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Diginovative Literacy Perspective: An Application for Engineering Candidates[1]

Dijinovatif Okuryazarlık Perspektifi: Mühendis Adayları için Bir Uygulama

ABSTRACT

This research aims to reveal the innovative literacy and digital literacy (*to be defined as diginovative)* awareness of prospective engineers and to put forward a comprehensive perspective. The study sample consisted of students at Kocaeli University. To collect data in the study, the innovative literacy scale, the validity and reliability of which were established by Yüksel et al. (2023), and the digital literacy scale created by NG (2012) and adapted into Turkish by Üstündağ et al. (2017) were administered electronically as a questionnaire. This study is important because it reveals the competencies of the digital literacy of prospective engineers. Additionally, it will contribute to the field by providing a comprehensive literature review. The findings show that the digital literacy skills of prospective engineers are generally sufficient. It is recommended that prospective engineers have a high level of digitalisation literacy to succeed in their profession
Keywords: Diginovative literacy, Innovative literacy, Digital literacy, Engineering education

ÖZET

Bu araştırma, mühendis adaylarının yenilikçi okuryazarlık ve dijital okuryazarlık (dijinovatif olarak tanımlanacak) farkındalıklarını ortaya koymayı ve kapsamlı bir bakış açısı sunmayı amaçlamaktadır. Araştırma örneklemi Kocaeli Üniversitesi öğrencilerinden oluşmuştur. Çalışmada veri toplamak için, geçerliliği ve güvenilirliği Yüksel vd., (2023) tarafından belirlenen yenilikçi okuryazarlık ölçeği ve NG (2012) tarafından oluşturulan ve Üstündağ vd. (2017) tarafından Türkçeye uyarlanan dijital okuryazarlık ölçeği elektronik olarak anket şeklinde uygulanmıştır. Bu çalışma, mühendis adaylarının dijital okuryazarlık yeterliliklerini ortaya koyması açısından önemlidir. Ayrıca, kapsamlı bir literatür taraması sunarak alana katkı sağlayacaktır. Bulgular, mühendis adaylarının dijital okuryazarlık becerilerinin genel olarak yeterli olduğunu göstermektedir. Mühendis adaylarının mesleğinde başarılı olabilmeleri için yüksek düzeyde dijital okuryazarlığa sahip olmaları önerilmektedir.
Anahtar Kelimeler: Dijinovative okuryazarlık, Yenilikçi okuryazarlık, Dijital okuryazarlık, Mühendislik Eğitimi

1. INTRODUCTION

The skills individuals need to acquire to contribute to today's society are the requirements of the current century, defined as 21st-century skills (Larson and Miller, 2011). Equipping with 21st-century skills is possible through education. At this point, universities have a great responsibility in the development of 21st-century skills.

Century individuals are using digital tools to support achieving goals in their life situations (Reddy et al., 2020). Universities need to develop the skills of both teachers and students to guide and enable digital transformation, and adapt to and use advanced technology (Bond et al., 2018; Khitskov et al., 2017). Technological changes have caused users to learn, forget, develop new competencies, and contribute content (Farias-Gaytan et al., 2022).

Studies on the increasing importance of innovation and the role of the creative individual in technology have become important topics in the academic literature. The definition of literacy in the classical sense is "to create awareness of lifelong learning, to develop this awareness, to enable individuals to acquire new skills for more effective learning" (OECD, 2008).

[1] This paper was presented as a paper at TAOM 2024 Annual Conference (https://www.yonad.org/taom2024)

While the importance of innovative information in education has increased, information and communication technologies, together with the internet, have fueled the advances and growth in the fields of banking, engineering, health, transportation, economy and most importantly, education in the 21st century. This digital revolution, which is restructuring societies and therefore reshaping the way they live in them, is almost impossible to take shape without innovation. This rapid and continuous growth in digital technology requires individuals to have the necessary skills and competencies to perform tasks and solve problems in digital environments.

This set of skills is defined as literacy skills. In parallel with this, innovative and digital literacy have become important issues today. Innovation is the process of generating new ideas and technologies. Digital literacy, on the other hand, is the ability to access, evaluate, use and produce information in the information age. Taken together, these issues are of great importance to ensure the sustainable development of individuals and societies.

Digital literacy and innovative literacy are two important skills of the 21st century (Kong, 2014). In today's world, where technology is developing rapidly, digital literacy has become a necessity. This skill makes people feel safe in accessing information, data analysis, using digital tools effectively, and ensuring information security. In addition to digital literacy, it is suggested that individual innovativeness is a feature that leads to beneficial results in organisations (Carlsen et al, 2012). Innovative thinking involves producing creative solutions by addressing existing problems from different angles.

There is a need to understand digital literacy, as research supports the fact that digital natives lack digital literacy (Anthonysamy et al., 2020). To consider digital literacy, Mohammadyari & Singh (2015) have stated that people must have multiple literacies to use digital technology effectively and efficiently, as digital literacy requires various types of knowledge, as well as an integrated understanding of these types. In other words, digital literacy means more than just being able to use computers or technologies for a task. An individual must develop functional skills, values, attitudes, and behaviours to become a digitally literate person (Anthonysamy et al., 2020).

Especially for younger generations, good innovative thinking and strong digital literacy can provide a competitive advantage in the business world. It is also seen as one of the cornerstones of social and economic development. Therefore, education systems need to focus on developing these skills and for people to constantly update themselves in these areas. Innovative and digital literacy improves individuals' technical skills and increases their competencies such as critical thinking, problem-solving and creativity. In this way, progress and innovation can be achieved on both a personal and societal level.

In this research, firstly, a conceptual framework will be drawn with a systematic literature review, in the second stage, the scales will be analysed with the structural equation model, and in the last stage, the results and suggestions will be discussed based on the findings.

2. CONCEPTUAL FRAMEWORK

The framework that forms the basis of the research is innovative digital (diginovative) literacy (*this concept is coded as a combination of innovative literacy and digital literacy for convenience*). In educational contexts, 'literacies' emphasise social practices shaped by emerging technologies, while digital literacy is a broader term that embraces the technical, cognitive, and social-emotional perspectives of learning with digital technologies, both online and offline. The more digitally literate the individual becomes, the easier it is for them to adapt, i.e. to switch to 'new literacies' mode (Ng, 2012).

2.1.Innovative Literacy Research

The existing literature has extensively examined the impact of digital transformation on innovation, with a focus on digital literacy, but the critical importance of innovative literacy is unknown. According to Yüksel & Günce (2017), innovative literacy is the ability of the individual to make sense of the events occurring in his environment and society, to be aware of the levels of technological developments and to understand all issues related to innovation. Innovative literacy; individuals can manage their personal information and generate new things in the short and long term by evaluating their behaviour, which is based on having an excellent investigative attitude to manage their work processes. According to the authors, individuals with innovative literacy are expected to have three basic abilities. These; researching and evaluating information about innovative decisions and using this information to solve problems (Yüksel et al., 2022).

Accordingly, innovative literate individuals are better aware of technological developments and have a better understanding of all issues related to innovation. Human capital is the entirety of the individual competencies of employees. The products and services produced in organisations result from the knowledge, experience and expertise of the employees (McGregor et al., 2004). Thus, human capital with innovative literacy will make innovative contributions to organisational processes such as decision-making, production and marketing.

2.2.Digital Literacy Research

Gilster (1972) first used the term digital literacy as "*the ability to both understand and use digitised information*". Digital literacy is an important skill that prepares individuals to navigate the digital age and lead organisational change for improved performance (Sahu et al, 2019). Digital literacy is defined in the British Futurelab's General Curriculum Handbook on Digital Literacy (Hague & Payton, 2010) as follows: Being digitally literate is having access to a wide range of applications and cultural resources that you can apply to digital tools. It is the ability to create and share meaning in different modes and forms; to create, collaborate and communicate effectively, and to understand how and when digital technologies can best be used to support these processes.

Digital literacy involves being able to perform successful digital actions embedded in life situations that can include work, learning, leisure, and other aspects of daily life. Digital literacy will vary for the individual, therefore, according to their particular life situation, and it will also be a lifelong process that develops as the individual's life situation evolves. Digital literacy is broader than computer literacy and will include elements drawn from a variety of related "literacies" such as information literacy, media literacy, and visual literacy.

Digital literacy will include the acquisition and use of knowledge, techniques, attitudes, and personal qualities, and will encompass the ability to plan, execute and evaluate digital actions in solving life tasks, as well as the ability to reflect on one's digital literacy development (Martin, 2005). It is defined as the awareness, attitude, and ability of individuals to use digital tools appropriately, making it easier to identify, access, manage, integrate, evaluate, analyse, and synthesise digital resources, create new knowledge, create media statements, and communicate with others to enable constructive social action. Digital literacy also often serves as an 'umbrella' term for several different educational practices that aim to equip the user to perform tasks in digitally rich societies (Leaning, 2019).

The current generation living in the digital age is considered to be "digital natives," often referred to as "individuals who grow up in an environment surrounded by and using computers, video games, digital music players, video cameras, mobile phones, and similar things" (Prensky, 2001).

Digital literacy includes cognitive and social skills as well as technical skills, and the five main digital skills of digital literacy include photo-visual skills, replication skills, networking skills, information skills, and socio-emotional skills (Eshet-Alkalai & Amichai-Hamburger, 2004). Digital literacy is significantly correlated with the accumulation of social capital online (Chan, 2022). An individual with a good level of digital literacy has the technical, cognitive, and relational skills to use technology in a variety of contexts, as digital literacy is a system of skills, abilities, and strategies used in a digital environment (Ng, 2012).

The proliferation of internet access and related applications requires individuals to have a certain level of digital literacy skills to benefit from it (Shelley et al., 2004). Digital literacy skills enable individuals to navigate digital environments in an informed and informed manner (Berson & Berson, 2003).

Digital literacy improves employees' creativity (Oldham & Da Silva, 2015), problem-solving skills (Hatlevik et al., 2015), and job performance (Pacheco & Coello-Montecel, 2023); it also fosters a collaborative environment (Cao et al., 2016).

2.3. Education and Research (21st century skills)

The need for well-equipped training to acquire 21st-century skills remains important in the competitive world. The pillar of higher education and education reveals the current studies on information societies. Educational outcomes support pathways to desirable opportunities for both education and employment. At a higher level in education, knowledge and technology-based investments impact intellectual capital, while at the same time raising social capital for the educational process in the form of respect and rewards. Poore (2011) argues that a well-educated society provides higher levels of collective intelligence. The use of technologies that include high-speed internet connections, digitised content, and a range of tailor-made

applications for various public sector services supports lifelong learning. The best examples of this are seen in Finland (Sharma et al, 2016).

Since literacy is defined as a learning process that allows individuals to develop their knowledge and potential (UNESCO, 2008), literacies are needed for knowledge, skills and competencies in digital and innovative behaviours while existing in the digital world. The disciplined way to do this is through education. Anything that improves literacy will have a positive impact on behaviour change (Yüksel et al., 2023).

Major companies such as Cisco, Intel, and Microsoft, through a sponsored project based at the University of Melbourne, have launched the 21st century to address the lack of formal education systems that cannot keep pace with the changing needs of the times. They carried out a study proposing the framework for the Assessment and Teaching of Century Skills (ATC21s). The framework also called the knowledge, skills, attitudes, values, and ethics (KSAVE) framework, groups ten skills: (1) creativity and innovation; (2) critical thinking, problem-solving, decision making; (3) learning to learn/metacognition (knowledge of cognitive processes); (4) communication; (5) collaboration (teamwork); (6) information literacy; (7) IT literacy; (8) citizenship - local and global; (9) life and career; and (10) personal and social responsibility – cultural awareness and competence (Binkley, 2012; Qadir, 2020).

However, the OECD (2015) report also drew attention to the conclusion that with the increase in the use of computers in classrooms, standardised test scores such as the Program for International Student Assessment (PISA) have not increased. This report reveals that it is not enough just to be a computer user, but also to be digitally literate. There is also a need for research and development skills, which are the direct drivers of the knowledge economy (Lawson & Lorenz, 1999).

2.4. Human Capital and Diginovative Literacy

Bontis (1998) argues that human capital is important because it is the source of innovation and strategic renewal. Undoubtedly, the knowledge and skills of human capital related to innovation and the expertise of this capital are worth examining. Innovative literacy is one of the new concepts related to the innovative and creative characteristics of human capital. For this reason, human capital is a basic building block in innovation activities (Yüksel et al., 2022).

Previous studies have considered highly skilled human capital as an important dimension of innovation processes (Kianto et al., 2017; Snell and Dean, 1992; Subramaniam and Youndt, 2005). Accordingly, many studies show that intellectual capital affects the innovative competencies of organisations. Subramaniam & Youndt (2005) state that human, structural, and customer capital, which are dimensions of intellectual capital, affect companies' innovation skills. Wu et al. (2008) argue that intellectual capital enhances an organisation's innovation performance. Edvinsson & Malone (1998) emphasise human capital theory from the perspective of creativity and innovation. Therefore, human capital is a basic building block in innovation activities. Moreover, qualified human capital is also a link between technological progress and socio-economic growth (Mincer, 1984). In this sense, nations and organisations need digitally literate individuals to move forward.

The literature review shows that studies that measure and model human capital with innovation and digital literacy are insufficient. To verify this, statistically up-to-date programs were used. A conceptual map was created based on the keywords that make up the theme of the research. To explain this conceptual mapping, a model showing the direct impact of digital literacy on innovative literacy is designed in Figure 1. This model is not included in the hypothesis but is only conceptually mapped through statistical programs.

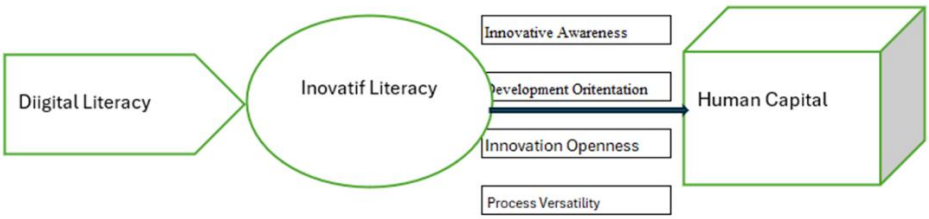

Figure I. The relationship between digital literacy, innovative literacy and human capital **Source (s):** Author's work

3. METHOD

3.1. Conceptual Synthesis and Hypotheses

3.1.1 Conceptual Synthesis

This research paper aims to conceptualise and test the chain of structures that connect people with greater digital literacy to innovative literacy. The literature review reveals that there is a bridge between digital literacy, practice, attitude towards the use of digital technologies, and work behaviour.

The data were obtained from the "Web of Science" database in March 2025. For bibliometric data, the Web of Science database was searched in English with the keywords "*innovative literacy*" and "*digital literacy*". The search criteria were selected as "document topic and keywords", and 855 publications were accessed within this scope. In the next stage, the sources accessed were limited to "Education & Educational Research", and the number of studies decreased to 365. Finally, these studies were limited to articles, and 232 articles were finally reached. Performance analysis, scientific mapping and bibliometric analyses were completed using the total VOSviewer (1.6.20) software program.

3.1.2 Publication and Citation Numbers by Year

The publication and citation numbers related to digital literacy by year are shown in Figure 2. Figure 2 shows the educational research on digital literacy and innovative literacy listed in WOS and the number of citations.

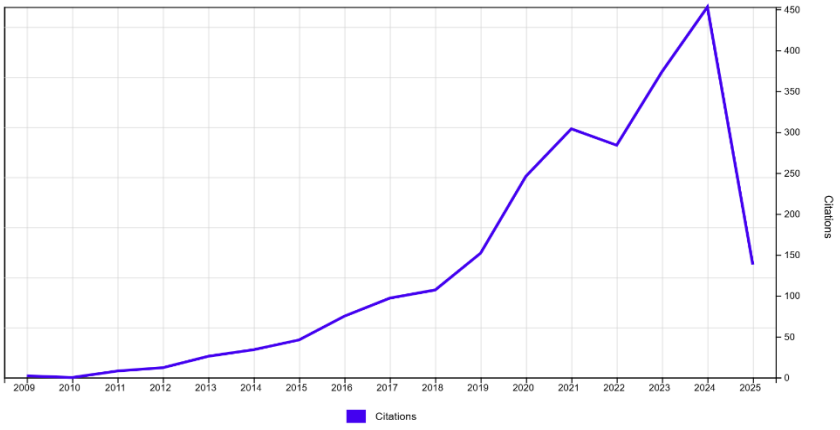

Figure 2. Distribution of publication and citation numbers by year **Source(s):** Author's work

Accordingly, Table 1 shows that the first publication accessed is from 2005. The number of publications and citations increased steadily from 2005 to 2025. The year with the highest number of publications was 2024 (f=32), while the number of citations was the highest in 2022 (f=779). Since the study was conducted in the first 3 months of 2025, it is thought that the data for 2025 will vary.

Table 1. Distribution of publication and citation numbers by year

Publication Years	Count	Publication Years	Count
2024	32	2015	9
2023	23	2012	7
2022	23	2011	5
2017	16	2010	4
2019	31	2014	4
2018	14	2008	3
2020	13	2016	3
2021	12	2005	2
2025	12	2009	2
2013	9		

Source(s): Author's work

3.1.2 Distribution of Educational Research by Index

The distribution of educational research according to publication index is given in Table 2. ESCI and SSCI publications are high.

Table 2. Web of Science Index

Web of Science Index	Count
WOS.ESCI	127
WOS.SSCI	91
WOS.BHCI	14
WOS.AHCI	13
WOS.SCI	9
WOS.BSCI	1

Source(s): Author's work

3.1.3. Results of Co-Citation Analysis of Countries/Regions

The distribution of Countries/Regions according to given in Table 3. That shows that most of the publications were observed in the USA, and the fewest studies were in YEMEN.

Table 3. Numbers by Countries/Regions

Countries/Regions	Count	Countries/Regions	Count	Countries/Regions	Count	Countries/Regions	Count
USA	46	ITALY	4	SINGAPORE	2	OMAN	1
SPAIN	27	THAILAND	4	ARGENTINA	1	POLAND	1
AUSTRALIA	25	CHILE	3	BELARUS	1	ROMANIA	1
CANADA	24	GERMANY	3	BELGIUM	1	SWEDEN	1
ENGLAND	21	NETHERLANDS	3	COLOMBIA	1	SWITZERLAND	1
PEOPLE'S R CHINA	14	SAUDI ARABIA	3	COSTA RICA	1	TANZANIA	1
SOUTH AFRICA	9	TÜRKİYE	3	CUBA	1	TURKEY	1
RUSSIA	8	AUSTRIA	2	EGYPT	1	YEMEN	1
PORTUGAL	7	ECUADOR	2	FINLAND	1		
BRAZIL	6	FRANCE	2	IRAN	1		
INDIA	6	GREECE	2	IRELAND	1		
NORWAY	6	KAZAKHSTAN	2	BRUNEI	1		
TAIWAN	6	MALASIA	2	ISRAEL	1		
UKRAINE	6	PAKISTAN	2	MEXICO	1		
SOUTH KOREA	6	RWANDA	2	NEW ZEALAND	1		
INDONESIA	4	SCOTLAND	2	NIGERIA	1		

Source(s): Author's work

Figure 3 shows that 232 publications received 2279 citations. Voogt (2013) Challenges to learning and schooling in the digital networked world of the 21st century is the most cited article with 222 citations (Table 4).

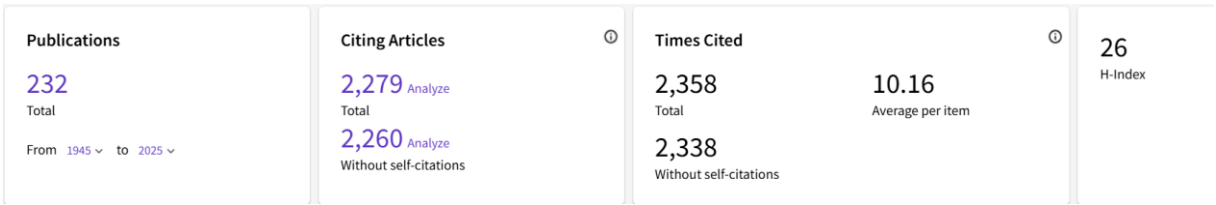

Figure 3. Citation Report **Source(s):** Author's work

Table 4: Distribution of Articles by Number of Citations

Author	Article	Journal	Count
Voogt, J; Erstad, O; (…); Mishra, P. (2013).	Challenges to learning and schooling in the digital networked world of the 21st century	JOURNAL OF COMPUTER ASSISTED LEARNING	222
Flewitt, R; Messer, D. & Kucirkova, N. (2015).	New directions for early literacy in a digital age: The iPad	JOURNAL OF EARLY CHILDHOOD LITERACY	176
Blau, I; Shamir-Inbal, T. & Avdiel, O. (2020).	How does the pedagogical design of a technology-enhanced collaborative academic course promote digital literacies, self-regulation, and perceived learning of students?	INTERNET AND HIGHER EDUCATION	109
Nedungadi, PP; Menon, R; (…); Raman, R. (2018).	Towards an inclusive digital literacy framework for Digital India	EDUCATION AND TRAINING	72
van de Oudeweetering, K & Voogt, J. (2018)	Teachers' conceptualisation and enactment of twenty-first-century competences: exploring dimensions for new curricula	CURRICULUM JOURNAL	62
O'Mara, J & Laidlaw, L.(2011)	Living in the iworld: Two literacy researchers reflect on the changing texts and literacy practices of childhood	ENGLISH TEACHING-PRACTICE AND CRITIQUE	53
Zhang, LT & Cassany, D. (2019)	The 'danmu' phenomenon and media participation: Intercultural understanding and language learning through 'The Ministry of Time	COMUNICAR	51
Miralles-Martínez, P; Gómez-Carrasco, CJ; (...); Fontal-Merillas, O. (2019)	Digital resources and didactic methodology in the initial training of History teachers	COMUNICAR	48
Istance, D & Kools, M. (2013)	OECD Work on Technology and Education: innovative learning environments as an integrating framework	EUROPEAN JOURNAL OF EDUCATION	44
Genlott, AA; Gronlund, A & Viberg, O. (2019)	Disseminating digital innovation in school - leading second-order educational change	EDUCATION AND INFORMATION TECHNOLOGIES	40

Source: Prepared by the Author via WOS

3.1.4 Results of Co-Citation Analysis of Co-Authors

Figure 4 shows the 6 co-author co-citations.

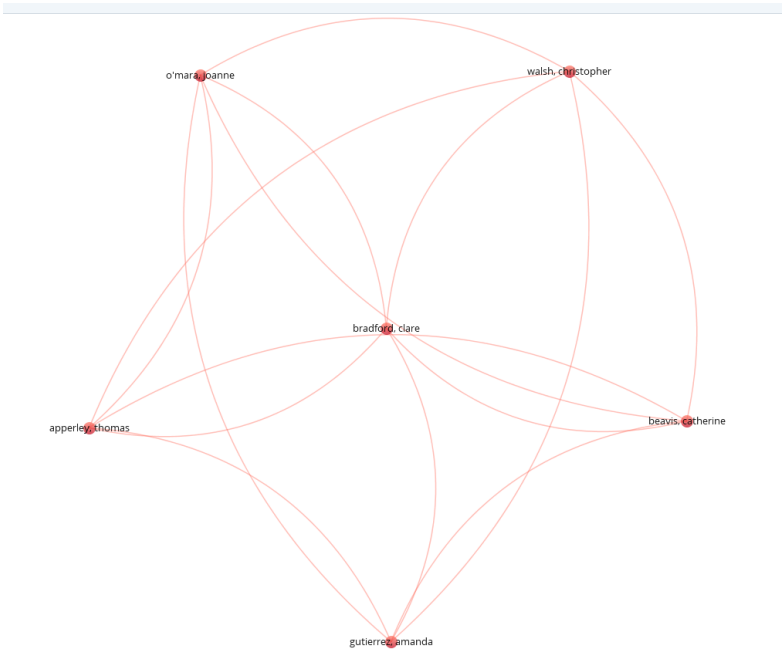

Figure 4. Co-citation analysis of co-authors **Source:** Prepared by the Author via WOS

According to the result of the co-citation analysis of the co-authors of the educational research on digital-innovative literacy, it was seen that there were 2062 authors. The threshold value was determined as 1 to list the co-cited authors, and it was concluded that 125 authors met this criterion. Since there was no relationship between some authors, the co-authorship network between the 5 authors with the highest relationship was extracted. The authors with the highest link strength are Bradford, Clare (bg=5), O'Mara,

Joanne (bg=5), Apperley, Thomas (bg=5), Gutierres, Amara (bg=5), Walsh, Christopher (bg=5) and Beavis, Catherine (bg=5). The most cited authors are Voogt, et al. (f=222), Flewitt, et al, (f=176), Blau et al.(f=109), Nedungadi et al, (f=72), van de Oudeweetering (f=62) and O'Mara, J and Laidlaw (f=53). As there is no link strength between these authors, they are not shown in the network analysis.

3.1.5 Social Network Analysis Results of Keywords

When the social network analysis results of the keywords were analysed, it was concluded that there were 1713 keywords, and when 3 was determined as the threshold value, it was concluded that there was a relationship between 217 of them

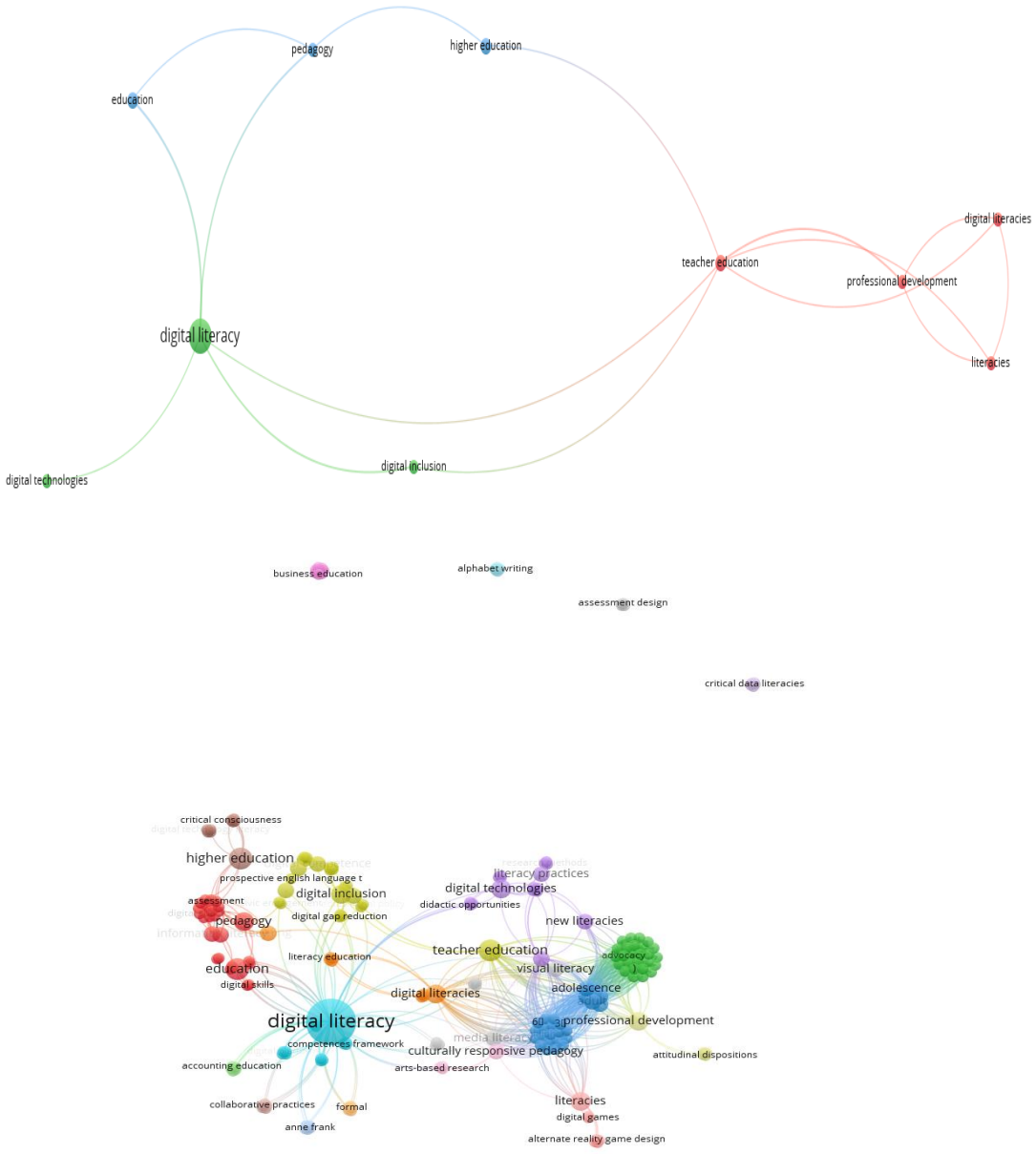

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Figure 5-6: Social Network Analysis Results of Keywords **Source:** Prepared by the Author via WOS

3.2 Hypothesis

Here, a well-designed digital literacy and innovation literacy tool that adequately captures and evaluates individuals' knowledge, skills, and expertise in innovation can provide a clue to the adequacy of their human capital for superior innovative performance. Based on the above conceptual framework, this study aimed to investigate the relationship between innovative literacy and digital literacy. The following hypothesis guided the study:

H1: Digital literacy is positively related to innovative literacy

3.3. Sampling and Data

Purposive sampling was used in this study. In purposive sampling, the main consideration is judgment about who can provide the best information to achieve the objectives of the study. Engineer candidates in technology faculties are suitable samples in terms of human capital. For this purpose, engineer candidates studying at the Faculty of Technology at Kocaeli University were selected. Links were sent to 110 students through the student information system. To provide a basis for method and response bias, it was requested to answer voluntary-based questionnaires with a cover letter. 110 candidates and 68 completed the questionnaire. Reminder e-mails were also sent, and the number of candidates was requested to be high. Due to the existence of the open-ended problem, more candidates were not reached.

The study is supported by data obtained from university students in the context of digital literacy of innovative literacy. In the study, two different scales were used, and 2 open-ended questions were asked.

1. Innovative Literacy Scale: It is a 4-dimensional 17-statement Likert-type scale developed by Yüksel et al. 2023, and its validity and reliability have been tested.

2. Digital Literacy Scale: It is a 10-statement Likert-type scale developed by Ng (2012). It has been tested for validity and reliability.

3. Open-ended question:

Q1. Have you taken any classes/trainings/courses related to innovation before?

Q2. Does digital literacy push you to innovative behaviour? If yes/no, why?

The research was designed to test whether digital literacy affects innovative literacy. The data collected through an online survey platform (Surveey) was used to create a database for statistical analysis. SEM was used to examine the relationships between the variables subject to the research.

Descriptive data were first analysed with IBM SPSS Statistics. Descriptive statistics (means, standard deviations, and correlations) were calculated to describe the sample and evaluate the relationships between variables, and then the validity of the scales was analysed for construct reliability, convergent validity, and discriminant validity.

3.4 Participants and Data Collection

The participants of this study consisted of 68 engineering candidates studying at Kocaeli University's Faculty of Technology. Participants were easily identified by sampling. The data were collected in the spring semester of the 2022-2023 academic year. 28% were female (n=19), 72% (n=49) and 1. Class (n=1) 1.47 %; 2nd grade (n=17) 25%; 3rd class (n=37) 54.41 % ; Class 4 (n=13) was determined as 19.11 %.

In the first stage, descriptive analyses were performed, and in the second stage, SEM analyses, which are an appropriate approach to examine the causal relationship between one or more variables, were performed.

Convergent validity involves evaluating scales relative to each other without using an exogenous measure (Kline, 2011). Innovative literacy and digital literacy scales were tested with a 5-point Likert scale.

4. RESULT

4.1. Analysis of Scales

AVE coefficients were calculated to test the convergent validity of the scales. In addition, reliability analysis was performed using Cronbach's Alpha and composite reliability (CR) coefficients. As can be seen in Table 1, the reliability of the measurements was ensured because Cronbach's Alpha and composite reliability coefficients should both be above 0.70 (Hair et al., 2013). Table 2 shows the KMO test results related to sample adequacy. Results > 0.50 indicate that the sample is sufficient.

Table I: Cronbach's Alpha Rate

Cronbach's Alpha	N of Items
,938	32

Table II. KMO Rate

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,867
Bartlett's Test of Sphericity	Approx. Chi-Square	830,395
	df	190
	Sig.	,000

Source(s): Author's work

In confirmatory factor analysis, which is a type of measurement model, SEM was used to test the validity of measurement tools. After the validity of the measurement tools was tested by confirmatory factor analysis, the default model was tested using the structural model. While testing the structural model, the maximum likelihood method was used as the estimation method. Table 3 shows the factor loads.

Table III. Factor Loading

	Initial Eigenvalues			Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9,919	49,597	49,597	9,919	49,597	49,597	4,522	22,611	22,611
2	1,816	9,079	58,675	1,816	9,079	58,675	3,425	17,127	39,738
3	1,276	6,378	65,053	1,276	6,378	65,053	3,232	16,159	55,896
4	1,119	5,594	70,647	1,119	5,594	70,647	2,950	14,750	70,647
5	,859	4,296	74,943						
20	,083	,413	100,000						

Source(s): Author's compilation

The exact distribution of the factor distributions of the dimensions in 4 dimensions can be seen in Table 4. The digital innovation scale is suitable for use in SEM with 20 questions.

Table IV. Last Factor Loading (I)

Rotated Component Matrix				
	Component			
	1	2	3	4
2	0,822			
L3	0,79			
DL4	0,758			
DL7	0,697			
PV1	0,645			
PV2	0,632			
IO2	0,558			
DL5	0,548			
IA1		0,79		
IO4		0,78		
IO3		0,74		
DL1		0,61		
DO2			0,77	
DO1			0,733	
DO5			0,694	
PV4			0,653	
DO3			0,549	
IA2				0,785
PV3				0,732
IA1				0,655

Table IV. Last Factor Loading/Description (II)

	Component			
	1	2	3	4
I can learn new technologies easily.	,822			
I follow important new technologies.	,790			
I have knowledge about many different technologies.	,758			
I am confident in the searches and evaluations I make to obtain information from the Internet.	,697			
I know how to do basic research	,645			
I know the sources of information gathering	,632			
I'm not afraid to try new things and make mistakes	,558			
I have the technical skills to use information and communication technologies for learning purposes and to develop digital teaching materials (e.g. presentations, digital stories, wikis, blogs) where I can showcase what I have learned.	,548			
A lot of new ideas come to my mind in my daily routine		,791		
When I want to learn new ideas, I don't hesitate to ask questions		,779		
I can see new opportunities and take advantage of them		,744		
I know how to solve the technical problems I encounter with the technologies I use		,606		
I'm interested in inventions, discoveries, inventions			,770	
I do research on topics I am curious about			,733	
I'm open to new ideas			,694	
I know what experimental research means			,653	
I synthesize information from different sources			,549	
I follow the support for innovation development				,785
I know the concept of intellectual property rights				,732
I know the concepts of innovation				,655

Source(s): Author's compilation

A new structure consisting of 14 expressions of the innovative literacy scale, 6 expressions of the digital literacy scale, and a total of 20 statements was created. The final factors were subjected to SEM analysis. In order to capture the fit values in the structure, which is thought to be due to the low number of samples, rotation was applied to the scale, and 2 more expressions were removed from the scale. The SEM diagram is presented in Figure II.

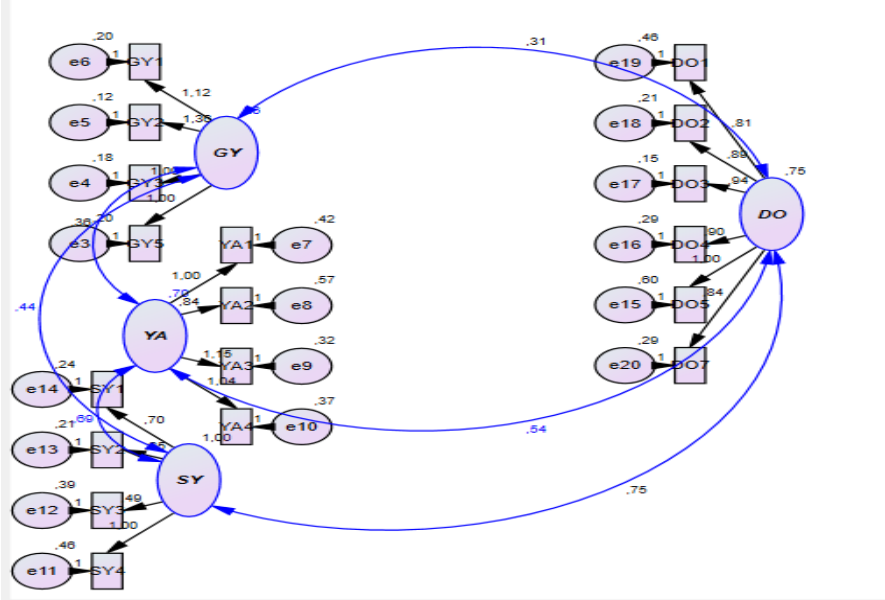

Figure II. SEM Diagram *Source(s): Author's compilation*

Table V. Diginovative Literacy Scale

Dimensions	Expressions
Development Orientation (DO)	I research topics I am curious about GY1 I'm interested in inventions, discoveries, inventions GY2 I synthesise information from different sources GY3 I am open to new ideas GY5
Innovation Openess (IO)	A lot of new ideas come to my mind in my daily routine YA1 I'm not afraid to try new things and make mistakes YA2 I can see new opportunities and take advantage of them YA3 When I want to learn new ideas, I don't hesitate to ask questions YA4
Process Versatility (PV)	I know how to do basic research SY1 I know the sources of information gathering SY2 I know the concept of intellectual property rights SY3 I know what experimental research means SY4
Digital Literacy (DL)	I know how to solve my technical problems (DO1) I can easily learn new technologies. DO2 I keep up with important new technologies DO3 I am familiar with many different technologies DO4 I have the technical skills I need to use ICT for learning and to create artefacts (e.g. presentations, digital stories, wikis, blogs) that demonstrate my understanding of what I have learnt (DL5) I am confident with my search and evaluation skills regarding obtaining information from the Web (DL7)

Source(s): Author's compilation added from Yuksel et al. (,2023)

The SEM results brought us closer to the conclusion that the students are development-oriented, open to innovation, prone to processes, close to new technologies and have digital skills, as well as do not know innovation and do not have a good command of R&D subjects.

Open-ended question analysis

At the end of the survey, 2 open-ended questions were sent to the engineer candidates:

Question 1. Have you taken any classes/trainings/courses related to innovation before? Yes/Undecided/No

Table VI. Open-ended question answers (Have you taken any classes/training/courses on innovation before?)

Answers	Custom	Frekans
Yes	14	% 20
I'm undecided	8	% 12
No	46	% 68
Frekans	68	%100

Source(s): Author's compilation

When Table VI is examined, it is seen that 46% of the participants have not taken any course/or training related to innovation. This is an important result to achieve the goal of the research.

Question 2: Does digital literacy push you to innovative behaviour? If yes/I'm undecided/No, why?

Table VII. Open-ended question answers (Does digital literacy push you to innovative behaviour?)

Answers	Custom	Frekans	**Reasons for answering no**	Custom
Yes	51	% 75	I'm not creative	2
Undecided	10	% 15	I don't understand innovation	2
No	7	% 10	I need to get an education	1
			insufficient	2
Total	68	%100		7

Source(s): Author's compilation

The purpose of asking this question is to determine the views of engineering candidates on innovation and to create a discussion for the article. When Table VIII is examined, 51 out of 68 engineer candidates thought that digital literacy would turn into innovative behavior, while 10 candidates were undecided on this question; 7 candidates, on the other hand, supported the research with their answers that "digital literacy will not create innovative behavior, and these reasons are that they do not have creativity competencies and will need innovation training.

5. DISCUSSION, CONCLUSION AND IMPLICATIONS

This study investigated the relationship between innovative literacy and digital literacy. Although theoretical studies suggest the importance of innovative literacy and digital literacy, there is no similar study that tests the relationships between these concepts with scales. Based on the literature and theoretical framework, this study suggests that the relationship between innovative literacy and digital literacy, which is the main hypothesis of the research, may exist.

Our analysis is successful because it reveals the impact of digital literacy skills on innovative literacy. Our research provides a comprehensive understanding of the digital competence that supports or hinders the innovative, literate individual, enabling these gaps to be filled. Of course, this study is not a prescription, but it focuses on the factors that will be necessary to emphasise the importance of innovative literacy and also draws attention to digital literacy. Innovative literacy contributes to innovative development by integrating with the digital information society, which increases human capital. Thus, the main hypothesis of the study supports our model.

This study contributes to the literature in measuring the impact of digital literacy on understanding the innovative literacy of engineering candidates. The results revealed that there was a positive relationship between innovative literacy and digital literacy. This research emphasises the important role of innovative and digital literacy in engineering candidates. At the same time, the study expands this understanding by showing that higher levels of innovative literacy among individuals lead to more effective digital literacy literature.

5.1.Theoretical Implications

The results of this study emphasise the importance of digital literacy in measuring innovative literacy and have important implications for the curriculum. First, it can be said that a candidate, especially one who is more familiar with digital tools, will be inclined to improve towards digitised innovation. Digital literacy is important for engineers to use multiple digital resources to evaluate any information they encounter. This result shows that having sufficient digital literacy is a prerequisite for them to use multiple resources in learning. One of the main mechanisms in this chain is their attitude towards the digitalisation of individuals and their demonstration of innovation using digital tools.

The nature of innovative literacy also develops from one's digital literacy skills. The ability of the individual to go beyond digital competence and digital use may be necessary for innovative literacy that includes innovation and creativity. The hypothesis that digital literacy affects innovative literacy confirmed the assumptions in this study.

Universities investing in digital literacy to remain innovative and up-to-date in the technological race will contribute to the quality of student learning and the ability to create career skills. Targeted training programs should be included to improve digital literacy skills. In particular, the study emphasises the strategic importance of digital innovation literacy as the main determinant of 'innovation focus' in Turkiye engineering education.

According to the findings of the article, it has been observed that engineering candidates have not received training on innovation, creativity, etc. before, and they do not consider themselves to be prone to innovation. Adding courses such as innovation to engineering education will strengthen diginovative literacy.

This work also informs managers' practices in a variety of ways. First, digital literacy contributes to boosting the innovative efforts of individuals and potentially aspiring engineers. Therefore, organisations should strive to build this capacity in the workforce to encourage innovative pursuits. Organisations can do this through recruitment and selection processes (digital innovation, attracting and employing literate candidates) or by focusing on training and development efforts. These processes are becoming increasingly important in light of the penetration of digital transformation into all aspects and types of organisations (Westerman & Bonnet, 2015). However, companies should not make the erroneous assumption that younger employees are necessarily more digitally literate. According to our study, hiring and selecting digitally literate employees is a better option than employing personally innovative individuals to promote a positive attitude towards digitalised innovation.

6. RESEARCH LIMITATIONS/IMPLICATIONS

This study has several limitations that should be taken into account in the interpretation of the results. The data were collected online from the engineering candidates by applying the convenience sampling method. The inclusion of participants with different backgrounds and characteristics in future studies will increase data diversity. Considering the insufficient empirical support for the innovative literacy scale in the literature, different designs can be used in future studies. This study is a new study that investigates the relationship between innovative literacy and digital literacy in the literature. The results of the study are significant. Therefore, both the repetition of this study in different contexts and further research involving different variables such as creativity, entrepreneurship, and firm performance will help us better understand the nature of the relationships between these concepts.

Ethical Approval: For this research, Ethics Committee Approval was received from the Kocaeli University Social and Human Sciences Ethics Committee with the decision number E-10017888-100-368914 dated 16.02.2023.

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APPENDIX A. Innovative Literacy Scale (Originality)

Items	Expressions
Innovative Awareness	I know the concepts of innovation (IA1)
	I follow the supports for the development of innovation (IA2)
	I can use R&D and technology knowledge to solve daily problems (IA3)
	I am interested in innovation, R&D and project management (IA4)
Development Orientation	I research topics that curious about (DO1)
	I'm interested in inventions, discoveries (DO2)
	I synthesise information from different sources (DO3)
	I have problem-solving skills (DO4) (Statement from the scale)
	I am open to new ideas (DO5)
Innovation Openness	Many new ideas come to my mind in my daily routine (IO1)
	I'm not afraid to try new things and make mistakes.(IO2)
	I can see new opportunities and evaluate them (IO3)
	I do not hesitate to ask questions when I want to learn new ideas (IO4)
Process Versatility	I know how to do basic research (PV1)
	I know information collection sources (PV2)
	I know the concept of intellectual property rights (PV3)3
	I know what experimental research means (PV4)
4 dimensions 17 items	

Ref. (Yüksel, et al., 2023)

ANNEX B- Digital Literacy Scale (Originality)

Items
I know how to solve my own technical problems (DL1)
I can learn new technologies easily (DL2)
I keep up with important new technologies (DL3)
I know about a lot of different technologies (DL4)
I have the technical skills I need to use ICT for learning and to create artefacts (e.g. presentations, digital stories, wikis, blogs) that demonstrate my understanding of what I have learnt (DL5)
My skills in information and communication technologies are sufficient. (DL6)
I am confident with my search and evaluation skills in regards to obtaining information from the Web (DL7)
I am familiar with issues related to web-based activities e.g. cyber safety, search issues, plagiarism (DL8)
ICT enables me to collaborate better with my peers on project work and other learning activities (DL9) (Expression from the scale)
I frequently obtain help with my university work from my friends over the Internet e.g. through Skype, Facebook, Blogs (DL10)
10 item

Ref. (Ng, 2012; Üstündağ, et al. 2017)