Makale Geçmişi / Article History
Alındı/Received: 20.05.2025
Düzeltme Alındı/Received in revised form: 31.08.2025
Kabul edildi/Accepted: 22.09.2025

ÖĞRETMEN DİJİTAL YETERLİK ÖLÇEĞİNİN ÖĞRETMEN ADAYLARINA UYARLANMASI

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Öz

Bilgi ve iletişim teknolojilerinin hızlı gelişimi, eğitimde dijital dönüşümün önemini giderek artırmaktadır. Bu dönüşüm, öğretmenlerin dijital yeterliklere sahip olmasını zorunlu hale getirmiştir ve bu bağlamda birçok ulusal ve uluslararası kuruluş, öğretmenlerin dijital yeterlikleri için çeşitli çerçeveler oluşturmuştur. Öğretmenlerin bu yeterliklerini geliştirmeleri, yenilenmiş öğretim ve öğrenim stratejileri kullanarak verimli öğrenme ortamları yaratmak için kritik öneme sahiptir. Geleceğin öğretmenleri olan öğretmen adaylarının dijital yeterlikleri, mesleki yaşamlarında teknolojiyi kullanma biçimlerini etkilemektedir. Bu nedenle, dijital yeterlik düzeylerini belirlemek ve iyileştirmek için adımlar atmak, öğretmen eğitimindeki eksiklikleri tespit etmek açısından önemlidir. Bu amaçlarla, Gümüş ve Kukul (2023) tarafından geliştirilen dijital yeterlik ölçeğinin öğretmen adayları üzerindeki uygulanabilirliği, çalışma kapsamında test edilmiştir. 46 maddeden oluşan ve 6 faktörlü bir yapıya sahip olan orijinal ölçek, 330 katılımcının verileriyle yapılan açıklayıcı faktör analizi sonucunda 39 madde ve 5 faktörlü bir yapıya indirgenmiştir. Faktörlerin toplam varyansın %62,35'ini açıkladığı tespit edilmiştir. Ardından, 514 katılımcıyla doğrulayıcı faktör analizi yapılmış ve ölçeğin geçerli ve güvenilir olduğu kanıtlanmıştır. Elde edilen nihai uyum değerleri [χ2/df=2.394; GFI=.909; NFI=.922; CFI=.953; RMSEA=.052; RMR=.033; SRMR=.043] şeklindedir. Sonuç olarak, 25 madde ve beş faktörden oluşan ölçek, öğretmen adaylarının dijital yeterliklerini ölçmek için geçerli ve güvenilir bir araç olarak sunulmuştur. Ölçeğin, öğretmen eğitim programlarının güncellenmesi ve geliştirilmesi süreçlerine de katkıda bulunacağı düşünülmektedir.

Anahtar Kelimeler: dijital yeterlik; bilgi ve iletişim teknolojileri; öğretmen adayları; dijital yeterlik ölçeği.

Yasal İzinler: Recep Tayyip Erdoğan Üniversitesi Sosyal ve Beşerî Bilimler Etik Kurulu, Tarih: 22.11.2023, Sayı: 2023/346.

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Atıf için: Yıldırım, M., Kurtoğlu, Y.B., & Reisoğlu, İ. (2026). Öğretmen Dijital Yeterlik Ölçeğinin Öğretmen Adaylarına Uyarlanması. Eğitim Teknolojisi Kuram ve Uygulama. 16 (1), 49-78. DOI: 10.17943/etku.1702688

ADAPTATION OF THE TEACHER DIGITAL COMPETENCE SCALE TO PRE-SERVICE TEACHERS

Abstract

The rapid development of information and communication technologies has gradually increased the importance of digital transformation in education. This transformation has made it mandatory for teachers to have digital competences, and in this regard, many national and international organizations have created various frameworks for teachers' digital competences. Teachers' development of these competences is crucial in creating productive learning environments through the adoption of innovative teaching and learning strategies. The digital competences of pre-service teachers, who will become future teachers, influence their use of technology in their professional lives. Therefore, taking steps to determine and improve digital competence levels is important in identifying and eliminating deficiencies in teacher education. For these purposes, the applicability of the digital competence scale developed by Gümüş and Kukul (2023) was tested among pre-service teachers within the scope of the study. The original scale, which consisted of 46 items and had a 6-factor structure, was reduced to a 39-item scale with a 5-factor structure as a result of exploratory factor analysis conducted on data from 330 participants. It was found that the factors explained 62.35% of the total variance. Then, a confirmatory factor analysis was conducted with 514 participants, and the scale was found to be valid and reliable. The final fit values obtained are [$\chi 2/df=2.394$; GFI=.909; NFI=.922; CFI=.953; RMSEA=.052; RMR=.033; SRMR=.043]. As a result, the scale comprising 25 items and five factors is presented as a valid and reliable tool for measuring the digital competence of pre-service teachers. It is believed that the scale will also contribute to the updating and development of teacher training programs.

Keywords: digital competence; information and communication technologies; pre-service teachers; digital competence scale.

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Geniş Özet

Günümüzde bilgi ve iletişim teknolojilerinde yaşanan hızlı gelişmeler, yaşamın birçok alanında olduğu gibi eğitimde de köklü değişimlere yol açmıştır. Dijital dönüşümün hız kazanmasıyla birlikte, teknolojinin eğitim ortamlarına entegrasyonu artık bir seçenek değil, bir gereklilik haline gelmiştir. Bu durum, öğretme ve öğrenme süreçlerinde dijital araçların daha fazla kullanılmasını ve eğitim ortamlarının buna uygun olarak yeniden yapılandırılmasını zorunlu kılmıştır. Bu bağlamda, öğretmenlerin sahip olması gereken dijital bilgi ve beceriler ön plana çıkarken, dijital yeterlik kavramı da akademik ve uygulamalı tartışmaların merkezine yerleşmiştir. Dijital yeterlik kavramı, bireylerin dijital kaynakları bilinçli, etkili ve sorumlu bir biçimde kullanmalarını sağlayan bilgi, beceri, tutum, strateji ve yetenekleri kapsamaktadır. Bu kavram, sadece teknik becerilerle sınırlı olmayıp aynı zamanda iletişim kurma, problem çözme, iş birliği yapma ve bilgiye ulaşma gibi birçok üst düzey bilişsel beceriyi de içermektedir. Eğitim bağlamında ise öğretmenlerin dijital yeterlikleri, öğretimin planlanması, uygulanması, değerlendirilmesi ve sürekli iyileştirilmesi gibi temel süreçlerde dijital teknolojilerden etkili biçimde yararlanabilme kapasitesiyle ilişkilidir. Bu nedenle öğretmen dijital yeterlikleri yalnızca teknik beceriler değil, aynı zamanda pedagojik, etik ve sosyo-kültürel unsurları da kapsayan çok boyutlu bir yapıyı ifade etmektedir. Öğretmenlerin dijital yeterliklerini tanımlamak ve bu yeterlikler doğrultusunda öğretmenleri geliştirmek amacıyla ulusal ve uluslararası ölçekte çeşitli dijital yeterlik çerçeveleri geliştirilmiştir. Bunlar arasında ISTE, UNESCO gibi kuruluşların çerçeveleri, öğretmenlerin dijital becerilerini sistematik olarak analiz etmekte ve bu alanda standartlar belirlemektedir. Özellikle Avrupa Komisyonu Ortak Araştırma Merkezi tarafından geliştirilen Vatandaşlar için Avrupa Dijital Yeterlik Çerçevesi (DigComp 2.1)'nde dijital yeterlikler; bilgi ve veri okuryazarlığı, iletişim ve iş birliği, dijital içerik oluşturma, güvenlik ve problem çözme olmak üzere beş yeterlik alanında ele alınmıştır. Carretero vd. (2017) çalışmasında detaylandırılan bu alanlar, bir çiçeğin yaprakları gibi bütüncül bir yapıyı oluşturarak, bireylerin dijital çağda başarılı olmaları için gerekli olan temel becerileri kapsamaktadır.

Bu çalışma kapsamında ise öğretmen adaylarının dijital yeterlikleri; “Güvenlik”, “Veri Okuryazarlığı”, “İletişim ve İş Birliği”, “Problem Çözme”, “Dijital İçerik Oluşturma” ve “Etik” olmak üzere altı boyutta değerlendirilmiştir. Bu sınıflandırma hem uluslararası çerçevelerle hem de Türkiye’nin sosyal ve kültürel yapısıyla uyumlu olacak şekilde yapılandırılmıştır. Gümüş ve Kukul (2023) tarafından geliştirilen ölçekte yer alan bu boyutlar, özellikle Türk eğitim sistemine uygunluğu, kısa ve anlaşılır madde yapıları ve hedef kitlenin kolayca yanıtlayabileceği bir yapı sunması açısından tercih edilmiştir. Bu bağlamda “Etik” ve “Güvenlik” faktörlerinin ayrı ayrı ele alınması, kültürel farklılıklardan kaynaklanabilecek algı farklarını da ortaya koymaktadır. Öğretmenlerin yüksek düzeyde dijital yeterliklere sahip olması, yalnızca öğretim sürecini desteklemekle kalmaz; aynı zamanda öğrencilerin dijital teknolojilerle olan ilişkilerini, bu teknolojileri nasıl kullanacaklarını ve dijital vatandaşlık bilinçlerini de şekillendirir. Öğretmenlerin verdikleri pedagojik kararlar, öğrencilerin dijital dünyada nasıl bir konum alacaklarını ve dijital becerilerini nasıl geliştireceklerini doğrudan etkilemektedir. Bu durum, özellikle COVID-19 pandemisi ve 6 Şubat 2023 tarihinde Türkiye'de yaşanan büyük depremler gibi olağanüstü durumlarda daha da belirginleşmiştir. Yüz yüze eğitimin sekteye uğradığı bu dönemlerde çevrim içi öğrenme ortamları ön plana çıkmış, öğretmenlerin dijital yeterliklerinin önemi katlanarak artmıştır. Bu nedenle öğretmenlerin dijital yeterlikleri yalnızca olağan durumlar için değil, kriz anlarında da etkili öğretim ortamları oluşturmak açısından stratejik bir öneme sahiptir. Bu noktada öğretmen yetiştirme programlarının içeriği

ve yapısı büyük önem arz etmektedir. Zira öğretmen adaylarının üniversite eğitimi süresince dijital yeterlik düzeylerinin geliştirilmesi, onların mesleki yaşamlarında bu becerileri etkili şekilde kullanabilmelerinin temelini oluşturmaktadır. Yükseköğretim Kurulunun öğretmenlik programları çerçevesinde de dijital yeterlik, temel öğretmen yeterliklerinden biri olarak tanımlanmakta ve bu becerilerin geliştirilmesine yönelik uygulamaların arttırılması gerektiği vurgulanmaktadır. Dijital yeterlik öğretmenlerin ve öğretmen adaylarının sahip olması gereken çağdaş bir yeterlik alanı olarak eğitim politikaları ve öğretmen yetiştirme programlarında öncelikli bir konu haline gelmiştir. Öğretmen adaylarının dijital yeterliklerini geliştirmeye yönelik yapılandırılmış ve kültürel bağlamla uyumlu eğitim modellerinin oluşturulması, dijital dönüşüm sürecinde nitelikli insan gücünün yetişmesine katkı sağlayacaktır. Bu nedenle, öğretmen adaylarının dijital yeterliklerini çok boyutlu bir yaklaşımla değerlendirmek ve bu yeterlikleri geliştirmeye yönelik sistematik stratejiler geliştirmek, eğitim sistemlerinin dijital çağa uyum sağlayabilmesi için büyük önem taşımaktadır.

Çalışmada, Gümüş ve Kukul (2023) tarafından öğretmenlere yönelik geliştirilen dijital yeterlik ölçeği öğretmen adayları için uygun hale getirilerek kullanılabilirliği kontrol edilmiştir. Çalışmanın açıklayıcı faktör analizi (AFA) örneklemini kolay ulaşılabilir örnekleme yöntemi ile belirlenen, 2023-2024 akademik yılı güz döneminde üniversitelerin eğitim fakültelerinin farklı bölümlerinde öğrenim gören 330 öğretmen adayı oluşturmaktadır. Çalışmanın doğrulayıcı faktör analizi (DFA) örneklemi ise, kolay ulaşılabilir örnekleme yöntemi ile belirlenen, 2023-2024 akademik yılı bahar döneminde üniversitelerin eğitim fakültelerinin farklı bölümlerinde öğrenim gören, AFA örneklem grubundan farklı olan 514 öğretmen adayından oluşmaktadır. Ölçek; on madde içeren "Güvenlik", dokuz madde içeren "Veri Okuryazarlığı", dokuz madde içeren "Problem Çözme", altı madde içeren "Dijital İçerik Geliştirme", yedi madde içeren "İletişim ve İş Birliği" ve beş madde içeren "Etik" olmak üzere toplam 6 faktörden ve 46 maddeden oluşmaktadır. Beşli likert tipinde hazırlanan ölçeğin derecelendirilmesi "1-Kesinlikle Katılmıyorum, 5-Kesinlikle Katılıyorum" arasında değişmektedir. Ölçeğin toplam varyans değerinin %71,967 olarak açıklandığı çalışmada, faktörlerin güvenirlik katsayıları "Güvenlik" α=.95, "Veri Okuryazarlığı" α=.91, "Problem Çözme" α=.94, "Dijital İçerik Geliştirme" α=.93, "İletişim ve İş Birliği" α=.95 ve "Etik" α=.90 olarak, ölçeğin tamamının güvenirlik katsayısı ise α=.97 olarak belirtilmiştir (Gümüş & Kukul, 2023).

Öğretmen dijital yeterlik ölçeğinin öğretmen adaylarına uyarlanması için ilk olarak maddeler detaylı şekilde incelenerek bu gruba uygunluğu değerlendirilmiş, bir alan uzmanı ve bir ölçme-değerlendirme uzmanının görüşleri alınarak uyarlamanın yapılması uygun görülmüştür. Daha sonra ölçeği hazırlayan araştırmacılardan gerekli izinler ve onay alınarak bir Türkçe dil uzmanı ve bir öğretim teknolojileri uzmanı görüşleri doğrultusunda maddelerin anlaşılırlığı, kelime ve cümle yapısı değerlendirilip ölçek formunun orijinal haliyle pilot çalışma yapılmasına karar verilmiştir. Pilot çalışma maddelerin öğretmen adayları tarafından doğru şekilde anlaşılıp anlaşılmadığını test etmek için örneklem grubu haricinde 12 öğretmen adayı ile gerçekleştirilmiştir. Her bir madde için öneri ve yorum yapılabilecek alanların yer aldığı form ile öğretmen adaylarının görüş ve önerileri alınmıştır. Bu kapsamda toplanan bilgiler değerlendirilmiş, maddelerin açıklık ve anlaşılırlık açısından yeterli olduğuna karar verilerek ölçeğin değişiklik yapılmadan kullanılması uygun görülmüştür. Tüm bu süreçler tamamlandıktan sonra ölçeğin örneklem grubuna uygulanması için izinler alınmış ve veri toplama sürecine geçilmiştir. Ölçek formu, öğretmen adaylarının çevrimiçi olarak doldurabilecekleri şekilde online form sistemine girilmiştir. Çevrimiçi form adresi öğretmen adaylarına e-posta aracılığıyla iletilmiş ve ayrıca bazı öğretim elemanlarının yardımıyla

uygulatılmıştır. Çalışmaya katılım tamamen gönüllülük esasına dayalı olup katılımcılardan e-posta adresi, isim, iletişim bilgisi gibi kişisel veriler toplanmamıştır. AFA tamamlandığında, madde çıkartma işlemlerinden sonra yeni ölçek formu aynı şekilde çevrimiçi olarak oluşturularak DFA için veri toplamaya hazır hale getirilmiştir. Ölçek, daha önce katılım sağlayan gruptan farklı gruplara uygulanıp veri toplama süreci tamamlanarak DFA yapılmıştır.

Maksimum olabilirlik (maximum likelihood) yöntemi ile yapılan faktör analizi, 46 madde üzerinde doğrudan eğik döndürme (direct oblimin) ile gerçekleştirilmiştir. Bu analiz sonucunda, "Problem Çözme" boyutuna yönelik 20. ve 21. maddelerin "Veri Okuryazarlığı" boyutu altında yapılandığı belirlenmiştir. Analiz işlemi sonucu herhangi bir faktör altında 0.30 üzeri yük değeri oluşturmayan, "Problem Çözme" faktörü altında yer alan 28. madde atılarak analiz tekrar yapılmıştır. Ardından faktör yük değeri .45 altında ve "Problem Çözme" faktörü altında yer alan 22., 23., 26. ve 27. maddeler atılarak analiz tekrar gerçekleştirilmiştir. Gerçekleştirilen analizde "Problem Çözme" faktörü altında yer alan 24. ve 25. maddeler .30 altı faktör yükü gösterince analiz 5 faktör üzerinden gerçekleştirilmiştir. Analiz sonucunda 5 faktörün özdeğerinin 1'den büyük olduğu görülüp toplam varyansın %62,35'ini açıkladığı bulunmuştur.

Yapılan AFA sonrasında ölçeğin birinci faktörü 11 maddeden, ikinci faktörü 6 maddeden, üçüncü faktörü 5 maddeden, dördüncü faktörü 10 maddeden, beşinci faktörü 7 maddeden olmak üzere 39 maddeli bir yapı ortaya çıkmıştır. Maddeler tekrar gözden geçirilerek ve ölçeğin orijinaline bağlı kalınarak birinci faktöre "Veri Okuryazarlığı", ikinci faktöre "Dijital İçerik Geliştirme", üçüncü faktöre "Etik", dördüncü faktöre "Güvenlik", beşinci faktöre "İletişim ve İş Birliği" adı verilmiştir. Ölçeğin orijinalinden farklı olarak 20. ve 21. maddelerin "Problem Çözme" faktöründen "Veri Okuryazarlığı" faktörüne kaydığı görülmüştür. Faktörlerin cronbach alpha katsayıları sırasıyla 0.92, 0.91, 0.90, 0.91, 0.89 olup ölçeğin geneli için 0.95'tir.

AFA'ya göre ölçeğin 5 faktör, 39 maddeden oluştuğu görülmüş olup ortaya çıkan modelin uygunluğunu test edebilmek adına, AFA'da uygulanan öğrenci grubundan farklı olarak 514 öğrenciden toplanan veri ile DFA yapılmıştır. Yapılan madde çıkarmaları ve modifikasyonlar sonucu nihai indisler: [$\chi 2/df=2.394$; GFI=.909; AGFI=.888; NFI=.922; CFI=.953; TLI=.946; IFI=.953; RMSEA=.052; RMR=.033; SRMR=.043] olarak hesaplanmış ve uyum iyiliği değerlerinin tavsiye edilen aralıkta olduğu belirlenmiştir. Ayrıca birleşim ve ayrışım geçerliği analizleri yapılarak ölçeğin uygun değerlere sahip olduğu görülmüştür.

AFA sonuçları doğrultusunda orijinal ölçekte yer alan "Problem Çözme" faktörünün yeterli temsil gücüne sahip olmadığı, bu faktördeki maddelerin ya çıkarıldığı ya da "Veri Okuryazarlığı" faktörü altında toplandığı görülmüştür. Böylece orijinal altı faktörlü yapı, beş faktör altında toplanmıştır. Yeni yapının toplam varyansın %62,35'ini açıkladığı ve bu oranın sosyal bilimlerde yeterli olduğu belirlenmiştir.

Özellikle "Problem Çözme" boyutunun öğretmen adaylarında oluşmaması, bu grubun mesleki deneyim eksikliğiyle ilişkilendirilmiştir. DFA sonucunda madde çıkarımları ve modifikasyonlarla elde edilen modelin uyum indekslerinin büyük oranda iyi ya da mükemmel düzeyde olduğu görülmüştür. Özellikle χ^2/df, GFI, AGFI, NFI, TLI, CFI ve RMSEA gibi temel uyum indekslerinin önerilen sınırlar içerisinde yer alması, modelin geçerli ve güvenilir olduğunu göstermiştir. Ek olarak, ölçeğin birleşim ve ayrışım geçerlikleri de incelenmiş ve CR ile AVE değerlerinin yeterli düzeyde olması sayesinde birleşim geçerliği sağlanmıştır. Ayrışım geçerliği ise HTMT değerleri üzerinden değerlendirilmiş ve tüm faktörler arasında beklenen düzeyde farklılıkların varlığı doğrulanmıştır. Tüm bu analizler sonucunda, 25 maddeden oluşan beş

faktörlü ölçek formunun öğretmen adaylarına yönelik geçerli ve güvenilir bir araç olduğu sonucuna ulaşılmıştır.

Çalışmanın sonuçları, öğretmen adaylarının dijital yeterlik düzeylerinin belirlenmesine ve geliştirilmesine yönelik veri toplamada kullanılabilecek güçlü bir ölçme aracı sunduğunu ortaya koymaktadır. Uyarlanan ölçek, öğretmen eğitimi programlarının gözden geçirilmesine, politika geliştirme süreçlerine katkı sağlayabileceği gibi, farklı demografik gruplarda ve daha geniş örneklemlerle yürütülecek çalışmalara da temel oluşturabilir. Ayrıca, öğretmen adayları ile öğretmenlerin dijital yeterliklerinin karşılaştırıldığı yeni araştırmalar için de kullanılabilecektir.

Introduction

In recent years, with the developments in Information and Communication Technologies (ICT), technology has played a more significant role in human life, and the digital transformation process has accelerated worldwide. This situation has initiated the development and transformation of education, making it necessary to incorporate technology more into educational environments. Due to this necessity, digital technologies have gained increased importance in educational environments, and teaching and learning conditions have undergone significant changes (Edstrand & Sjöberg, 2023). These developments have revealed teachers' need for different competences to provide inclusive, integrative, and productive learning environments that utilize digital technologies. This situation has brought the concept of digital competence to the agenda (Ilomäki et al., 2016). However, the continuous development of technology integration requires teachers not only to use existing tools but also to be constantly learning and adapting professionals (Moreira-Choez et al., 2024).

As teachers' digital competences have become an important issue, various digital competence frameworks have been developed to define teacher digital competences and determine digital competence standards (Education and Training Foundation, 2019; Elliot et al., 2011; Falloon, 2020; Herring et al., 2016; The International Society for Technology in Education [ISTE], 2021; Kelentrić et al., 2017; Mentoring Technology-Enhanced Pedagogy [MENTEP], 2018; Redecker & Punie, 2017; Schola Europaea, 2020; UNICEF, 2022; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2018). Digital competence is generally defined as the knowledge, skills, attitudes, abilities, and strategies that individuals must have to use digital resources consciously and effectively while performing different tasks, such as communicating, problem-solving, collaborating, accessing, using, and evaluating information (Eshet-Alkali & Amichai-Hamburger, 2004; Ferrari et al., 2012). Specifically, it is emphasized that teachers' competences in the context of digital education should encompass not only technological skills but also the ability to apply effective teaching strategies in digital learning environments (Tzafilkou et al., 2023).

Teacher digital competence, in general, is defined as the knowledge, skills, and attitudes that teachers must have to plan, implement, evaluate, and continuously monitor and regulate teaching using digital technologies (Basilotta-Gómez-Pablos et al., 2022; Caena & Redecker, 2019; Lucas et al., 2021). It is described as a comprehensive and complex concept with social, socio-cultural, ethical, and pedagogical dimensions that extend beyond the use of digital tools and technologies in educational environments, encompassing technical knowledge and skills (Guillén-Gámez & Mayorga-Fernández, 2020; Lund et al., 2014). This complexity has led to different definitions of digital competence and the focus on different dimensions in research.

Guillén-Gámez and Mayorga-Fernández (2020) focused on three basic dimensions of digital competence for teachers: attitudes towards ICT, knowledge, and the use of these technologies in education. Similarly, Dias-Trindade and Moreira (2020) examined the digital competences of high school teachers. They focused on three dimensions: teachers' professional competences, pedagogical competences, and students' competences. The European Digital Competence Framework for Citizens (DigComp 2.1), developed by the European Commission's Joint Research Centre, addresses digital competences in five areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. These areas, detailed in Carretero et al.'s (2017) study, form a holistic structure, similar to a flower's petals (Figure 1), encompassing the fundamental skills necessary for individuals to succeed in the digital age.

Figure 1. The DigComp framework (European Commission, Joint Research Centre, 2024).

In this study, the digital competences of pre-service teachers were evaluated in six different dimensions: "Security", "Data Literacy", "Communication and Collaboration", "Problem Solving", "Digital Content Creation", and "Ethics". In this context, items related to the protection of digital devices and personal data were evaluated under the "Security" dimension. In contrast, items related to the evaluation and management of data accessed in the digital environment were considered under the "Data Literacy" dimension. The items that include communicating with digital technologies and the concept of digital citizenship are classified under the "Communication and Collaboration" dimensions, the items that involve determining needs and technological solutions and solving problems are classified under the "Problem-Solving" dimension, and the items covering the design and development of digital content are classified under the "Digital Content Creation" dimension. Items covering social traditions and principles are discussed in the "Ethics" dimension. These dimensions were preferred because they were structured according to the Turkish social and cultural context, taking into account the sub-dimensions outlined in the frameworks published by national and international institutions and organizations on digital competence (Gümüş & Kukul, 2023). The primary reason for its adoption is that the DigComp 2.1 framework is an internationally recognized standard developed by the European Commission that systematically addresses digital competences across five comprehensive dimensions.

Furthermore, it is frequently referenced in the literature alongside frameworks from other important institutions such as UNESCO, ISTE, and OECD, and is a well-established structure used by many researchers. Its ability to remain up to date with changes in technology is also a key reason for its preference. As a matter of fact, among the factors of the scale developed by Gümüş and Kukul (2023) and used in this research, the formation of the "Ethics" dimension, unlike DigComp 2.1, was interpreted as the "Ethics" and "Safety" dimensions measuring different skills, as well as social and cultural differences. For this reason, in this study, the applicability of the digital competence scale developed by Gümüş and Kukul (2023) was preferred, which was designed with consideration of the target audience's culture and features a straightforward structure with concise, understandable, and up-to-date expressions.

Teachers must effectively organize the teaching process and create efficient learning environments by utilizing innovative teaching and learning strategies. To meet this expectation, teachers must have advanced digital competences (Lucas et al., 2021; Redecker & Punie, 2017). Likewise, students are expected to have advanced digital competences to continue learning in today's information-based society and to become qualified, equipped individuals with 21st-century skills (Siiman et al., 2016). In this context, both teachers and students need advanced digital competences, which are considered essential today (Cabero-Almenara et al., 2020). Teachers are expected to continually improve their digital competences to navigate rapidly changing educational environments, especially in light of technological advancements, and prepare students for the digital world (Falloon, 2020). Teachers' advanced digital competences significantly influence how students use and benefit from digital technologies and are crucial in supporting and enhancing students' learning (Lucas et al., 2021). Teachers' pedagogical decisions regarding digital technologies and the learning opportunities they offer effectively promote students' active use of digital technologies in their lives and careers, thereby improving their digital competences (Reisoğlu, 2022). Furthermore, a study by Behnamnia and Hayati (2025) found a strong correlation between the development of teachers' digital research skills and their perceptions of self-confidence and competence. This finding indicates that digital competence is not only about acquiring technical skills but also a process that increases teachers' self-confidence in using technology.

Following the worldwide COVID-19 pandemic and the earthquakes in Turkey on February 6, 2023, which suspended face-to-face education, online education environments have become essential platforms that allow teaching and learning to continue. The digital competences of teachers and pre-service teachers have also gained importance (Jimarkon et al., 2021). The pandemic has clearly been a catalyst for improving teachers' digital competencies. However, systematic and continuous professional development programs are vital for the sustainability of this development (Ivanov et al., 2025). Teacher digital competence is essential for strengthening pedagogical practice in distance education environments (Can, 2020), where pedagogical problems are encountered, and pedagogy cannot be fully implemented or designed. Therefore, greater importance should be placed on the digital competences of teachers and pre-service teachers (Lucas et al., 2021). At this point, focusing on teacher training programs would be helpful. Teacher training programs play a crucial role in equipping future teachers with digital competence and tailoring these competences to the needs of the age (Jimarkon et al., 2021). Momdjian et al. (2025) examined the role of direct instruction, integrated application, and modeling strategies in developing

digital competence among pre-service teachers. They found that teacher education programs offer limited opportunities in this regard.

Digital competence has become increasingly important in education as one of the essential competences that teachers must have at an advanced level today (Basilotta-Gómez-Pablos et al., 2022). At this point, it is necessary to focus on university education, the first official step in developing teachers' professional digital competences (Eickelmann & Drossel, 2020). One of the aims of teacher education is to develop pre-service teachers' digital competences and efficacy beliefs, and to train them to be technology-literate (Eickelmann & Drossel, 2020; Council of Higher Education [YÖK], 2018). Experts emphasize that teacher education programs should equip pre-service teachers with the effective use of digital technologies that future generations will have access to and provide opportunities to prepare them for their professional lives by making them digitally competent, so that they can integrate technology into their future classrooms (Instefjord, 2015; Toker et al., 2021). Pre-service teachers need these competences to use digital technologies more effectively in their professional lives and create productive learning environments (Almås et al., 2021). However, teacher education programs may lack the digital competences for pre-service teachers to properly integrate technology into their future classrooms and support their students' learning by providing efficient learning environments (Instefjord, 2015; Sutton, 2011). In this case, pre-service teachers introduced to new technologies and learning platforms throughout their professional lives after graduation may encounter difficulties in discovering and critically evaluating them (Camilleri et al., 2021).

The development of digital competences during pre-service teacher education has become a debated topic in the literature (Falloon, 2020). It is stated that the pre-service training that in-service teachers receive can impact their digital competences (Eickelmann & Drossel, 2020). In this context, teachers' digital experiences during their undergraduate education impact their ability to use digital competences efficiently in their professional lives (Tomte et al., 2015). It is essential to take steps to determine and improve the digital competence levels of pre-service teachers. This can also be useful in providing information on what needs to be done to identify and address current deficiencies in teacher education (Eickelmann & Drossel, 2020; Hanell, 2018). Numerous studies in the literature have addressed the digital competence levels of pre-service teachers (García-Vandewalle García et al., 2023; Haşlaman et al., 2023; Ortega-Sánchez et al., 2020; Reisoğlu & Çebi, 2020; Quast et al., 2023).

In the literature, studies on the digital competence levels of pre-service teachers have employed various data collection tools, including scales (Párraga et al., 2022), surveys (Çebi & Reisoğlu, 2020; García-Vandewalle García et al., 2023), reflection reports, and e-portfolios (Haşlaman et al., 2023). An important consideration in using these tools is that there are significant differences in perceptions of digital competence, experience levels, and application contexts between pre-service and in-service teachers. A review of the literature reveals that pre-service teachers, despite generally belonging to the digital-native generation, often experience difficulties in effectively integrating digital tools into pedagogical contexts (Momdjian et al., 2024; Yang et al., 2022). Pre-service teachers demonstrate a more open attitude towards technology and are eager to explore innovative digital tools; however, due to their limited classroom experience, their ability to meaningfully integrate these tools into teaching processes is underdeveloped (Farjon et al., 2019; Instefjord, 2015). In contrast, in-service teachers, despite having rich classroom experience and pedagogical knowledge, face

distinct challenges due to ingrained habits and resistance to technology integration (Howard & Gigliotti, 2016).

Furthermore, pre-service teachers' digital competences are primarily based on personal use experiences, and they have been found to lack sufficient experience with technology for educational purposes (Dolezal et al., 2025). This situation demonstrates that the digital competences of both groups may be developed to varying degrees, highlighting the need for measurement tools tailored explicitly for pre-service teachers. Indeed, most existing scales have been developed for practicing teachers and may not fully reflect the characteristics of pre-service teachers, such as their limited experience, theoretical educational background, and restricted opportunities for pedagogical practice. The number of Turkish scales developed or adapted to determine the digital competence levels of pre-service teachers is relatively low (Karakuş et al., 2022). In particular, considering the differences in digital competence perception, experience level, and application context between pre-service teachers and in-service teachers, the need for customized measurement tools for each group becomes apparent (Aydin et al., 2024). For this reason, within the scope of the research, it was aimed to test the usability of the digital competence scale prepared by Gümüş and Kukul (2023) for teachers, which is thought to be suitable for pre-service teachers, and to adapt it to the target audience. In this context, it is believed that the research will help fill the gap in existing literature.

Method

In this study, the Digital Competence Scale, developed by Gümüş and Kukul (2023) for teachers, was adapted for pre-service teachers, and its usability was evaluated.

Sample

The study's exploratory factor analysis (EFA) sample consists of 330 pre-service teachers studying in different departments of education faculties at universities in the fall semester of the 2023-2024 academic year, determined using an easily accessible sampling method. Demographic information about the EFA sample group of the research is presented in Table 1.

Table 1. Demographic information of the EFA sample

Variable		f	%
Gender	Female	248	75.2
	Male	82	24.8
Branch	Science	20	6.06
	Elementary Mathematics Teaching	70	21.21
	Guidance and psychological counseling	24	7.27
	Art Education	9	2.72
	Classroom Education	65	19.69
	Social Sciences Education	47	14.24
	Turkish Education	95	28.78
Grade	1. Grade	100	30.30
	2. Grade	99	30
	3. Grade	86	26.06
	4. Grade	45	13.63

The confirmatory factor analysis (CFA) sample of the study consists of 514 pre-service teachers, selected using an easily accessible sampling method, who differ from the EFA sample group in terms of their academic departments and education faculties, and are studying in universities during the spring semester of the 2023-2024 academic year. The demographic information of the sample group that applied for the CFA of the research is presented in Table 2.

Table 2. Demographic information of the CFA sample

Variable		f	%
Gender	Female	375	72.95
	Male	139	27.05
Branch	Science	58	11.28
	Elementary Mathematics Teaching	98	19.07
	Guidance and psychological counseling	70	13.62
	Art Education	13	2.53
	Classroom Education	93	18.09
	Social Sciences Education	94	18.29
	Turkish Education	88	17.12
Grade	1. Grade	116	22.57
	2. Grade	151	29.38
	3. Grade	143	27.82
	4. Grade	104	20.23

Data Collection Tools

In the study, a demographic information form and the Teacher Digital Competence Scale were used. This section provides information on the data collection tools used in the study.

Demographic Information Form

A demographic information form consisting entirely of multiple-choice questions was used to determine the gender, departments, and grade levels of the pre-service teachers participating in the study.

Teacher Digital Competence Scale

In the study, the scale developed by Gümüş and Kukul (2023) to assess teachers' digital competences was adapted for use with pre-service teachers. The scale consists of "Security" (10 items), "Data Literacy" (9 items), "Problem-Solving" (9 items), "Digital Content Creation" (6 items), "Communication and Collaboration" (7 items), and "Ethics" (5 items). It consists of 6 factors and 46 items. The rating scale is a five-point Likert-type scale ranging from "1-Strongly Disagree" to "5-Strongly Agree". In the study where the total variance value of the scale was reported as 71.967%, the reliability coefficients of the factors were as follows: "Security" (α=.95), "Data Literacy" (α=.91), and "Problem Solving" (α=.94), "Digital Content

Creation" (α=.93), "Communication and Collaboration" is stated as (α=.95), "Ethics" is stated as (α=.90), and the reliability coefficient of the entire scale is stated as (α=.97) (Gümüş & Kukul, 2023).

Data Collection Process

First, the items were examined in detail to make the teacher digital competence scale suitable for pre-service teachers. Their suitability for pre-service teachers was evaluated, and it was deemed appropriate to adapt it for this audience by consulting with a field expert and a measurement and evaluation expert. Then, after obtaining the necessary permissions and approval from the researchers who prepared the scale, the comprehensibility of the items, words, and sentence structure was evaluated in line with the opinions of a Turkish language expert and an instructional technology expert. It was decided to conduct a pilot study of the scale in its original form. The pilot study was conducted with 12 pre-service teachers outside the sample to test whether they correctly understood the items. The opinions and suggestions of pre-service teachers were collected through a form that included fields for comments on each item. By evaluating the information collected in this context, it was determined that the items were suitable in terms of clarity and understandability, and it was deemed appropriate to use the scale without modification. After all these processes were completed, permission was obtained to apply the scale to the sample group, and the data collection process began.

The scale form has been entered into the online form system, allowing pre-service teachers to complete it online. The online form address was sent to the pre-service teachers via email and implemented with the help of some faculty members. Participation in the study was voluntary, and no personal data, such as email addresses, names, or contact information, was collected from the participants. In addition to the scale items, the form also includes the participants' gender, department, and class information. After the item removal process was completed, the new scale form was created online in the same manner and was made ready to collect data for CFA. The scale was applied to groups different from those that had previously participated, the data collection process was completed, and CFA was performed.

Data Analysis

When examining the number of samples required for factor analysis, data must be collected at least five times the number of items (Yaşlıoğlu, 2017, p. 75). For this reason, data collection continued until sufficient samples were obtained for analysis, while attempting to include as many sample groups as possible.

The data obtained during the EFA were analyzed using IBM SPSS Statistics v27. Frequency and percentage values from descriptive analyses were used to interpret demographic data. The data collection process was conducted via an online form, preventing incomplete data entry. Therefore, the resulting data set found no empty or incorrect entries. Before analyzing the data, the z-score was first calculated, and any extreme data were detected and removed from the dataset. When there is extreme data in the answers, it is recommended that it be removed from the dataset to prevent such erroneous situations, as it has a high impact on factor calculations (Tabachnick & Fidell, 2014). In this context, extreme values were removed before conducting normality tests to determine whether the collected data followed a normal distribution. The collected data showed a normal distribution. In the normality analysis, it was determined that the kurtosis and skewness coefficients fell within

the range of -1 to +1 (Morgan et al., 2004), and the histogram, Q-Q plot, and P-P plot graphs conformed to a normal distribution. Upon completing these analyses, the EFA findings from 330 participants deemed suitable for analysis were reported.

The CFA was conducted in the study using AMOS 22. The analysis was conducted using a dataset obtained from 514 participants. The model's goodness-of-fit was examined to assess whether the factor structure was consistent with theoretical assumptions. During the analysis, items that needed to be removed from the model were identified and gradually removed. The analyses were then repeated. These processes were continued until the compliance values reached a satisfactory level and the process was completed. The findings obtained were reported in detail.

Findings

Exploratory Factor Analysis

To determine the scale's factor structure, it is necessary to assess the suitability of the collected data for factor analysis before performing EFA. For this control, the Kaiser-Meyer-Olkin (KMO) value should be examined. The lower limit for this value, which varies between 0 and 1, is 0.5; the range of 0.5-0.7 is considered to be medium, the range of 0.7-0.8 is considered to be good, the range of 0.8-0.9 is considered to be very good, and values above 0.9 are considered to be excellent (Field, 2009). As a result of the analysis, the KMO value was 0.93. The Bartlett's sphericity test result was determined as [$\chi 2(741) = 8484.755$, $p = .000$], and it was determined that the correlation between the items was sufficient. These values indicate that the data are suitable for factor analysis.

Factor analysis using the maximum likelihood method was performed with direct oblimin rotation on 46 items. To gain a clearer understanding of the factor structures and given the correlation between the factors, the analysis process was conducted using the "direct oblimin" rotation method (Stevens, 1996). As a result of this analysis, it was determined that the 20th and 21st items regarding the "Problem-Solving" dimension were structured under the "Data Literacy" dimension. The analysis was repeated by removing the 28th item under the "Problem-Solving" factor, which had a load value of less than 0.30 for any factor. Then, the analysis was repeated by removing the 22nd, 23rd, 26th, and 27th items, which had factor loadings below .45 and were under the "Problem-Solving" factor. In the analysis, the 24th and 25th items under the "Problem-Solving" factor showed factor loadings below .30; therefore, the analysis was carried out on five factors. As a result of the analysis, it was found that the eigenvalues of the five factors were greater than 1 and explained 62.35% of the total variance. Table 3 reflects the EFA results.

Table 3. EFA Results

Items	Data Literacy	Digital Content Creation	Ethics	Security	Communication and Collaboration
Item 14	.786				
Item 15	.781				
Item 13	.764				
Item 18	.759				
Item 12	.751				
Item 17	.694				
Item 11	.640				
Item 19	.627				
Item 20	.550				
Item 21	.545				
Item 16	.486				
Item 31		.889			
Item 30		.813			
Item 32		.758			
Item 29		.658			
Item 33		.648			
Item 34		.632			
Item 44			-.859		
Item 45			-.841		
Item 43			-.828		
Item 42			-.768		
Item 46			-.656		
Item 1				.752	
Item 5				.731	
Item 8				.725	
Item 2				.711	
Item 3				.699	
Item 10				.668	
Item 9				.633	
Item 7				.620	
Item 6				.570	
Item 4				.528	
Item 38					.644
Item 36					.602
Item 41					.594
Item 40					.568

Item 39					.565
Item 35					.490
Item 37					.478
Eigenvalue	13.96	4.00	2.83	2.12	1.41
Explained Variance	35.79	10.26	7.27	5.43	3.61
Cronbach alpha (α)	.92	.91	.90	.91	.89

After EFA, a 39-item structure emerged, with the first factor comprising 11 items, the second comprising 6, the third comprising 5, the fourth comprising 10, and the fifth comprising 7. By reviewing the items again and adhering to the original scale, the first factor was named "Data Literacy", the second factor was named "Digital Content Creation", the third factor was named "Ethics", the fourth factor was called "Security", and the fifth factor was named "Communication and Collaboration". It was observed that, unlike the original version of the scale, items 20th and 21st shifted from the "Problem-Solving" factor to the "Data Literacy" factor. The Cronbach alpha coefficients of the factors are 0.92, 0.91, 0.90, 0.91, 0.89, respectively, and 0.95 for the overall scale.

Confirmatory Factor Analysis

According to EFA, the scale consisted of 5 factors and 39 items, and CFA aimed to determine the extent to which the results obtained were suitable for the structure being measured (Özdamar, 2013). For this purpose, to test the suitability of the model emerging from EFA, CFA was conducted using data collected from 514 students, a different student group from the one applied in EFA.

As a result of the analysis, with χ2/df fit value, GFI (Goodness of Fit Index), AGFI (Adjusted Goodness of Fit Index), NFI (Normed Fit Index), CFI (Comparative Fit Index), IFI (Incremental Fit Index), TLI (Tucker-Lewis Index), RMSEA (Root Mean Square Error of Approximation), RMR (Root Mean Square Residual), SRMR (Standardized Root Mean Square Residual) values were examined. While examining these values, all values were interpreted together, rather than considering any single value (Tabachnick & Fidell, 2014). The fit values obtained before modifying the model are as follows: [χ2/df=3.428; GFI=.802; AGFI=.777; NFI=.837; CFI=.878; TLI=.870; IFI=.879; RMSEA=.069; RMR=.045; SRMR=.058]. As a result of the analysis, modification suggestions were examined, and it was determined that the seventh item under the "Digital Content Creation" factor, the first item under the "Data Literacy" factor, and the ninth item under the "Security" factor required modification due to having too many items. Therefore, it was decided to delete the items. The fit values obtained after this process are as follows: [χ2/df=2.891; GFI=.837; AGFI=.814; NFI=.870; CFI=.910; TLI=.903; IFI=.911; RMSEA=.061. RMR=.038; SRMR=.052]. As a result of the analysis, modification suggestions were examined, and it was determined that the third and 11th items under the "Data Literacy" factor required modification due to having too many items. Therefore, it was decided to delete the items. The fit values resulting from this process are as follows: [χ2/df=2.695; GFI=.858; AGFI=.837; NFI=.884; CFI=.923; TLI=.917; IFI=.924; RMSEA=.057. RMR=.036; SRMR=.047]. As a result of the analysis, modification suggestions were examined, and it was determined that the 10th item under the "Data Literacy" factor and the first item

under the "Security" factor required modification due to having too many items. Therefore, it was decided to delete the items. The fit values obtained after this process are as follows: [χ2/df=2.507; GFI=.877; AGFI=.857; NFI=.899; CFI=.936; TLI=.931; IFI=.937; RMSEA=.054. RMR=.034; SRMR=.047]. As a result of the analysis, modification suggestions were examined, and it was determined that the second item under the "Digital Content Creation" factor and the fourth and sixth items under the "Communication and Collaboration" factor had too many modifications. Therefore, it was decided to delete the items. The fit values resulting from this process are as follows: [χ2/df=2.503; GFI=.889; AGFI=.869; NFI=.906; CFI=.941; TLI=.935; IFI=.941; RMSEA=.054. RMR=.034; SRMR=.047]. As a result of the analysis, modification suggestions were examined, and it was determined that the second item under the "Data Literacy" factor and the first item under the "Ethics" factor required modification due to having too many items. Therefore, it was decided to delete the items. The fit values obtained after this process are as follows: [χ2/df=2.464; GFI=.903; AGFI=.882; NFI=.916; CFI=.948; TLI=.942; IFI=.948; RMSEA=.053. RMR=.033; SRMR=.044]. As a result of the analysis, modification suggestions were examined, and it was determined that the third item, "Data Literacy," contained too many modifications. Therefore, it was decided to delete the item. The fit values obtained after this process are as follows: [χ2/df=2.394; GFI=.909; AGFI=.888; NFI=.922; CFI=.953; TLI=.946; IFI=.953; RMSEA=.052; RMR=.033; SRMR=.043]. The analysis was completed because the fit indices obtained at this stage reached an acceptable level. Table 4 presents the fit indices for both the adapted and original scales.

Table 4. CFA Goodness of Fit Indices

Model Fit Indices	Model Value	Recommended Value	Resources	Evaluation	Original Scale
χ2/	2.3	≤3	Kline (2016)	Good Fit	3.264
GFI	.90	≥0.90	Davcik (2014)	Good Fit	.827
AGF	.88	≥0.90	Schermelleh-Engel et al.	Acceptable	.807
NFI	.92	≥0.90	Hu & Bentler (1999)	Good Fit	.900
CFI	.95	≥.95	Marsh et al. (2004)	Perfect Fit	.928
TLI	.94	≥0.90	Fan et al. (2016)	Good Fit	-
IFI	.95	≥.95	Hu & Bentler (1999)	Perfect Fit	.928
RM	.03	≤0.05	Kline (2016)	Perfect Fit	.042
RM	.05	≤0.08	Sanders et al. (2005)	Good Fit	.057
SR	.04	≤0.05	Brown (2015)	Perfect Fit	.048

When Table 4 is examined, it can be seen that the adapted scale indices are similar to the fit indices of the original scale, and some indices are even better. The indices were calculated, and it was determined that the goodness-of-fit values were within the recommended range. Figure 2 shows the factors, the items under each factor, the factor loadings, and the correlations between factors.

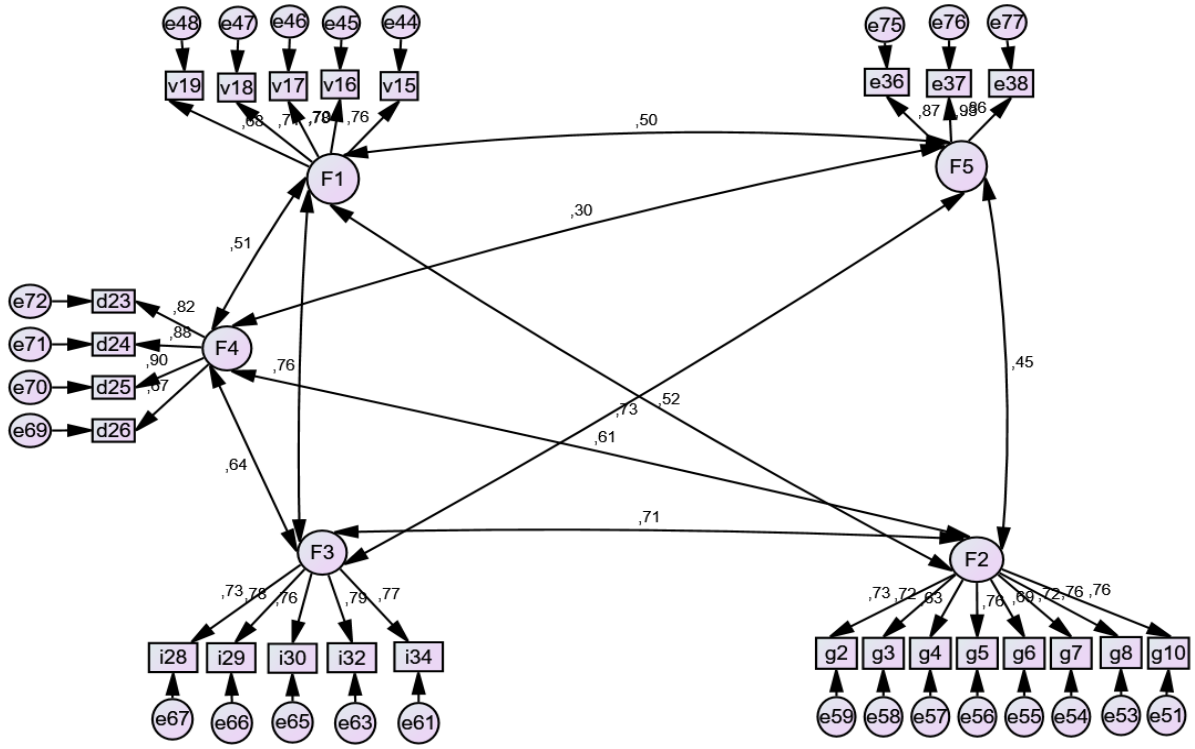

Figure 2. CFA Diagram.

Convergent Validity

Convergent validity is a concept that provides evidence that different measurement tools consistently measure the same conceptual structures, and it states that these measurement tools should correlate with each other at a moderate level or higher (Gürbüz & Şahin, 2018). As a result of CFA, although it can be said that a certain level of convergent and discriminant validity has been achieved after the measurement model has been verified, studies conducted in recent years have also included results regarding the convergent and discriminant validity of the scales as additional evidence in addition to the CFA results (Gürbüz, 2021). When evaluating convergent validity, it is essential to note that the model has good convergent validity if the Average Variance Extracted (AVE) is higher than.50; The Composite Reliability (CR) value must be higher than .70 and the AVE value (Hair et al., 2014). Table 5 presents the scale's factor loadings, AVEs, and CRs.

Table 5. Convergent validity results for the scale

Factor	Items	Factor Loadings (>.5)	Average Variance Explained	Composite Reliability (CR>.7)
Data Literacy (F1)	D15	.758	.53	.85
	D 16	.699		
	D 17	.781		
	D 18	.705		
	D 19	.677		
Security (F2)	S2	.731	.52	.90
	S3	.722		
	S4	.632		
	S5	.764		
	S6	.686		
	S7	.721		
	S8	.762		
	S10	.76		
Communication and Collaboration (F3)	C28	.732	.59	.88
	C29	.782		
	C30	.761		
	C32	.794		
	C34	.773		
Digital Content Creation (F4)	DC23	.818	.68	.89
	DC 24	.884		
	DC 25	.897		
	DC 26	.673		
Ethics (F5)	E36	.872	.79	.81
	E37	.933		
	E38	.863		

As shown in Table 5, the AVE values for all factors were greater than 0.50, and the CR values were greater than 0.70 and also greater than the AVE values. In addition, all item factor loadings exceed 0.50, indicating that the items are reliable (Hair et al., 2014).

Discriminant Validity

Discriminant validity describes the extent to which a factor of the measurement tool differs from others. It argues that the factors must be related to one another at a certain level and distinct from one another to exist independently (Farrell, 2010). In order to say that a measurement tool has discriminant validity, the square root of the AVE value must be greater than the correlation values between factors (Fornell & Larcker, 1981). Table 6 presents the AVE and correlation values for the scale factors.

Table 6. AVE and Factor Correlation Values for the Scale

Factor	AVE	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Data Literacy (F1)	.53	(.728)				
Security (F2)	.52	.729	(.723)			
Communication and Collaboration (F3)	.59	.757	.715	(.769)		
Digital Content Creation (F4)	.68	.514	.610	.640	(.823)	
Ethics (F5)	.79	.500	.451	.515	.296	(.890)

In Table 6, the ($\sqrt{AVE}$) values of the factors are given in parentheses on the table's diagonal. Other values are correlation values between factors. When the table is examined, the ($\sqrt{AVE}$) values for Factors 3, 4, and 5 appear greater than the inter-factor correlation values in their rows and columns. However, it was observed that the (($\sqrt{AVE}$)) values for Factors 1 and 2 were not more significant than all the values in their rows and columns. This may indicate that Factors 1 and 2 cannot be fully differentiated from other factors. For this reason, Heterotrait-Monotrait ratio of correlations (HTMT) values, an alternative indicator of discriminant validity, were examined. HTMT, a criterion for evaluating discriminant validity, is below .90, indicating that discriminant validity is achieved (Henseler et al., 2015). Calculated HTMT values are shown in Table 7.

Table 7. Heterotrait-Monotrait (HTMT) Correlation Ratio Analysis Results

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Data Literacy (F1)					
Security (F2)	.742				
Communication and Collaboration (F3)	.772	.717			
Digital Content Creation (F4)	.546	.631	.661		
Ethics (F5)	.508	.464	.522	.306	

When Table 7 is examined, it is seen that the HTMT values for the scale's sub-factors are below the threshold. For this reason, it can be said that the HTMT analysis results for the scale have appropriate values and that discriminant validity is ensured.

Reliability

It is necessary to trust that the information obtained with the scale can be obtained in repeated measurements and that the same results are error-free. For this reason, the scale's reliability was examined using Cronbach's alpha internal consistency and CR coefficients (Fornell & Larcker, 1981; McDonald, 1985). Cronbach's alpha reliability coefficient for the overall scale was 0.89. For the CR coefficient, values above 0.7 are considered good, and those between 0.6 and 0.7 are acceptable (Malhotra, 2010). The fact that both reliability levels exceed 0.70 for each dimension provides evidence of the measurement's reliability (Nunnally & Bernstein, 1994). Values regarding the scale's reliability are presented in Table 8.

Table 8. Reliability Analysis Results

Factors	Composite Reliability (CR>.7)	Cronbach alpha (α)
Data Literacy (F1)	.85	.84
Security (F2)	.90	.89
Communication and Collaboration (F3)	.88	.88
Digital Content Creation (F4)	.89	.88
Ethics (F5)	.91	.92

Conclusion, Discussion and Recommendations

Within the scope of the study, the applicability of the digital competence scale prepared for teachers by Gümüş and Kukul (2023), which was found to have a suitable item and factor structure for pre-service teachers, was tested. The scale's validity and reliability were assessed. In this process, EFA was first conducted to obtain consistent results and to detect structural differences resulting from sample changes (Orçan, 2018). EFA examined how pre-service teachers shaped the scale's factor structure. The statistical analysis revealed that the original six-factor structure was reduced to five factors by removing seven items from the "Problem-Solving" factor and clustering the remaining two items under the "Data Literacy" factor. The "Data Literacy" factor accounts for 35.79% of the total variance, the "Digital Content Creation" factor accounts for 10.26%, the "Ethics" factor accounts for 7.27%, the "Security" factor accounts for 5.43%, and the "Communication and Collaboration" factor accounts for 3.61%. It has been determined that the five factors identified were above 40%, which is considered sufficient in multi-factor scales (Büyüköztürk, 2018), and explained 62.35% of the total variance. In addition, the best lower limit for the social sciences has been determined as 60% (Karagöz & Bardakçı, 2020), and the model demonstrates construct validity. Accordingly, removing items 22, 23, 24, 25, 26, 27, and 28, which had factor loading

values below .45, resulted in a structure with 39 items, each with factor loading values ranging from .48 to .89. It is seen that the factors in the six-factor and 46-item structure in the original scale explain 71.97% of the total variance. The factor loadings range from 0.54 to 0.87 (Gümüş & Kukul, 2023). Since items with low factor loadings poorly represent the general structure, removing them may have reduced the scale's overall conceptual scope and its capacity to explain variability, although it provided structural improvements. This may indicate that the adapted scale does not cover the conceptual constructs as broadly as the original scale, or that it performs differently in a particular cultural or demographic context. However, when the values are examined, it can be said that with EFA, a structure suitable for pre-service teachers and close to the original scale was obtained.

The failure of pre-service teachers to achieve the "Problem Solving" dimension included in the original scale as a result of the EFA may be associated with their lack of professional experience. Indeed, studies indicating that pre-service teachers have low problem-solving skills in digital environments are common in the literature (Méndez et al., 2017; Napal-Fraile et al., 2018; Rizal et al., 2019). It has been stated that teachers are not prepared to perform well in problem-solving in digital environments compared to other higher education graduates (OECD, 2019). This may be associated with the in-service teacher training that teachers receive. In particular, the lack of systematic development of digital problem-solving skills in teacher education programs may have caused this situation (König et al., 2020). Similarly, Instefjord and Munthe (2017) stated that pre-service teachers' competence in technology integration is limited, and this negatively affects their problem-solving skills. This may also be due to the pre-service teachers' lack of experience with digital problems they may encounter in real classroom settings. A lack of practical experience can hinder pre-service teachers' ability to develop effective strategies for solving technological problems (Tondeur et al., 2012). Furthermore, the digital competences of pre-service teachers often remain at a basic level and may be insufficient to solve complex problems (Falloon, 2020). In this context, acquiring both theoretical knowledge and practical experience is critical for developing pre-service teachers' digital problem-solving skills (Pettersson, 2021).

CFA was conducted to test whether the structure revealed by the EFA was valid for pre-service teachers. The item removal process was completed in six stages, and the indices obtained regarding the overall fit of the model were found to be at an acceptable to excellent level. When these values were compared with those of the original scale, all were found to be closer to the recommended ranges. These values, which are closer to or within the recommended ranges, indicate that the scale produces more valid and reliable results for the target population. In this context, the first-level CFA revealed that the five-factor scale structure had acceptable fit values.

Convergent and discriminant validities were also examined to evaluate the suitability of the scale's factor structure. As a result of the convergent validity analysis, it was observed that the CR values for the factors exceeded 0.70, and the AVE values exceeded 0.50. According to these results, convergent validity was achieved (Hair et al., 2014). As a result of the discriminant validity analysis, it was determined that the square roots of the AVEs for some factors were not significant in all inter-factor correlations. Additionally, HTMT values, another indicator of discriminant validity, were examined. All of these values were below 0.90, indicating that discriminant validity was achieved (Henseler et al., 2015). As a result of these

analyses, including EFA and first-level CFA, it was determined that the 25-item form of the adapted scale had acceptable psychometric properties and was suitable for pre-service teachers.

This adapted scale measures pre-service teachers' digital competence levels using a five-point likert-type structure. Separate subscale scores can be calculated for each factor, and the total score can be used to determine the overall level of digital competence. The subscale mean can be obtained by summing the scores for each item in the factor and dividing by the number of items in the factor. The "Data Literacy" factor measures pre-service teachers' skills in data collection, analysis, and interpretation; the "Digital Content Creation" factor measures their ability to create and edit digital materials; the "Ethics" factor measures their awareness of ethical behavior in digital environments; the "Security" factor measures their ability to implement digital security measures; and the "Communication and Collaboration" factor measures their competence in communicating effectively and collaborating on digital platforms. The scores obtained enable us to identify which digital competence areas pre-service teachers excel in and which require development. High scores indicate a high perception of digital competence in the relevant field, while low scores indicate a need for supportive training and developmental activities in that area.

As a result, within the scope of the scale applicability study, it has been demonstrated that the digital competence scale developed by Gümüş and Kukul (2023) for teachers can be utilized to measure the digital competence of pre-service teachers, ensuring the validity and reliability of the form created for this purpose. For this reason, considering the need to determine and improve pre-service teachers' digital competence levels (Falloon, 2020), the adapted scale can facilitate the collection of valid and reliable data on this subject. Revealing the digital proficiency levels of pre-service teachers using the scale can serve as a basis for necessary changes to the teacher education curriculum and for informing political decisions. Additionally, the scale can be considered a measurement tool for researchers conducting studies with large samples, where various demographic variables are examined. In this context, since the study was conducted in several state universities, new studies can be carried out with a larger sample and involving pre-service teachers from private universities. This enables a more comprehensive evaluation of the scale's validity and reliability across various demographic and institutional contexts.

Additionally, studies can be conducted on reconceptualizing the extracted "Problem Solving" factor for pre-service teachers, developing items suitable for this group's level of experience, and then reintegrating the factor into the scale. In this context, it is critically important to design items that better reflect the digital problem-solving skills pre-service teachers may possess before their actual classroom experiences. At the same time, studies examining the digital competences of pre-service teachers and in-service teachers can also be conducted. Thus, the effectiveness of teacher training programs can be evaluated, and the development of digital competence in the professional development process can be modeled. These research recommendations will contribute to a more comprehensive and accurate measurement of digital competence, providing important data for the development of teacher education policies.

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