SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Development Digital Maturity Attributes Based on Higher Education Business Processes

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ABSTRACT

Transformation in the digital aspect is a crucial part of the higher education development in digital age transformation. The objective of this study is to identify the transformation of digital maturity requirements in universities as higher education institutions from Indonesia, which will later be used as criteria for forming a digital maturity model. The research method is mixed, involving both qualitative and quantitative analyses. The type of research applied is the Exploratory Sequential Design, where the data is collected and analyzed with the qualitative method, then follows up the results with a quantitative one to explore a phenomenon. The content validity index applied in this study is used to validate digital maturity requirements. It has been applied to various digital technology companies, government policies in higher education systems, and management applied to multiple universities. The results can guide universities in navigating digital transformation in their institutions. This study highlights that previously proposed digital maturity models need to sufficiently consider the business processes of higher education and the need for security and privacy dimensions, which have not been extensively discussed in the literature.

Keywords:

Digital maturity; digital maturity requirements; digital transformation; higher education business processes

1. Introduction

Digital technology innovation has rapidly transformed the organizational landscape, influencing competitive strategies, customer behavior, service provision, and business operations. In this context, digital transformation (DT) has become a vital strategy for organizations to maintain relevance [1]. However, DT is not just about implementing technology; it involves comprehensive changes in organizational culture, leadership, work processes, and technological adoption to create new value [2]. The COVID-19 pandemic has further accelerated the momentum of DT, showcasing its role not only in competition but also in organizational resilience [3]. As research on DT expands, it encompasses various sectors such as education, manufacturing, media, and healthcare across different nations and regions [4, 5]. In the public sector, including education, DT offers opportunities to learn from other sectors like finance, manufacturing, and media that have successfully embraced digitalization [6]. Education, particularly higher education, faces complex challenges in adopting DT.

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https://doi.org/10.37934/araset.64.1.5074

According to [7], higher education institutions struggle with technological innovation and organizational management. Additionally, higher education ranks eighth in terms of innovation compared to other industries, indicating a slower response to technological changes [8].

DT in higher education involves a comprehensive overhaul of culture, workforce, and technology. This transformation enables the creation of new operational models, alters institutional strategies, and modifies value propositions [9, 10]. The adoption of DT in universities is increasingly recognized as urgent, with institutions evolving toward new models that emphasize technology integration and strategic transformation [11]. These changes significantly impact teaching practices, workload distribution, and student experiences, while also influencing organizational strategies [12]. Furthermore, DT shifts traditional teaching methods toward more student-centered approaches, fostering creativity, initiative, and flexibility [13, 14]. To succeed in this transformation, universities must adopt both pedagogical and technological advancements to prepare students for the evolving challenges of the digital workforce and society [15]. Xiao [16] highlights that digital transformation in higher education has a wide-reaching impact, especially when technologies like the Internet of Things (IoT), Artificial Intelligence (AI), big data, blockchain, and cloud services are effectively implemented. These technologies offer new opportunities for student engagement that may not be available in traditional classrooms [17].

The Indonesian government has recognized the importance of digitalization in higher education, aligning with its broader economic goals of becoming one of the world's top ten economies by 2030 [2]. Human resource development, particularly education and training tailored to the digital job market, is a key priority in this vision. Mid-level higher education institutions in Indonesia are focusing on IT infrastructure, clear vision goals, and employee support to seize digital opportunities [18]. The COVID-19 pandemic has further pushed higher education institutions toward digital transformation in governance [19]. Research by Aditya *et al.,* [20] identifies major barriers to DT in Indonesia, such as contextual, technical, and cultural issues, which must be addressed for successful integration. Understanding the challenges and barriers faced by higher education institutions in implementing DT is essential for anticipating and addressing future needs [21, 22]. Leveraging digital technology to solve these challenges and achieve desired future conditions is critical for institutions undergoing transformation [23, 24]. To measure the success of DT, a change management framework is necessary, and the digital maturity model (DMM) is a widely used tool for evaluating the progress of digital transformation [25, 26]. The DMM helps organizations identify their current stage in the DT process and guides them in making improvements [27, 28].

However, existing DMMs in the education sector have limitations. Many are adapted from non-educational sectors and do not fully consider the unique business processes of educational institutions [1, 15]. To address this gap, a digital maturity model specifically designed for higher education institutions is needed. This model should be based on an understanding of the digital maturity requirements specific to educational institutions, helping universities navigate their DT journey [29]. In Indonesia, higher education institutions do not yet have a comprehensive DMM. This study aims to identify the digital maturity requirements for higher education in Indonesia, which will serve as criteria for developing a digital maturity model. The research follows an Exploratory Sequential Design, combining qualitative data from supporting documents with quantitative data from expert responses to questionnaires [30-32].

1.1 Business Processes of Higher Education in Indonesia and Future Challenges

Business processes in higher education refer to structured activities that produce outputs aligned with user needs, as outlined in Permenristekdikti No. 71 Tahun 2017. These processes are categorized

into three sections: main, supporting, and management. The main process encompasses education, research, and community service [33], as shown in Table 1. Supporting processes include academic administration, finance, student services, human resources, quality assurance, and secretarial tasks. Management processes involve strategic planning and vision development. In some institutions, the management process may be integrated with supporting activities [34].

Table 1
Business processes of higher education in Indonesia

Business processes of higher education in Indonesia	
Main process (Tri Dharma Perguruan Tinggi/Three Principles of Higher Education)	Supporting process
i. Education: a. New student admissions b. Entrance selection c. Teaching, practicum, tutorial, and evaluation d. Academic support and student services e. Final project and passing exam f. Graduation g. Work placement h. Alumni services ii. Research: a. Preparation of roadmap b. Partnership c. Proposal submission and grant selection d. Implementation and administration e. Reporting, publication, and dissemination f. Transfer of science and technology works iii. Community service: a. Preparation of Roadmap b. Partnership c. Proposal submission and grant selection d. Implementation and administration e. Technology and entrepreneurship incubation f. Reporting, publication, and dissemination g. Transfer of solution and startup company operations	i. Vision, mission, goals, and strategic planning ii. Quality assurance iii. Administration iv. Financial management v. Human resource management vi. Facilities and infrastructure management vii. Logistics management viii. ICT management ix. Technology management and IPR x. Project management
Output users of main process	
i. Graduates ii. Graduate users	iii. Publications, citations iv. Innovations (IPR)
v. Scientific, technological, and social works vi. Startup companies	

Higher education business processes in Indonesia are regulated by various laws, including Permenristekdikti No. 71 of 2017, which outlines guidelines for mapping business processes and standard operating procedures [35, 36]. This regulation defines the core processes in higher education, focusing on the Tridharma of Higher Education: Education, Research, and Community Service. These processes are further supported by Law No. 12 of 2012 and Permendikbud No. 3 of 2020, which establish national standards for higher education, governing the organization of Tridharma activities.

The main business processes include education, which covers admissions, teaching, student services, final assignments, and graduate placement; research, involving the development of research roadmaps, partnerships, proposal submissions, publications, and the conversion of research into scientific work; and community service (PKM), which includes preparing roadmaps, partnering with communities, proposal submissions, and disseminating research-based solutions to help create

startups. Supporting processes, crucial for the success of the main processes, include strategic planning, quality assurance, finance, human resources, and ICT management [37].

In the digital era, higher education must adapt to global competitiveness by integrating digital technologies to transform business models and enhance human resource quality, innovation, and multi-platform capabilities [38]. The Ministry of National Development Planning emphasizes the need for reforms in education to align with digital demands, including personalized learning, digital classrooms, and preparing the workforce for future challenges. With Indonesia ranked 116th out of 189 in the Human Development Index, there is a clear need for targeted reforms to foster a technological ecosystem that supports the evolving educational landscape.

1.2 Digital Transformation Maturity in Higher Education

Digital transformation (DT) begins with "digitization," the conversion of analog or physical data into digital formats using computer technology, a process initiated since the advent of computers [39]. It evolves into "digitalization," where organizations leverage digital technology and data to enhance business processes, improve productivity, and reduce costs. This stage has been widely adopted by modern organizations, where resources and capabilities support continued operations [39]. The digital era brings changes in behavior and business, necessitating continuous enhancement of digital capabilities. These capabilities, such as IT mastery and knowledge, create organizational value and mark the initial step of DT [40]. According to [41], DT involves not just implementing technology but also complex organizational changes: culture, leadership, and work processes—to create new business value. Zhu *et al.,* [42] emphasize that DT requires adaptive changes in organizational structure and has sparked interest across sectors like healthcare, education, and financial services due to its customer-centered approach.

In higher education, DT is a priority due to rapid technological advancements and the influence of Industry 4.0 [25]. Alenezi [43] highlights that DT in higher education can address challenges like declining student admissions, increasing operational costs, and changing educational demands. Beyond adopting digital technologies, transforming teaching and learning models is vital for survival and maintaining competitiveness [25]. Higher education leaders have identified four key goals for DT: enhancing the student learning environment, improving operational efficiency, increasing computational power for research, and driving educational innovation. Institutions must evolve integrally to remain sustainable, and DT provides a promising path [25]. Rof *et al.,* [44] explore how universities implement DT through innovations like virtual campuses, email, websites, and social networks, which affect decision-making, connectivity, and digitization processes in higher education. Akour and Alenezi [38] further emphasize that DT is crucial for developing graduates with strong digital skills and workforce expertise.

Digital maturity models (DMM) are used to assess organizations' readiness for DT [45]. DMMs identify gaps and areas needing improvement, guiding organizations in their digital transformation journey [29, 46]. Gumaelius *et al.,* [47] explain that while DT and digital maturity (DM) are sometimes used interchangeably, DM is a systematic approach to DT. Llopis-Albert *et al.,* [48] add that DM specifically reflects an organization's status in digital transformation. The DMM serves as a roadmap for organizations to assess their readiness for digital change based on specific parameters, allowing them to manage and direct DT efforts systematically and efficiently [49]. DM is measured through dimensions and elements that represent action areas critical for progress towards DT [50]. A dimension is a measurable component reflecting key aspects of DM, while elements or sub-dimensions provide specific criteria for assessing an organization's maturity level [51].

Despite extensive research on DMMs in various industries, higher education DMMs are limited, mainly focusing on managing information systems and still in early stages of development [52, 53]. One of the more developed models, the Digital Maturity Framework for Higher Education Institutions (DMFHEi), was adopted in Croatian universities [54, 55]. However, the DigCompOrg framework primarily focuses on teaching and learning [56]. Alenezi [43] compares various DMMs from companies like Accenture, BCG, Deloitte, EY, KPMG, McKinsey, and PWC, and concludes that company-developed models are useful in practice. Ifenthaler & Egloffstein [29] examine five models, including PwC's Digital Barometer and the Industry 4.0 Maturity Index. A DMM developed from Eggers & Bellman [57] and Petkovics *et al.,* [58] is also used to measure DT maturity in higher education in the UAE. However, existing DMMs for higher education generally overlook business processes, adapting models from other sectors [29]. Thus, a review of DMMs from various models [45, 56, 59-62] offers a broader understanding of the impact of digital technology on higher education.

1.3 Identifying Requirements for Digital Transformation Maturity in Higher Education

Requirements for DM include the need for organizations to develop digital capabilities to adapt to digital realities [63]. This involves engaging digital transformation goals, assessing their effectiveness, implementing digital strategy measures, and revising change management [64]. We have identified the requirements for digital transformation maturity for higher education business processes, as shown in Figure 1.

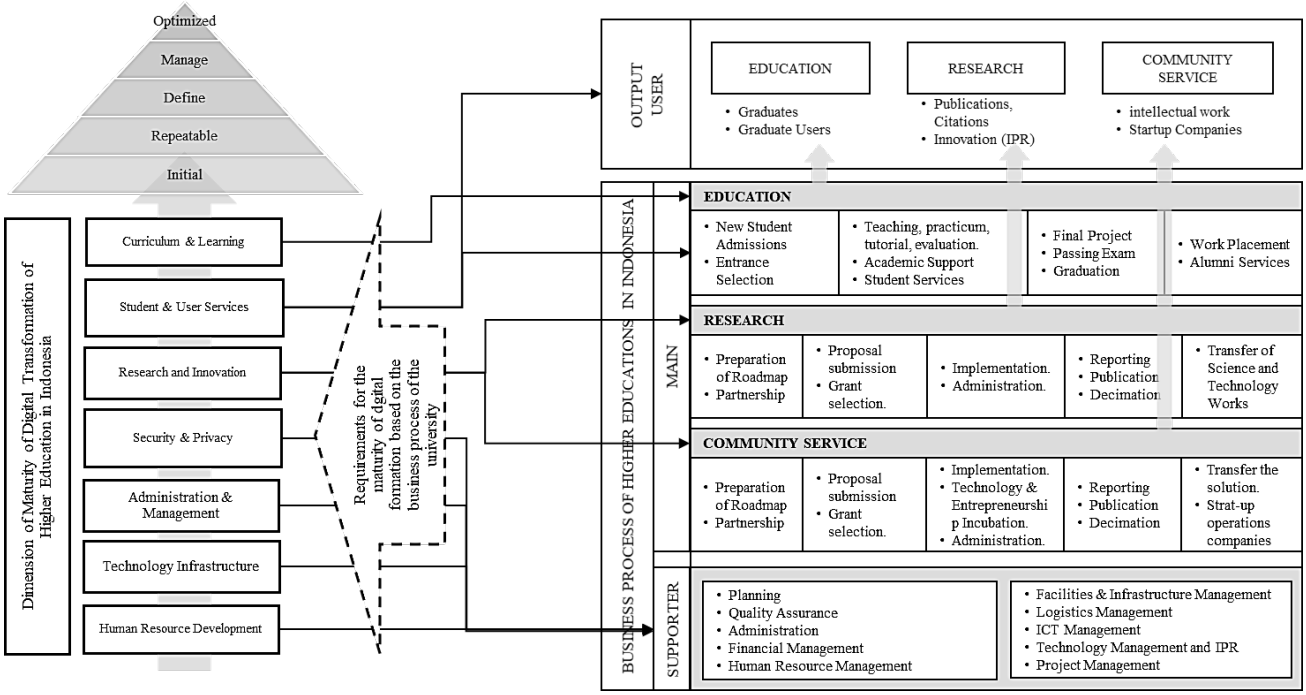

Fig. 1. The design of the digital maturity model for higher education in Indonesia based on business processes

Table 1 identifies the primary and supporting business processes of higher education, illustrated in Figure 1. These processes generate outputs with added value in education (competent graduates), research (impactful publications), and community service (technological solutions for startups) [65]. The Higher Education business processes align with digital maturity dimensions, such as Curriculum, Learning, and Student Services, connected to the central Education process through linking arrows

[25, 66]. Attributes of digital maturity from these dimensions are identified via literature review and validated by experts to assess the digital maturity level of higher education [15].

1.4 Digital Maturity Requirements in the Dimension of Administration and Management

Higher education institutions must implement an effective technology-based administration and management system that aligns with their vision, mission, and goals to support digital transformation (DT) [11, 45, 67]. Strategic planning is essential for integrating digital technology into business activities and effectively communicating these strategies to stakeholders [68]. This dimension encompasses business processes like vision, mission and planning, quality assurance, financial management, administration, human resources, infrastructure, and logistics. The digital maturity (DM) requirements in this dimension include:

i. Digital leadership: Leaders must guide organizations in the digital era, demonstrating openness to innovation, a clear digital vision, strategic direction, digital skills, continuous learning, and fostering collaboration and connectivity [24, 41, 56, 61, 69-73].
ii. Data and information management: Effective management of university operations and decision-making requires a robust information management system, a data management repository, digital libraries, student and alumni data management, business intelligence, and information system integration [34, 53, 74-76].
iii. Governance: This refers to the management and regulation of resources used in business processes, enhancing efficiency, transparency, and operational security through policies related to digital technology management, risk management, and evaluation of key performance indicators (KPIs) for digital governance performance [3, 29, 43, 67].

1.5 Digital Maturity Requirements in the Dimension of Technology Infrastructure

Digitally mature universities possess reliable technology infrastructure that supports the integration of technology in essential business processes such as education, research, student creativity programs, innovation, and administration [43, 54, 56, 61]. Key requirements for digital maturity (DM) in this dimension include effective ICT infrastructure planning and procurement, which ensure the identification, selection, and application of digital technologies align with university goals and vision. This involves transparent procurement processes, regulatory compliance, and stakeholder involvement for input and feedback [43, 54].

Furthermore, ICT asset management is crucial for optimizing the efficiency of IT usage, minimizing maintenance costs, and ensuring compliance with software licenses [29]. This includes maintaining an inventory of ICT assets, establishing maintenance policies and procedures, and managing the lifecycle of these assets to maximize their value [77, 78]. Additionally, ICT capacity and scalability are vital for enabling the technology infrastructure to accommodate an increasing number of users and evolving needs. This encompasses the ability to handle growth in hardware, server space, data centers, and network equipment while ensuring that information systems can support additional functionalities and an expanding user base [56, 78]. Overall, a well-structured ICT framework is essential for achieving digital maturity in higher education institutions.

1.6 Digital Maturity Requirements in the Dimension of Human Resources Development

Human resources development refers to the ability of higher education institutions to have sustainable human resources development policies and programs in terms of digital skills [3] and their relationship with awareness of business and technology integration in achieving organizational vision [59]. The DM requirements in this dimension includes the following.

i. Digital skill is a person's ability to use digital technology to aid work processes [15]. Requirements in digital skills include mastering information technology, data analysis skills, and effective digital communication through various platforms, such as email, instant messaging, and social media [6, 59].
ii. Understanding of business and technology includes integration between business and technology aspects in human resource management, such as the ability to link business needs with technology solutions in the context of human resources [79], designing technology-based employee development programs [15], and human resource capabilities in problem solving and creativity through digital literacy [80].
iii. Awareness and adaptability skills are the ability of individuals or organizations to understand, accept, and adapt to digital technology developments [1], such as learning agility [81], flexibility and adaptability, and organizational awareness [82].

1.7 Digital Maturity Requirements in the Dimension of Curriculum and Learning

Higher education institutions effectively harness the potential of digital technology in educational business processes, particularly in curriculum and learning processes [60]. Additionally, they are capable of well-integrating technology into learning processes, include using some of online learning media platforms, digital collaboration tools, and project-based learning involving technology [54]. The DM requirements in this dimension includes the following.

i. Digital learning design consisting of learning between lecturers and students integrated with digital technology effectively to achieve comprehensive learning outcomes [79], then the new role of Lecturers as mentors, regulators, and learning facilitators, as well as being examples in lifelong learning [56], flexible learning time and place, and innovative teaching and learning methods with ICT, such as project-based or game-based learning, adaptive learning, augmented reality (AR) and virtual reality (VR), flipped classrooms, and online collaboration [83].
ii. Integration of technology in the curriculum [3] including incorporating digital competencies as an integral part of the curriculum, using digital learning tools [84], collaborative projects utilizing technology in learning evaluation that can be recognized as forms of professional (expert) learning, using digital media in learning, such as multimedia, like videos, images, and simulations, and leveraging digital media, to explain concepts or learning materials [17].
iii. The development of digital competencies in education is crucial to preparing students to thrive in a digital society [85], such as digital skills, mastery of tools, and digital information literacy [25]. Digital problem-solving skills, digital creativity [17], and data analysis skills [56].
iv. Technology-based learning evaluation can provide timely, depersonalized, and meaningful feedback to students [85]. Such evaluations track individual progress provided by

technology and measure student participation in online activities, such as assignments, quizzes, or forum discussions [86].

1.8 Digital Maturity Requirements in the Dimension of Research and Innovation

Digitally mature higher education institutions can promote business processes in research, community service, and innovation in technology and education [54]. This includes the development of research projects using the latest technology, research collaboration with other institutions, and the use of technology in research data collection and analysis [61]. The DM requirements in this dimension includes the following.

i. The existence of a research collaboration network supported by ICT, namely the involvement of researchers with a network of other researchers who use ICT, is essential [54], this allows the use of analytical technology, such as big data analysis and artificial intelligence, to improve research analysis and innovation capabilities [38]. This includes collaborative platforms, the use of ICT in the preparation and publication of scientific papers [29], and ongoing training for researchers in applying ICT to scientific research [3].
ii. Research collaboration with stakeholders ensures that research results provide relevant benefits that stakeholders or the community can implement, supported by ICT such as researcher collaboration with the community [54], applied research, and professional projects supported by ICT and/or for ICT [3].
iii. The ability to protect research results and innovations through copyrights, patents, trademarks, and industrial design rights, as well as efforts to transform research results into products or services that can quickly enter the market through ICT support [54], such as integrating intellectual property and commercializing research results with IT support is important [29].

1.9 Digital Maturity Requirements in the Dimension of Student and User Services

Digitally mature universities are capable of providing student services utilizing technology. Additionally, there are services available for other users (faculty, educational staff, alumni, graduates, and other partners). Additionally, there are services available for other users (faculty, educational staff, alumni, graduates, and other partners). The DM requirements in this dimension includes the following.

i. Digital-based student services that make the student experience more effective and flexible [29], such as online promotion and registration, digital platform-based student services, ease of integration, technical support services, and ICT accessibility [54].
ii. Loyalty programs in higher education digitalization that aim to create an inclusive campus environment [59], enhance student experience, and build long-term bonds between students and the institution, [54] including access to information, personalized communication, integration with mobile applications [29] (2020), alumni programs (*), quality content, feedback, and surveys [54].
iii. Other user services, such as ICT-based career planning and development for employees and partner information needs based on ICT include providing job vacancy information, training, and other cooperation programs [54].

2.0 Digital Maturity Requirements in the Dimension of Security and Privacy

This dimension emphasizes the importance of security and privacy when using technology in higher education [87], such as the ability to have adequate policies and infrastructure to protect sensitive data, manage security risks, and ensure compliance with privacy regulations and data protection [50]. The DM requirements in this dimension includes the following.

i. Data security, such as access control to data and information, and user identity management to maintain security [88], security audits, security awareness [36], and network security by protecting networks used to transmit or store digital data [87].
ii. Privacy rights & protection policies are requirements for digital maturity [89], such as the ability to identify and recover digital data after a disaster or security incident [90], policies and procedures for managing encryption keys used in data protection [87], and university policies to comply with applicable laws and regulations in the use of digital technology [91].

2. Methodology

The method used in this study was mixed method, where two types of analysis were conducted: qualitative and quantitative analyses [92]. The purpose of combining these two research methods is to provide a deeper understanding of the research questions or issues compared to when the methods are used separately [32]. The type of research applied was exploratory sequential design, where the researcher collected and analyzed qualitative data first, and then followed it up with a quantitative phase [93]. The goal is to explore a phenomenon before deciding which variables need to be measured quantitatively [32]. Qualitative data in this research came from documents, specifically from literature reviews, while quantitative data was obtained from respondents' answers regarding the requirements for digital transformation maturity in Indonesian universities. The purpose of collecting qualitative data first is to explore existing phenomena, followed by collecting quantitative data to explain the correlations between variables found in the qualitative data [92]. The design of the exploratory sequential design is as follows:

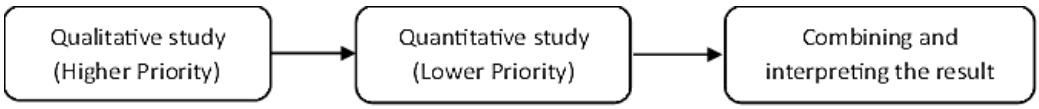

Fig. 2. Exploratory sequential research design

The qualitative method in this research was used to address the research question about the requirements to achieve digital transformation maturity in Indonesian universities. Subsequently, the quantitative method was used to validate the qualitative data obtained based on assessments provided by experts in the questionnaire.

2.1 Qualitative Analysis

Qualitative analysis in this study was conducted by reviewing the literature to identify the requirements for achieving digital transformation maturity in Indonesian universities [92]. This literature review involves examining previous researchers' findings to determine the criteria for digital transformation in higher education institutions. Data collection was facilitated using the Publish or Perish application to gather necessary articles by inputting relevant keywords. Initially, the

total number of articles retrieved using Publish or Perish was reduced to focus on those directly related to the research theme.

After gathering data through literature review, the criteria for digital transformation maturity in universities were validated by experts. These experts were asked to provide feedback on whether the identified criteria were sufficient or if additional criteria tailored to the conditions and circumstances in Indonesia were needed.

2.2 Quantitative Analysis

Quantitative analysis in this research was conducted using a research instrument to assess the alignment of digital transformation maturity requirements in universities with business processes, identified through literature review and input from experts based on Indonesian conditions [92]. Subsequently, these requirements were formulated into a questionnaire and validated by experts through online (Google Form) or virtual face-to-face assessments. The validity of the questionnaire's content was tested using the Content Validity Index (CVI) method [94], where agreement among experts on the questionnaire items was calculated, providing an index as a quantification of expert assessment, as seen in Figure 2. CVI was chosen as it is commonly used to assess the validity of instruments measuring various constructs [94-97].

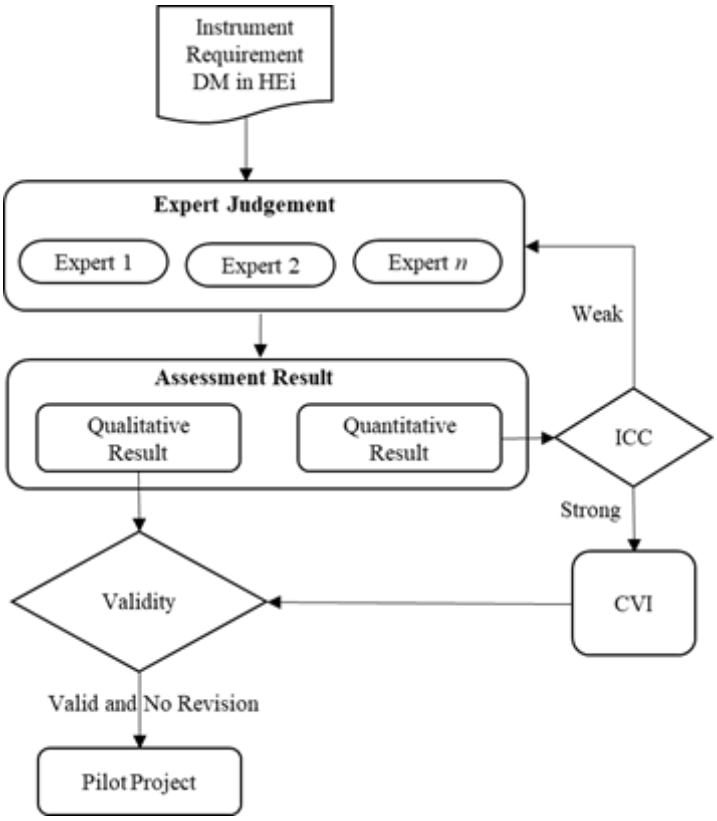

Fig. 3. Stages of validation of digital transformation maturity requirements instrument for adoption by higher education institutions [94]

2.3 Content Validity Index (CVI)

According to Lynn [98], CVI can be grouped into two types: individual item content validity (i-CVI) and scale-level content validity (s-CVI). In testing validity with CVI, the procedural steps are as follows:

i. Preparing a content validation sheet aimed at facilitating experts in understanding the tasks to be performed. The validity rating scale uses an ordinal scale with four criteria: 1 = not relevant, 2 = somewhat relevant, 3 = relevant, and 4 = very relevant to avoid medians that refer to neutral criteria [32].
ii. Selecting several Subject Matter Experts (SMEs). Experts were chosen based on their expertise relevant to the research objectives [99], as seen in Table 2.
iii. Conducting content validation face-to-face or online. Experts provided scores and additional comments.
iv. Calculating CVI, which includes i-CVI and s-CVI values, by converting scores where 1 and 2 are represented by the number 0, indicating not acceptable, while scores of 3 and 4 are represented by the number 1, indicating acceptable [94], as shown in Table 3.

Instrument reliability test using Intraclass Correlation Coefficients (ICC) assesses inter-rater agreement levels [100] using statistical data management applications. According to Portney & Watkins [101] on ICC interpretation, values less than 0.5 indicate poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate very good reliability [32].

Table 2
Recommended number of members by some researchers

Number of subject matter experts	Acceptable CVI values	Recommendation source
2 Experts	At least 0.80	[66]
3 to 5 experts	Must be 1	[94]
At least 6 experts	At least 0.83	[94]
6 to 8 experts	At least 0.83	[98]
At least 9 experts	At least 0.78	[98]

Table 3
Definition and formula for I-CVI, S-CVI/Ave, and S-CVI/UA

CVI Index	Definition	Formula
Content Validity Index (CVI)	According to content experts, the percentage of items is rated three or four in terms of relevance.	(Items agreed upon) / (number of experts) = I-CVI
S-CVI/Ave (Scale-Level Content Validity Index using Average method)	Average I-CVI scores for all items on the scale or proportion of relevance rated by all experts. The relevant proportion is the average relevance rating by each expert.	S-CVI is calculated as the sum of I-CVI scores divided by the number of items in I-CVI. (Sum of proportions of relevance ratings) / (Number of experts) = S-CVI / Ave
S-CVI/UA (Scale-Level Content Validity Index based on Universal Agreement method)	This is the percentage of scale items rated 3 or 4 by all experts. Universal Agreement (UA) score of 1 indicates 100% agreement among experts on that item; otherwise, UA score of 0 indicates no agreement at all.	(Sum of UA Scores) / (Number of items) = SCVI/UA

Note: These definitions and formulas are developed based on the recommendations [66, 98, 102, 103].

2.4 Subject Matter Experts

The subject matter experts in this study have professional experience [104]. The first are the experts in digital technology who have experience in Artificial Intelligence, the Internet of Things, data analytics, and others to provide insights into identifying requirements that influence the digital maturity of an organization [105]. The second are the experts in higher education policymakers (government) with experience in the higher education system in Indonesia and its dynamics [12]. Lastly are the experts in higher education management who have experience in the challenges and opportunities faced by universities in the development of technology (rectors or deans) [10].

Convenience sampling [106] was used, where the selection was based on criteria, namely having a minimum of 5-10 years of experience in their field of expertise and having a good reputation recognized by peers or the community. There were 6 experts to assess the validation of the digital transformation maturity requirements of higher education in Indonesia, including 2 experts in digital and information technology, 1 expert as the Head of the Directorate of Education Services Region 7 (LLDIKTI 7) East Java Indonesia for the higher education policy system, and 3 experts in higher education management, namely rectors and deans of universities in Indonesia.

3. Results

Identification of digital maturity requirements through a survey of 6 expert panels was conducted from March 8 to May 18, 2024, using Google Form where each expert independently filled out the survey.

3.1 Results of Qualitative Analysis

The qualitative analysis in this study was sourced from supporting documents, namely literature reviews [50] on digital transformation maturity requirements in higher education institutions and data collected from expert inputs. The supporting documents refer to international journal articles collected using the Publish or Perish application. Analysis with Publish or Perish revealed 36 articles discussing the same topic. Data obtained from this qualitative analysis were then compiled into an instrument in the form of a questionnaire consisting of 74 items across 7 dimensions as listed in Table 4. The data obtained was then compiled into a questionnaire and distributed to experts to gather quantitative data on the relevance of each item to assess the requirements for digital transformation maturity in higher education.

Table 4
Dimensions, sub-dimensions, and criteria (requirements) of digital transformation maturity in Indonesian higher education institutions

Dimensions	Sub dimensions	No.	Criteria (requirements)	Reference
Administration and management	Digital leadership	1	Openness to innovation	[69-71]
		2	Digital vision	[56, 72]
		3	Leader as strategic director	[41]
		4	Digital skills and continuous learning	[24]
		5	Collaboration and connectivity	[107]
	Data and information management	6	College driver's license	[76]
		7	Data repository management	[76]
		8	Digital library	[34]

Table 4. Continued

Dimensions, sub-dimensions, and criteria (requirements) of digital transformation maturity in Indonesian higher education institutions

Dimensions	Sub dimensions	No.	Criteria (requirements)	Reference
		9	Student and alumni data management	(*)
		10	Business intelligence (BI)	[74]
		11	System integration	[53]
	Government	12	Policies and procedures	[43]
		13	Risk management	[21]
		14	KPI evaluation	[3]
	Infrastructure planning and procurement	15	ICT needs analysis and strategic planning	[108]
Technology infrastructure		16	Procurement of equipment and software	[108]
		17	Consultation and involvement of related parties	[43]
	Asset management	18	ICT asset inventory	[29]
		19	Asset maintenance	[77]
		20	Asset life cycle management	[78]
	Capacity and scalability	21	Physical infrastructure and networks	[56]
		22	Information system reliability	[78]
Human resource development	Digital skills	23	Mastery of information technology	[15]
		24	Data analysis capabilities (executive reporting)	[59]
		25	Digital communications	[6, 59]
	Understanding business and technology	26	Business and technology integration	[3]
		27	Employee development	[15]
		28	Problem solving and creativity through digital literacy	[80]
	Awareness and adaptability	29	Learning agility	[81]
		30	Flexibility and adaptability	[82]
		31	Organizational awareness	[83]
Curriculum and learning	Digital learning design	32	Learning based on a more integrated approach	[56]
		33	The new role of lecturers in learning	[56]
		34	Flexible study time and place	[83, 108]
		35	Innovative learning and teaching methods with ICT	[83, 108]
	Integrating technology in curriculum review	36	Technology based curriculum development	[84]
		37	Utilization of digital learning devices	(*)
		38	Technology-based collaborative learning	[17, 109]
		39	Use of digital media in learning	[17, 109]
	Digital competency development	40	Mastery of digital tools	[25]
		41	Digital information literacy	[25]
		42	Digital problem-solving ability	[17]
		43	Digital creativity	[17]
		44	Data analysis capabilities	[56]

Table 4. Continued
Dimensions, sub-dimensions, and criteria (requirements) of digital transformation maturity in Indonesian higher education institutions

Dimensions	Sub dimensions	No.	Criteria (requirements)	Reference
	Evaluation of technology-based learning	45	Individual progress tracking	[110]
		46	Measuring student participation	[86]
Research and innovation	Research collaboration network with ICT support	47	Researcher involvement	[38]
		48	Utilization of analytics technology	[38]
		49	Collaborative platform	[29]
		50	Use of ICT in the preparation and publication of scientific papers	[3]
		51	Continuous training of researchers for ICT in scientific research	[3]
	Research collaboration with stakeholders	52	Collaboration between researchers and the community	[108]
		53	Applied research and professional projects supported by ICT and/or for ICT	[3]
	Intellectual property (IP) license and commercialization of research results	54	IP and ICT integration	[108]
		55	Understanding of IP and Commercialization of research results	[29]
Student and other user services	Digital based student services	56	Online promotions and registration	[29]
		57	Digital platform-based student services	[108]
		58	Ease of Integration	[108]
		59	ICT technical support, services and accessibility	[108]
	Loyalty program (customer experience)	60	Access to information	[29]
		61	Personalized communication	[29]
		62	Integration with mobile apps	[29]
		63	Special program for alumni	(*)
		64	Quality content	[108]
		65	Feedback and surveys	[108]
	Other user services	66	ICT-based employee careers	[108]
		67	ICT-based partners need information	[29]
Security and privacy	Data security	68	Identity and access management	[88]
		69	Security audits	[36]
		70	Security awareness	[87]
		71	Network security	[87]
	Privacy policy and protection	72	Disaster recovery	[87]
		73	Key management	[87]
		74	Legal compliance	[91]

3.2 Quantitative Analysis Results

3.2.1 Reliability and content validity testing

Reliability test is a measure indicating how trustworthy an instrument is, meaning when this instrument is repeatedly used to measure the same thing, the results are consistent or relatively

stable due to its consistency [111]. The reliability test resulted in an intraclass correlation coefficient (ICC) with an average agreement of 0.791, falling between 0.750-0.90, indicating good reliability [94] as seen in Table 5. This means that there was acceptable agreement for all requirement items across all dimensions. Statistical testing procedures and their results, along with qualitative observations by experts for each item, produced a validated final instrument.

Table 5
Instrument reliability test using intraclass correlation coefficient (ICC)

Average measure - intraclass correlation	N	Confidence interval 95%	Results
0.791	6	0.857	Accepted

(Source: processed using statistical processing applications)

Validity testing estimates how accurate an instrument is in research [96]. Content validity analysis uses the formulas explained in Table 3, yielding I-CVI and S-CVI values as seen in Table 6. Based on these calculations, the S-CVI value is 0.930 or at least 0.83 with 6 experts [94], indicating a high level of agreement among experts regarding the relevance of these items, thus validating the content comprehensively.

Table 6
Validity index (S-CVI/Ave)

Number of Items	S-CVI/Ave	Results
74	0.930	Accepted

3.2.2 Results of identifying the maturity requirements for digital transformation of Indonesian higher education

A total of 74 items (I) concerning the maturity requirements for the digital transformation of Indonesian higher education were evaluated by experts, and the I-CVI results are shown in Table 7. There are 3 items of digital transformation maturity requirements that are irrelevant or have values below 0.83, as seen in Table 7. Firstly, in the dimension of human resource development with business understanding and technology understanding criteria, it is employee development. The second is the new role of lecturers in learning in the curriculum review and digital learning design criteria and the third is digital information literacy on the competence development. The last two requirements' items are included in the curriculum and learning dimension.

Table 7
The calculation results of I-CVI for all digital maturity requirements of higher education institutions

DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category
I 1	1.00	Relevant	I 21	1.00	Relevant	I 41 (*)	0.00	Eliminated	I 61	1.00	Relevant
I 2	1.00	Relevant	I 22	1.00	Relevant	I 42	1.00	Relevant	I 62	0.83	Relevant
I 3	1.00	Relevant	I 23	1.00	Relevant	I 43	0.83	Relevant	I 63	1.00	Relevant

(Source: data were processed using MS Excel)
(Note: * item that is not relevant to the agreement of the experts)

Table 7. Continued
The calculation results of I-CVI for all digital maturity requirements of higher education institutions

DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category	DM item requirements in Hei	I-CVI	Category
I 1	1.00	Relevant	I 21	1.00	Relevant	I 41 (*)	0.00	Eliminated	I 61	1.00	Relevant
I 2	1.00	Relevant	I 22	1.00	Relevant	I 42	1.00	Relevant	I 62	0.83	Relevant
I 3	1.00	Relevant	I 23	1.00	Relevant	I 43	0.83	Relevant	I 63	1.00	Relevant
I 4	1.00	Relevant	I 24	0.83	Relevant	I 44	0.83	Relevant	I 64	1.00	Relevant
I 5	1.00	Relevant	I 25	0.83	Relevant	I 45	0.83	Relevant	I 65	1.00	Relevant
I 6	1.00	Relevant	I 26	1.00	Relevant	I 46	1.00	Relevant	I 66	1.00	Relevant
I 7	0.83	Relevant	I 27 (*)	0.00	Eliminated	I 47	1.00	Relevant	I 67	1.00	Relevant
I 8	1.00	Relevant	I 28	1.00	Relevant	I 48	1.00	Relevant	I 68	1.00	Relevant
I 9	0.83	Relevant	I 29	1.00	Relevant	I 49	1.00	Relevant	I 69	1.00	Relevant
I 10	1.00	Relevant	I 30	1.00	Relevant	I 50	1.00	Relevant	I 70	1.00	Relevant
I 11	1.00	Relevant	I 31	1.00	Relevant	I 51	0.83	Relevant	I 71	1.00	Relevant
I 12	1.00	Relevant	I 32	0.83	Relevant	I 52	1.00	Relevant	I 72	0.83	Relevant
I 13	1.00	Relevant	I 33 (*)	0.00	Eliminated	I 53	1.00	Relevant	I 73	1.00	Relevant
I 14	1.00	Relevant	I 34	1.00	Relevant	I 54	1.00	Relevant	I 74	1.00	Relevant
I 15	1.00	Relevant	I 35	1.00	Relevant	I 55	1.00	Relevant			
I 16	0.83	Relevant	I 36	1.00	Relevant	I 56	1.00	Relevant			
I 17	1.00	Relevant	I 37	1.00	Relevant	I 57	1.00	Relevant			
I 18	1.00	Relevant	I 38	1.00	Relevant	I 58	1.00	Relevant			
I 19	1.00	Relevant	I 39	1.00	Relevant	I 59	1.00	Relevant			
I 20	0.83	Relevant	I 40	1.00	Relevant	I 60	1.00	Relevant			

(Source: data were processed using MS Excel)
(Note: * item that is not relevant to the agreement of the experts)

3.3 Discussion of Qualitative data

Literature review conducted has shown that there are 7 dimensions of requirements for achieving digital transformation maturity in higher education institutions. These dimensions include

administration and management, technology infrastructure, human resource development, curriculum and learning, research and innovation, student and user services, as well as security and privacy. Each of these dimensions is further divided into several sub-dimensions and specific criteria (requirements). The research results indicate that the 7 dimensions can be divided into 21 sub-dimensions and 74 criteria (requirements), as shown in Table 4. Out of these 74 criteria, 71 items are derived from the literature review and 3 items from expert suggestions. The suggestions provided by experts are in the dimension of administration and management, specifically in the sub-dimension of data and information management, with suggestions on student and alumni data management items. Furthermore, experts also provided suggestions in the dimension of curriculum and learning, particularly in the sub-dimension of integrating technology in curriculum review, with suggestions on utilizing digital learning tools [112]. Lastly, experts gave suggestions in the dimension of student and user services, in the sub-dimension of loyalty programs (customer experience), with suggestions for special programs for alumni.

After obtaining data on the criteria for digital transformation requirements in Indonesian higher education institutions, these were compiled into a questionnaire in Google Forms to gather validation data from experts. The questionnaire was created using Google Forms to minimize paper waste, facilitate data collection and analysis for researchers, and make it easier for respondents to provide answers.

3.4 Discussion of Quantitative Data

Validation Validation from experts has identified the requirements for digital transformation maturity (DM) in higher education, leading to the acceptance of 71 out of 74 items categorized into 21 criteria and 7 dimensions for a pilot digital maturity model aimed at developing digital maturity in Indonesian higher education institutions. A key requirement within the management and administration dimension is the presence of digital leadership, which is critical for driving successful digital transformation in universities. This finding aligns with existing literature [24, 61, 113]. Furthermore, effective data and information management are essential for informed decision-making and governance in higher education, utilizing ICT to enhance efficiency, transparency, and operational security. The maturity requirements in this dimension are vital in supporting the university's business processes, ensuring that core activities such as education, research, and community service are aligned with anticipated outcomes.

In the technology infrastructure dimension, three primary requirements have been identified: universities must possess the capability to plan and procure ICT infrastructure, effectively manage ICT assets, and assess ICT capacity and scalability. This model slightly differs from the Digital Maturity for Higher Education Institutions (DMHEi) model [54] regarding digital maturity requirements. The current model emphasizes the need for technology infrastructure capabilities to handle increasing volumes of data and users, as well as adapting to evolving technological demands, such as artificial intelligence and data centres [114].

The human resource development dimension encompasses various requirements, including digital skills, an understanding of business and technology in human resources, and adaptability. Expert validation showed that technology-based employee development programs aimed at improving understanding of business and technology received low ratings [115]. Experts suggested that university human resources focus on technology users, while emphasizing the need for developing smart university IT in alignment with business plans. Thus, employee development in this context is not prioritized for digital transformation maturity. Nevertheless, the need for universities to connect business needs with technology solutions in human resource management, such as

utilizing Enterprise Resource Planning (ERP) systems, remains relevant. The ability to enhance problem-solving and creativity through digital literacy is still viewed as significant by experts [116].

In the curriculum and learning dimension, our findings diverge from previously established models [54], highlighting the necessity of developing technology-based curricula that incorporate digital competence as a core element. This aligns with the literature [84, 85]. Two attributes received expert consensus: first, the evolving roles of lecturers, which received low validation ratings. Experts indicated that, in the digital age, lecturers must transform into mentors, regulators, and facilitators, embodying lifelong learning and professional improvement, as stipulated by Indonesian Law Number 14 of 2005 concerning Teachers and Lecturers. The second attribute is digital information literacy, which experts believe is essential for fostering students' digital competencies. Additionally, there is a requirement for technology-based learning evaluations that can provide timely, meaningful feedback to students.

In the research and innovation dimension, experts concurred on all initial requirements, which include establishing research collaboration networks supported by ICT, collaborating with stakeholders, and protecting research outcomes through intellectual property rights. Digitally mature universities should also deliver reliable student services through technology, such as online promotion and registration, integrated digital platforms for efficient service, and technical support for ICT accessibility [117]. Furthermore, these services extend to other users, including lecturers, educational staff, alumni, and partners, with systems in place for employee career planning and providing information on job vacancies and training programs. These elements contribute to creating loyalty programs that facilitate the digitalization of higher education and foster an inclusive campus environment [59].

Finally, in the security and privacy dimension, universities must demonstrate the capacity to safeguard sensitive data, manage security risks, and comply with privacy regulations. These requirements are often overlooked in digital maturity models within higher education [50, 87]. Essential requirements in this dimension include data security measures, such as access control and user identity management, alongside security audits to systematically evaluate information system vulnerabilities [118]. Furthermore, universities should implement user training to recognize and mitigate security threats and protect networks for digital data transmission and storage using firewalls, Intrusion Detection Systems (IDS), and Intrusion Prevention Systems (IPS). Additionally, the establishment of privacy and protection policies is crucial for digital maturity [89], including disaster recovery protocols, encryption key management, and compliance with applicable laws governing digital technology usage.

4. Conclusions

This study focuses on validating the digital maturity requirements of higher education institutions in Indonesia based on their business processes. It serves as an advanced stage for developing a Digital Maturity Model (DMM) in the higher education sector, which can be used as a tool to measure digital maturity levels and strategies for digital transformation in universities. To achieve this goal, we conducted a systematic literature review of 27 digital maturity models and referenced several reputable international journals discussing digital maturity in higher education. We employed the Content Validity Index (CVI) method to validate digital maturity requirements evaluated by experts in digital technology, higher education policy systems (government), and higher education management. The validation results were used to construct a digital maturity model comprising 7 dimensions: management and administration; technology infrastructure; human resource development; curriculum and learning; research and innovation; student and user service; and

security and privacy. This model includes 21 criteria and 71 sub-criteria detailed in this study. Our study contributes to research by proposing digital maturity requirements for forming a digital maturity model for higher education based on existing business processes in Indonesia. Our work highlights that previously proposed models have not adequately considered university business processes and the need for security and privacy dimensions, which have been underexplored in the literature. This study only presents essential digital maturity requirements for higher education business processes in Indonesia. The relationship between one requirement and another in terms of temporal alignment has not been explored yet. Further research could focus on digital maturity requirements related to identifying more comprehensive business processes, such as using the Business Model Canvas (BMC) method to develop higher education business models, digital technology development, and enhancing operational efficiency and effectiveness.

Acknowledgement
This research was funded by the researcher's personal funds.

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