have a critical role in stimulating their students gain new skills and competences for the 21st century (Karataş, 2015). Individuals need to criticize and question their knowledge to produce creative solutions to problems that they encounter, to communicate effectively, and to design and produce new results (Trilling & Fadel, 2009). Identifying the skills that individuals should today have is as important as learning the extent to which individuals are familiar with 21st-century skills. Additionally, measurement tools have been developed to research individuals' 21st-century skills. The literature includes scale adaption and development studies to evaluate 21st-century skills of students, teachers, and administrators. The scale adaption and development studies have investigated 21st-century skills in different sample groups including administrators (Çoban et al., 2019; Karaca-Atik et al., 2023), teachers (Deborah, 2012; Keskin & Yazar, 2015; Storksdieck, 2016), pre-service teachers (Anagün et al., 2016; Gür et al., 2023; Orhan-Göksun, 2016; Özyurt, 2020), university students (Berg et al., 2021; Koyunlu Ünlü & Dökme, 2022; Yılmaz & Alkış, 2019), high school and university students (Çevik & Şentürk, 2019), secondary and high school students (Kang et al., 2010), secondary school students (Ball et al., 2016; Karakaş, 2015; Ongardwanich et al., 2015), primary school students (Belet-Boyacı & Atalay, 2016), and preschool students (Yalçın et al., 2020).

The existing body of research on scale development has sought to measure the skills of students, pre-service teachers, and in-service teachers. However, a review of the literature yielded no result for a detailed and comprehensive measurement tool developed in Turkey or adapted to Turkish to investigate the competence of

teachers in teaching of 21st-century skills. Therefore, it emerges as a necessity to develop a detailed and comprehensive scale to explore pre-service teachers' competence in all 21st-century skills. More specifically, there is a need for an up-to-date measurement tool to explore PSTs' 21st-century skills who soon to teach students expected to acquire and develop those skills. Existing scales are not specific to the field and are not sufficient to explore this issue for PSTs. Therefore, it is hoped that the scale developed in this study will be valid, reliable and more comprehensive for use in future studies.

Defining the characteristics of the target audience, i.e., students, is a critical issue to consider in planning and designing an educational process (Callison & Lamb, 2004). Thus, teachers should first know the target audience well and plan the teaching environment in line with their characteristics (Melvin, 2011). From this point of view, teachers are expected to have and developed competence to communicate effectively with students and guide them (Orhan-Göksün & Aşkın Kurt, 2017). Teachers should have pedagogical, cultural and professional knowledge and be well-informed of contemporary approaches to teaching so that they can organize the teaching environment according to students' needs. Thus, teachers are the key stakeholders with the main responsibility for preparing and implementing teaching programs to keep up with the 21st-century skills and bring them into their teaching environments (Gürültü et al., 2020). As much as students are expected to have these skills, teachers are expected to have the competence to help students acquire these skills. Organizing activities about 21st-century skills is one of the most important competences expected of teachers in the 21st century. These activities increase students' academic achievement in a planned and programmed manner (Gürültü et al., 2018). Teachers' and students' having 21st-century skills undoubtedly affect each other (Bernhardt, 2015; Garba et al., 2015). Therefore, it is of critical importance to determine PSTs' level of 21st-century skills of PSTs who soon carry out the task of teaching 21st-century students. Earlier studies that have assessed the learning or teaching of 21st-century skills have often focused on examining a subset of these skills. However, they have not made a systematic assessment of the entire set of 21st-century skills (Jia et al., 2016). Thus, this study aimed to analyze PSTs' perceptions of their competence in the 21st-century skills. It is believed that this study help identify areas in pre-service teacher education, which need to be improved to better address the issue of teaching 21st-century skills. In other words, this study can be useful in determining the strengths and weaknesses of the science curriculum in the acquisition of 21st-century skills. Such studies can also be used as a self-reflection or assessment tool for in-service and pre-service teachers to learn about 21st-century skills and pinpoint areas that need revision and improvement. In addition, this study can help teacher educators develop a better understating of how to train and prepare pre-service teachers to teach 21st-century skills.

It is important to investigate PSTs' 21st-century skills according to different variables because teachers need to have these skills (Kan & Murat, 2018). Various variables such as gender, year of study, university, and specific teaching disciplines are most likely to cause differences in preservice teachers' 21st century skills. Atlı (2019) also states that the year of study is an important factor that affects students' perceptions. Thus, the fact that PSTs in the fourth year of study have higher levels of skills than those in the earlier years of study is an expected result due to their longer educational background and experience (Berkant & Varki, 2022). Additionally, the fact that pre-service teachers studying Turkish education and classroom teaching have higher levels of multidimensional 21st-century skills compared to pre-service science teachers can be explained by the fact that the social studies-based education in Turkish education and classroom teaching provides an advantage in terms of developing these skills (Aydın, 2019; Bal, 2018). Likewise, the difference in the cognitive levels of students studying at universities that accept students scoring highly on the university entrance exam also causes a variation in their perceptions. Today, everything from technology to from culture and from social life to business world is changing and developing rapidly. Therefore, students need teachers equipped with 21st-century skills to be successful in this age (Çepni, 2016). Knowing whether PSTs have these skills will help teachers understand how to teach these skills to students (Gülen, 2013). It is important to know that different variables affect PSTs' skills because determining whether they have 21st-century skills makes it possible to identify different strategies for their teaching education (Atalay et al., 2016). PSTs' having knowledge of 21st-century skills is critical because it allows them to have an idea about how to teach these skills to their students (Yalçın, 2018). Teaching students these skills can affect their future success. New strategies, course materials, and instructional technologies to teach these skills can be developed (Darling-Hammond, 2006).

In the restructuring of higher education, multidimensional 21st-century skills should be more prominent in curricula in order to create a generation that is knowledgeable about critical thinking, creativity, and cultural values and can compete in a global context (Aydın, 2019). Similarly, education programs need to be created to complement multidimensional 21st-century skills in every possible way (Bal, 2018). There is a need for studies investigating the success of the training in 21st century skills (Gürültü et al., 2018). Similarly, the success of the

programs applied to individuals should be monitored by continuous measurement in order to develop 21st-century skills (Kandemir, 2006). It is important to develop more individualized education programs for 21st-century skills (Zeybek, 2015). The study is valuable in terms of the design of individualized teaching programs and the multidimensional evaluation of competences of pre-service teachers who still continue their education in teaching 21st-century skills. This study is also significant because it allows educators, program developers and researchers to determine the extent to which current practices and teacher training programs in Türkiye are sufficient in developing pre-service teachers' competence in 21st-century skills teaching. Thus, it can provide fresh insights into the usefulness of teacher training programs and practices. This study aimed to compare PSTs' 21st-century skills according to gender, year of study, and university. Accordingly, the research problem was formulated as "What are the 21st-century skills levels of PSTs?". In line with this problem, the following sub-problems were addressed:

1. Is there a statistically significant difference in PSTs' 21st century skills mean scores according to their gender?
2. Is there a statistically significant difference in PSTs' 21st century skills mean scores according to their year of study?
3. Is there a statistically significant difference in PSTs' 21st century skills mean scores according to their universities?

METHOD

This study used a cross-sectional survey design, which is a quantitative research design. Accordingly, the characteristics to be examined by the researcher were measured at once over the sample, and then statistical analyses of the data were made (Fraenkel & Wallen, 2006). The survey model in educational research is the model in which researchers summarize the characteristics (skills, preferences, attitudes, etc.) of individuals, groups, or the physical environment (such as schools) (Fraenkel et al., 2012).

Participants

The sample consisted of 799 PSTs who were studying in the first-, second-, third-, and fourth years of study at the education faculties of the universities in the Aegean region in the 2019-2020 academic year. Tables 1, 2, and 3 below presents the demographics of the sample group.

Table 1. Distribution of PSTs by Gender

Gender	f	%
Female	647	81.0
Male	152	19.0
Total	799	100

Table 2. Distribution of PSTs by Year of Study

Year of Study	f	%
First-year	173	21.7
Second-year	111	13.9
Third-year	260	32.5
Fourth-year	255	31.9

Table 3. Distribution of PSTs by University

Year of Study	f	%
Aydın Adnan Menderes University (A)	123	15.6
Afyon Kocatepe University (B)	112	14
Manisa Celal Bayar University (C)	81	10.1
Dokuz Eylül University (D)	141	17.6
Dumlupınar University (E)	127	15.9
Muğla Sıtkı Koçman University (F)	80	10
Pamukkale University (G)	90	11.3
Uşak University (H)	45	5.6
Total	799	100.0

Data Collection

The following 5-point Likert type scales were used to explore PSTs' 21st-century skills. The scale items are rated as "Strongly Agree", "Agree", "Neither agree or disagree", "Disagree", "Strongly disagree". All of these scales were considered as a sub-scale to determine 21st-century skills. The data were analyzed using confirmatory factor analysis (CFA). The remaining items for the 21st-century skills scale as a result of CFA are presented in the confirmatory factor analysis section below. The scale was administered to PSTs within a two course-hour time in the middle of the academic year.

The Process of Developing the 21st-Century Skills Scale

The 44-item Teacher Communication Skills Scale was developed by Çetinkanat (1997) to evaluate teachers' perceptions of communication skill, and the Cronbach's alpha coefficient was calculated as .81 for the total scale. The Individual Innovativeness Scale was originally developed by Hurt and others (1977) and adapted to Turkish by Kılıçer and Odabaşı (2014). The scale includes 20 items to measure individuals' level of innovativeness, and the Cronbach's alpha was calculated as .82 for the total scale. The Critical Thinking Scale was developed as a result of the Delphi project organized by the American Philosophical Society in 1990 by Facione and others (1998) to determine critical thinking dispositions. The scale translated and adapted into Turkish by Kökdemir (2003) consists of 51 items, and the Cronbach's alpha was calculated as .88 for the total scale. The 40-item Entrepreneurship Skills Scale was developed by Bilge and Bal (2012) to evaluate perceptions and attitudes about entrepreneurship, and the Cronbach's alpha was calculated as .83. The Kaufman Domains of Creativity Scale developed by Kaufman (2012) with the perspective of domain-specific creativity was adapted into Turkish by Şahin (2016). As a result of the exploratory and confirmatory factor analysis, the scale consists of 42 items, and the Cronbach's alpha was calculated as .90 for the total scale. The Cooperative Skills Scale was developed by Güngör and Özkan (2011) as a 5-point Likert scale type consisting of a 20-items with 10 negative and 10 positive items. The maximum score that can be obtained is 100, and the minimum score is 20. The Cronbach's alpha was calculated as .80 for the total scale. The Technology Literacy Scale was developed by Keleş (2014) to measure knowledge deepening, knowledge creation, and technology literacy. This graded-performance scale consists of 27 items, and the Cronbach's alpha was calculated as .92 for the total scale. The Media Literacy Scale was developed by Karaman and Karataş (2009) and consists of 17 items to explore the relationship of pre-service teachers with mass media and to determine their levels of media literacy. The Cronbach's alpha was calculated as .84 for the total scale. All items in these measurement tools were determined and selected by seeking the opinions of two science education experts working on this subject.

The construct validity of the 21st-Century Skills Scale was analyzed using exploratory factor analysis (EFA). The Kaiser-Meyer-Olkin test run to measure the sampling adequacy for the scale was .920, and the Barlett's test of sphericity was found to be statistically significant at $\chi^2(9180) = 30474.887$, $p < .000$. The 21st-Century Skills Scale was suitable for EFA. For the 136 items, the data analysis revealed an eight-factor structure, and it accounted for 50.03% of the sample variance. The Cronbach's alpha values for communication, innovativeness, critical thinking, entrepreneurship, creativity, cooperative, technology and media were .95, .86, .82, .94, .91, .71, .95 and .93, respectively. The EFA for all items was performed with the data collected from 298 pre-service science teachers in a pilot study. According to the results of the EFA, statistical analyses were carried out with 136 items. As a result of EFA, seven items were deleted, and 129 items remained. Considering the EFA results, items that go to more than one factor and need to be removed are the 4th, 5th, 7th items in the innovativeness factor, the 7th, 8th, 12th items in critical thinking factor, and the 5th item in the creativity factor (Table 4). If an item has a high or acceptable factor loading for more than one factor, the difference between the two load values is expected to be greater than 0.10 (Tabachnick & Fidell, 2001) to decide under which factor the item will be included. If there is a difference of 0.10 or more between the factor loadings of an item, the item is attributed to the factor with a high factor loading. For this reason, the 12th item in critical thinking and the 5th item in creativity were removed due to multiple factor loadings.

Table 4. 21st Century Skills Scale Items with Loadings from EFA

Items	1	2	3	4	5	6	7	8	Items	1	2	3	4	5	6	7	8
C1	.69								Cr1					.35			
C2	.71								Cr2					.41			
C3	.70								Cr3					.31			
C4	.56								Cr4					.41			
C5	.68								Cr5			.32		.31			
C6	.74								Cr6					.39			
C7	.75								Cr7					.42			
C8	.67								Cr8					.54			
C9	.64								Cr9					.40			
C10	.37								Cr10					.73			
C11	.62								Cr11					.74			
C12	.74								Cr12					.73			
C13	.65								Cr13					.77			
C14	.70								Cr14					.72			
C15	.54								Cr15					.67			
C16	.59								Cr16					.36			
C17	.52								Cr17	.31				.49			
C18	.47	.32							Cr18					.65			
C19	.59								Cr19					.43			
C20	.52	.32							Cr20					.64			
C21	.55								Cr21					.67			
C22	.54								Cr22	.32				.53			
C23	.63								Cr23	.33				.56			
C24	.49								Cr24					.56			
C25	.57	.31							Cr25					.58			
C26	.65								Cr26					.63			
C27	.49								Co1							.36	.64
C28	.64								Co2							.37	.58
I1						.50		.32	Co3							.34	.64
I2						.52			Co4								.47
I3	.32					.56			Co5								.44
I4							.59		Co6								.50
I5							.70		Te1			.45					
I6						.46			Te2			.55					
I7							.63		Te3			.59					
I8						.51			Te4			.61					
I9						.57		.34	Te5			.54	.34				
CT1							.50		Te6			.61					
CT 2							.49		Te7			.60					
CT3							.37		Te8	.34		.63					
CT4							.47		Te9			.61					
CT5							.46		Te10			.61					
CT6							.55		Te11			.65					
CT7					.53				Te12	.32		.61					
CT8					.53				Te13			.63					
CT9							.34		Te14		.34	.61					
CT10							.37		Te15			.64					
CT11							.51		Te16			.61					

CT12	.34		.39	Te17		.66
Ent1	.57			Te18	.33	.57
Ent2	.63			Te19	.36	.57
Ent3	.58			Me1		.58
Ent4	.49			Me2		.59
Ent5	.53			Me3	.30	.60
Ent6	.60			Me4		.62
Ent7	.59			Me5		.61
Ent8	.66			Me6		.62
Ent9	.57		.31	Me7		.62
Ent10	.59	.30		Me8		.54
Ent11	.49		.34	Me9		.57
Ent12	.61			Me10		.66
Ent13	.58			Me11		.67
Ent14	.48	.32		Me12		.60
Ent15	.47		.34	Me13		.63
Ent16	.41			Me14		.62
Ent17	.50					
Ent18	.56					
Ent19	.55		.31			
Ent20	.39					
Ent21	.54		.31			
Ent22	.52	.33				

Note: Communication=C, Innovativeness=In, Critical Thinking=CT, Entrepreneurship=Ent, Creativity=Cr, Cooperative=Co, Technology=Te and Media=Me

Within the scope of congruent validity, the correlations between the scores on the sub-scales of the 21st-Century Skills Scale for PSTs were examined. The correlation coefficients were showed in Table 5.

Table 5. Correlation Coefficient Values

Sub-scales	Innovativeness	Critical Thinking	Entrepreneurship	Creativity	Cooperative	Technology	Media	Total
Communication	.56**	.60**	.61**	.49**	.49**	.56**	.50**	.73**
Innovativeness		.66**	.68**	.48**	.21**	.55**	.51**	.78**
Critical Thinking			.75**	.60**	.24**	.63**	.57**	.84**
Entrepreneurship				.63**	.23**	.70**	.60**	.87**
Creativity					.20**	.62**	.50**	.77**
Cooperative						.25**	.22**	.32**
Technology							.62**	.83**
Media								.76**

As shown in Table 6, the correlation coefficients ranged from .20 to .75 and at .01 significance level. The sub-scales of the entire scale had a statistically significant correlation with each other. The Cronbach's alpha coefficients was calculated for Communication Skills (.94), Innovativeness (.86), Critical Thinking (.80), Entrepreneurship Skills (.93), Creativity (.90), Cooperative Skills (.70), Technology Literacy (.94), and Media Literacy (.93).

CFA was performed to decide the construct validity of the scale. The goodness of fit values were found to be acceptable ($X^2 = 30787.92$, $SD = 8119$, $p < .001$, $X^2/SD = 3.79$, $NFI = .96$, $CF7 = .96$, $RMSEA = .05$). The standardized path coefficients were found to be between .30 and .82 and statistically significant at $p < .001$ level.

The path coefficients of the model related to the structure of scale is presented in Table 6. The sub-scales of Communication Skills, Innovativeness, Critical Thinking, Entrepreneurship Skills, Creativity, Cooperative Skills, Technology Literacy and Media Literacy consist of 28, 6, 9, 22, 25, 6, 19 and 14 items, respectively.

Table 6. 21st Century Skills Scale Items with Loadings from CFA

Item	Path coefficient	Item	Path coefficient	Item	Path coefficient
Communication1	.61	Entrepreneurship1	.66	Creativity23	.67
Communication2	.63	Entrepreneurship2	.59	Creativity24	.47
Communication3	.64	Entrepreneurship3	.68	Creativity25	.46
Communication4	.54	Entrepreneurship4	.52	Creativity26	.35
Communication5	.64	Entrepreneurship5	.54	Cooperative1	.39
Communication6	.67	Entrepreneurship6	.72	Cooperative2	.41
Communication7	.64	Entrepreneurship7	.64	Cooperative3	.45
Communication8	.66	Entrepreneurship8	.72	Cooperative4	.63
Communication9	.66	Entrepreneurship9	.69	Cooperative5	.82
Communication10	.33	Entrepreneurship10	.72	Cooperative6	.82
Communication11	.67	Entrepreneurship11	.70	Technology1	.58
Communication12	.73	Entrepreneurship12	.72	Technology2	.63
Communication13	.65	Entrepreneurship13	.71	Technology3	.67
Communication14	.69	Entrepreneurship14	.59	Technology4	.76
Communication15	.57	Entrepreneurship15	.54	Technology5	.55
Communication16	.57	Entrepreneurship16	.38	Technology6	.72
Communication17	.58	Entrepreneurship17	.58	Technology7	.75
Communication18	.50	Entrepreneurship18	.67	Technology8	.76
Communication19	.66	Entrepreneurship19	.66	Technology9	.71
Communication20	.60	Entrepreneurship20	.51	Technology10	.75
Communication21	.60	Entrepreneurship21	.65	Technology11	.75
Communication22	.60	Entrepreneurship22	.66	Technology12	.61
Communication23	.68	Creativity1	.61	Technology13	.73
Communication24	.51	Creativity2	.67	Technology14	.64
Communication25	.63	Creativity3	.64	Technology15	.71
Communication26	.65	Creativity4	.51	Technology16	.68
Communication27	.51	Creativity5	.51	Technology17	.74
Communication28	.60	Creativity6	.37	Technology18	.68
Innovativeness1	.70	Creativity7	.30	Technology19	.70
Innovativeness2	.75	Creativity9	.36	Media1	.63
Innovativeness3	.66	Creativity10	.44	Media2	.73
Innovativeness6	.65	Creativity11	.46	Media3	.77
Innovativeness8	.75	Creativity12	.38	Media4	.79
Innovativeness9	.78	Creativity13	.42	Media5	.73
CriticalThinking1	.56	Creativity14	.47	Media6	.74
CriticalThinking2	.60	Creativity15	.45	Media7	.75
CriticalThinking3	.53	Creativity16	.49	Media8	.63
CriticalThinking4	.60	Creativity17	.66	Media9	.68
CriticalThinking5	.65	Creativity18	.70	Media10	.74
CriticalThinking6	.56	Creativity19	.64	Media11	.62
CriticalThinking9	.44	Creativity20	.71	Media12	.67
CriticalThinking10	.66	Creativity21	.67	Media13	.61
CriticalThinking11	.58	Creativity22	.70	Media14	.72

As a result of CFA, the path coefficients of the remaining 129 items were above .30 and the goodness-of-fit indices values are acceptable. These results showed that the 21st-century skills scale valid and reliable. The factor loadings were well above the cut-off point .30, as proposed by Roberts and Bacon (1997). The goodness-of-fit indices show acceptable values and good fit values, as shown in Table 7 (Hu & Bentler, 1995; Tabachnick & Fidell, 2007).

Table 7. Goodness-of-Fit Indices of 21st Century Skills Scale for CFA Model

Fit indices	Value	Criterion
NFI	.96	Excellent
NNFI	.97	Excellent
IFI	.97	Excellent
RFI	.96	Excellent
CFI	.97	Excellent
GFI	.83	Good
AGFI	.81	Good
RMR	.052	Excellent
RMSEA	.058	Excellent
χ^2/df	3.79	Good

Data Analysis

Because all the data were normally distributed, MANOVA were used in the data analysis. In addition, other descriptive statistics are presented. In the comparison of descriptive statistics, the evaluation was made based on mean scores that can be obtained from the scale and its sub-scales. The Pearson correlation coefficient was calculated in relational analyses. The level of significance was set at .05.

After the data collection period of nearly two months, the data were screened and cleaned from errors. Based on the obtained data, validity and reliability analyses were made. Skewness and kurtosis values were used to check the normality of data. The skewness index was between -1.17 and .30, while the kurtosis index was between -.31 and 1.96 (Table 8). Considering the skewness and kurtosis values for all the sub-scales, all values were within a good interval (between -2 and +2) (Tabachnick & Fidell, 2001).

Table 8. Means, Standard Deviations, Skewness and Kurtosis Values for Sub-Scales

Sub-scales	\bar{X}	SD	Skewness	Kurtosis
Communication	4.37	.44	-1.17	1.96
Innovativeness	4.23	.59	-.75	1.04
Critical Thinking	4.08	.52	-.44	1.11
Entrepreneurship	4.02	.54	-.35	.34
Creativity	3.76	.56	-.12	-.31
Cooperative	3.13	.51	.30	1.67
Technology	4.02	.57	-.25	.20
Media	4.03	.59	-.21	.11
Total	3.96	.40	-.39	1.09

Research Ethics

This research study was evaluated by Aydın Adnan Menderes University Educational Research Ethics Committee in 2019 and found ethically acceptable (ADU – no: 2019/02).

FINDINGS

Results for PSTs' Levels of 21st Century Skills

Table 9 presents the descriptive statics for the research problem “What are the 21st-century skills levels of PSTs?”. The mean score of 799 students on the total scale is 3.96.

Table 9. Descriptive Statistics on 21st Century Skills

Sub-scales	N	\bar{X}	SD
Communication	799	4.37	.44
Innovativeness	799	4.23	.59
Critical Thinking	799	4.08	.52
Entrepreneurship	799	4.02	.54
Creativity	799	3.76	.56
Cooperative	799	3.13	.51
Technology	799	4.02	.57
Media	799	4.03	.59
Total	799	3.96	.40

As seen in Table 9, the arithmetic mean of the total score obtained by PSTs on the 21st-Century Skills Scale was calculated as $\bar{X} = 3.96$. This shows that in terms of the total scale, PSTs got a value above the average score ($\bar{X} = 2.50$). The arithmetic means of the scores obtained on the sub-scales varied between $\bar{X} = 3.13$ and $\bar{X} = 4.37$. According to these findings, PSTs' scores in the communication, innovativeness, critical thinking, entrepreneurship, technology and media sub-scales were above the average in terms of 21st-century skills. On the other hand, the scores in the creativity and cooperative sub-scales were below the average. Looking at the scores on the subscales, PSTs got the lowest mean score on the cooperative skills sub-scale.

Results for PSTs' Levels of 21st Century Skills According to Gender

MANOVA was used to answer the sub-problem "Is there a statistically significant difference in PSTs' 21st century skills mean scores according to their gender?" Table 10 presents the descriptive statistics for the gender variable.

Table 10. Descriptive Statistics for 21st Century Skills and Sub-scales by Gender

Sub-scales	Gender	N	\bar{X}	SD
Communication	Male	152	4.18	.50
	Female	647	4.42	.42
Innovativeness	Male	152	4.16	.59
	Female	647	4.25	.59
Critical Thinking	Male	152	4.03	.55
	Female	647	4.09	.51
Entrepreneurship	Male	152	3.96	.62
	Female	647	4.03	.52
Creativity	Male	152	3.69	.60
	Female	647	3.78	.55
Cooperative	Male	152	3.23	.63
	Female	647	3.11	.47
Technology	Male	152	3.96	.62
	Female	647	4.03	.56
Media	Male	152	4.05	.60
	Female	647	4.02	.59

For the first MANOVA, Levene's Test ($p > .05$) provided the assumption of equality of variance for all eight sub-scales, and Box's M Test (Box's $M=22.134$; $F=1.945$; $p > .05$) provided the assumption of equality of variance-covariance matrices. According to the multivariate F-test results, there was a statistically significant difference between the groups according to gender on a linear combination of the sub-scales of 21st century skills [Wilks' Lambda = .927, $F(8, 790)= 7.788$, $p<.05$, $\eta^2= .073$]. When the partial eta-squared value was examined, it explained 7.3% of the variance, indicating a medium effect size. Univariate F-test results were presented in Table 11.

Table 11. Univariate Test Results for 21st Century Skills

Sub-scales	F	sd	Error sd	p	η^2
Communication	35.756	1	797	.000	.043
Innovativeness	3.204	1	797	.074	.004
Critical Thinking	2.095	1	797	.148	.003
Entrepreneurship	2.177	1	797	.141	.003
Creativity	3.492	1	797	.062	.004
Cooperative	6.722	1	797	.010	.008
Technology	1.731	1	797	.189	.002
Media	.267	1	797	.605	.000

As can be seen in Table 11 above, there is a significant difference between the groups only for the communication sub-scale ($\alpha = .05/8 = .006$ after Bonferroni correction). According to the descriptive statistics in Table 10, female had significantly higher 21st century skills than male in the communication sub-scale. The partial eta-squared value showed that this effect was small.

Results for PSTs' Levels of 21st Century Skills According to Year of Study

MANOVA was used to answer the sub-problem "Is there a statistically significant difference in PSTs' 21st century skills mean scores according to the year of study?". Table 12 presents the descriptive statistics and Table 13 presents MANOVA results for the scores on the total scale and its sub-scales according to the year of study variable.

Table 12. Descriptive Statistics by Year of Study

Sub-scales	Year of Study	N	\bar{X}	SD	Sub-scales	Year of Study	N	\bar{X}	SD
Communication	First-year	173	4.31	.43	Creativity	First-year	173	3.67	.57
	Second-year	111	4.43	.44		Second-year	111	3.88	.55
	Third-year	260	4.44	.41		Third-year	260	3.84	.52
	Fourth-year	255	4.32	.47		Fourth-year	255	3.70	.57
Innovativeness	First-year	173	4.25	.60	Cooperative	First-year	173	3.16	.54
	Second-year	111	4.28	.61		Second-year	111	3.12	.49
	Third-year	260	4.27	.53		Third-year	260	3.07	.50
	Fourth-year	255	4.17	.62		Fourth-year	255	3.18	.50
Critical Thinking	First-year	173	4.05	.52	Technology	First-year	173	3.97	.60
	Second-year	111	4.10	.53		Second-year	111	4.10	.55
	Third-year	260	4.14	.47		Third-year	260	4.07	.56
	Fourth-year	255	4.04	.55		Fourth-year	255	3.97	.57
Entrepreneurship	First-year	173	3.98	.49	Media	First-year	173	3.94	.58
	Second-year	111	4.07	.55		Second-year	111	4.11	.59
	Third-year	260	4.06	.53		Third-year	260	4.06	.60
	Fourth-year	255	3.96	.58		Fourth-year	255	4.02	.58

For the second MANOVA, Levene's Test ($p > .05$) provided the assumption of equality of variance for all eight sub-scales, and Box's M Test (Box's $M=168.753$; $F=1.531$; $p > .05$) provided the assumption of equality of variance-covariance matrices. According to the multivariate F-test results, there was a statistically significant difference between the groups according to the year of study variable on a linear combination of the sub-scales of 21st century skills [Wilks' Lambda = .941, $F(24, 788)= 2.033$, $p < .05$, $\eta^2 = .020$]. When the partial eta-squared value was examined, it explained 2.0% of the variance, indicating a small effect size. Univariate F-test results were presented in Table 13.

Table 13. Univariate Test Results for 21st Century Skills

Sub-scales	F	sd	Error sd	p	η ²
Communication	4.982	3	795	.002	.018
Innovativeness	1.773	3	795	.151	.007
Critical Thinking	2.029	3	795	.108	.008
Entrepreneurship	2.129	3	795	.095	.008
Creativity	6.150	3	795	.000	.023
Cooperative	2.429	3	795	.064	.009
Technology	2.449	3	795	.062	.009
Media	2.110	3	795	.098	.008

As can be seen in Table 13 above, there is a significant difference between the groups for the communication and creativity sub-scales ($\alpha = .05/8 = .006$ after Bonferroni correction). According to the descriptive statistics in Table 12, third-year students had significantly higher 21st century skills than first-year and fourth-year students in the communication sub-scale. In addition, second-year and third-year students had significantly higher 21st century skills than first-year and fourth-year students in the creativity sub-scale. The partial eta-squared value showed that these effects were small.

Results for PSTs' Levels of 21st Century Skills According to Year of University

MANOVA was used to answer the third sub-problem “Is there a statistically significant difference in PSTs’ 21st century skills mean scores according to their university?”. Table 14 presents the descriptive statistics and Table 15 presents MANOVA results.

Table 14. Descriptive Statistics by University

Sub-scales	University	N	\bar{X}	SD	Sub-scales	Year of Study	N	\bar{X}	SD
Communication	A	123	4.43	.45	Creativity	A	123	3.02	.52
	B	112	4.35	.56		B	112	3.28	.69
	C	81	4.38	.35		C	81	3.14	.44
	D	141	4.42	.41		D	141	3.09	.42
	E	127	4.36	.35		E	127	3.17	.50
	F	80	4.24	.47		F	80	3.08	.46
	G	90	4.45	.41		G	90	3.16	.38
	H	45	4.23	.47		H	45	3.12	.56
Innovativeness	A	123	4.24	.59	Cooperative	A	123	3.02	.52
	B	112	4.23	.64		B	112	3.28	.69
	C	81	4.16	.53		C	81	3.14	.44
	D	141	4.31	.55		D	141	3.09	.42
	E	127	4.24	.58		E	127	3.17	.50
	F	80	4.19	.60		F	80	3.08	.46
	G	90	4.23	.65		G	90	3.16	.38
	H	45	4.18	.57		H	45	3.12	.56
Critical Thinking	A	123	4.10	.50	Technology	A	123	4.07	.55
	B	112	4.08	.57		B	112	4.02	.61
	C	81	4.08	.47		C	81	3.95	.52
	D	141	4.05	.56		D	141	4.07	.57
	E	127	4.08	.44		E	127	4.02	.56
	F	80	4.05	.54		F	80	3.88	.65
	G	90	4.12	.53		G	90	4.05	.55
	H	45	4.10	.50		H	45	4.04	.57

Entrepreneurship	A	123	4.05	.58	Media	A	123	4.10	.61
	B	112	4.04	.60		B	112	4.08	.60
	C	81	3.95	.51		C	81	3.95	.56
	D	141	4.03	.56		D	141	4.02	.61
	E	127	4.05	.47		E	127	4.04	.51
	F	80	3.92	.51		F	80	3.92	.51
	G	90	4.04	.58		G	90	4.08	.67
	H	45	3.94	.51		H	45	3.93	.64

Aydın Adnan Menderes University (A); Afyon Kocatepe University (B); Manisa Celal Bayar University (C); Dokuz Eylül University (D); Dumlupınar University (E); Muğla Sıtkı Koçman University (F); Pamukkale University (G); Uşak University (H)

For the third MANOVA, Levene's Test ($p > .05$) provided the assumption of equality of variance for all eight sub-scales, and Box's M Test (Box's $M=467.587$; $F=1.429$; $p > .05$) provided the assumption of equality of variance-covariance matrices. According to the multivariate F-test results, there was a statistically significant difference between the groups according to the year of study variable on a linear combination of the sub-scales of 21st century skills [Wilks' Lambda = .904, $F(56, 4227)=$, $p<.05$, $\eta^2= .014$]. When the partial eta-squared .value was examined, it explained 1.4% of the variance, indicating a small effect size. Univariate F-test results were presented in Table 15.

Table 15. Univariate Test Results for 21st Century Skills

Sub-scales	F	sd	Error sd	p	η^2
Communication	2.768	7	791	.004	.024
Innovativeness	.642	7	791	.721	.006
Critical Thinking	.221	7	791	.980	.002
Entrepreneurship	.849	7	791	.547	.007
Creativity	.413	7	791	.895	.004
Cooperative	2.700	7	791	.005	.023
Technology	1.101	7	791	.360	.010
Media	1.196	7	791	.302	.010

As can be seen in Table 15 above, there is a significant difference between the groups for the communication and creativity sub-scales ($\alpha = .05/8 = .006$ after Bonferroni correction). According to the Bonferroni test results, the communication skills of PSTs significantly differed according to their university. Communication skills showed a significant difference between Muğla Sıtkı Koçman University ($\bar{X} = 4.24$) and Pamukkale University ($\bar{X} = 4.45$). Taken together, the Bonferroni test result showed that communication skills of PSTs studying at Pamukkale University students were higher than the communication skills of PSTs studying at Muğla Sıtkı Koçman University. The partial eta-squared value showed that this effect was low. In addition, the cooperative skills of PSTs also differed significantly according to their university. There was a significant difference between Aydın Adnan Menderes University ($\bar{X} = 3.02$) and Afyon Kocatepe University ($\bar{X} = 3.28$). Taken together, the Bonferroni test result showed that, the cooperative skills of PSTs studying at Afyon Kocatepe University were higher than the cooperative skills of PSTs studying at Aydın Adnan Menderes University. The partial eta-squared value showed that this effect was small.

DISCUSSION & CONCLUSION

This study set out to compare and analyze PSTs' 21st-century skills in terms of gender, year of study, and university. The analysis results showed that PSTs' 21st-century skills differed statistically according to gender in two sub-scales. In the communication skills sub-scale, the mean score of female PSTs was statistically significantly higher than that of male PSTs. There was no statistically significant difference in other sub-scales according to the gender variable. In line with results of this study, Özdemir Özden et al. (2018) found that female pre-service teachers have higher mean scores of 21st-century skills than male pre-service teachers. The level of PSTs' characteristics of "New Millennium Students" differs significantly according to gender, year of study (first year and fourth year of study), universities, and family income level (Şahin, 2010). Similarly, significant results were found in favor of female PSTs according to gender in career and life skills and knowledge and technology skills

within the scope of PSTs' 21st century skills perception scale (Kan & Murat, 2018). It can be said female PSTs had higher scores in the communication sub-scale due to their more extroverted character traits. This result of the study is consistent with earlier studies on the same subject (Gökbulut, 2020; Gülen, 2013; Karakaş, 2015). Female students' level of using activities for problem solving, active learning, communication skills was also found to be higher than male students (Gülen, 2013). Female students had higher score of 21st-century skills (Karakaş, 2015). Based on the current results, female PSTs significantly differed from male PSTs in terms of their 21st-century skills. However, some studies also reported inconsistent results. Despite pre-service teachers' high scores of 21st-century skills, there was no significant difference according to gender (Gökbulut, 2020). Similarly, in a study conducted with teachers from different branches, there was no statistically significant difference in 21st-century skills according to gender and working environment of teachers (Eğmir & Çengelli, 2020; Uyar & Çiçek, 2020). Çevik and Şentürk (2019) found that male PSTs had higher 21st century skills than females. Similarly, there was no significant difference between male and female PSTs in learning and renewal skills sub-scales of the 21st-century skills efficacy perception scale (Kan & Murat, 2018). Similar results were found in the study of Bozkurt and Çakır (2016) who determined that there were significant differences according to year of study and gender. In this study, the multidimensional 21st-century skills of female PSTs were higher than male PSTs. Similarly, Dilekli and Karagöz (2018) reported higher levels of these skills for females compared to males. It can be said based on these results that female PSTs have become advantageous in terms of 21st-century skills due to the formal and informal education they receive. Female students may generally have more communication practice and experience, which can help them improve their communication skills.

The study also examined whether PSTs' 21st-century skills differ statistically according to the year of study. Their mean scores of the communication and creativity skills sub-scales differed significantly according to according to the year of study. There was no statistically significant difference in the other sub-scales. The mean score of third-year PSTs was statistically significantly higher than that of first-year and fourth-year PSTs for the communication skills subscale. The mean score of second-year and third-year PSTs was also statistically significantly higher than that of first-year and fourth-year PSTs for the creativity skills sub-scale. In line with the present results, Özdemir Özden et al. (2018) found that third-year pre-service teachers had a higher mean score of 21st-century skills than second-year pre-service teachers. Kılıç (2011) found a significant difference in students' scientific creativity according to the type of school they attended and their year of study. The level of pre-service teachers' carrying the characteristics of "New Millennium Students" also differed according to the year of study (first year and fourth year) (Şahin, 2010). The present result that third-year PSTs had a higher mean score than others in terms of creativity and communication skills can be explained by the fact that they have already acquired sufficient knowledge, skills, and behaviors to be a teacher. The reason for the result that fourth-year PSTs had lower communication and creativity mean scores might be that they experience career concerns and test anxiety because they soon to take a public personnel selection examination to be become a teacher.

The study finally examined whether PSTs' 21st-century skills differ statistically according to their universities. The mean scores of communication and cooperation skills differed significantly according to university. The mean scores on other subscales did not differ statistically significantly according to university. For the communication skills sub-scale, the mean scores of PSTs studying at Pamukkale University were statistically significantly higher than those at Muğla Sıtkı Koçman University. For the cooperative skills sub-scale, the mean scores of PSTs studying at Afyon Kocatepe University were statistically significantly higher than those of PSTs studying at Aydın Adnan Menderes University. The present results are in parallel with some earlier studies. PSTs' 21st-century skills efficacy perception scores did not differ in terms of learning and renewal skills and life and career skills sub-scales according to their university. Additionally, PSTs studying at Erciyes University had statistically higher scores in terms of knowledge, media, and technology skills (Kan & Murat, 2018). Eğmir and Çengelli (2020) found that teachers' 21st-century skills differ according to the school type and seniority. The level of pre-service teachers' characteristics of "New Millennium Students" varied according to fields and universities (Şahin, 2010). PSTs' level of skills differed according to their achievement in terms of their scores on the university placement exam. It can be said this difference in the dependent variables was basically caused by this disintegration. In addition, the learning experiences of PSTs at their universities vary due to the different teaching staff, technological infrastructure, and the different content of the departments. These changing learning experiences may have affected PSTs' 21st century skills of. Students studying at universities without technological infrastructure may have also lower technology skills.

Pre-service teachers' 21st-century skill differed in terms of university and department (Orhan-Göksun & Kurt, 2017). In Turkey, high school students take a placement exam (called ÖSYS, Student Selection and

Placement Examination) to attend a university. They are placed in different universities and departments according to their scores on this exam (ÖSYM [Student Selection and Placement Center], 2011). For this reason, the placement of students in universities depends on their achievement. As a result, 21st-century skills of pre-service teachers can differ by universities where they study. In addition, learning experiences of students at different universities vary due to the different teaching staff and the different content of the departments.

In this study, PSTs' 21st-century skills differed in some sub-scales of the 21st century skills scale according to gender, year of study, and university. In this context, it is recommended to conduct research on the acquisition of 21st century skills at different levels of universities and educational institutions that train future science teachers considering other variables. The findings of this study will shed light on future studies to be carried out on pre-service teachers' acquisition of 21st century skills. A further study can be done with pre-service teachers in different disciplines and in-service teachers. Further research can also be carried out to measure 21st-century skills of in-service teachers.

The important limitation of this study is that it was based on the answers given by 799 PSTs studying at university in the Aegean region. It was recommended to conduct more generalizable research with more participants covering not only a region but also other regions. In addition, qualitative research would provide more in-depth data regarding PSTs' 21st-century skills.

Statements of Publication Ethics

Throughout this research study, research and publication ethics were observed. Ethical permission of the present research was approved by Aydın Adnan Menderes University Educational Research Ethics Committee.

Researchers' Contribution Rate

First author has made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data. The second author has been involved in drafting the manuscript or revising it critically for important intellectual content. The third author has given final approval of the version to be published.

Conflict of Interest

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in BUEFAD belongs to the authors.

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