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TRANSFORMING EDUCATION IN THE 21ST CENTURY: THE ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY IN ENHANCING DIGITAL COMPETENCE

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Abstrak

Studi ini mengeksplorasi peran Teknologi Informasi dan Komunikasi (TIK) dalam meningkatkan kompetensi digital sebagai elemen penting transformasi pendidikan di abad ke-21. Kompetensi digital diteliti melalui dua konstruk utama yaitu Data Information and Knowledge (DIK), and Communication and Collaboration (CC). Penelitian ini menganalisis dampak TIK terhadap kompetensi digital, khususnya DIK dan CC, dalam konteks transformasi pendidikan abad ke-21. Pendekatan kuantitatif digunakan dengan memanfaatkan perangkat lunak IBM SPSS Statistics 22 dan AMOS untuk analisis data yang optimal, termasuk analisis faktor konfirmatori untuk mengidentifikasi setiap variabel secara akurat. Studi ini mensurvei 100 responden, yang terdiri dari mahasiswa program Doktor dan Magister dari Fakultas Ilmu Pendidikan, melalui kuesioner daring. Hasil penelitian menunjukkan bahwa (a) TIK memiliki pengaruh positif yang signifikan terhadap DIK dan (b) TIK berpengaruh positif terhadap CC. Hasil penelitian menunjukkan bahwa penggunaan TIK secara signifikan memengaruhi perkembangan kompetensi digital, menggarisbawahi pentingnya pengintegrasian teknologi ke dalam mata kuliah pendidikan tinggi untuk membantu mahasiswa yang siap menghadapi masa depan. Implikasi bagi pendidikan menyoroti peran penting TIK dalam meningkatkan kualitas pendidikan. Pengembangan TIK yang berkelanjutan juga sangat penting untuk meningkatkan kompetensi digital pendidik yang vital untuk berhasil menavigasi transformasi pendidikan abad ke-21.

Kata Kunci: *teknologi informasi dan komunikasi, kompetensi digital, abad ke-21, transformasi pendidikan*

Abstract

This study explores the role of Information and Communication Technology (ICT) in enhancing digital competence as a critical element of educational transformation in the 21st century. Digital competence is examined through two main constructs such as Data Information and Knowledge (DIK), and Communication and Collaboration (CC). This research analyzes the impact of ICT on digital competencies, specifically DIK and CC, within the context of 21st century educational transformation. A quantitative approach was employed, utilizing IBM SPSS Statistics 22 and AMOS software for optimal data analysis, including confirmatory factor analysis to accurately identify each variable. The study surveyed 100 respondents, comprising Doctoral and Master's program students from the Faculty of Education, through an online questionnaire. The findings indicate that (a) ICT has a significant positive effect on DIK and (b) ICT positively influences CC. The findings show that ICT use significantly affects the development of digital competence, underscoring the significance of incorporating technology into higher education courses to help learners who are prepared for the future. The implications for education highlight the crucial role of ICT in enhancing the quality of education. Continuous development of ICT is essential for improving the digital competencies of educators, which is vital for successfully navigating the educational transformation of the 21st century.

Keywords: *information and communication technology, digital competence, 21st century, education transformation*

A. INTRODUCTION

Education transformation presents opportunities and challenges, necessitating careful preparation to integrate 21st century skills in curriculum, practice, and digital strategies (Erstad & Siddiq, 2022). The current trend suggests that education can enhance quality through 21st century skills and digital technology collaborations in practice-based teacher education (Meneses et al., 2023). 21st century education is renowned for adapting teaching approaches, fostering meaningful learning habits, and utilizing the latest Information and Communication Technology (ICT) for user experience (Peña-Ayala, 2021). This makes it possible to gain domain knowledge from various digital literacies and develop 21st century competencies or skills.

ICT has significantly impacted education development in the last two decades, addressing widespread needs and 21st century educational transformation to improve the future of the next generation (Peeraer & Van Petegem, 2015). ICT policies can enhance education quality, meet high targets at all levels, and significantly influence professionalism distribution,

despite ongoing controversy (Kudasheva et al., 2015). ICT studies' importance rises due to intensive information exchange, and modern telecommunications facilities, creating new opportunities in education at all levels (Büyükbaykal, 2015).

ICT in education has transformed traditional teaching methods into modern, smart education through technology and online platforms like e-learning, enhancing teacher professionalism and material delivery (Talebian et al., 2014). The European Commission has identified digital competence as a key competency for utilizing ICT creatively in education, aiming to achieve educational goals effectively (Svensson & Baelo, 2015). The need for improved teacher education programs requires innovative ICT teaching methods and a deeper exploration of professional digital competency practices (Tømte et al., 2015).

Modern, technologically enhanced learning environments have replaced traditional classroom instruction as a result of the integration of ICT in education. Students in a variety of circumstances can now receive more flexible, individualized, and accessible education thanks to platforms like e-learning, online classrooms, and interactive multimedia technologies (Khan, 2015). This change not only improves the way educational materials are delivered, but it also greatly raises instructors' professionalism by giving them cutting-edge resources to meet a range of learning demands (Falloon, 2020). ICT plays an increasingly important role in supporting dynamic and learner-centered instructional practices as educational systems change to meet the needs of the digital age.

The European Commission has recognized the value of digital competency and named it one of the fundamental skills for lifelong learning, particularly when it comes to innovative and successful ICT use in the classroom. This ability supports the more effective attainment of educational goals by empowering educators to navigate, adapt, and innovate in technologically rich environments (Keengwe, 2023). As a result, there is an increasing need for better teacher preparation programs that prioritize pedagogical approaches that are consistent with digital professionalism in addition to integrating ICT resources. To create teaching strategies that are adaptable to technological developments and able to equip teachers and students for the demands of the 21st century educational environment, a

more thorough investigation of professional digital competency is essential (Zhu et al., 2016).

In contrast to other aspects of digital competence, DIK and CC are generative and transferable, which logically justifies their primacy. DIK and CC function at a conceptual level that endures throughout technological advancements, in contrast to technical skills, which are frequently platform-dependent and prone to quick obsolescence (Alvarez-Cedillo et al., 2019). They position ICT not just as a tool for efficiency but as a stimulant for intellectual autonomy and epistemic development, closely aligning with higher-order thinking abilities and system-oriented learning methodologies (Tomte, 2022). Therefore, by redefining digital competence as a transformational educational construct rather than a purely technical one, concentrating on DIK and CC fills a crucial research vacuum.

The digital era has led to a significant shift in education, focusing on ICT and fundamental competencies related to data, information, and knowledge (Dickerson, 2022). In general, the influence of ICT application factors on the development of information, data and knowledge determines the success of today's leading countries (Bilan et al., 2023). Advanced digital technology in educational ICT is enhancing communication and collaboration, with secure data storage recommendations becoming best practices in a smart society (Zelenay et al., 2019). The proposed solution involves examining the impact of ICT on teachers' digital competence, focusing on aspects of Data Information and Knowledge (DIK) and Communication and Collaboration (CC).

B. RESEARCH METHOD

Research Design

The impact of ICT on students' digital competency in higher education was examined in this study using a quantitative research approach. The design was selected to enable statistical study of the correlations between variables and objective measurement. This research uses quantitative methods which are supported by factor analysis in order to identify relationships between the variables that make up the factors or dimensions and the factors formed using IBM SPSS Statistics 22.

Research Site and Participants

The research was conducted at the Faculty of Education, a leading academic institution known for its commitment to advancing educational practices through technology integration. This research utilized online questionnaires distributed to 100 Doctoral and Master's Programs students at the Faculty of Education, focusing on their perceptions as teachers or educators, to gather data for a reference population. These individuals were chosen on the basis of their familiarity with ICT-based teaching methods and their involvement with digital learning environments. The range of specializations and academic levels provide a thorough understanding of how ICT may improve digital competency. The online survey was filled out voluntarily by each participant, and throughout the study, ethical principles including informed consent and confidentiality were closely adhered to.

Instrument and Data Collection

The primary instrument used for data collection in this study was a structured online questionnaire designed to measure the dimensions of digital competence, specifically focusing on DIK, as well as CC. The question items in this research can be seen in Table 1.

Varieble	Question	Description
Information and Communication Technology	10	Utilization of information and communication technology for educational institutions (ICT will lead to exploration, skillful at using ICT, easy to operate ICT, etc.)
Data Information and Knowledge	8	Digital competencies related to data, information and knowledge for teachers (know the benefits of information, use search engine techniques, understand the role of information, etc.)
Communication and Collaboration	5	Digital competencies related to communication and collaboration for teachers (understand communication systems, apply Microsoft Teams, apply collaboration tools, etc.)

Table 1. Distribution of the Questionnaire

The questionnaire items were developed based on validated constructs from previous studies and adapted to the context of higher education and ICT integration. The way to determine the number of samples to be taken in this research uses a purposive sampling technique.

Data Analysis

Data analysis is supported by making path diagrams using the AMOS program to obtain more accurate data, so that the results of the influence of one variable on another can be known. Initially, descriptive statistics were used to compile the participants' demographic profiles and general answers. The correlations between the variables of interest were then investigated using inferential statistical techniques. Descriptive statistics and inferential analysis were used to examine patterns in the data, and Confirmatory Factor Analysis (CFA) was used to confirm the constructs and determine how closely the variables in the study were related.

C. RESULT AND DISCUSSION

Confirmatory Factor Analysis

The results of the CFA of the third variable in the research include the exogenous variable ICT and the endogenous variable DIK, and CC. The results of the analysis related to KMO and Bartlett's Test are 0.693 > 0.50, while the significance value is 0.000 < 0.05. The analysis results related to Anti-image Matrices from the ICT variable are 0.845 > 0.50, the DIK variable is 0.639 > 0.50, and the CC variable is 0.662 > 0.50. Interpretation of the analysis results from Communalities from the ICT variable is 0.685 > 0.50, the DIK variable is 0.860 > 0.50, and the CC variable is 0.827 > 0.50. Total Explained Variance which is formed from one factor is able to explain 79.053% of the variation. The Scree Plot results also show that there is one point with an Eigenvalue > 1, namely 2.372. The interpretation of the final analysis results seen from the Component Matrix for factor one includes ICT 0.827, DIK 0.927, and CC 0.909.

Analysis of Path Diagram

The final path diagram results of the impact of information and communication technology on digital competence which includes data

information and knowledge as well as communication and collaboration can be seen in Figure 2.

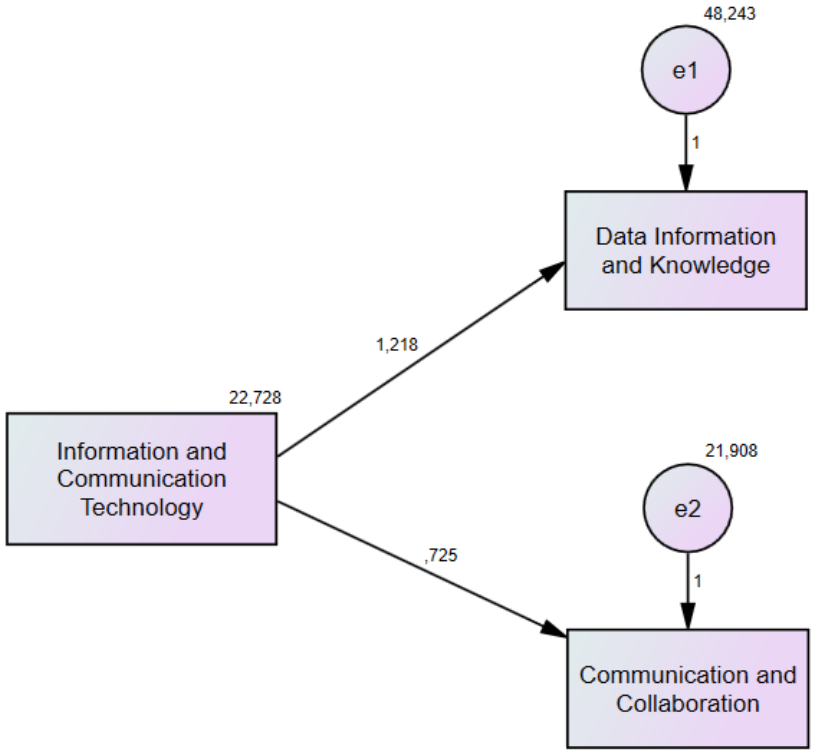

Figure 1. Path Diagram

Hypothesis Test

Hypothesis testing is carried out to see how much influence each variable has. For more clarity, the findings are detailed in Table 2 regarding regression weights.

Constructs	Estimate	S.E.	C.R.	P	Explanation
DIK <--- ICT	1.218	0.146	8.321	***	Significant
CC <--- ICT	0.725	0.099	7.345	***	Significant

Table 2. Regression Weights

Based on Table 2, the study accepts the first hypothesis test, indicating a significant positive influence of ICT on DIK and CC, rejecting H0. The

findings suggest that ICT enhances teachers' digital competence in DIK and CC aspects.

ICT has a statistically substantial and favorable impact on both DIK ($\beta = 1.218$, $p < .001$) and CC ($\beta = 0.725$, $p < .001$), as Table 2 shows. These results suggest that ICT integration has a greater impact on epistemic information processing than creative-critical aptitude in the setting of higher education, particularly among teachers working in technology-intensive learning environments. This differential effect implies that before completely enabling higher-level creative and critical pedagogical practices, ICT adoption in higher education first improves instructors' ability to acquire, assess, and organize digital material.

By presenting DIK and CC as separate but progressively related epistemic consequences of ICT integration, these findings not only validate linear correlations but also advance the creation of a more explicit conceptual model of digital competence. The development of digital competence in higher education may follow an epistemic progression, where information knowledge serves as a foundational competency that permits further creative–critical engagement, according to the greater path coefficient for DIK (Lomos et al., 2023). By suggesting a hierarchical and progressive structure influenced by instructional context, this finding enhances current frameworks for digital competence, which frequently treat competence dimensions as parallel or similar.

These findings theoretically move the definition of digital competence from a functional skill set to an epistemic construct based on meaning-making and knowledge assessment. ICT is not just a tool for increasing efficiency but also a catalyst for epistemic transformation in the setting of higher education, where educators are expected to model critical inquiry and creativity (Devi & Aparna, 2020). This viewpoint highlights the significance of educational mediation in converting ICT use into higher-order digital competence and challenges technology-centric presumptions.

This study extends the conversation by elucidating how ICT contributes to various dimensions of digital competence within higher education, as opposed to restating alignment with earlier research. In addition to evaluating the model across disciplinary contexts and teaching experience levels, future research should build on this model by investigating

DIK as a mediating construct between ICT use and CC. Theoretical understandings of digital competence as a dynamic and context-dependent construct in modern higher education will be further refined by such targeted investigation (Pech et al., 2021).

The Impact of Information and Communication Technology

Innovative ICT usage improves teaching and learning productivity by facilitating digital technology acquisition, enhancing teacher self-efficacy, and integrating skills (Hafifah & Sulistyo, 2020). Digital technology offers teachers a unique opportunity to enhance their knowledge and skills through ICT, making it a priority in educational institutions (Lomos et al., 2023). Several studies related to discussing the impact that can arise from the use of ICT as a whole can be seen in Figure 2.

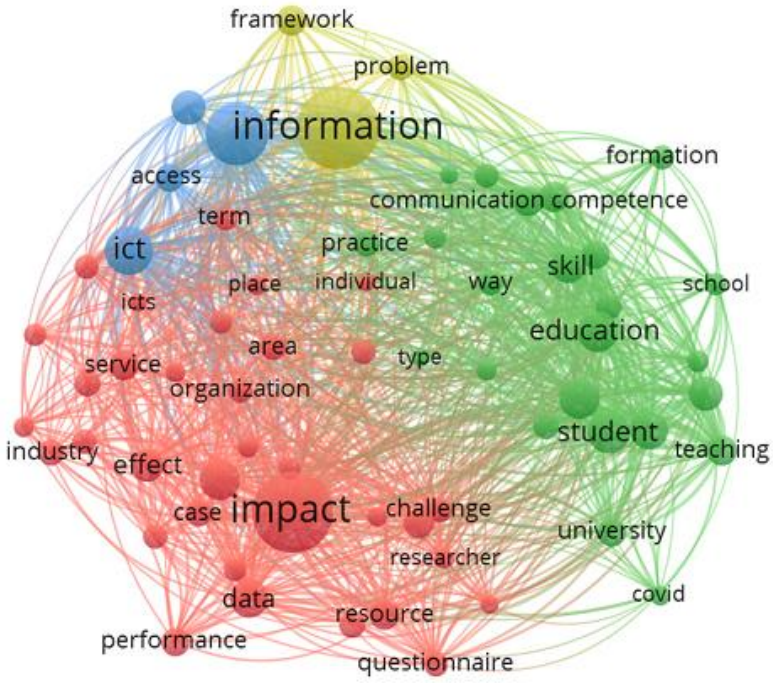

Figure 2. The Impact of Information and Communication Technology

The picture depicts a keyword co-occurrence network visualization, which is typically used in text mining or bibliometric analysis to map and detect links between terms that appear frequently in a set of research data or

academic literature. Red Cluster; Focuses on terms like impact, data, resource, performance, effect, which may relate to outcomes, effects, or applications of ICT. Green Cluster; Includes student, education, communication, skill, competence, indicating a focus on learning, teaching, and digital skills development. Blue Cluster; Centers on ICT, information, access, emphasizing technology and data accessibility. Yellow Cluster; Contains framework, problem, likely pointing to theoretical or conceptual foundations.

This visualization shows how research in the field of ICT and education is interconnected across different themes. For instance, "ICT" is strongly linked to "information" and "access", suggesting discussions around digital infrastructure. "education", "student", and "competence" are closely tied, highlighting a focus on developing skills in educational settings. The central position of "impact" indicates that many studies investigate how ICT influences education, performance, and digital competence. Overall, the image helps identify the key focus areas and thematic linkages in literature related to ICT and educational transformation.

Research shows ICT significantly impacts information, communication, skills, education, students, teaching, and universities, enhancing educational quality in the 21st century (Mailizar & Fan, 2020). Integrated educational institutions utilize innovative and creative systems in information technology to enhance the potential of latent students (Faraasyatul'Alam et al., 2021). Education standards often utilize an integrated learning management system with various online platforms for superior functionality ('Alam, Sobri, et al., 2023). There are a few studies on the impact of ICT on students' digital competency in higher education. Many previous studies focused on ICT more in terms of access, literacy, or the use of technology, but this study highlights the close and significant relationship between ICT use and the development of digital skills.

The integration of ICT in DIK can enhance teacher professionalism and digital competence, thereby enhancing teacher quality. Factors influencing education quality include facility completeness, learning process quality, administrative services, and teacher quality (Wiyono et al., 2020). ICT impacts CC by promoting interactive collaboration and adapting communication languages to students' needs. It also facilitates collaborative

supervision, allowing teachers to use performance-based learning in line with 21st century education goals, enhancing the effectiveness of teaching and learning (Wiyono et al., 2021). Studies frequently examine the effects of ICT on students or teachers. This study only highlights the following: masters require digital capabilities, and students must constantly develop their ICT abilities to ensure the transformation process is successful.

The effective use and management of ICT in educational institutions contributes to the development of a healthier organizational culture among teachers and students. Strategic implementation of innovative cultural models enhances the effectiveness of digital-based learning processes (Burhanuddin & Supriyanto, 2018). ICT development in schools impacts teachers and students' digital competence, preparing them for a higher quality education ecosystem. Indonesian millennial generation's potential to drive this ecosystem has gained attention, emphasizing the importance of ICT in supporting learning (Muslihati Muslihati, 2020). Even though the literature has long discussed 21st century skills, this study focuses on the use of ICT to develop skills at every age, therefore it provides more convincing evidence for the inclusion of ICT in higher education curriculum.

In contrast to previous studies that consistently support the use of ICT as a digital literacy tool or as a teaching tool, this study offers a new contribution by highlighting the significant impact of ICT use on the development of digital competency among high school students. This highlights the close relationship between the use of technology and the growth of digital literacy, which eventually translates to the use of graduates in coping with the 21st century ('Alam, Supriyanto, et al., 2023). In addition to this, the study does not only focus on students as ICT users, but also highlights the need for developing digital skills as a key player in educational transformation. The simultaneous study of these two aspects indicates that there is a holistic viewpoint that the success of ICT integration in the curriculum cannot be explained by the students' workforce. As a result, this research offers a more comprehensive and contextual approach compared to previous studies since it links ICT to the development of digital skills, curriculum integration, and lecturer strategies for transforming technology-based education.

Numerous studies indicate that effective ICT use enhances 21st century skills, such as digital literacy, teamwork, and critical thinking (Redecker, 2017). Prior research indicates that digital competency significantly influences how doctoral and master's program students can develop their digital skills (Caena & Redecker, 2019). According to literature, ICT is not a panacea for education, illustrating the foundations of the student-centered learning approach (Inamorato dos Santos et al., 2023). Accordingly, the results of this study are consistent with other studies that indicate that the use of ICT contributes positively to the improvement of educational quality, the development of digital skills, and the transformation of education in the 21st century, whether through the development of digital literacy among students or the use of technology as a facilitator of technology-based education.

ICT's impact on social life, particularly in education, significantly influences digital competence in DIK and CC aspects. Its development in education includes artificial intelligence, augmented reality, visual reality, e-learning, and e-training ('Alam, Wiyono, et al., 2023). It revolutionizes learning through immersive experiences, interactive environments, and student involvement, highlighting future investments in large scale (Al-Ansi et al., 2023). The growing use of ICT-based educational applications will foster a lifelong learning process that fosters adaptability, enabling future digital technology benefits to lead to exceptional competency success (Llorente-Cejudo et al., 2023).

D. CONCLUSIONS

By showing that the educational benefit of ICT is greatest when it improves DIK and CC rather than just technical or operational skills, this study adds to the conversation on digital competence. By establishing DIK and CC as fundamental epistemic dimensions that empower educators to critically assess digital content and imaginatively create meaningful learning experiences, the findings enhance current frameworks. This study reframes ICT as a catalyst for higher-order cognitive development in teaching practice, in contrast to earlier research that focused on ICT efficiency and accessibility. The findings show that successful ICT integration enhances teachers' critical thinking and creative agency, emphasizing that educational

value is determined by pedagogical aim rather than just technology use. Therefore, future studies should concentrate on investigating DIK and CC as important mediating variables in ICT-based learning models, capturing their developmental dynamics through experimental or longitudinal approaches. The development of professional development programs that go beyond technical instruction to transformative digital competency for 21st century education will be aided by such focused investigation.

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