Оригинальная статья / Original paper

doi:10.17853/1994-5639-2026-4578

Developing a digital transformation framework for 21st-century learning

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Abstract. *Introduction.* In academic and pedagogical discourse, there remains a paucity of research and theoretical models that elucidate the relationship between the development of teachers' digital competences and the implementation of an updated learning model for the 21st century, particularly within the Technical and Vocational Education and Training (TVET) system. *Aim.* The *aim* of this research is to develop and test a concept of digital transformation in education that demonstrates the didactic potential of digital technologies to modernise the teaching and learning processes in TVET. *Methodology and research methods.* The methodology is based on a three-stage, mixed-methods design for the research and development process, comprising diagnostic, design, and constructive stages. The study involved 200 TVET teachers who participated voluntarily to identify their attitudes and professional gaps in the field of digital pedagogy. *Results.* The research findings revealed a consistent relationship between teachers' levels of digital competence, the nature of its practical application, and their readiness to transform their professional practice. Based on these findings, a conceptual model for the digital transformation of the learning process in TVET has been developed, aimed at fostering innovative practices, critical thinking, and collaborative activities among students. *Scientific novelty.* The *scientific novelty* lies in the creation of an integrated theoretical and methodological model that systematically links digital tools with the didactic principles of cultivating the 4Cs competencies within the practice-oriented environment of TVET. *Practical significance.* The *practical significance* resides in providing TVET institutions with a strategic roadmap for the systematic implementation of 21st-century competencies, thereby enhancing their adaptability, resilience, and competitiveness.

Keywords: TVET, 21st-century learning model, 21st-century competencies: critical thinking, creativity, communication, and collaboration in education, digital transformation in education, digital pedagogy

Acknowledgements. The authors would like to thank Lembaga Penelitian dan Pengabdian Masyarakat (Institute for Research and Community Service) Universitas Negeri Padang for funding this work with a contract number: 1792/UN35.15/LT/2024.

For citation: Wulansari R.E., Huda A., Nabawi R.A., Sakti R.H., Jasman, Masek A. Developing a digital transformation framework for 21st-century learning. *Obrazovanie i nauka = The Education and Science Journal*. 2026;28(6). doi:10.17853/1994-5639-2026-4578

Создание концепции цифровой трансформации для обучения в XXI веке

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Аннотация. *Введение*. В научно-педагогическом дискурсе сохраняется дефицит исследований и теоретических моделей, раскрывающих взаимосвязь формирования цифровых компетенций педагогов с реализацией обновленной модели обучения для XXI века, особенно в системе технического профессионального образования (ТПО). *Цель* исследования – разработка и апробация концепции цифровой трансформации обучения, демонстрирующей дидактический потенциал цифровых технологий для модернизации учебного процесса в ТПО. *Методология, методы и методики.* Методология основана на трёхэтапном смешанном проектировании процесса исследования и разработки (диагностика, проектирование, конструктивный этап). В исследовании добровольно участвовали 200 преподавателей ТПО для выявления их установок и профессиональных дефицитов в области цифровой педагогики. *Результаты* выявили устойчивую взаимосвязь между уровнем цифровых компетенций педагогов, характером практики их применения и готовностью к трансформации деятельности. На основе полученных данных разработана концептуальная модель цифровой трансформации процесса обучения для ТПО, направленная на развитие инновационных практик, критического мышления и коллаборативной деятельности обучающихся. *Научная новизна* заключается в разработке целостной теоретико-методологической модели, системно увязывающей цифровые инструменты с дидактическими принципами формирования компетенций 4К в практико-ориентированной среде ТПО. *Практическая значимость* состоит в предоставлении образовательным организациям ТПО стратегической «дорожной карты» для системного внедрения компетенций XXI века, что повышает их адаптивность, устойчивость и конкурентоспособность.

Ключевые слова: техническое профессиональное образование, модель обучения в XXI веке, компетенции XXI века: критическое мышление, креативность, коммуникация и кооперация в образовании, цифровая трансформация образования, цифровая педагогика

Благодарности. Авторы выражают благодарность Институту исследований и общественных услуг Государственного университета Паданга за финансирование данной работы в соответствии с договором № 1792/UN35.15/LT/2024.

Для цитирования: Вулансари Р.Э., Худа А., Набави Р.А., Сакти Р.Х., Джасман, Масек А. Создание концепции цифровой трансформации для обучения в XXI веке. *Образование и наука.* 2026;28(6). doi:10.17853/1994-5639-2026-4578

Introduction

The present generation of youth is being taught in a society filled with various digital electronics, which shapes their life [1]. Another benefit of digital technologies is comprehensive access to knowledge by the technology [2]. Education systems around the world are adapting to the new societal expectations due to the use of digital technology and are ready to meet new learning needs of learners in the 21st century [3]. Education has been affected a lot by advancement in technology and changes in global economies hence, changing the features of education. TVET institutions are confronted with this emerging need to prepare learners for a world characterised by visionary growth in technological knowledge and development. As industries continue to become technology savvy and global, the importance of TVET in producing human resource for the 21st century cannot be overemphasised. Many of the teaching practices used in TVET may have their roots in traditional classroom teaching but may not prepared learners for the current labour market demands in terms of competencies where applicant not only need technical skills but are expected to. Therefore, they need to solve problems creatively, communicate effectively, work in teams etc. For TVET to continue to be effective it must incorporate transformative teaching practices that incorporate use of technology as well as promoting 21st-century skills. This shift beckons for creation of a digital transformation framework; a systematic and integrated model integrating digital with transformative pedagogy for improving the pedagogy and andragogy results. As such a framework would support the modernisation of the ecosystem of TVET education, so it would also facilitate the transition of learners to the demands of the digital economy.

The industrial revolution 4.0 forced learning century change compelled the TVET institutions to change their teaching techniques as they must adopt the distant teaching-learning process. As such, remote teaching must afford students the kind of learning experiences they would compel them to get a full physical education experience [4]. In developing and structuring in-service training for TVET teachers, municipalities and institutions are also allowing for these changes as well [5]. In the context of the present period, general new standards of students' education and development in information and communication technology have influenced the need for TVET teachers to reflect their teaching practices on a regular basis [6]. This study enriches the area by summarising some theoretical considerations and by offering a model to effectively integrate digital technology in the learning continuum. However, the current literature has begun to discuss digital pedagogy, but it seems a bit limited in terms of extensive studies and surveys that enrich and correspond the learning and innovative skills (4Cs), life and careers skills as well as information media and technology skill that are in P21 learning.

Consequently, the solution offered in this research is to design the Digital Transformation Framework for 21st-Century Learning for TVET educators so that the framework would help TVET educators to apply the use of technology in learn-

ing properly. In this research, transformative pedagogy relates to the constructive development of learning environment and process which support the transformative learning. It also allows for challenging of assumptions, consideration of experience from a social perspective, and for the fundamental involvement in social justice. As for the type of a teaching method, it is usually aimed at projects, involving acting and techniques which concern problem-solving [7]. Hence, technologies can provide such kinds of experience. Based on the previous scholars' studies on the use of technology in learning and its importance has been underscored [8]. However, the full potential of technologies in learning remains unrealised in TVET universities due to a lack of knowledge on its utilisation and function.

Digital pedagogy refers to the ability of applying digital technologies into teaching and learning practices, thus enhancing learning and teaching, assessment, and curriculum. Transformative learning can be described by several elements all of which focus on the process and context of learning (pedagogy) that is underlined by reflection, experience, and dialogue. Therefore, digital pedagogy is instructional use of technologies. Several earlier papers, including the paper by N. M. Nielsen [9] also stressed on the efficiency of the technology in the VET, but the methodology of these papers included more of the work on certain technologies in teaching. In the case of technology integration into teaching and learning, technology is employed as an addendum with little revolutionary changes in the teaching-learning process. J. Birdman, A. Wiek and D. J. Lang [10] also stressed the application of technologies in TVET, but its emphasis is on making student develop simple technical abilities in the utilisation of technologies in teaching-learning processes as compared to shifting of courses or sharp change in teaching-learning processes.

Unlike this study does not only view technology as an instrument in methodological change but also as the agent of such change. In this study, technology is identified as the centre of the pedagogical transformation framework where the education revolves around the processes of acquiring the competencies of the 21st century including critical thinking, creativity, communication and collaborative learning skills within a technological leaning environment. G. Caniglia, B. John, L. Bellina et al. [11] highlighted the need for the development in TVET to fit the skills demanded in the 21st-century workplace, with an emphasis on the skills required in the 21st century. While this study deals with the need to exercise some important skills including critical thinking, problem solving and collaboration, its approach to teaching and learning at the current stage lacked sufficient incorporation of ICTs as tools that can support the development of these skills. W. Leal Filho, E. Pallant, A. Enete et al. [12] also believe that education should include competencies allowing working in the 21st century; however, the authors' discussion is somewhat more geared towards educational policy and is less related to technological learning approaches in class.

Our paper builds a more elaborate theoretical framework, pay attention to the practical use of technology integrated into TVET class. Technology is not only viewed in a utilitarian way as a means of executing project objectives and supporting PBG,

virtual collaboration and technology-based evaluation, but also as a chief means of delivering engaging and interactive learning. T. Lovat [13] states that e-learning cannot occur without corresponding changes in, and approaches to, teaching and learning practices. Various processes indicated by constructivism as learning systems in which students are active constructors of knowledge have also started being adopted in several TVET studies, but with a still very limited application of digital models. Our study builds on this idea by considering the various technologies as enablers that motivate students towards independent as well as collaborative learning. With the help of computers and other digital resources, like simulators, PBL, or collaborative tools, the constructivist paradigm fits within the fully digital paradigm.

One of the main novelties of this research is in offering applications, directions, and perspectives applicable to learners, teachers, and curriculum developers in their efforts to implement transformative learning in digital teaching environments. Besides, this framework might foster learning processes and contexts which enable and support educative transformations. This study seeks to establish effective ways of adopting ICTs into TVET instructor training as well as learner interaction for the purpose of redesigning instructional approaches for increased effectiveness. The proposed research aims at understanding the status of DT in TVET, explore the educators' engagement in integrating effective innovations into the TVET system and looks at the creation of a blueprint that would capture and responds to the Learning needs of the students as well as delivering knowledge that complies with industry requirements. On this note, this research will endeavour to add knowledge and practice on the improvement of TVET pedagogies in preparation for and as a response to the needs of the 21st century.

Literature Review

The application of Information Communication Technology (ICT) in education has been under increasing emphasis especially in Technical and Vocational Education and Training (TVET) in the recent past. L. Probst, L. Bardach, D. Kamusingize et al. [14] has indicated that although TVET has conventionally focused on the practical aspects of technical training, the emergence of the new generations of industry requires technological integration. G. Caniglia, B. John, L. Bellina et al. [11] consider ICT education successful when students are trained to acquire both functional skills and post-millennium skills, which include problem-solving, creative thinking, interpersonal and communication skills, and teamwork. These skills are immensely valuable in todays' world that is so globalised as well as digitised. Studies by T. Lovat [13] have provided further insights on the use in using ICT in learning entities and on the transforming outcomes of applying digital pedagogy into educational paradigms. However, while earlier literature has attempted to discuss the integration of technology in learning and impact on the learning achievement, often such a discussion has been more tool or application specific rather than a broader transformation of the whole learning methodology. W. Leal Filho, E. Pallant, A. Enete et al. [12] argue that this requires presenting technology not only in a scientific form but

changing the paradigm of how teaching and learning occurs and how it can incorporate active learning, problem-solving activities and student-centred approaches.

Secondly, L. Probst, L. Bardach, D. Kamusingize et al. [14] argue that constructivist learning theory supports the idea that students acquire knowledge actively. This theory becomes more important as we see students who can access technology in a learning environment, they are able to work as well as explore in the task as well as be able to solve problems on their personal. However, there is still limited research conducted on the construction of a digital transformation framework particularly for the enhancement of TVET with the incorporation of 21st-century skills in the learning model. This research therefore seeks to provide that missing link by developing a framework that conforms to the technical and technical-tool-hybrid requirements of today's industries, but at the same time educates students for the dynamic and challenged global workplace.

Furthermore, previous research in TVET usually defines the mismatch between the industry demand and the existing approaches to learning and teaching. A. Aslan [15] points out that since the main goal of the TVET institution is to develop skills pertinent to the industry it serves, the non-utilisation of the technological aspects in training impairs learners to understand changes in environments within industries. This is best demonstrated in industries where the digitisation of work processes has disrupted conventional career paths and tasks requiring generalists as creative problem solving underpins them. This perspective is shared with the study of A. A. P. Cattaneo, C. Antonietti, and M. Rauseo [16], arguing that teachers need to adapt to new paradigms of education, by integrating students into the digital environment where such competencies are necessary for performing the work. Besides, feelings in terms of technical competencies as well low and high-hard technical competencies are blending with more acknowledgement of developing the acquisition of the soft competencies incline to the communication competencies such as collaborations, conversations, and some problem-solving ones mediated through the online learning. D. Divayana, P. Suyasa, and N. Widiartini [17] explain that such skills become more core to present-day learning paradigms and that new media environments and technology enhanced communication tools are valuable for developing them. However, awareness and application of these technologies remain low in most of the TVET institutions, as most of them still use traditional instruction paradigms, which are characterised by technical content delivery.

Most of the papers reviewed also supported the need to incorporate professional development for the TVET educators. In their study, H. Dongpin, Y. Bei, L. Jiutong et al. [18] note that there is a necessity to provide the teachers permanent professional development to prepare them as innovators in the understanding and practical application of ICT. First, this elevation could lead to a lack of support and resources to foster technological changes or a transition towards more student learning centred pedagogy. Therefore, although there is an upwards trend in research work on the role of digital technology in TVET, few of these research activities have outlined how such transformations can be effectively done or offer a guideline on how such

transformations could be achieved in TVET practices. This study seeks to fill that gap by constructing a digital transformation framework for TVET to capture how educators can apply appropriate digital technology to promote essential skills in the 21st century and map the learning outcomes to suit industry needs. In doing so, this research will extend the existing work to provide a more practical and integrated model for enhancing TVET pedagogies in the context of new technologies.

Materials and Methods

Research Types and Procedures

This study is a quantitative design and will use three phase mixed design of survey, design, and development [19]. Self-administered survey instruments can offer numeric results from a large pool of respondents, which gives a definite 'what' to a posed question. This design starts by using quantitative survey data to understand a field or a particular audience and then uses this structure as a reference in building the module as the final outputs are formed. This study begins with several activities: acquiring background information relevant to the study, literature review, research proposal development, data collection through archives, and development of research instruments. The second phase will consist of the process of developing the Digital Transformation Pedagogy Framework for P21 Learning for the TVET Educators. This stage will also look at the impact of digital transformative pedagogy on 21st-century learning skills among the TVET educators. Data for the survey shall be obtained through a quantitative method of data collection.

Population and Sample

The quantitative strategy for field work have begun with mailing questionnaires to 200 TVET educators for determining the digital transformative pedagogy. In terms of sample, selection, we used the stratified random sampling technique for the selection of participants. Due to the extensive existing literature in this field, a meta-analysis will be conducted to synthesise studies on the implementation of digital transformative pedagogy and 21st-century skills among TVET educators. The purpose of our study is to develop a framework for the construction of a teaching module on 21st-century skills and the 4Cs. The Meyer Model will act as a conceptual framework for the creation of the modules. The third phase will entail the production of the final research report as well as write-up of papers that constitute the research.

Research Instruments

The development of the instrument was influenced by the research conducted by S. Taimur and M. Onuki [20] for digital transformative pedagogy instrument as well as the P21 Partnership for 4Cs skills instrument and the instrument indicators can be seen at Table 1. The survey utilised a Likert Scale that encompassed response options ranging from Strongly Agree (5) to Strongly Disagree (1). Since the purpose of using the instrument is to measure the intended construct and to achieve comparable results when the research is replicated, the reliability of the instrument through validation needs to be ascertained through the pilot study. Also, it was im-

portant to identify the goals of the study to find the right instrument and to choose the right group of participants.

Table 1

Instrument indicators

Variables and indicators			Total
Skills in 21st-century learning	Learning and innovation skills	4Cs skills (critical, creative, communication and collaboration)	6
	Life and career skills	The ability to navigate the complex life and work environments in the global competition	5
	Information media and technology skills	Technology and media-driven environment,	5
Digital transformative pedagogy	Transformative orientation	Constructivist approach helps to integrate digital technologies into teaching	5
	Pedagogical practices	Student engagement	5
	Digital pedagogical competencies	Knowledge, skills, attitudes, and approaches in relation to digital technology	5

Pilot Study

Since the indicators allowing for evaluating the impact of the proposed digital transformation framework in enhancing the pedagogy of TVET were developed as instruments, a pilot study was conducted. During the pilot study a survey instrument was used to assess the current practices of teachers, the extent to which they integrate technology in their classroom, and their perceptions towards the adoption of the digital transformation framework. Moreover, a group of participants was interviewed using a semi-structured format to obtain more detailed information about each participant and the challenges they face regarding ICT integration into practice. The results of validity and reliability of instruments can be seen in Table 2.

Table 2

Validity and reliability of instruments

Indicators	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
Learning and innovation skills	0.862	0.822	0.624
Life and career skills	0.821	0.961	0.681
Information media and technology skills	0.723	0.912	0.691
Transformative orientation	0.622	0.921	0.752
Pedagogical practices	0.666	0.911	0.723
Digital pedagogical competencies	0.734	0.813	0.589

The results from the pilot study availed the insights that were used to improve the reliability and validity of the instrument used. This involved reforms in some of the questions, supplementing some questions with examples related to the digital context of TVET, and making sure that question content fitted with elements of the digital transformation framework. Apart from aiding in the calibration of the

instruments, the pilot study introduced fundamentals for the large-scale research to validate the educator's preparedness and viewpoints regarding the implementation of innovative practices in education in the setting of digital transformation. These changed instruments will be used in the larger study to collect more detailed information on the effect of the framework to teaching and learning outcomes in TVET contexts.

Data Analysis Technique

In the study, a quantitative data analysis technique will be employed to comprehensively evaluate the effectiveness of the proposed digital transformation framework. The quantitative data collected through survey instruments were analysed using SPSS and SmartPLS software. Inferential statistical tests, such as structural equation modelling (SEM), were selected for data analysis based on the hypotheses, as shown in Table 3.

Table 3

Research hypothesis

No.	Hypothesis (H0)
H01	There is no positive relationship among digital pedagogical competencies towards pedagogical practices, transformative orientation and life and career skills
H02	There is no positive relationship among pedagogical practices competencies towards life and career skills, information media and technology skills and learning and innovation skills
H03	There is no positive relationship among transformative orientation towards life and career skills, information media and technology skills and pedagogical practices
H04	There is no positive relationship among digital pedagogical competencies towards pedagogical practices, transformative orientation, life and career skills, information media and technology skills and learning and innovation skills

Moreover, to investigate the relationship between educators' perceived preparedness to implement the digital transformation framework and the actual use of technology in instruction, correlation analyses will be conducted. Quantitative analysis will give an overall view of the current state of the pedagogy in the TVET system, perceived efficacy of the technology and expected changes by the implementation of the proposed framework. Therefore, through the triangulation of data, this study will provide clear conclusions on the possibility of the readiness of TVET educators towards digital transformation and make sound recommendations on how their practices can be enhanced towards the implementation of 21st-century learning environment. This mixed method approach will not only enhance the validity of the results but will also offer detailed contextual information useful to shape future educational practices and policies in TVET.

Results and Discussion

Digital Transformation Framework

This study develops a Digital Transformation Framework (Figure 1) that serves as a roadmap to assist educators in Technical and Vocational Education and Training (TVET) with integrating digital technology into their practice. The above framework

is based on faculty development which features use of technology in learning and digital pedagogical competencies features life and career, information, media, and technology skills and learning innovations skills. With this framework, this study seeks to assist the TVET educators to come up with approach that basically includes the technology in TVET education hence enable transformation in converting the student's generation to be fit to face the world challenges.

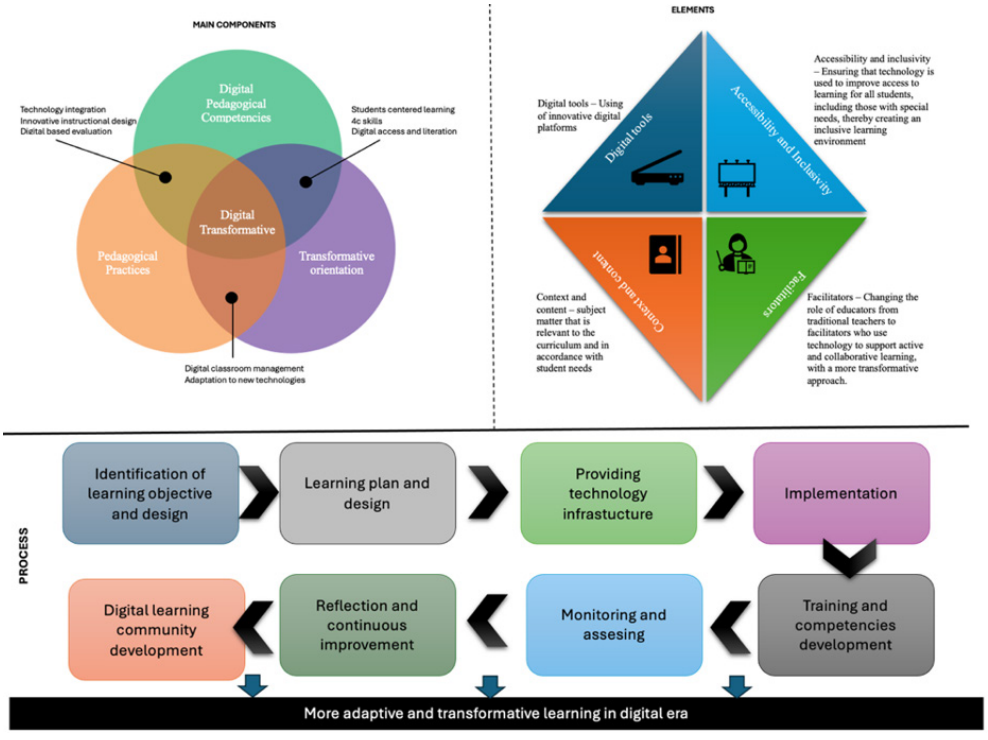

Fig. 1. Digital transformation framework

The framework begins with three key components: digital pedagogical competency, transformational orientation, and effective pedagogical practices. Teachers are expected to not only use computers and the internet effectively but also to be able to assess the instructional material and the teaching learning process, their specific teaching personality and medium, to fulfil modern classroom requirements. Indeed, with high levels of digital pedagogical content knowledge, educators can use technology for enacting meaningful learning experiences that foster collaboration and creativity as well as increase students' engagement. This framework has also accentuated the transitional development of teachers' transformative perspective that enables them to make the right transformation in the face of advanced technologies and progressive approaches to teaching. The teachers who have promotional attitude towards using ICT are more prepared to apply technology consciously,

change their practice, and design environment that will foster learners' higher order thinking skills and flexibility in solving sophisticated tasks in the rapidly changing conditions. In addition, the mentioned Digital Transformation Framework is aimed at deploying the use of practices that will enhance the students cuing level. It requires teachers to integrate technology in their instruction by using project-based learning, simulations, and digital collaborations incidental to students' participation to allow them to acquire life and career competencies and information media and technology skills.

Using technology in learning especially in technical and vocational education and training or TVET is an important element for preparing for the future generation of students. The creation of the Digital Transformation Framework is intended not only to enhance approaches to teaching but also students' learning and skills that should match the demands of a digital world economy. This literature review examines the key components underpinning the framework: Digital competencies for teachers, 'post digital' perspectives of learning, and 21st-century literacies, such as lifelong learning and work, media and information, and learning and knowing. M. J. Koehler, P. Mishra, and W. Cain [21] concluded that digital literacy is crucial for teachers so that they can use technologies in teaching process. The Technological Pedagogical Content Knowledge or TPACK model underscore the interconnected nature of content, pedagogy and technology. Effective as well as efficient TVET educators are expected not only to comprehensively know their areas of specialisation but also to be able to embrace Information Communication Technology to support instructional processes effectively. S. A. Meyers [8] also stated that digital literacy is basic for teachers for two reasons: it enables them to assist learners in making sense of digital worlds. Lack of these competencies might then lead to teachers' inability to effectively facilitate learner interactions as well as enable meaningful learning in a digital environment.

Transformative orientation then relates to the extent to which educators are ready and capable of changing considering technology and need for education change. In transformative learning, people experience new ways of perceiving, thinking, feeling or knowing, which should be embraced to advance technology integration in education. J. Mezirow [7] stated that, in TVET, a transformative orientation is significant because it is useful for modifying teaching to align with changes in industry and technology. Y. Luo and H. Du [22] explained that when teachers are embracing a transformative perspective, they are more likely to try out new forms of pedagogy for example problem-based learning and flipping of classes which are more effective in deep learning. School Practices, Teacher Professionalism, and Application of Information Technology. The literature repeatedly underscores the opinion that the integration of technology into learning practices improves learning. D. G. H. Divayana, P. W. A. Suyasa, and N. K. Widiartini [17] noted that technology enhances the excuse practices through collaborative, student oriented, and inquiry learning practices. For simulants, virtual labs, portfolio, they foster learners' practical experiences in related learning environments for preparing them for work-

place situations. The need for integration of that technology to be pedagogically appropriate, that is, it should not only be applied to delivering content, but also to promoting thinking, creativeness and problem solving.

Life and Career Skills. There is growing importance of 21st-century competencies particularly the life and career competencies in TVET. In the opinion of C. Antonietti, A. Cattaneo, and F. Amenduni [1], students who are trained in these areas are well equipped to competently engage global markets and ecosystems. Hence, through accommodating technology into learning delivery system, the teachers can offer the students a chance to exercise these important skills, for instance, from shared inter- online assignments or exercises that model real life problems. These experiences assist students to become more flexible to handle all the dynamic career fields. The use of information media and technology literacy skills is integrated within the learning models of the 21st century. They describe these skills as critical consumption of information, media literacy, and Digital citizenship. These are skills that must be acquired by students in TVET as they join markets that require them to be computer literate. In the work of C. Antonietti, A. Cattaneo, and F. Amenduni [1], it is stated that integration of technology for learning prepares the learner for production of content in addition to consuming it in future, specific areas of production include manufacturing information technology, and design. Hard Skills include Data Literacy Skills, Learning and Innovation Skills. T. Lovat [13] concluded that apart from digital readiness, famed P21 Skills map, provides focus on learning and innovation skills which include Creative, analytical thinking, communication, and cooperative or collaborative skills. Innovation is one of the major factors of growth, in this case, institutional TVET educates students in the competency. Through adoption of digital technologies in classroom practices, teaching and learning processes can be enriched in collaborative and creativity for instance, through group platform where students can work jointly or on inter-disciplinary projects. In his work, T. F. Remington [6] promoted student creativity by encouraging students to explore and pursue new methods for accomplishing set tasks, as detailed in his subsequent paper.

Challenges in Digital Integration. While the literature reveals the advantages by integrating the computer in teaching learning practices the following are the challenges: some of the obstacles include lack of infrastructures, or professional developments, and most importantly; resistance to change proposed. In this case, these challenges must be met if we are to effectively implement the need for a Digital Transformation Framework; educators need sufficient training and resources. M. J. Koehler, P. Mishra, and W. Cain [21] identified that using technology in classrooms requires both technology skills and knowledge and education knowledge, skills and dispositions, thus professional development programmes should address both areas. Sustainability and Long-term Impact are the next category for EME certifications. The research conducted by M. J. Koehler, P. Mishra, and W. Cain [21] highlights the necessity for ongoing evaluation and maintenance of methodologies to ensure that the transformation enhances educational practice in the long term. C. J. Bonk and D.

J. Cunningham [23] explained that due to emphasis on learning, technology integration into K-12 classrooms should be continuously assessed from the perspective of learning outcomes of learners. Furthermore, there is a need to embrace the dynamic and contextual nature of the digital pedagogical frameworks because of constantly emerging technologies and shifting learning objectives. This adaptability is very essential with a view to maintaining the relevance of the Digital Transformation Framework as a tool for preparing learners for future work environments.

Further, the Digital Transformation Framework is also aimed at making TVET teachers aware of supporting students in learning and innovation skills as well as creativity, and collaboration and critical thinking skills. Use of technology in classroom makes it easier for the teacher to create situations that lead to working in teams to address certain issues, creating projects and designing creative solutions using technology. The problem and project-based method of strategy is very appropriate for preparing students for the dynamic context of the industry. The framework also incorporates factors of constraint that could help explain why teachers might be slow to adopt technology – lack of access to technology, little training, or resistance to change. Thus, in this context, one of the key aspects forms the basis of the framework is the necessity to facilitate continuing professional development for the educators. Professional development IS needed so that the teachers are ready for the roles and responsibilities that are part of the teaching they do in the classroom every day. By so doing the gap in technology adoption will be closed and digital transformation will be implemented efficiently.

Additionally, the framework also includes a need for its application in assessment and evaluation of technology integration in learning. Teachers are expected to undertake an assessment that involves assessing student's ICT skills and creativity. This assessment is not limited to students' academic performance but considers possible advancements in student 21st-century skills, including collaboration, critical thinking, and creative problem solving. In totality, the Digital Transformation Framework is both an instructional reference for implementing instruction and use of technology in teaching, as well as an umbrella strategy for transforming teaching practice in the TVET sector to adequately prepare students. Hence, through integrating innovative and transformational and technological enhanced learning and teaching strategies, into workers development the aims at training generation of workers, who are not only technically competent but also proactive to managed change in the dynamic global world of work. The adaptation of this framework should yield better, more relevant, effective and prepared TVET education for future challenges. Figure 2 clearly illustrates how design thinking is integrated within the Digital Transformation Framework.

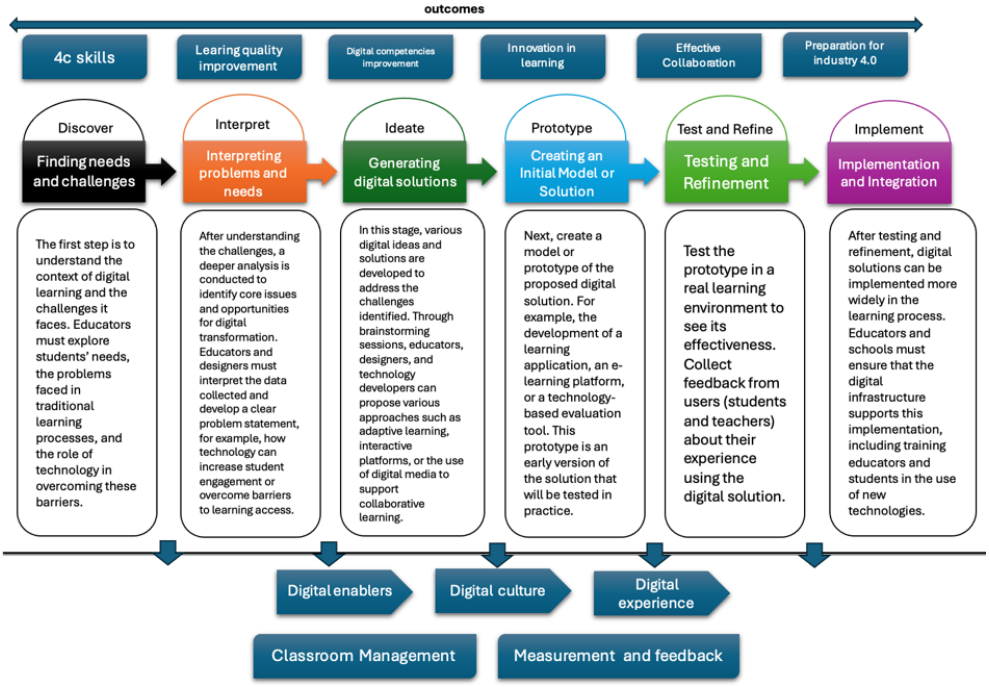

Fig. 2. Design thinking in the Digital Transformation Framework

Note. Derived and adapted from S. Taimur and M. Onuki [20]

Technology enhanced learning can be enhanced through observations that have efficiency, collaborative, project based, and student-centred orientations. This paper, therefore, affirms a growing body of evidence that in the appropriateness of digital technology to a particular pedagogy, the skills that are required in the 21st century, e.g. skilled thinking, creativity and teaming are suitable for the TVET system. Through TPACK also argue the centrality of a balance of technological, pedagogical, and content knowledge, thereby adding credence to the proposal that enhanced teacher information mastery of technology can help enhance these processes. M. J. Koehler, P. Mishra, and W. Cain [21] also studied caters to the hypothesis that when teachers possess high levels of Digital Competency, then they are in better position to better integrate technology for enhancing the technique of creating more learner centred environments. On the other hand, there are several works that do not present a complete affirmative correlation with digital transformation in education. For example, enthusiasm for technology in education is based on naïve assumptions because the integration of technology in classrooms is not backed with revolutionary improvement of instructional practices and learning environments and technologies are incorporated to support conventional approaches to teaching and learning. The presence of technologies many teachers still do not teaching in an innovative way literally, and impact of technologies on students' meaningful

learning achievement remains insignificant. Research by K. Hew and T. Brush [3] revealed that the major issues arising from implementing digital transformation in the classroom include external factors they include minimal infrastructure, lack of professional development and students that resist change.

The process of the adoption of digital technologies is slower than policies and infrastructures suggest due to disparities between policy and practice. In revealing this, D. Nafpaktitis, D. Triantis, P. Tsiakas et al. [24] argued that as much as education technology and learning systems have been adopted deeply in many countries and institutions, considerable learning gains are yet to be witnessed. D. Nafpaktitis, D. Triantis, P. Tsiakas et al. [24] confirmed that preparedness of the technology-enhanced education environment in schools, including teachers, students and curricula is more important than a supply of the technologies. Moreover, technology is capable to increase the efficacy of education. D. Nafpaktitis, D. Triantis, P. Tsiakas et al. [24] stated that although technology enables access to information, it does not necessarily foster proper critical and collaborative thinking, which are essential for 21st-century learning. Regarding this, there is a growing emphasis on the extent and quality of pedagogical leadership and the teacher as enabler function.

On the other hand, the integration of technology by arguing that education must be keen to keep up with emergence of more advanced digital technology in the industrial world. L. Probst, L. Bardach, D. Kamusingize et al. [14] emphasised that technology is not merely an object; it is an enabler and catalyst for change in pedagogical approaches. They argued that digital transformation can foster innovation in the delivery of learning content, providing personalised and location-specific delivery tailored to the nature of Technical and Vocational Education and Training (TVET), as it involves the provision of technical and vocationally based learning. Therefore, while extensive research done established great potential for the implementation of the digital transformation framework in education, especially in the field of TVET, there are obstacles that must be addressed before the framework can be implemented. Far from avoiding the issues raised by the critics of vocational education, our study aims also to capture the wonderful opportunities that digital technology could bring to the vocationally oriented education. Our work is somewhere in between, as it acknowledges the implementation difficulties while at the same time, creating a more comprehensive framework helpful in the proper incorporation of technology into teacher training in the pedagogy of TVET such that the teachers are competent in digital skills and can adjust their strategies to the modern world of work. Therefore, our research proposes to fill this gap by developing a broader framework for IDM which involves not only the technology aspect of integration but the shift in paradigm that is required for the delivery of 21st-century skills.

Assumption Tests

Normality Test

The normality test is one of the prerequisites in data analysis to check the distribution of data used in this study to fit the general assumption of the parametric analysis. The normality test is to analyse the approximate normality of the respon-

dent's data which is obtained through questionnaires regarding digital pedagogical competence, the transformation orientation, life and career skills, and the information technology skills. The Shapiro-Wilk test was used in this study because this test is appropriate for small sample size equal to less than 2000.

Table 4

Normality test results

Variables	p-value
Skills in 21st-century learning (SCL)	0.083
Digital transformative pedagogy (DTP)	0.150

In the Shapiro-Wilk test, if the p-value is greater than 0.05, the data distribution is considered normal. Following the analysis of the data above (Table 4), all the variables have p-values greater than 0.05 and the data points spread out following and approaching the diagonal line (Figure 3). Thus, it could be confirmed that the study variables are normally distributed which is in line with the normality assumption for the study.

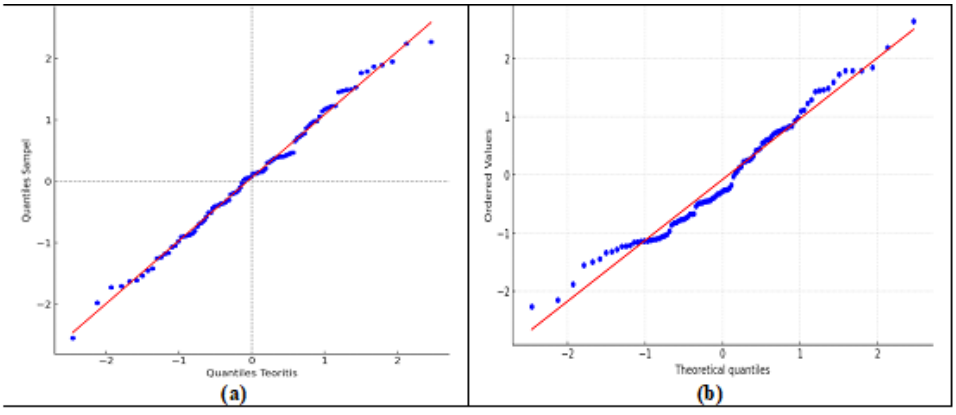

Fig. 3. QQ Plots Normality Test of Skills in 21st-century learning (a) and digital transformative pedagogy (b)

Multicollinearity

Multicollinearity, autocorrelation and heteroscedasticity are important in regression to test that the model used in regression fulfils the requisite assumptions of simple linear regression. By performing these three tests (Table 5), the accuracy, reliability, and appropriateness of the resulting model of the data are improved. The multicollinearity test has the intention of check whether there is high degree of linear relationship between the independent variables in the model and the autocorrelation test has the intention of check whether there is correlation between

the residuals or prediction errors in the regression model. Where residuals are correlated, it means that the result of the previous observations influences the current observation. While, the objective of the heteroscedasticity, is to determine the variability of the residuals of the regression model. Heteroscedasticity takes place when the variance in the prediction error is conditional on the values of the predictor variables.

Table 5

Multicollinearity, autocorrelation, heteroscedasticity test

Variables	Multicollinearity		Autocorrelation	Heteroscedasticity		Results
	Tolerance	VIF	DW	t	Sig.	
SCL	0.365	4.234				No multicollinearity
DTP	0.371	5.243				
SCL			2,032			No autocorrelation
DTP						
SCL				0.134	0.467	No heteroscedasticity
DTP				0.233	0.825	

By using the results obtained from the Table 5, we found out that the multicollinearity, autocorrelation, heteroscedasticity were not present in the data collected for this study. This is because in multicollinearity, two independent variables in the regression do not have high linear relationship and the value of VIF < 10. It can also see that in the autocorrelation data there are no problems associated with autocorrelation where each of the residual in the regression model is correlated. To test for it, the Durbin-Watson test is used. The Durbin-Watson test value is close to 2 and therefore this means that there is no autocorrelation. Like the heteroscedasticity data, the bandwidth also appears constant throughout the model prediction values. This employs the Gleiser test which enable for the identification of heteroscedasticity.

Structural Models and Hypotheses Testing

Assessment of the structural model in SEM using PLS is conducted by evaluating the R-squared (R^2) values and the significance of the path coefficients through estimation, as presented in Table 6.

Table 6

R-square (R^2) results

Variables	R-Square
Skills in 21st-century learning (SCL)	0.583
Digital transformative pedagogy (DTP)	0.632

In the R-Square results provided in the Table 6, it will be noted that the R-Square figures obtained for the study are 0.583 for the skills in 21st-century learning variable and 0.632 for the digital transformative pedagogy variable. It suggests that the

skill factor features an impact of 60% on the Digital transformative pedagogy variable in addition to an impact of 40% with a mediator. Therefore, the following factors are suggested to be affecting the two facets directly and indirectly via the mediating variable: The direct effect estimate of 60% means that the entire skill factor without any regard to the influence of the mediating variable can account for 50% of the variation in Digital transformative pedagogy. Despite the value obtained being relatively low (0.583) compared to the previous variables, it is still a good measure of the contribution of skills to digital transformative pedagogy efficiency. This means that digital transformative pedagogy variable greatly depends on the transformative orientation, pedagogical practices and digital pedagogical competencies factors, as the R-Square value equals to 0,632 and it explains more than half of the existing variations. This suggests that to enhance the impact of digital transformation in teaching learning, emphasis should be given on enhancing the transformative orientation, meaningful effective practices and-band digital competencies. This means that through the mediating variable, the influence is 40%, which suggests that other variables such as interventions or any other intermediate acts as key in determining the outcome of digital transformative pedagogy.

Table 7

Hypotheses testing

Hypothesis	β	T statistics	P Values	Results
H01. Digital Pedagogical Competencies → Pedagogical Practices x Transformative Orientation x life and career skills	0.733	12,746	0.000	Accepted
H02. Pedagogical Practices Competencies → life and career skills x information media and technology skills x learning and innovation skills	0.417	8,432	0.000	Accepted
H03. Transformative Orientation → life and career skills x information media and technology skills x Pedagogical Practices	0.639	17,536	0.000	Accepted
H04. Digital Pedagogical Competencies → pedagogical practices x transformative orientation x life and career skills x information media and technology skills and learning and innovation skills	0.735	10,345	0.000	Accepted

Hypothesis H01 states that digital pedagogical competence has a significant positive influence on pedagogical practices moderated by Transformational Orientation and Life and Career Skills. The results of the analysis indicate that this relationship is 0.733 (Table 7), which means that enhancing digital pedagogical competence can enhance pedagogical practices to the degree of 73.3% considering the impact of transformational orientation and life and career skills. It confirms that the existence of the relationship is quite significant based on a t-statistic equal to 12.746; it is higher than t-critically equal to 1.96 and further supported by the p-values calculated as 0.000. This p-value is very small and therefore it should conclude that the findings support the rejection of the null hypothesis hence digital pedagog-

ical competence has a positive impact on the pedagogical practices taken. Hence our research supports the hypothesis under test. These findings support the role of IT competence of teaching practices for embracing transformational type of education and learning of life and career competencies making the use of interactive technologies in teaching enhance more meaningful and appropriate teaching learning practices appropriate for the 21st century.

In concurrence with TPACK model, it is underscored that direct personal technology education by the teachers is one of the important components in the context of learning strategies. This aligns well with the research of M. J. Koehler, P. Mishra, and W. Cain [21], as well as P. Pucer, I. Trobec, and B. Žvanut [25], which has found that teachers who can integrate ICT improve the teaching and learning environment in the classroom, thereby enhancing teaching methods suitable for the 21st century. Furthermore, teacher digital competence involves the support of pedagogical innovation. M. J. Koehler, P. Mishra, and W. Cain [21] found that teachers with a high level of digital skills are better equipped to address changes in pedagogy, which may include transformational approaches focusing on the development of skills such as life and career skills among students. P. Pucer, I. Trobec, and B. Žvanut [25] emphasised that digital pedagogical competence not only promotes more relevant and effective forms of instruction but also contributes to the acquisition of skills that are beneficial for students. M. J. Koehler, P. Mishra, and W. Cain [21], as well as P. Pucer, I. Trobec, and B. Žvanut [25], supported the results of the H01 hypothesis. This concerns not only the enhancement of the diffusion of a more pro-transformative pedagogical orientation, which emphasises competencies for improving teaching practices at school, but also the necessary skills required by learners in the context of the modern world of work and life. Hypothesis H02 states that Pedagogical Practice Competence has a significant positive effect on Life and Career Skills, which is moderated by Information, Media, and Technology Skills, and Learning and Innovation Skills. Thus, the analysis results revealed that the coefficient of this relationship is 0.417, which means that enhancing the competence of continued pedagogical practice in the conditions of learning the use of technologies, information, media, and innovations allows to enhance life and career competencies by 41.7%. Also, it has been found that the t-statistic value of 8.432 shows that this relationship is statistically significant, and it is much higher than the t-critical. a relationship between the two variables and the p value of 0.000 shows that the relationship is extremely significant and strong, so a null hypothesis is rejected, and the hypothesis is accepted. Consequently, such findings suggest that competence relative to pedagogical practice is critical in building 21st-century skills particularly career-oriented skills in the lives of students. Besides, the information, media and technology, and innovation and learning aspects are also part of the pedagogical competence in forming important aspects of skills needed by students in the dynamic modern workplace.

According to D. A. Sprenger and A. N. Schwaninger [26], more specific and effective pedagogical practices have a significant impact on the learning and innovation skills that students need to meet the demands of both working and personal life,

such as critical thinking, creativity, and collaboration. Embedding information technology and media into teaching strategies assist students in not only finding and using information efficiently, but also in learning how to adapt to change or to be innovative in the context of technology. Sufficient pedagogical competence means the efficiency of the teacher's interaction with the students in terms of mastering technologies, media, and information and increasing the skills necessary for successful career activities. However, teacher training path associate with high pedagogical capability may enable one to construct the learning environment that foster the development of life and career skills by using innovation knowledge that reflects technological advancement. D. A. Sprenger and A. N. Schwaninger [26], along with N. Lee [27], provided studies that corroborate evidence showing that pedagogical competence is not only a significant factor affecting learning outcomes but is also clearly linked to students' capacity to meet the challenges of the new world of work, which is increasingly characterised by technological and digital environments.

Hypothesis H03 states that Transformation Orientation has a significant positive effect on Life and Career Skills, which is moderated by Information, Media, and Technology Skills and Pedagogical Practices. In terms of technology, information, media skills, and proliferative pedagogy, it is revealed that the coefficient figure for this relationship is 0.639: meaning that by enhancing transformation orientation, life/career skills can be upgraded by 63.9%. Analysing the results, the t = 17.536 of the total models signifies that results are highly statistically significant; in fact, it well surpasses the t critical and the p = 0.000 indicates a very strong and reliable result. While the null hypothesis is rejected, the plausible assumption is drawn and accepted or concluded. Widespread transformation orientation as a grounded learning approach proving that teaching career and life skills is effective is very high. This orientation is very useful in applying information, media and technologies skills in learning and helps to reinforce links between practice and learners. With a change management perspective, the educators can prepare the learners for the opportunities of the new world of work that is characterised by increased use of technology.

Credible backup evidence for these findings can be sourced from other research highlighting the need for embracing transformational educational orientation geared towards utmost development of new skills for living and working, information, media and technology skills and sound instructional practices. J. Mezirow [7] noted that in Transformative Learning theory, transformative learning can achieve the kind of fundamental shift in students' perspective to prepare them for the volatility of the real world. This is even more related to the way how life and career competencies can be built, giving regards to the learning-activity approach that implies not just the acquisition of knowledge but also the reflection on one's practice. N. M. Nielsen explained that [9] 21st-century education also supports the systematic integration of a transformational orientation in learning ICM and Technology Skills and Career and Technical Skills Education likewise. This approach is useful in a way that not only the students become users of technology but also becomes the learners who are able to transform and use the technology to solve certain chal-

lenges which may be encounter in the real society. The skills can be developed by the application of technology under transformative pedagogical practices within collaborative and student-centred learning. Moreover, newly identified pedagogies for deep learning demonstrate that when a transformational stance is taken, they can better support key life and career outcomes in preparation for a digital world. Transformative learning environments in pedagogy implies making learners ready to face the world challenges through designing creativity and collaboration together with critical thinking levels.

Hypothesis H04 states that Digital Pedagogical Competence has a significant positive effect on Pedagogical Practice, which is moderated by Transformational Orientation, Life and Career Skills, Information, Media, and Technology Skills, and Learning and Innovation Skills. The outcomes of the analysis reveal that the proposed connection possesses the coefficient of 0.735, which suggests that, considering diverse skills and transformational orientations impacting pedagogical practice, it is possible to enhance digital pedagogical competence by 73.5%. The calculated t-statistic stands at 10.345 which is higher that t-critical – it means that this relationship is statistically significant the value of p is 0.000, which means that this result is very significant. The null hypothesis is thus rejected while the research accepts the constructed alternative hypothesis. The results presented above show that digital pedagogical competence directly influences the development of teaching practices when balanced with transformational orientations that foster reflectiveness and creativity. Besides, other areas of learning including life and career, technology and media, and learning and innovation also help to bolster this connection. This indicates that the quality of transformative learning, students' preparation for the ever-evolving nature of work and the creation of innovative learning centred on 21st-century skills can all be enhanced by educators' content mastery of digital technologies.

Support for these findings can be seen from M. J. Koehler, P. Mishra, and W. Cain [21] emphasised the importance of digital pedagogical competence in strengthening pedagogical practices that focus on 21st-century skills. Technological Pedagogical Content Knowledge (TPACK) revealed that the integration of digital technology in education not only improves teaching effectiveness but also enriches students' learning experiences, especially when combined with a transformational orientation that encourages innovative and critical learning. This reinforces the idea that teachers' digital competence is essential in creating teaching practices that are relevant to the needs of the modern world. In addition, D. G. H. Divayana, P. W. A. Suyasa, and N. K. Widiartini [17] also stated that digital pedagogical competence plays an important role in developing information, media, and technology skills as well as learning and innovation skills among students. Teachers who can utilise technology effectively tend to be better able to encourage creativity, collaboration, and problem solving, which are core to 21st-century skills. J. Birdman, A. Wiek, and D. J. Lang [10] noted that educators' mastery of technology also helps students prepare themselves for an increasingly digital-based world of work. A transformational orientation sup-

ported by technology can enrich pedagogical practices by encouraging the development of life and career skills, which are increasingly important in a changing global world. The use of technology in learning facilitates innovation and adaptive skills that are essential for students to face future career challenges.

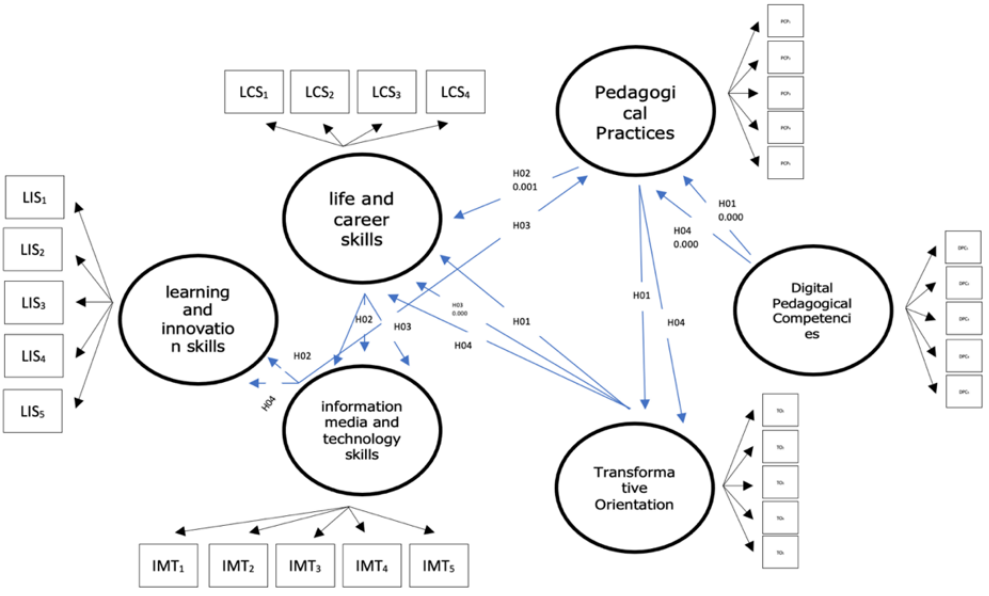

Fig. 4. Causal relationship model

Figure 4 presents a conceptual and structural framework that operates under Structural Equation Modelling (SEM) and that depicts the cause-and-effect relationships among the major constructs in the development of learning competencies in the 21st century. This model incorporates the core competency variables of Learning and Innovation Skills, Life and Career Skills and Information, Media, and Technology Skills interacting. The third construct is connected to the advanced pedagogical variables, that is, Pedagogical Practices, Digital Pedagogical Competence, and Transformative Orientation, which are the mediators and end outcome strategies. All the latent constructs are assessed using multiple observed indicators (e.g. LIS, LCS, BMI, PC, DPC and TO). The arrows show the direction of the assumed causal relationships (H01–H04) with the degree of their significance, which prove the integrative nature of the digital competence and the pedagogical practices in determining the transformative orientation of education. This model is an analytical model that is being used to establish the effectiveness of innovative learning methods in enhancing the holistic competencies of both educators and students.

Table 8

Effect size

Hypothesis	F-square	Effects
H01. Digital Pedagogical Competencies → Pedagogical Practices x Transformative Orientation x life and career skills	0.835	High
H02. Pedagogical Practices Competencies → life and career skills x information media and technology skills x learning and innovation skills	0.524	High
H03. Transformative Orientation → life and career skills x information media and technology skills x Pedagogical Practices	0.946	High
H04. Digital Pedagogical Competencies → Pedagogical Practices x Transformative Orientation x life and career skills x information media and technology skills and learning and innovation skills	0.613	High

The results of our study indicate that each hypothesis proposed has a strong positive relationship between the variables tested, with a high coefficient value, indicating a significant influence in each relationship. For H01, the influence of Digital Pedagogical Competence on Pedagogical Practices moderated by Transformation Orientation and Life and Career Skills has a coefficient of 0.835 with a high category (Table 8). This shows that the mastery of digital pedagogical competence by educators is very important in improving pedagogical practices, especially in the context of educational transformation and the development of students' life skills. In H02, Pedagogical Practice Competence has a significant influence on Life and Career Skills, Information, Media, and Technology Skills, and Learning and Innovation Skills, with a coefficient of 0.524 which is also in the high category (Table 8). This shows that effective pedagogical practices encourage the development of essential 21st-century skills among students.

H03 shows a very strong relationship between Transformation Orientation and Life and Career Skills, Information, Media, and Technology Skills, and Pedagogical Practices, with a coefficient of 0.946, categorised as very high (Table 8). This confirms that the transformational approach in education is very effective in facilitating the development of skills needed by students in the digital era. Finally, H04 shows that Digital Pedagogical Competence influences Pedagogical Practices, Transformation Orientation, Life and Career Skills, Information, Media, and Technology Skills, and Learning and Innovation Skills, with a coefficient of 0.613 in the high category (Table 8). This strengthens the finding that educators' mastery of digital technology significantly supports more transformative and in-depth teaching practices and helps students develop important skills for the future.

M. J. Koehler, P. Mishra, and W. Cain [21] suggested the integration of technologies in teaching has not only the positive impact on the quality of education but enables teachers to construct profound and significant learning environments according to the requirements of students. Moreover, D. G. H. Divayana, P. W. A. Suyasa, and N. K. Widiartini [17] noted that the importance of pedagogical competence in

developing learning, information, media and technology and life and career skills, as well as skills for innovation. Teachers with digital competence in teaching effectively builds a more collaborative and engaging environment in concert with encouraging student innovative thinking when solving a problem or handling unpredictable situations that came with digital change. Moreover, contrastive observation on the transformational pedagogy for deep learning and found that the approach largely contributes to the enhancement of the student skills crucial for the working and future life. This pedagogical transformation is contained in making learning that promotes thinking abilities, imaginative and innovative, which are useful in endowing student's information, media as well as technology competency skills. W. Leal Filho, E. Pallant, A. Enete et al. [12] concluded that shifts endorsed learning culture develop student pertinent talents to excel in the world of work in the changing times at the global level. There is an added value in a transformative approach for the simple reason that it prepares students not only for mastery of technology but for innovation in an age of ever-increasing dependence on such tools.

Conclusion

Thus, the findings of our study suggest that digital transformation is central to the effort of enhancing the contemporary TVET learning environment. The study proves that to meet 21st-century TVET education requirements, educators that work in this sector should not only use but also transform their practice in terms of the application of digital technologies. To this end, it provided a synthesis of digital pedagogical competencies, transformative orientation, and core 21st-century skills that can inform the improvement of students' readiness for the technology-focused workforce in TVET institutions. The research findings show that the conception of a transformation framework enables the improvement of student activities through the introduction of a digital model in teaching and learning environments. It also highlights the importance of teachers updating their knowledge, to understand how to address the use of ICT in teaching and learning and other emerging practices. In conclusion, this framework gives direction to the TVET educators and institutions on how to enhance their practices so that the student will be prepared to compete in the global community with knowledge in a digital economy. Currently, the adoption of such a framework shall go a long way to confronting the future work force challenges, enhance the relevancy of TVET education, futuristic and impactful for the 21st century. Consequently, the findings of this study have important implications for the delivery of TVET education systems. Moreover, incorporating competencies in teaching and troubleshooting digitally, and the portrayal of skills crucial for life and work in the 21st century, into the work of TVET educators, will strengthen the value of instruction. The digital transformation framework derived in this research acts as a working roadmap for the educators and academic institutions in enhancing student-centric, innovative, and technology mediated teaching-learning environment. The usage of this framework may result in the enhancement of learning achievements, efficiency in transition to work environment and globalisation of ed-

ucation. This research therefore forms part of this emergent stream of literature on digital transformation in educating in the context of TVET. It comes up with a novel approach that focuses on the integration of digital teaching learning practices and the teaching, training, and development of on-duty 21st-century competencies to meet the peculiar demands of TVET educators and students. The study also contributes quantitative data to the current understanding of TVET teacher preparedness and barriers to using technology effectively. In addition to that, it provides meaningful recommendations for policy makers and organisations that are interested in enhancing the strategic implementation of TVET education by incorporating use of digital technology. However, the study is not without some limitations Some of them include the following the study is a pioneer in the subject area and has made the following contributions. First, this study largely concentrates on the TVET systems in the contexts of Malaysia and Indonesia, it is recognised that the generalisable application of findings in these two countries may differ from other countries with dissimilar educational or technology contexts. Second, the study is based on the educators' perceptions and may lead to the over or underestimation of digital competencies and the prevalence of effective teaching practices. In the same regard, the study does not comprehensively dissect the chronology effects of the proposed digital framework concerning the students' learning outcome as the work is constructed based on Implementation rather than evaluation. Further research should be conducted where more cultural or geographical realities can be used to validate the digital transformation framework to determine its generality. Survey research could be carried out following the cohorts from different levels of learning to assess the effectiveness of the framework in enhancing the achievements of student or preparing them to fit in the job market. Further, future research could utilise other additional data source, for instance, by observing classrooms or by using students' feedback to triangulate the results of the study in a better manner to complement the findings on use of digital practices in TVET education. Last, research could examine the applicability of potential development, for example, artificial intelligence or virtual reality, in the enhancement of the digital approach to the delivery of TVET pedagogy.

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Jasman – data analysis, text editing.
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Conflict of interest statement. The authors declare that there is no conflict of interest.

Received 11.09.2025; revised 10.12.2025; accepted for publication 26.12.2025.
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Информация о конфликте интересов. Авторы заявляют об отсутствии конфликта интересов.

Статья поступила в редакцию 11.09.2025; поступила после рецензирования 10.12.2025; принята в печать 26.12.2025.
Авторы прочитали и одобрили окончательный вариант рукописи.