

Managing Pedagogical Efficiency Through TPACK Framework in Digital Learning

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Abstract

Modern-day twenty-first-century education is now being constructed around the pillars of a framework that supports and dwells on Information and Communication Technology in the learning process. Nowadays, teachers are supposed to develop a pedagogical approach that integrates and blends with technology in learning. An appropriate structure of educational practice can motivate students' critical design, creativity as well as thinking skills. As seen in recent times the global Pandemic Covid-19 forced almost all learning institutions and the learning process to make extensive use of digital media, digital channels, online or virtual learning teleconferencing, mobile cellular technology, and any digital learning resource that could aid the outside the classroom form of learning. There are numerous digital learning applications in the form of computers or mobile devices that can be utilized for teaching and learning. Digital Learning primarily was designed to make learning easy & interactive but needs digital tools to exercise it. However, it is often seen many digital learning tools are way complex and need special training, hence making the teacher find it more complicated and often adapt to not practice it in their pedagogical approach. TPACK is a framework that highlights the labyrinth involved with the adoption of a particular digital learning tool and its use between the three basic components of knowledge (technology, pedagogy, and content). This particular article takes a deeper dive into the TPACK framework and how essential it is to integrate technology into education with ease. This article further helps in understanding how knowledge transfer works in a pedagogy. The article concludes with the variety of scientific works of literature reviewed. This article can hence acknowledge that to validate ICT in education TPAK framework is an important tool. It further helps in analyzing how teachers consider their knowledge zones crosses & limits to effectively teach and engage students with technology.

Keywords: TPACK, digital learning, 21st century, limitations, teachers, students, Knowledge, ICT.

1. Introduction

The educational challenge for almost all the learning organizations of the 21st century is to develop a skillful society that is based on knowledge via the proper integration of Information and Communication Technology (ICT) in the learning process. When seen ICT from the point of view of digital learning & training, it acts as a backbone as digital learning cannot be facilitated without the presence of ICT in the learning process. This digital education & learning process has pushed teachers to modify their pedagogical approach according to modern digital education forms. The teachers are now expected and required to integrate ICT into the learning process. Integration of ICT in the learning atmosphere is considered to enable teachers to be the facilitators of digital education. It is teachers from all disciplines, irrespective of the subject or topic they teach are expected to figure out ways to develop and design learning materials that adapt to the technologies, and can simultaneously assure the success of students amidst 21st-century digital education, which is another question of the teacher itself is capable to do so or not! As per Hernawati & colleagues (Hernawati & Jailani, 2019), the teachers can only succeed in employing this ICT in their pedagogical approach if, and only they can do so or are provided training beforehand on;

- How to use various digital learning tools and use learning strategies to create different learning materials and experiences.
- If they are provided with adequate access to a variety of learning materials to understand what is the trend, and how others are working and how to develop meaningful content for their students so that the student is not in an abyss, and is guided in the right direction with the right pedagogical approach and the appropriate ICT in digital learning.
- In addition, the teacher's pedagogical skills integration with the correct ICT, for the process of learning is extremely crucial as the pedagogical approach helps students

towards understanding creative as well critical thinking, whilst the ICT makes sure it is done in the easiest, most creative and innovative as well as in an understanding way.

Therefore, it is necessary to understand, how the 21st century is advancing with digital tools for learning incorporating ICT, such as devices, applications, programs, etc. To evaluate the efficiency of digital learning tools in an educational organization, there is one very widely used framework to validate the educational capabilities as a whole in the learning, teaching & development context of an organization, which is known as the TPACK (Technology Pedagogical Content Knowledge) framework. This article analyzes how TPACK can be used to harness the potential of the teachers and at the same time validate the adoption and exercise of the digital learning tools incorporated in a learning organization for the benefit of the learners and trainers.

2. Research Question

How can teachers, trainers, learners & educational organizations use their digital learning tools to the best capabilities using the TPACK Frameworks help?

3. Purpose of the study

This particular study takes a deeper dive into the validation of digital learning tools incorporated by higher educational institutions' HEIs. The purpose of this study is to help HEIs understand and validate the practice of their digital learning tools by teachers and learners. The purpose of the study is to evaluate the digital efficiency of a trainer and learner with digital learning tools and what steps needs to be taken to make the learners and trainers digitally capable to practice the digital learning tools with ease so that the learning becomes, interactive, easy, motivational and flexible.

4. Limitations of the study

The primary limitation of the study is that it does not reflect any qualitative or

quantitative data. As often seen in many types of research and especially with the acceptance of technology, quantitative data is regarded as more authentic. The study uses the SLR method for its analysis, which is a systematic literature review and the conclusion is based on the literature arguments and analysis. The study does not cover the aspect of the perceived ease of use of technology in education as per the acceptance of the learners and trainers, rather it focuses on the capabilities of the learners and trainers and how they can use the digital learning tools to their full potential by harnessing proper knowledge points such as technology, content, pedagogy.

5. Literature Review

Digital learning Platforms That are Supported by ICT

As per Hernawati & colleagues (Hernawati & Jailani, 2019), the birth of the internet has changed the way we perceived learning. The internet of things and ICT together have opened up so many avenues for digital learning that one platform is not constant, and the trends keep changing. The recent trend now is (Mobile/ Cell phone technology), The 21st century is the mobile century, and hence it is exploited for the use of learning with various learning applications and tools. This has given digital learning extra wings as now learning is at the disposal of the learner. As mobile learning is becoming more popular it is bringing in more challenges for teachers to adjust their pedagogical styles, and create content that is adaptable to such learning applications and at the same time is understood and easily conveyed. Although mobile learning is considered an activity that allows learners to become more productive & engages them whilst it is being used, it is equally creating more pressure on teachers to keep adapting to updates, formats as well as internet bandwidths & latencies without even being practically trained on how to deal with all such formats.

The modern-day is progressing and many hand-held devices such as mobile phones, notepads, Kindle, etc. are on the market along with them come numerous

applications, that are compatible and can be used for various purposes including education & learning. There are various topic-oriented educational applications available in the app or play stores that cover topics like language learning, science & mathematics, and others. On a rough note, for learning mathematics, there are above 4000 mobile applications, and there are more than 500,000 educational apps worldwide which are still increasing (educational app store, 2022). However, there have been not many researches in the field of education that have examined the exercise of digital tools or applications and their associated pedagogy. By progressing and promoting the use of digital tools such as cell phones or other hand-held devices in classrooms with their associated applications, teachers, trainers, and educators need to examine their efficiency in teaching & learning.

Digital education is the need of the 21st century & therefore various learning applications for mobile phones and software for desktops are being developed continuously to take education to the next level, however, but most of these applications are more focused on the content and how consumption of technology is done, whilst hardly covering on the pedagogical domain. Therefore, to make digital learning more feasible for teachers & students the TPACK framework is needed. As mentioned by the authors Tay, Lim & Koh in their study (Tay. et.al, 2012) that the use of ICT can raise the teacher's knowledge of the content and also the pedagogical capabilities in learning & teaching. According to Schoenl & colleagues (Schoenl & Fusarelli, 2008), it is stated that the exercise of ICT as a medium for instructional tools and the pedagogical capabilities of teachers are the reasons to support the learning organization as well as teachers to face the problems that might arise whilst enhancing the student or the learners' learning skills. As per Koehler and Mishra (Harris & Matt Koehler, 2009), the Technology Pedagogical Content Knowledge (TPACK) framework is a combination of content, pedagogical capabilities, and technological integration capabilities in the learning process in the classroom. Shulman's TPACK model (1986), was only designed with the Pedagogical Content Knowledge (PCK) capabilities whereas the modern-day TPACK framework is

the perfect blend of the three spheres of knowledge (content, pedagogy, and technology) which targets raising the basic knowledge when a teacher examines and studies the topic or a specific subject and realizes that technology can boost the learning experience.

Technological Pedagogical Content Knowledge (TPACK) Framework

As described by Koehler and Mishra (Harris & Matt Koehler, 2009) Technological Pedagogical Content Knowledge (TPACK) framework aims to identify the concept of digital learning needed by teachers for novelties in their pedagogical approach. TPACK simultaneously aims to answer the likeliness of confusion, as well as the complex stacked type of the teacher's or trainer's information. The TPACK framework expands on the concept of that Shulman's, Pedagogical Content Knowledge. At the very center of the TPACK framework, is a blend of three fundamental forms of learning: The is, Technology (TK), Pedagogy (PK), and Content (CK). The TPACK approach goes way ahead in penetrating these three learning forms in the division. The TPACK framework proceeds ahead by highlighting the types of learning that intersect at the intersection points between three fundamental forms: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK) Refer to figure 1 below.

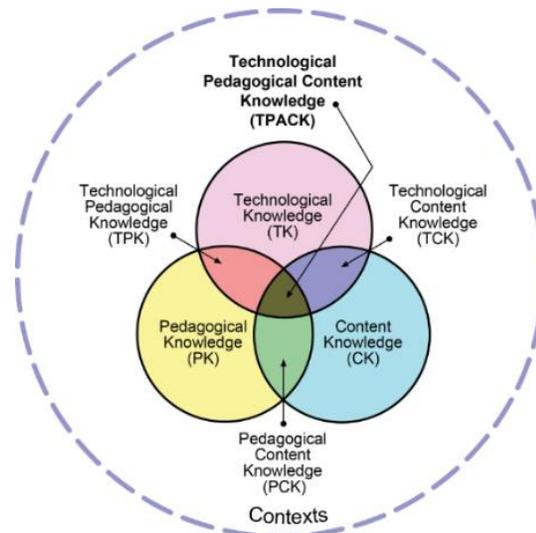


Figure 1 TPACK Framework (Mkoehler, 2011)

Content Knowledge (CK) – Subjects or course topics that will be taught or trained needs to be commanded by the teachers, educators, or trainers. This is a cluster of educational concepts, theories, and hypotheses, substantiation of the information, categorized methods, proofs, and also the realization of various learning practices as well as methodologies to promote that information (Insook , Ko, & Li, 2015).

Pedagogical Knowledge (PK) – Teachers must command the exercise of the course of action and policies or different approaches for teaching and learning, encompassing estimating the intended learning goal (ILG) the learning values digital or non-digital learning values, as well as aims. It is necessary for the process of assessing the lesson plans and moderating the learner's or student's learning capabilities (Keengwe, 2009).

Technology Knowledge (TK) – A teacher must have a mindset and knowledge about how to work with technology, tools, and resources and be able to consistently adapt to changes in information technology. This knowledge includes understanding information technology comprehensively and applying it in daily life and at work and having the capacity to use information technology appropriately to help achieve goals (Sahin, 2011).

Pedagogical Content Knowledge (PCK) – According to Shulman in 1986 PCK is envisioned by the thought of varying themes and topics for teaching or training. The modification, alterations, and tweaking that happens when the teacher or instructor explains a subject and whilst doing so seeks various methods to interpret and represent it as well as adjust the learning aids to the substitute design and towards a learner's primary form of learning. PCK comprises education, digital learning, teaching, offline and online learning, and other aspects that are related to the assessment of the pedagogical approaches and curriculum evaluation (Fernandez, 2014).

Technological Content Knowledge (TCK) – Teachers have to take into consideration and realize the impact content and technology can force on each other. The teacher is considered to have in-depth knowledge of the topic he/she is going to teach or is teaching already. In doing so the teacher should be able to tweak, edit, modify, create, and

improvise on the topic being taught; by employing appropriate technology that eventually can help the students or learners understand the content with ease by the help of technology (Listiawan.et.al & Purwanto, 2018).

Technological Pedagogical Knowledge (TPK) – An idea given by Chai & colleagues (Chai.et.al, 2013), on the exercise of a particular technology incorporated for learning can put an impression of a new form or an approach in other words different pedagogical style. This consists of understanding the pedagogical capabilities and implementing pedagogical policies that are corresponding with technological advancements.

Technological Pedagogical Content Knowledge (TPACK) – TPACK is the foundation of productive and efficient teaching practices with the support of technology, which usually needs the knowledge of portraying the concepts by using technology; Pedagogical styles, approaches, and patterns apply technology to highlight the content; the knowledge about things that are complicated or simple to learn or understand making it simpler for the learners or students to overcome problems with the help of technology and innovations. TPACK further helps in analyzing the student or the learner's primary knowledge and philosophy about ICT and how technological innovations can be implemented and used to expand the current knowledge bank of the learner and strengthen the learner's philosophy. Chai & colleagues (Chai. et.al, 2013) have reviewed several around 74 journal papers that investigated ICT integration with the TPACK framework. The understanding of the TPACKs must be learned by the teachers to efficiently enforce ICT in the classroom. TPACK is a framework for teachers, educators, trainers & students that addresses the issue of incorporating technology into learning which has been exercised apart from content learning and pedagogical training.

Further discussions

As stated by Steinle & Lynda Bal (Steinle & Lynda Ball, 2013), every teacher has TPACK capabilities to harness when it comes to digital tools for learning, such as a mathematics teacher needs to have the skills of a well-connected CK and PCK, that a

teacher can have the freedom to enter tweak or modify pre-lecture and post-lecture for interactive, monitored and effective learning. This keeps the teachers engaged and brings more innovative ideas for content and keeps the process in a loop which helps teachers to evaluate or assess their capabilities and knowledge. As per Chinnappan (Chinnappan, 2009), Pedagogical Content Knowledge (PTK), comprises the teacher's knowledge about the educational content as per their subject, topic, or expertise and the methods used by the teacher to showcase the content via the mode of technology that is considered to be suitable to a learner's learning forms. Further, as per Muhtadi & colleagues (Muhtadi, 2017), Technology is regarded to raise the teacher's efficiency, and therefore the use of technology is done by the teachers to increase productivity in their professional training. As technology grows rapidly the developments in digital platforms and tools impact the teacher's TPACK standards forcing the matching TPACK framework to change as new technologies are added. As per the exercise of technology for learning used by the teachers, it is crucial that the teachers, make themselves aware and have enough knowledge about the digital tools they will be practicing for the learning process. Therefore, the course designers or management should provide enough time for each teacher, trainer, and educator to familiarize themselves with the digital tools, platforms, and applications they are supposed to use for teaching or training.

Case studies & arguments

The capability of TPACK teachers in classrooms according to research from various countries highlights that various subject learning turns out to be more effective, including the learning of mathematics which is often considered by the students or learners as a tough subject. As to Patrick & colleagues (Patrick et al, 2016), study conducted in Tanzania, Africa showed that more than 50% of teachers in terms of preparedness for classroom technology integration were not prepared with the content or the knowledge of the ICT for education at their research institution Nelson Mandela African Institution of Science and Technology, Tanzania. However, with the fact with this

percentage index and the lack of technological knowledge in modern-day society a teacher would make knowledge transferred to other learners or students completely obsolete. It is only by the means of bargaining the connection between the three essential elements such as TK, CK, and PK a true classroom technology integration can be achieved.

As per Bakir (Bakir, 2015), the trust in the proficiency to exercise ICT and the degree of understanding of the content rendered to teaching becomes highly effective in schools. Therefore, as per the results gathered in the study by Niess & Colleagues (Niess, 2009), show that teachers engaged in teaching particular subjects such as mathematics with sufficient TPACK identify that the ICT have an optimistic influence on them in addition to.

- Free, integrated, and paid access to various educational & learning resources for teaching and training.
- Ease of communication with fellow partners, teachers, and educators sharing of ideas, and concepts on different types of teaching and learning approaches.
- Implementing creative, interactive, and innovative teaching and learning practices and the facilitation of interactive lessons.
- Ability to perform administrative tasks.
- High level of confidence in exercising the correct form of pedagogical approach to achieve optimum results.

Therefore, teachers must harness and build their TPACK capabilities alongside good self-confidence (Muhtadi, 2017). Other studies by Leendertz & colleagues (Leendertz. et.al, 2013), highlight that the TPACK capabilities can be regarded as a central element for future teachers according to the subject expertise in language or science & mathematics. The TPACK framework is not only designed to help teachers integrate technology into the pedagogy but also helps students develop the ability to

understand a particular topic or subject with much ease and as per their learning pattern.

According to the research on TPACK's capabilities and its influence on student performance Tanak (Tanak, 2018), highlights that fast-paced technological developments in the 21st century have transformed the pedagogical style. Therefore, it is considered essential that teachers incorporate technology into their teaching practice in the classroom, particularly for specific subjects or topics. According to Tanak (Tanak, 2018), TPACK's capability is crucial for developing students' credentials. There are numerous positive impacts of ICT in education, and it is there to stay as we see smartphones have become an essential part of students, teachers, or any individual's life. Therefore, it is crucial to develop educational content and exercise the use of ICT in delivering that educational content to students with the TPACK framework as it helps in validating what digital tool is suitable for the teacher & the students.

Final statements

There is still a fair share of critics for TPACK, but the framework is still relevant. There are many research & innovations; study communities that understand and implement different aspects of TPACK globally. As per (Mary C. Herring, 2016), TPACK's official website that is <http://tpack.org/> consists of over 6,000 registered users who have common shared interests that together have compiled a detailed bibliography of TPACK-related literature involving over 600 articles and which is swiftly growing. Further as per (Voogt, Fisser, & Roblin, 2013), a survey of this bibliography shows the deep research and diverse topics that have been researched. People usually need help in different areas of their study and research. These include areas such as mathematics, science, social studies, history, and music. The TPACK framework has been around for years and is starting to get more attention. It brings together people from all over who are interested in learning more about this theory and how it can be used in practical ways like education. According to (Insook, Ko, & Li, 2015), a teacher's PCK (pedagogical content knowledge) can change and mature over time, which makes them more effective at

teaching. Some teachers might already have a high level of maturity to do their job with minimal guidance, but others need support.

6. Methodology

According to Snyder (Snyder, 2019), a literature review is a method that helps to compose, clarify and focus the subject of a study. Literature reviews are useful when the aim is to provide an overview of the body of current literature in a certain area or to examine the validity or accuracy of a theory or competing theories. In addition, as per (Tranfield, Denyer, & Smart, 2003) systematic literature reviews (SLR) are useful when establishing research questions and need answers regarding specific points or issues in the field. Further literature reviews can be conducted to evaluate the state of knowledge on a particular topic; for example, to create research agendas or identify research gaps. It can also be useful if the aim is to engage in theory development or simply discuss a particular matter. As stated by (Thomé, Scavarda, & Scavarda, 2016, p. 409) a systematic literature review (SLR) is a highly detailed, systematic investigation of the available data. It is a veritable overview of existing research that aims to answer specific research questions. This type of research article is used by researchers in many disciplines for enhancing the value of what they have already discovered. In general, literary reviews can be divided into qualitative and quantitative research; they may or may not be included in a scientific publication.

For this article, the research method utilized is the systematic literature review, which aims in the direction to give an overview of how the exercise of digital learning tools for education can be exploited to its optimum potential by incorporating the TPACK framework capability of the teachers and how it can influence on the students' performance. Further, it also helps to understand what type of digital learning or information and communication tools (ICT) higher education institution HEIs can adopt or use for their educational purposes in context with the knowledge and capabilities of

their teachers & students.

7. Data Collection

The systematic literature review (SLR) was done according to the secondary data in the form of journals, articles, e-books, and reports. The data was collected, studied, and analyzed through various scientific journals available on the internet from various publishers and authors. Some of the publishers where the scientific journals were cited are ScienceDirect, which has scientific or medical articles, ScienceDirect is a good place to start when the research is more concerned with secondary data in the form of a literature review. Science Direct currently hosts over 18 million pieces of content from nearly 4,000 academic journals and 30,000 e-books. Another publisher is Elsevier, which is one of the world's biggest academic publishers, based in the Netherlands. It specializes in scientific, technical, and medical publications for a wide range of industries.

8. Data Sampling

For this article, the data sampling is done as per the academic needs. The cited articles and journals that have been analyzed and studied are the ones that describe the benefits of the TPACK framework and talked about its limitations. Articles that discussed case studies were given higher priority, as they give an anchored validation to the systematic literature review. The emphasis was given to articles with keywords (TPACK) technological pedagogical content knowledge and more stress was given to cite literature from recent years and not older than 2010, however, in some cases where and when the model was created by Davis, the article does require citations and references from yesteryears. The data was collected as per the need of the paper and literature that discussed TPACK instrument measuring such as (The Correlation Between Social Media Usage in Academic Context and Self-Efficacy towards TPACK) were omitted and not included in this study as the main aim of this article is to understand how TPACK framework can help teachers, learners, and educational institutions overcome educational transformations and trends as time progresses. The paper does not analyze how much

social media or any digital platform is utilized in a particular HEI or educational setup but how incorporating the TPACK framework can help educational institutions to understand their adopted form or technology, educational content, and the pedagogical approach is accepted by the end user for the learning outcomes.

9. Conclusion

ICT with the help of the TPACK framework can be used as validating tools, self-knowledge evaluation tools, and knowledge-enhancing tools to foster pivotal and creative philosophy, and genuine and creative issues resolving. Teachers will need regular training with changing ICT trends to master their skills to formulate lessons that are integrated with technology even with the TPACK framework. To exploit the ICT to its optimum teachers must incorporate the TPACK framework, which involves selecting the right content in accordance with the digital platforms, figuring out the correct pedagogical approach and method, and assessing the learners as per their learning patterns. Learning that allows student participation by teachers, creates learning and teaching possibilities that are following developing trends. It's only through a simultaneous change in the technological, human service, and management domain that the full potential of digital learning can be realized.

References

- Bakir, N. (2015). An exploration of contemporary realities of technology and teacher education: lessons learned. *Journal of digital learning & teacher education*, vol. 31(3), pp. 117-130. doi:10.1080/21532974.2015.1040930
- Chai.et.al, C. S. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society*, vol. 16(1), pp. 31-51. Retrieved March 28, 2022 from https://www.researchgate.net/publication/290044779_A_Review_of_Technological_Pedagogical_Content_Knowledge
- Chinnappan, M. (2009). *Role of mobile digital technology in fostering the construction of pedagogical and content knowledge of mathematics*, pp.75-86. Retrieved April 28, 2022, from <https://ro.uow.edu.au/edupapers/83>
- educationalappstore. (2022). *Best educational apps*. Retrieved Mar 25, 2022, from <https://www.educationalappstore.com/>
- Fernandez, C. (2014). Knowledge base for teaching and pedagogical content knowledge (pck): some useful models and implications for teachers' training. *Problems of Education in the 21st Century*, vol.(1), pp. 79-100. Retrieved Mar 25, 2022
- Harris, J. & Matt Koehler, &. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, vol. 9(1), pp. 60-70. Retrieved March 20, 2022, from https://www.researchgate.net/publication/241616400_What_Is_Technological_Pedagogical_Content_Knowledge
- Hernawati & Jailani. (2019). Mathematics mobile learning with TPACK framework. *Journal of Physics: Conference Series 5th ICMSE2018*, 1-8. doi::10.1088/1742-6596/1321/2/022126
- Insook , K., Ko, B. & Li, W. (2015). Effects of improving teachers' content knowledge on teaching and student learning in physical education. *Research Quarterly for Exercise and Sport*, vol. 86(2), pp. 130-139. doi:<https://doi.org/10.1080/02701367.2014.987908>

- Keengwe, J. O. (2009). Technology and student learning: towards a learner-centered teaching model. *2009 Association for the Advancement of Computing in Education (AACE)*, vol. 17(1), pp. 11-22. doi:1065-6901
- Leendertz.et.al, V. (2013). Echnological pedagogical content knowledge in South African mathematics classrooms: a secondary analysis of SITES 2006 data. *Journal of the association for mathematics education of South Africa* , vol. 34(2), pp. 1-9. Retrieved April 22, 2022, from <https://pythagoras.org.za/index.php/pythagoras/article/view/232/360>
- Listiawan.et.al. & Purwanto, A. R. (2018). Mathematics teachers Technological Content Knowledge (TCK) in using dynamic geometry software. *Journal of Physics: Conference Series*, 1-9. doi:10.1088/1742-6596/1114/1/012121
- Mary C. Herring, M. J. (2016). *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators*. New York , USA: Routledge.
- Mkoehler. (2011). *Using the TPACK image*. Retrieved Apr 2022, 2022, from <http://tpack.org/>
- Muhtadi, W. B. (2017). The Integration of technology in teaching mathematics. *Journal of Physics: Conference Series The First Ahmad Dahlan International Conference on Mathematics and Mathematics Education*, 943. doi:10.1088/1742-6596/943/1/012020
- Niess, R. N.K. (2009). Mathematics Teacher TPACK Standards and Development Model. *Cite Journal*.
- Patrick.et.al. (2016). Classroom ICT integration in Tanzania: opportunities and challenges from the perspectives of TPACK and SAMR models. *International Journal of Education and Development using Information and Communication Technology*, vol. 12(1), pp. 107-128. doi:1814-0556
- Sahin, I. (2011). Development of survey of Technological Pedagogical and Content Knowledge (TPACK) . *TOJET: The Turkish Online Journal of Educational Technology* , vol. 10(1), pp. 97-105. Retrieved Mar 28, 2022
- Schoenl & Fusarelli (2008). Innovation, NCLB, and the fear factor: the challenge of leading 21st century schools in an era of accountability. *SAGE Journals*, vol. 22(1). doi:10.1177/0895904807311291

- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, vol. 104, pp. 333-339. doi:<https://doi.org/10.1016/j.jbusres.2019.07.039>
- Steinle, V. & Lynda Ball, C. B. (2013). Mathematics education : yesterday, today and tomorrow. *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia*, Vol. 2, pp. 816. doi:9780734048448
- Tanak, A. (2018). Designing TPACK-based course for preparing student teachers to teach science with technological pedagogical content knowledge. *Kasetsart Journal of Social Sciences*, pp. 53-59. doi:10.1016/j.kjss.2018.07.012
- Tay,et.al. (2012). Pedagogical approaches for ICT integration into primary school English and mathematics: a Singapore case study. *Australasian Journal of Educational Technology* , vol. 28(4). doi:<https://doi.org/10.14742/ajet.838>
- Thomé, A. M., Scavarda, L. F. & Scavarda, J. A. (2016). Conducting systematic literature review in operations management. *Production Planning & Control the management of operations*, vol. 27(5), pp. 408-420. doi:<https://doi.org/10.1080/09537287.2015.1129464>
- Tranfield, D., Denyer, D. & Smart , P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*,, vol. 14, pp. 207-222. doi:10.1111/1467-8551.00375
- Voogt, J., Fisser, P. & Roblin, N. (2013). Technological pedagogical content knowledge - a review of the literature. *Journal of computer assisted learning*, vol. 29(2), pp. 109-121. doi:10.1111/j.1365-2729.2012.00487.x