EDUCATION REVOLUTION: CONCEPTUALIZING THE TEACHING 4.0 COMPETENCIES MODEL

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ABSTRACT
Education 4.0 revolution has caused enormous changes to the education system. This includes its impact on teaching methods and strategies. The combination of various uses of technology known as Technology 4.0 has simplified the planning system, knowledge delivery process and also produced more effective and efficient outcomes. High skills and competence among the educators are crucial to meet the needs and criteria of teaching with Technology 4.0. Several important criteria need to be taken into account in calibrating the level of skills and competencies of teachers. As there is no special model to measure the level of Teaching 4.0 competencies, the proposed framework of the model was created to take into account the importance of each necessary component. The combined result of the components from the three main models namely Technological, Pedagogical and Content Knowledge (TPACK), Adaptive Teaching Competency (ATC) and DigCompEdu Model has resulted in a development of Teching 4.0 Competencies Framework Model. This model is expected to provide a solution to a more effective and comprehensive system in terms of measuring the level of Teaching 4.0 competencies in education system, specifically to any educational institution in need.

Keywords: Education 4.0, technology 4.0, teaching competency, teaching 4.0 competency

INTRODUCTION

Education Revolution has greatly forced the education system to a new paradigm. Education 4.0 is one of the great revolutions. It changes almost the entire education system including teaching and learning methods with the existence and improvement of the use of more sophisticated existing technologies. The technology brought by the Education 4.0 revolution has had a huge impact on teaching strategies and methods. The use of 4.0 technology with smart technology concept such as smart mobile, cloud computing, artificial intelligent (AI), virtual classroom, 3D printers and robotics has made the way of new phase knowledge delivery. Dalmarco et al. (2019) describes 4.0 technology as the integration of different technologies into an autonomous, knowledge-and sensor-based, self-regulating production system.

The need for use of Technology 4.0 has prompted educators to be more competent in their job scope. Conventional teaching methods have become a method that is considered outdated and wearisome (Oke & Fernandes, 2020; Kopcha 2012; McKnight et al., 2016). The use of smart technology is said to help simplify the work starting from planning to preparing lesson plans, determining teaching methods and strategies and delivering process including the student assessment. It is considered to provide a more effective and efficient teaching method (Ghomi & Redecker, 2019). This whole process is known as "Teaching 4.0".

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The Need of Teaching with Technology 4.0

Teaching and learning in the 21st century era no longer based on teacher-centered learning. Educators are encouraged to act as facilitators who drive and lead students to learn and complete their assignments. Various technology tools have been used for a long time in planning, preparing and delivering lessons. Technologies such as laptops, smart phones and tablets are widely used as teaching aids. It is considered to be able to facilitate the delivery process to students and can even attract students to enjoy their learning process better. In addition, the use of smart boards, LCD projectors and 3D printers have become something that is commonly use in the classroom. However, most of these technologies are used separately and to a limited extent.

The combination of technological diversity in a single learning session is very important in line with the 4.0 education revolution where, technological tools are not only functioning as aids in teaching and learning, but as a substitute for the human teachers. Instructors or teachers no longer have to give full-time lectures but serve as facilitators guiding the student learning sessions. This is where Technology 4.0 functions by combining two or more technology to help students explore, understand and share knowledge independently. The use of virtual classes, virtual teachers, hybrid learning, online class discussion and various virtual learning sessions do not require teachers and students to be physically present in the same location. This not only simplifies the learning process but also reduces the gap of learning limitations caused by geographical factors for example. Several studies support the importance of use of 4.0 technology in teaching (Mohktar & Noordin, 2019; Saud et al., 2020; Kowang et al., 2020; Bonfield et al., 2020; Oke & Fernandes, 2020; Terkowsky et al., 2019; Mourtzis, 2018; Lopez-Garcia et al., 2019). Although the use of the term "Technology 4.0" and "Teaching 4.0" is still limited and not widely used but the concept of combination use of various technologies has long been used.

Teaching 4.0 Competency

Teaching 4.0 has become a cornerstone of teaching methods in this new era. The rapid development and change to various types of technology has presented a major challenge to educators to remain competitive in their field of work (Masdoki & Din, 2021; Ghomi & Redecker, 2019; Cabero-Almenara & Llorente-Cejudo, 2020). The extent to which educators are able to use and master ever-changing technological skills into their teaching strategies is still questionable. Technology 4.0 competencies is defined as the ability to handle, innovate and troubleshoot problems related to Technology 4.0 whereas Teaching 4.0 competencies is the ability to handle, innovate and troubleshoot Technology 4.0 in planning, preparing teaching and in the process of delivering teaching effectively. It is a necessity for the teaching staff to ensure that they always remain competitive so that the teaching process can be carried out effectively. In spite of this, , the lack of empirical studies to test the level of teaching competencies based on Technology 4.0 at the global and local levels has become a limitation to the education system to ensure that teachers have achieved the appropriate level of competence.

There are arguments that state the use of various technologies is complicated and will make teaching difficult because it requires more time to plan and prepare the materials (Cabero-Almenara & Llorente-Cejudo, 2020; McKnight et al., 2016; Bonfield et al., 2020). Instructors claim that it increases their workload as well as difficult to regulate the extent to which students are disciplined in using Technology 4.0 during the learning process. (Onyishi & Sefotho, 2020; Fragkaki et al., 2020; Lye 2013; Kamal et al., 2020; Diedericks et al., 2019). Whether or not these arguments are an issue, it shows that teaching staff is actually unskilled or less competent in using Technology 4.0 properly so that they think it is a burden to them. Therefore, to answer these various possibilities, it is necessary for the education system to have a measurement tool tomeasure and evaluate the level of competencies of teachers. As a result, they can identify weaknesses, make self -reflection, constantly improve skills and ensure teaching methods designed using Technology 4.0 are able to simplify tasks and not to be an increase of workload to them.

Theoretical Foundation of Teaching 4.0 Competencies

Several theories are identified in forming a model that can be use to build a method of assessing the level of Teaching 4.0 competencies. Many aspects need to be taken into account to ensure that it is able to provide a reliable and trustworthy finding. Three technological models have been identified in underlying the basic

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model of Teaching 4.0 Competencies, namely the Technological, Pedagogical, Content Knowledge (TPACK) model (Koehler and Mishra, 2006), Adaptive Teaching Competency (ATC) model (Beck et al., 2008) and the DigCompEdu model (Redecker, 2017).

A. Technological, Pedagogical, Content Knowledge (TPACK)

The TPACK model was introduced by Punya Mishra and Matthew J. Koehler (2006) to solve several questions related to teaching, namely: i) to measure the level of teacher's knowledge and how they develop their knowledge, ii) to introduce pedagogical approaches as professional development and, iii) as a guide to effective pedagogy. TPACK was built as an improvement to Pedagogical Content Knowledge (PCK). It is based on content knowledge theory (CK) and pedagogy knowledge (PK) by Shulman (1986). Shulman's study shows that individual educators have unique knowledge skills that can be conveyed in various forms of presentation to provide understanding to students. When it was first introduced, PCK explained the importance of relationship between content knowledge and pedagogy and how teaching could be adapted to a wide variety of students 'abilities and backgrounds. This is a measure instructor's level of skill in imparting knowledge through an appropriate pedagogical approach. Nordin and Faekah (2016) define TPACK as an understanding of the relationship and interaction between technological knowledge, content knowledge and pedagogical knowledge in the learning process. However, Mishra and Koehler (2006) argue that modern technology has changed pedagogical teaching and learning styles including classroom environment to a more effective pedagogical method of teaching. Elements of technology use have created a theoretical framework of TPACK as shown in Figure 1:

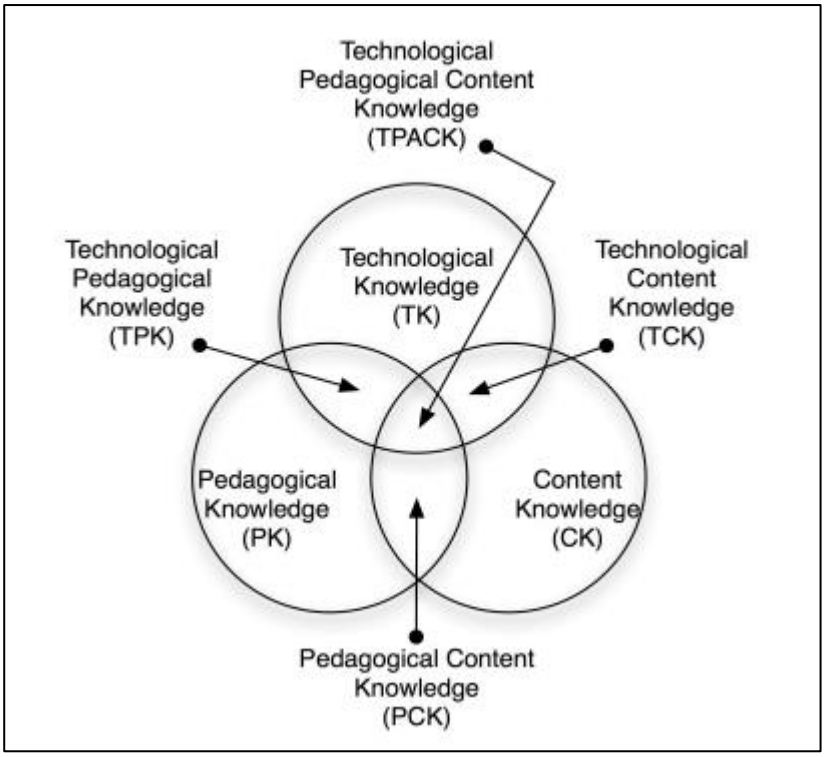

Figure 1. Technological Pedagogical Content Knowledge (TPACK)
Source: Mishra & Koehler (2006)

Basically, the combination of three main constructs namely TK, CK and PK has resulted in TPACK. Spector et. al (2014) describes the main components in the TPACK framework as follows;

i) **Content knowledge (CK):** refers to any subject knowledge that is the responsibility of the teacher to teach.

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ii) **Pedagogical knowledge (PK):** refers to teachers' knowledge of various teaching practices, strategies, and methods to promote student learning.

iii) **Technological knowledge (TK):** refers to teachers' knowledge of traditional and new technologies that can be integrated into the curriculum.

Next there are four components in the TPACK framework explaining how these three bodies of knowledge interact, constrain, and influence each other as follows;

i) **Technology Content Knowledge (TCK):** refers to the knowledge of the reciprocal relationship between technology and content. Disciplinary knowledge is often determined and constrained by technology and its representative capabilities and functions.

ii) **Knowledge of Pedagogical Content (PCK):** is Shulman's (1986) understanding of how a particular topic, problem, or problem is structured, represented, and adapted to various interests and abilities of learners, and presented for teaching.

iii) **Technological Pedagogical Knowledge (TCK):** refers to the understanding of technology that can restrain and be able to carry out certain pedagogical practices and;

iv) **Technology Pedagogy Content Knowledge (TPACK):** refers to knowledge of the complex relationships between technology, pedagogy, and content that enables teachers to develop appropriate and context -specific teaching strategies**.**

Clearly TPACK emphasizes the use and application of information technology communication and how it can help build effective teaching (Koehler & Mishra 2006). Nevertheless, some researchers have found that the instruments used are unclear and not applicable globally (Eng & Keong 2019; Elas et. Al 2019; Brantley-Dias & Ertmer 2013; Jamieson-Proctor 2013; Koh et.al 2015; Adam 2017). According to Koehler, Mishra, Kereluik, Shin, & Graham (2014), there are over 600 journal articles that have used the TPACK framework reported since 2006. However, the constructed instruments are still unclear in the Malaysian context (Eng & Keong 2019). Researchers also found that TPACK did not take into account information regarding the background and work culture of instructors before evaluating the use of technology in the context of their teaching pedagogy (Adam 2017). Due to very rapid technological change, the TPACK instrument is seen as too broad and lacks a clear focus on the technology being measured (Jamieson-Proctor 2013; Brantley-Dias & Ertmer 2013; Adam 2017). Therefore, researchers expect that the integration of Technology 4.0 into TPACK technology component will be able to build a better and clearer instrument in measuring teaching skills in line with the technology used in the era of Education 4.0.

B. Adaptive Teaching Competency (ATC)

Adaptive Teaching Competency Theory (ATC) (Beck et al., 2008) is defined as the ability and capability of educators to adapt their teaching plans according to the different levels of student learning. It is a continuation of the theory of Adaptive Teaching where ATC looks at the extent to which educators' competence and ability to adapt to their teaching diversity. Brühwiler and Blatchford (2011) describe four main dimensions of ATC that need to be mastered namely i) in-depth subject content knowledge ii) diagnosis of student learning taking into account students' knowledge, needs and character iii) teaching methods as part of delivery approach and iv) management classes to create conditions that facilitate the learning process.

The approach that educators need to take before adapting teaching is to implement planning to proactively change the curriculum. This can be done by taking into account the level of differences of more specialized students in terms of their readiness, interest and learning profile (Schipper et. Al. 2017). Therefore, if viewed from the theoretical and pedagogical perspective explained, ATC emphasizes the in-depth involvement of students in constructing learning, meaning and adapting content and teaching activities responsively (Luciano Beltramo 2017). Consequently, educators need to know the level of student diversity and how to adapt selected methods. Technology is seen to play a very important role in supporting the application of diverse and

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appropriate teaching strategies (Barana et. Al. 2017). This study also shows the use of technology successfully replaces the physical presence of educators and it is also able to provide feedback that sometimes cannot be done directly.

C. DigCompEdu

The European Framework for the Digital Competence of Educators (DigCompEdu) published in 2017 describes the digital competences specific to the teaching profession (Redecker, 2017). This framework is based on extensive expert consultations and aims to structure existing insights and evidence into one comprehensive model, applicable to all educational contexts. To allow educators to get a better understanding of this framework and to provide them with a first assessment on their individual strengths and learning needs, an online self-assessment instrument has been developed, freely accessible in a number of languages. This DigCompEdu proposes 22 basic competences, organized into six areas, which educators should ideally acquire as shown in Table 2.

Table 1. Areas of educators' digital competence according to the DigCompEdu Framework

Areas	**Competences (professional, pedagogic and of learners)**
Professional Digital Engagement	Organizational communication Professional collaboration Reflective practice Digital continuous professional development (CPD)
Digital resources	Selecting Creating and modifying Managing, protecting, sharing
Teaching and learning	Teaching Guidance Collaborative learning Self-regulated learning
Assessment Empowering	Assessment strategies Analyzing evidence Feedback and planning
Empowering learners	Accessibility and inclusion Differentiation and personalization Actively engaging learners
Facilitating learners' digital competence	Information and media literacy Communication
Organizational	Content creation Responsible use Problem solving

Referring to the table above, it can be seen that almost all frameworks have competency levels, especially the progressive development aspect of competencies. Based on all six areas of DigCompEdu, it has classified competencies into three intervals (basic, intermediate and advanced). The model looks at the dimensions and efficiencies of all frameworks with a focus on technological and pedagogical efficiencies. The two main criteria of this model are i) Technology: the professional competencies that need to be developed by every teacher in an educational institution committed to the Knowledge Society and; ii) Pedagogy: competencies that are directly linked to the process of teaching, learning and citizenship development of students.

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THE WAY FORWARD AND FUTURE PERSPECTIVES

Looking at the importance of Teaching 4.0 competencies which is also one of the lifelong learning, it is necessary for the parties involved in the education system to give thoughtful emphasis to the skills aspects of educators and teachers to be in line with the needs of today's technology. This can help produce more efficient and effective teaching methods and strategies. Furthermore, it will help to ensure that students can truly be prepared to receive knowledge that is conveyed better based on their different capabilities with more personalized learning (Yunos & Din, 2019; Din, 2020; Amid & Din 2021; Hafifi & Din, 2021, Masdoki & Din, 2021b). This is supported by the proposed combination of the three models discussed as in the following Table 2.

Table 2. Components' comparison of TPACK, ATC & DigCompEdu Model

TPACK	ATC	DigCompEdu
Technological knowledge	Content knowledge	Professional Digital Engagement
Pedagogical knowledge	Student's knowledge needs & character	Digital resources
Content knowledge	Management of class	- Teaching & learning - Assessment empowering - Empowering Learners - Facilitating learner's digital competence organizational

Each of the components of the model has been identified and classified into three phases of competence namely i) Planning & preparation, ii) Teaching process, and iii) Outcome & reflection. The detail is as in Figure 2.

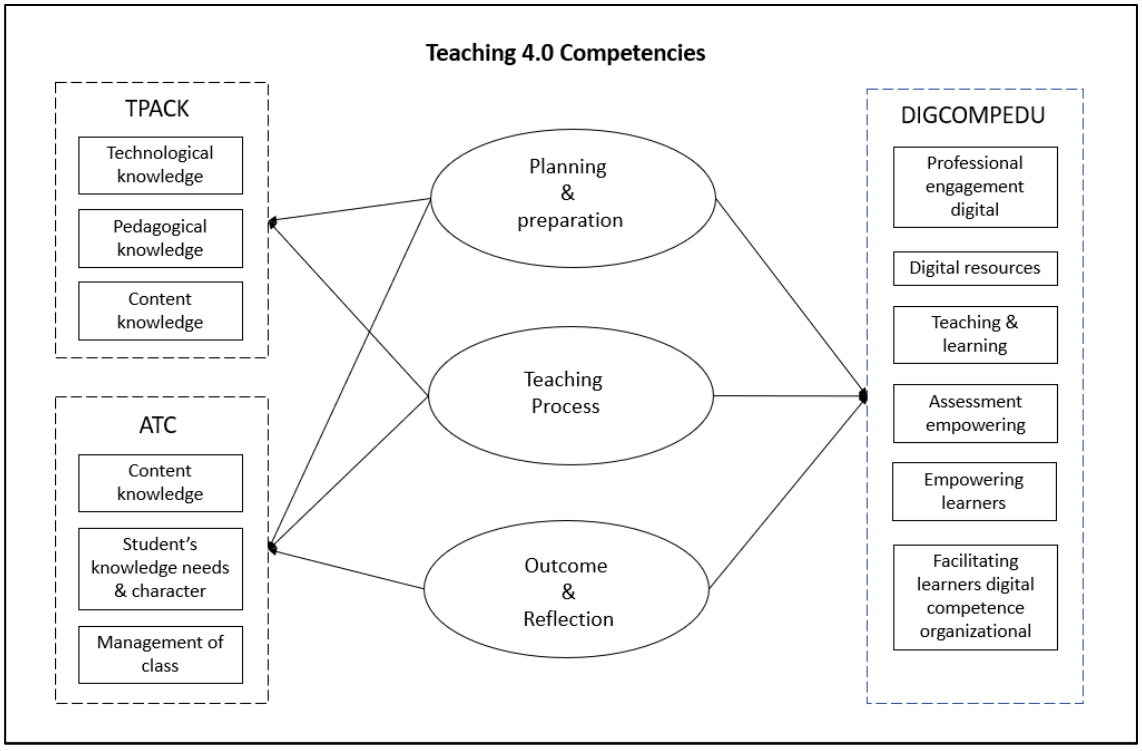

Figure 2. Proposed Framework Model for Teaching 4.0 Competencies

For the first phase, planning and preparation, consists of components from the TPACK model. These components emphasize aspects of technological knowledge, pedagogical knowledge and content knowledge. It also consists of two components from the ATC model which are content knowledge and student's knowledge needs and character. All of these components are exceptionally important to prepare a good strategy that meets the needs of the learners and to provide the best and effective teaching method. At the same time, it should be considering the outcome that to be achived which focuses on the six componnets of DigCompEdu namely; professional engagement digital, digital resources, teaching and learning, assessment empowering, learners' empowerment and facilitating learners' digital competence and organizational. Second phase Teaching 4.0 competencies focus on the teaching process which highlighted in terms of class management, teaching & learning methodology and facilitating learners 'digital organizational competence. The second phase also has the same component from the ATC model, such as student's knowledge needs and character. This is to ensure that (i) the teaching delivery process can be diversified according to the needs of various levels of students and (ii) to come up with additional and various teaching methods. The final phase of outcome and reflection emphasizes on teaching outcomes, assessments, identifying weaknesses and making improvements. The components involved are digital professional engagement, assessment empowering, and empowering learners. Overall, all stages of Teaching 4.0 Competencies are connected with those all variables from the TPACK, ATC and DigCompEdu models. These components are important to help measure the Teaching 4.0 competencies. A detail studies to analyze and validate the relationship between each component from the three models as variables and Teaching 4.0 element should be done. Hence, a proper instruments or tools should be developed based on this model to provide an empirical finding.

DISCUSSION & CONCLUSION

This shift in technology transformation 4.0 has given a huge impact to the teaching staff to be able to improve their technology skills. It alsot has a greater impact in producing highly innovative students. Technology must have changed the task from instructors to facilitators who are more flexible in imparting knowledge either physically or virtually compared to traditional instructors who are limited in the way of class communication. It is reported that teachers' roles in the classroom are decreasing through the blended learning approach. They described their traditional role as, "being the star of the show…the one up in the front giving all the information," and as simply "standing there, just spoon-feeding the students is no more relevant these days (McKnight et al, 2016). Thus, the findings from our study have implications for education system as a whole specifically on educational institutions to implement technology training initiatives for teachers to enhance teaching and learning so as to make learning more personalized.

Educational institutions should give more attention on supporting teachers by providing appropriate technological facilities and workshops. In tandem, encouraging teachers to share their knowledge and skills using specific technology and to compile a list of favorite resources to share and collaborate with colleagues locally and internationally. Another key implication lies on optimizing the 3 phases of teaching identified in our study for successful strategy of Teaching 4.0 and produce a greater teaching outcome. In the meantime, the integration of Technology 4.0 by teachers should be monitored and observed, making sure that the innovative changes are moving towards more transformative uses. Hence, a good instrument is needed for measuring and assessing the teacher's capability and competencies that can be used for institution's reference and improvement.

LIMITATION

This study is limited to basic review and framework model proposal. It is not yet been tested and no specific instruments have been developed. It is recommended for further research to be done on specific education institution to provide the empirical results.

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References

Adam, A. (2017). A framework for seeking the connections between technology, pedagogy and culture: A study in the Maldives. *Journal of Open, Flexible, and Distance Learning, 21*(1), 35-51.

Amid, A. & Din, R. (2021). Acceptance and Use of Massive Open Online Courses: Extending UTAUT2 with Personal innovativeness. *Journal of Personalized Learning, 4*(1) 2021, 57-66.

Barana, A., Fioravera, M., Marchisio, M., & Rabellino, S. (2017, July). *Adaptive teaching supported by ICTs to reduce the school failure in the project "Scuola Dei Compiti".* In *2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC) (Vol. 1, pp. 432-437).* IEEE.

Beck, E., Baer, M., Guldimann, T., Bischoff, S., Bru¨hwiler, C., Mu¨ller, P., et al. (2008). *Adaptive teaching skills. Analysis and structure, modifiability and effect of action-steering teacher knowledge. [Adaptive teaching competency. Analysis and structure, variability and effects of teacher knowledge on teachers' actions]*. Munster, Germany: Waxmann.Luciano.

Beltramo, J. (2017). Developing adaptive teaching practices through participation in cogenerative dialogues. *Teaching and Teacher Education,* 63, 326–337. https://doi.org/10.1016/j.tate.2017.01.007

Bonfield, C. A., Salter, M., Longmuir, A., Benson, M., & Adachi, C. (2020). Transformation or evolution? : Education 4.0, teaching and learning in the digital age. *Higher Education Pedagogies, 5*(1), 223-246.

Brantley-Dias, L., & Ertmer, P. A. (2013). Goldilocks and TPACK: Is the construct 'just right?'. *Journal of Research on Technology in Education*, *46*(2), 103-128.

Brühwiler, C., & Blatchford, P. (2011). Effects of class size and adaptive teaching competency on classroom processes and academic outcome. *Learning and instruction*, *21*(1), 95-108.

Cabero-Almenara, J., & Llorente-Cejudo, C. (2020). Covid-19: radical transformation of digitization in university institutions. *Virtual Campuse, 9*(2), 25-34.

Dalmarco, G., Ramalho, F. R., Barros, A. C., & Soares, A. L. (2019). Providing industry 4.0 technologies: The case of a production technology cluster. *The Journal of High Technology Management Research, 30*(2), 100355.

Diedericks, J. C., Cilliers, F., & Bezuidenhout, A. (2019). Resistance to change, work engagement and psychological capital of academics in an open distance learning work environment. *SA Journal of Human Resource Management, 17*(1), 1–14. https://doi.org/10.4102/sajhrm.v17i0.1142

Din, R. (2020). Notes from the Chief Editor: On Universal Design and Agile Development. *Journal of Personalized Learning, 3*(1), i-vii.

Elas, N., Majid, F., & Narasuman, S. (2019). Development of technological pedagogical content knowledge (TPACK) for english teachers: The validity and reliability. *International Journal of Emerging Technologies in Learning (IJET)*, *14*(20), 18-33.

Eng, C. Y., & Keong, T. C. (2019). Pengetahuan teknologi pedagogi kandungan di Malaysia: Satu kajian meta analisis. *Journal of ICT in Education, 6*, 86-95.

Fragkaki, M., Mystakidis, S., & Filippousis, G. (2020, June). *Work-in-Progress—Design and Evaluation of an Augmented and Virtual Reality Flipped-Learning Course for K-12 Educators.* In *2020 6th International Conference of the Immersive Learning Research Network (iLRN) (pp. 275-278).* IEEE.

Ghomi, M., & Redecker, C. (2019, May). Digital Competence of Educators (DigCompEdu): Development and Evaluation of a Self-assessment Instrument for Teachers' Digital Competence. In *CSEDU (1)* (pp. 541-548).

Hafifi, M. H. M., & Din, R. (2021). Penggunaan Video sebagai Medium Pembelajaran Kendiri untuk Meningkatkan Produktiviti Belia Tani. *Journal of Personalized Learning, 4*(1), 43-56.

Jamieson-Proctor, R., Albion, P., Finger, G., Cavanagh, R., Fitzgerald, R., Bond, T., & Grimbeek, P. (2013). Development of the TTF TPACK survey instrument. *Australian Educational Computing, 27*, 26-35.

Kamal, A. A., Shaipullah, N. M., Truna, L., Sabri, M., & Junaini, S. N. (2020). Transitioning to online learning during COVID-19 Pandemic: Case study of a Pre-University Centre in Malaysia. *International Journal of Advanced Computer Science and Applications*, *11*(6), 217–223.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). *The technological pedagogical content knowledge framework. In Handbook of research on educational communications and technology* (pp. 101-111). Springer, New York, NY.

Koh, J. H. L., Chai, C. S., & Lee, M. H. (2015). Technological pedagogical content knowledge (TPACK) for pedagogical improvement: Editorial for special issue on TPACK. *The Asia-Pacific Education Researcher, 24*(3), 459-462.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education, 59*(4), 1109-1121.

Kowang, T. O., Bakry, M. F., Hee, O. C., Fei, G. C., Yew, L. K., Saadon, M. S. I., & Long, C. S. (2020). Industry 4.0 Competencies among Lecturers of Higher Learning Institution in Malaysia. *International Journal of Evaluation and Research in Education, 9*(2), 303-310.

Lopez-Garcia, T. J., Alvarez-Cedillo, J. A., Sanchez, T. A., & Vicario-Solorzano, C. M. (2019). Review of trends in the educational model of distance education in Mexico, towards an education 4.0. *Computer Reviews Journal, 3*, 111-121.

Lye, L. T. (2013). Opportunities and Challenges Faced by Private Higher Education Institution Using the TPACK Model in Malaysia. *Procedia - Social and Behavioral Sciences, 91,* 294–305. https://doi.org/10.1016/j.sbspro.2013.08.426

Masdoki, M., & Din, R. (2021a). Teaching 4.0 Competency in Higher Learning Institutions: A Systematic Mapping Review. *International Journal of Learning, Teaching and Educational Research, 20*(10), 217-231.

Masdoki, M., & Din, R. (2021b). Conceptual Study on Teaching 4.0 Competencies among Lecturers of Kolej MARA and Kolej Profesional MARA. *Journal of Personalized Learning, 4*(1), 81-88.

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education, 48*(3), 194-211.

Mishra, P. M. & Koehler. J., (2006). *Technological Pedagogical Content Knowledge: A Framework for Integrating Technology in Teacher Knowledge. Educators College Record.* Michigan State University Research.

Mourtzis, D. (2018, June). Development of skills and competences in manufacturing towards Education 4.0: A teaching factory approach. In *International Conference on the Industry 4.0 model for Advanced Manufacturing* (pp. 194-210). Springer, Cham.

Nordin, H., & Faekah, T. A. T. 2016. Validation of A Technological Pedagogical Content Knowledge Instrument in A Malaysian Secondary School Context. *Malaysian Journal of Learning and Instruction, 13*(1), 1-24.

Oke, A., & Fernandes, F. A. P. (2020). Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th industrial revolution (4IR). *Journal of Open Innovation: Technology, Market, and Complexity, 6*(2), 31.

Onyishi, C. N. & Sefotho, M.M. (2020). Educators' perspectives on the use of differentiated instruction in inclusive classrooms: Implication for teacher education. *International Journal of Higher Education, 9*(6), Page 136 – 150.

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu* (No. JRC107466). Joint Research Centre (Seville site).

Saud, M. S., Rameli, M. R. M., Kosnin, A. M., Yahaya, N., Kamin, Y., Zakaria, M. A. Z. M., Mokhtar, M., Abdullah, A. H., Suhairom, N., Kamis, A., Rahman, F. A., Minghat, A. D., Daris, Z. M., Alhassora, N. S. A., & Omar, M. (2018). Readiness In Implementing Teacher Training Programmes Based on Industrial Revolution 4.0: Evidence from Malaysian Public Universities. *Journal Of Engineering Science and Technology, 13*(Special Issue on Icite 2018), 42–48.

Schipper, T., Goei, S. L., de Vries, S., & van Veen, K. (2017). Professional growth in adaptive teaching competence as a result of Lesson Study. *Teaching and Teacher Education, 68,* 289-303.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4-14.

Spector J.M. (2014). *Handbook of Research on Educational Communications and Technology.* Springer Science+Business Media New York.

Terkowsky, C., Frye, S., & May, D. (2019). Online engineering education for manufacturing technology: Is a remote experiment a suitable tool to teach competences for "Working 4.0"? *European Journal of Education, 54*(4), 577-590.

Yunos, S., & Din, R. (2019). The Generation Z Readiness for Industrial Revolution 4.0. *Creative Education, 10*(12), 2993–3002.