Theories and Models Employed to Understand the Use of Technology in Education: A Hermeneutic Literature Review

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Abstract

Research that employs theory provides a framework and structure in which complex phenomenon, can be understood. While many theories have been developed to study people's technology usage, the plurality of perspectives offered are complex to navigate due to the diverse range of problems and topics addressed and the varied theoretical foundations used. Moreover, when focusing on the integration of technology within educational contexts, studies conducted by researchers with a technology focus mainly explore how and why using technology benefits education. On the contrary, studies driven by educational researchers do not necessarily advocate for technology integration but rather aim to explore the educational issues surrounding the use of technology. While triangulating theories can expand knowledge, selecting the most appropriate and suitable theory is often confusing and overwhelming. This paper is aimed at assisting and guiding researchers with this problem. A hermeneutic approach was followed to review the different theories and models commonly used to study technology acceptance/adoption/use within education, whilst catering for methodological diversity and cross-disciplinary dialogue. The dimensions of aims and purpose, strategy, paradigm, and perspective and value of technology were used to categorise the different theories, with four categories emerging. The review indicates that for researchers with a positivist paradigm, technocentric view, and who aim to predict or prescribe technology use in a normative manner, the categories of technology acceptance/adoption/use theories and education and technology models are most suitable. However, for researchers with an interpretivist paradigm who view technology as an enabler and aim to explain social dynamics of technology adoption in a descriptive manner, the categories of social theories and structuration theories are most appropriate. In addition, the categorisation of theories and the detailed account of the hermeneutic review method can be used to guide future researchers wanting to pursue similar studies.

Keywords Technology; Information Systems; Education; Technology; Adoption; Technology Acceptance; Technology Integration; Social Theories; Structuration theories; Hermeneutic Literature Review

1 Introduction

Theory, derived from the Greek word *theoria* is "an explanation of a phenomenon arrived at through the examination and contemplation of relevant facts" (Oxford & Dictionaries, 2019). While Bacharach (1989) proposes all theories aim to organise complex relationships among different concepts within given boundaries and constraints through answering questions, Sovacool & Hess (2017) argue that there is no consensus as to the definition of 'theory'. Consequently, multiple views of theories exist, with some theories offering prescriptions to be followed, some providing statements as a lens for viewing or explaining the world, and others offering testable propositions for empirical investigation (Gregor, 2006; Reeves et al., 2008) claim that utilising theories for research is essential, as theories provide a framework to understand complex phenomena, such as the workings of societies and organisations, and how and why people behave and interact in generalised and specific contexts. Furthermore, Gregor (2006) claims that developing theories are essential within academia as they enable researchers to inform practice through the accumulation of knowledge in a systematic manner. According to Moore & Benbasat (1991) undertheorised research is futile because it only solves immediate research problems, whereas research that employs theory provides the structure and foundation for the research phenomenon to be explained (Mueller & Urbach, 2013); enables one to make sense of the intrinsic complexities and lack of order in the world (Kimmons et al., 2020); and offers researchers a roadmap of how to conduct empirical work (Jackson, 2005). However, for theories to be useful, they need to offer an understanding of the research phenomenon and be applicable to the specific discipline (Lewin, 1951; Stewart & Klein, 2016).

Regarding technology use [1], theories have been developed to answer questions, explain, predict, and assess people's technology usage (Taherdoost, 2018). As the field of Information Systems (IS) studies the impacts and influences of technology on the behaviour of individuals, groups, and organizations in a wide range of contexts (Hirschheim & Klein, 1989) and draws on multiple disciplines such as computer science, operations, sociology, and psychology (Orlikowski & Baroudi, 1991; Halawi & McCarthy, 2006), many technology adoption theories fall within this field. Over the last thirty years numerous theories have been developed to facilitate investigation into varied questions and to enhance the breadth and depth of generated knowledge. Tarhini et al., (2015) contend that selecting the most appropriate model is extremely difficult due to the diverse range of problems and topics addressed, the varied theoretical foundations used, and the plurality of perspectives (Orlikowski & Baroudi, 1991). Furthermore, when focusing on technology integration within education, Mama & Hennessy (2013) state that even though research in this field spans many decades, much of the findings are inconsistent, contradictory, or unconvincing. A possible reason may be that researchers mainly focus on the integration of technology within educational contexts when exploring how and why using technology benefits education (Cuban, 1993, 2001; Prensky, 2010; Lim et al., 2013; Ertmer et al., 2015; Nkula & Krauss, 2015; Avidov-Ungar & Forkos-Baruch, 2018). Additionally, technologically deterministic researchers (Gellerstedt et al., 2018) have an implicit bias as they assume the goal of technology integration to be adoption, with non-adoption considered a failure (Straub, 2009). On the other hand, studies driven by educational researchers do not necessarily advocate for technology integration but rather aim to explore the educational issues surrounding the use of technology (Vandeyar, 2014; Lawrence & Tar, 2018).

Consequently, selecting an appropriate theory is not trivial, but rather confusing and overwhelming as no specific theory or perspective dominates (Halawi & McCarthy, 2006). Furthermore, researchers also need to consider what theories exist within both fields of study (technology and education), decide which is most suited to their particular research problem (Stewart & Klein, 2016), and then explicitly utilise the chosen theory to collect, analyse, and present their findings (Hennessy et al., 2005; Jones & Czerniewicz, 2011; Lim et al., 2013; Sovacool & Hess, 2017; Hew et al., 2019). Therefore, a holistic view is needed to offer researchers a wide-range of potential theories to be used when researching topics related to the use of technology within educational contexts.

2 Objective and Research Question

This paper aims to provide an analysis and synthesis of theories used to investigate technology adoption within education from various perspectives. This paper is important as it will enable researchers to not only appreciate the main theories used to explore technology and education but will also assist them in selecting other theories which might be more appropriate for their research. The paper intends to answer the following research question: *What are the different theories used to study technology adoption and use within an educational context?*

The paper presents a rationale for the hermeneutic literature review method used to identify, select, and analyse the relevant theories within the fields of technology and education. Next, a brief overview of the hermeneutic framework, details of how it was implemented within this literature review, and the categorisation dimensions selected, are explained. Utilising the results, the different categories of theories commonly used to study technology and education are then presented along with brief descriptions of each theory, and a comparative table of the theories within each category. A discussion is then provided along with rationales for the theory categorisations and guidelines to assist researchers in selecting the most appropriate theory for their research. Finally, the limitations encountered, and conclusion are presented.

3 Methodology

Stand-alone literature reviews are important as they develop knowledge by bringing together different perspectives and dimensions within research (Green et al., 2006; Okoli & Schabram, 2010; Rowe, 2014; Boell & Cecez-Kecmanovic, 2015a; Geeling et al., 2016; Snyder, 2019). According to Xiao & Watson (2019) and Watson (2015), literature reviews facilitate academic enquiry by building knowledge through creating awareness of existing research via identifying relevant scholarly work, and then offering an understanding, interpretation, and critical assessment within a particular domain (Snyder, 2019; Boell & Cecez-Kecmanovic, 2014, 2015a, b).

Systematic Literature Reviews (SLRs) are becoming increasingly popular as they minimise researcher bias (Snyder, 2019) and offer reproducible and systematic processes to identify research gaps and deliver a comprehensive overview of all available evidence on a given topic (Xiao & Watson, 2019; Boell & Cecez-Kecmanovic, 2015a, b; MacLure, 2005) argue that this does not mean other literature review methods are inferior, but rather that they vary in

terms of being less or more systematic (Okoli & Schabram, 2010). Even though all literature reviews can benefit from being more systematic (Boell & Cecez-Kecmanovic, 2015a, b; MacLure, 2005; Snyder, 2019) contends a solely systematic approach is not suitable for all studies. Snyder (2019), Rowe (2014), Boell & Cecez-Kecmanovic (2015a; 2015b) and MacLure (2005) suggest that an emergent process is preferable when the review is done across different disciplines and reviewing all relevant papers is not possible as it encourages learning from interrelated fields of research and enables researchers to provide a more holistic overview of the particular research topic. Boell & Cecez-Kecmanovic (2014), Rowe (2014) and Geeling et al., (2016) propose using a hermeneutic review as an alternative.

A hermeneutic approach is still systematic and clearly outlines search and selection procedures (Boell & Cecez-Kecmanovic, 2015b), but encourages methodological diversity (Watson, 2015) through repeated and continuous integration between the searching of texts with the researcher's interpretation. Each added paper influences the understanding of the research topic (Boell & Cecez-Kecmanovic, 2010). As this paper aims to provide an overview of theories originating from different disciplines i.e., technology and education, a hermeneutic approach has been used to facilitate a cross-disciplinary dialogue between researcher and text with constant movement between exploring each theory independently, and then understanding how each theory contributes to a shared meaning (Boell & Cecez-Kecmanovic, 2015a, b) of technology adoption, acceptance, and integration within an educational context.

3.1 Overview of Hermeneutic Literature Reviews

The hermeneutic approach to literature reviews is interpretive in nature (Geeling et al., 2016) and involves a cyclical process that assists researchers continually identifying relevant literature, and in doing so adopting new areas of focus until the addition of more literature makes no substantial contribution to a better understanding of the research phenomenon (Boell & Cecez-Kecmanovic, 2010). According to Boell & Cecez-Kecmanovic (2010; 2014; 2015a) the process repeatedly identifies a small number of extremely relevant papers, with each successive iteration resulting in a better understanding of the particular phenomenon. The hermeneutic circle, which constantly moves between understanding individual pieces of the literature, to obtaining an overall picture of the entire research area (Gadamer, 2004), begins with searching for relevant literature with either field searches or the use of search operators (Boell & Cecez-Kecmanovic, 2010, 2014, 2015a). The papers found are then sorted based on factors such as relevance, citations, publication date, and the title, abstract, and keywords, which are then analysed for relevance (Boell & Cecez-Kecmanovic, 2010, 2014; Rowe, 2014). Thereafter, full texts of the selected papers are read to identify and understand important concepts, to become acquainted with the discourse used, and to discover how different authors interpreted similar results (Boell & Cecez-Kecmanovic, 2010). Lastly, methods such as reference tracking i.e., the refinement of search criteria, are used to identify further relevant literature and then the hermeneutic cycle begins again. This process continues until saturation is reached (Boell & Cecez-Kecmanovic, 2010, 2014; Rowe, 2014). While the graphical representation of the hermeneutic circle for reviewing literature (see Fig.1) depicts each stage taking place in a sequential manner, in reality all processes are iterative, interwoven, and inform each other (Boell & Cecez-Kecmanovic, 2010, 2014).

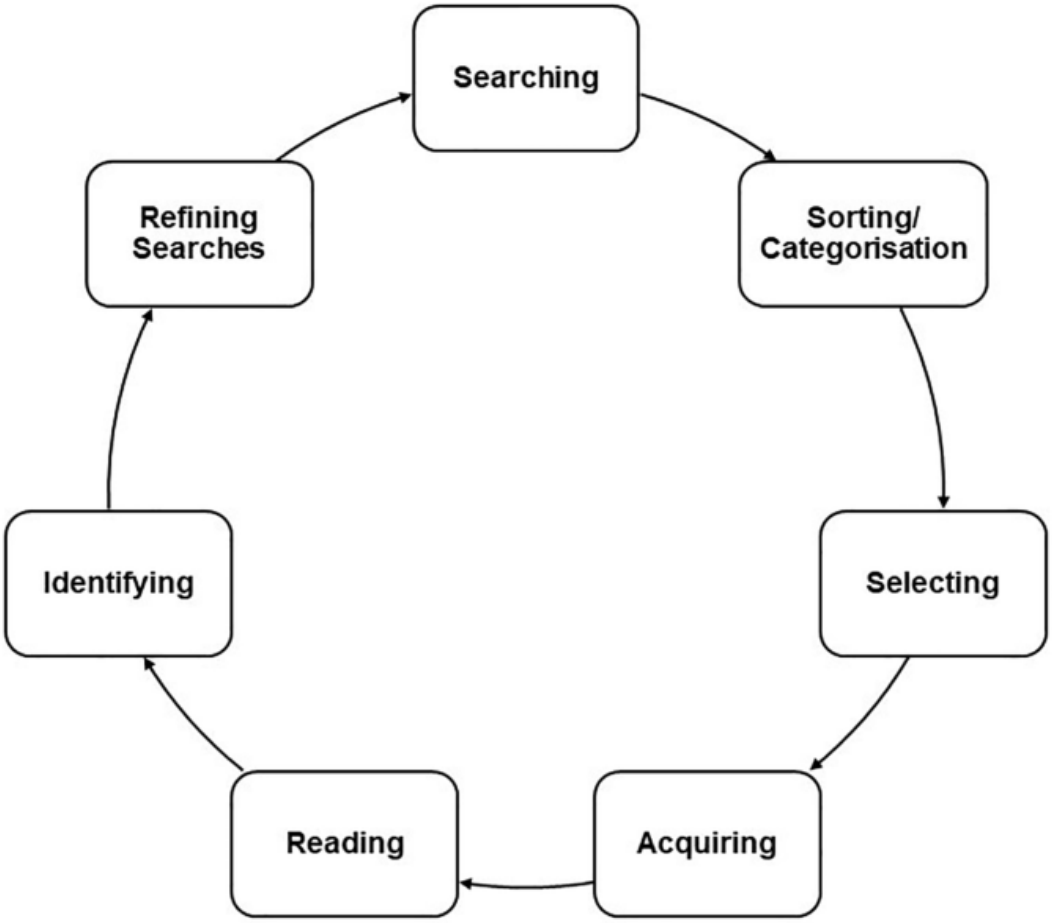

Fig. 1. Hermeneutic Circle for reviewing literature

(Boell & Cecez-Kecmanovic 2010; 2014)

3.1.1 Categorisation

According to Pothos & Wills (2011), categorisation involves the identification of the shared characteristics of the different objects, events, ideas, or theories and the organisation and the subsequent classification of these elements into higher-level groups. McGarty, Skorich and Mavor (2015) contend that categorisation does not only simplify the researcher's understanding, but also aids in making sense of the world (Kimmons et al., 2020), and provides coherence to the diverse theories and models used to understand technology use within the field of education (Tondeur, Petko, Christensen, Drossel, Starkey, Knezek & Schmidt-Crawford, 2021). Vergne & Wry (2014) claim that using categorisation plays a crucial role in developing coherence, as it groups together items with common attributes, which in turn assists researchers in making sense of vast amounts of information. Furthermore, Sovacool and (2017) argue that categorisation enables researchers in selecting the most appropriate, best-fit theory for the goals and aims of their study.

When categorising elements, it is necessary to first define the dimensions or characteristics to be considered (Vergne & Wry, 2014). Drawing on the theory categorisation work of Gregor (2006), Kimmons et al., (2020), Sovacool & Hess (2017), and Tondeur et al., (2021),

the following four dimensions have been selected for this study: (i) *aims and purpose* describing what the theory is trying to achieve i.e., prediction, explanation, or description (Gregor, 2006; Kimmons et al., 2020; Sovacool & Hess, 2017; Tondeur et al., 2021), (ii) *strategy* describing whether the theory attempts to provide explanations of individual choices within a specific social context i.e., descriptive, or aims to provide an account of whether technology positively or negatively affects the choices individuals should make i.e., normative (Sovacool & Hess, 2017), (iii) *paradigm* describing the underlying view of the researcher (Gregor, 2006; Sovacool & Hess, 2017), and (iv) *perspective and value of technology* describing whether the theory views technology use as a goal or a way to address educational issues (Kimmons et al., 2020).

Even though the categorisation of theories is not static (Sovacool & Hess, 2017) and the boundaries are often 'fuzzy' (Vergne & Wry, 2014), the process followed in this study represents a classical view, where dimensions are clearly defined; membership depends on meeting all specified criteria; and any entity can only belong to one category (Smith & Medin, 1981). However, as theories are often multifaceted and complex, it is possible that they may not entirely fit into only one category (Sovacool & Hess, 2017). Furthermore, a theory may also belong to other categories depending on the dimensions not considered in this study. Additionally, although the process of creating categories and assigning theories to categories is explicitly explained, it is still possible that these theories could be categorised differently by other researchers, depending on their analysis of the theories' characteristics (Sovacool & Hess, 2017). Lastly, while categorisation is important as it provides a lens to systematically consider theory choices, Sovacool & Hess (2017) propose triangulation of categories and integration of theories should also be considered to facilitate deeper understandings of research phenomenon.

3.2 Conducting the Hermeneutic Literature Review

The hermeneutic review process was carried out in stages, with several iterations taking place to ensure that a holistic list of theories and models, appropriate for researching technology use within education, were identified. Details of each iteration and the decisions made about categorisations, are presented in the sections below. It is important to note that even though many articles were found using the above searches, in line with the aims of the paper and as it is not possible to identify all relevant theories and models across multiple disciplines (Snyder, 2019; Rowe, 2014; Boell & Cecez-Kecmanovic, 2015a, b; MacLure, 2005), only relevant articles related to the most common and well-known theories and models were selected.

3.2.1 Iteration 1 - Initial Search and Categorisation

The review process started off with searching for literature using relevant terms and concepts relating to the study's research question. The preliminary search words included: 'technology adoption', 'technology acceptance', and 'technology integration'. The Boolean operator 'OR' was used, as papers including any one of these terms were considered relevant (Boell & Cecez-Kecmanovic, 2014). Searches were conducted on Google™ and Google Scholar™, as these multi-disciplinary, open access databases cover a wide-range of

journals and academic grey literature, such as conference proceedings, reports, and theses (Xiao & Watson, 2019; Boell & Cecez-Kecmanovic, 2014).

According to Bodoff (2009) it is impossible to predefine all relevant search terms as changes and refinements are needed as more is learnt about the phrases used within the body of literature (Boell & Cecez-Kecmanovic, 2015b). The initial search terms resulted in a vast number of articles, but on reading the titles and abstracts of the papers, it became evident that the words 'theories' OR 'models' had to be added to the search terms to find more appropriate papers. Even though Tondeur et al., (2021) claim theories are more theoretical than conceptual, the words 'theory', 'model' and 'framework' words were used to conduct the search as they are often used interchangeably (Sovacool & Hess, 2017; Kimmons et al., 2020). While the refined search string still returned numerous articles, after reading the title, keywords, and abstract of the papers (listed on Google Scholar™ up to the fourth page), only papers directly related to the research question were selected. This resulted in an initial total of 34 papers, of which the full text was acquired and read in detail.

Thereafter, categorisations were done by identifying commonalities between the theories, using the four dimensions selected for this study. From this initial assessment (which included only theories with normative strategies, positivist paradigms, and implicitly bias views of technology) two categories emerged: *technology acceptance* and *adoption theories* (30 papers), where the primary aim is to predict technology use; and *education and technology models* (4 papers), where the primary aim is to prescribe and describe the levels of technology adoption. It is noteworthy that within both categories most authors have technocentric views and advocate for greater technology integration within educational contexts.

3.2.2 Iteration 2 - Refined Search and Categorisation

According to Boell & Cecez-Kecmanovic (2010; 2014), initial searches need to be refined to minimise irrelevant literature and identify additional papers or theories, based on an initial understanding of the research topic. Additional terms such as 'theories of technology, 'teaching', and 'education' were used with the Boolean operator 'AND' to ensure that papers matching both search terms would be retrieved (Boell & Cecez-Kecmanovic, 2014). Furthermore, the search term 'teaching with technology' was added to assess whether theories used to specifically research the use of technology within an educational context had been missed. To further understand education and technology models identified from the initial search, the terms 'levels of technology use', and 'stages of technology integration' were also added. The Boolean operator 'OR' was again utilised to ensure that any papers matching at least one search term, would be retrieved (Boell & Cecez-Kecmanovic, 2014). In this way, an additional 18 papers were identified, read and added to the *education and technology models* category as their primary aim was to describe teachers' progressive levels of technology use. As with the previous theories placed into this category, the paradigms operated from positivistic viewpoint, with normative strategies, and implicitly biased views of technology.

3.2.3 Iteration 3 - Search for Information Systems and Social Theories and Additional Categories

After reading the papers found using the initial and refined search terms, it was evident that additional theories are being used to research the social aspects of technology integration within education. An additional search was therefore conducted after adding the terms 'information systems theories' and 'social theories'. This search resulted in 46 papers being identified.

In addition to identifying key social theories used to research technology adoption within education, Structuration Theory (ST) (Giddens, 1984) was also found to be an important social theory and thus further searches were conducted adding the terms 'structuration theory', 'technology acceptance' and 'technology adoption' using the Boolean operator of 'AND'. This resulted in an additional 17 papers detailing the use of ST and its theoretical descendants for understanding technology integration in education.

As the search terms used were constructed to identify social theories, only social theories were found, and therefore an additional category called *social theories* was created. However, even though structuration theory is considered a social theory, the principles of structuration as defined by Giddens' (1984), and the subsequent adapted models are more complex than traditional social theories. Thus, a separate category named *structuration theories* was also added.

3.2.4 Iteration 4 - Reference Checking, Journal and Author Searches

Reference tracking (backward searching), which is an effective and powerful way to identify further studies by using the list of references at the end of a paper (Boell & Cecez-Kecmanovic, 2010), was then utilised to identify further relevant papers (Xiao & Watson, 2019). Next, Bradford's law of scattering, which states that most articles related to a specific topic are published in a handful of 'core' journals (Bradford, 1934; Boell & Cecez-Kecmanovic, 2010), was used to identify popular and well-known journals in the fields of technology and education. The journals searched in this regard include Computers and Education, Computers in Human Behaviour, Journal of Research on Technology in Education, Education Research Review, Review of Education Research, and EduTech Research and Development. In addition, to ensure the articles found and selected offered a holistic overview of the theories used to study technology and education, searches were also conducted using the names of key authors in both fields (Hennessy, D'Angelo, McIntyre, Koomar, Kreimeia, Cao, Brugha & Zubairi, 2022; Okoli & Schabram 2010; Boell & Cecez-Kecmanovic, 2010). The list of information systems theories by Larsen & Eargle (2015) was also accessed and checked to ensure that the most common and well-known theories had been included in the review. Lastly, the researcher carried out 'backtracking of searches' to ensure that new studies published after the first round of searching, were also included (Hennessy et al., 2022; Okoli & Schabram, 2010). Following this process an additional 17 articles were added to the review.

According to Levy & Ellis (2006) and Xiao & Watson (2019) searching ceases when repeated searches provide the same results, with no new information being obtained. As additional

searches did not identify any significant or further relevant theories, saturation was reached, resulting in a total of 129 'theory' papers included in this literature review[2]. A summary of the search process conducted and number of articles found can be found in Table 1.

Table 1 Summary of the Search Processes

Search Terms	Papers	Description
Iteration 1		
Technology adoption models/theories OR Technology acceptance models/ theories OR Technology integration models/ theories	34	As initial search terms returned a vast number of articles, search terms were adjusted to include the words 'models' and 'theories'. Articles identified were then briefly assessed and only those related directly to the aims of the research were selected for inclusion.
Iteration 2		
Theories of technology AND teaching Theories of technology AND education Teaching with technology Levels of technology use OR Stages of technology integration	17	Searches were then further refined, employing terms commonly used in educational technology literature, to focus models/theories that focus on education and teaching. Again, articles were briefly assessed and those relevant to the research topic were selected for inclusion.
Iteration 3		
Information systems theories Social theories	44	Searches were then conducted to identify additional technology adoption theories developed from a more subjective and social perspective. Again, articles were briefly assessed and those related to the research topic were selected for inclusion.
Structuration theory AND technology acceptance Structuration theory AND technology adoption	17	When searching for social theories, Structuration theory was identified relevant to the research topic, and thus searches were conducted to identify variations of the original Structuration theory. Articles were then screened, and those detailing structuration type theories were selected for inclusion.
Iteration 4		
Reference checking Core journals Key authors List of Information Systems theories Backtracking of searches	17	To ensure key theories and articles had not been omitted, reference lists of all articles included thus far were checked; all defined searches were conducted on well-known journals that publish technology adoption studies within education; searches were conducted using the names of key authors in both disciplines; the list of information systems theories was checked; and all searches were rerun to ensure that recent relevant studies were not missed.

The column named papers in Table 1, provides the number of papers selected to identify, categorise and describe the theories and models dealing with technology adoption and education

3.2.5 Hermeneutic Review – Theories and Categories

After completing the searching, sorting, acquisition, and reading process multiple times, a total of 19 theories were identified, to be included in the review. Theories were then sorted

and placed into the 4 categories, based on the theory's prevailing aim, strategy, paradigm, and view of technology.

To illustrate how the theories were assigned to categories, the process and decisions made in regard to one of the theories, i.e., Task Technology Fit (TTF), is detailed. Firstly, the prevailing aim, which describes what the theory is trying to achieve (Gregor, 2006; Kimmons et al., 2020; Sovacool & Hess, 2017; Tondeur et al., 2021), was assessed. Goodhue & Thompson (1995) state that the theory aims to measure and predict the impact of the fit between the task and the technology on performance, and thus TTF was categorised as being predictive. Secondly, the strategy, which defines the way the theory is actioned (Sovacool & Hess, 2017), was reviewed. Goodhue & Thompson (1995) claim that high fit between technology and task results in a positive perception of performance when using technology, and thus TTF was categorised as normative. Thirdly, the paradigm which describes the underlying view of the researcher (Gregor, 2006; Sovacool & Hess, 2017), was examined. TTF does not consider internal constraints that may limit technology use (Rail & Selnes, 2019), but rather aims to assess how technology impacts performance (Khan et al., 2018). Therefore, TTF was categorised as having a positivist paradigm. Lastly, the perspective and value of technology which describes how the theory views technology use (Kimmons et al., 2020), was assessed. TTF contends that performance improvements can only be realised once technology is utilised (Goodhue, 1988; Goodhue & Thompson, 1995), and was categorised as having a technocentric view [3].

While the initial selection and categorisation of theories and models in the paper was done by only one researcher, two other experienced academics in the field of technology and education, reviewed the entire search and categorisation process to minimise selection bias and ensure inter-rater reliability (Boell & Cecez-Kecmanovic, 2014, 2015a). Search terms, theories included, and categorisations were discussed and debated resulting in the adjustment of certain search terms, the separation of the social theory category into two categories, the inclusion of three additional theories, and a categorisation change for one theory. Table 1 provides a summary of the search processes.

The resulting categories, along with a brief description of each of the theories' origin, constructs, empirical research, and criticisms are presented next. Thereafter, the rationales used for the categorisations and the subsequent guidelines which could assist researchers when selecting the best-fit theory for their specific study, are detailed.

4 Review of The Theories and Models

4.1 Technology Acceptance/Adoption/Use Theories and Models

Admiral, Louws, Lockhorst, Paas, Buynsters, Cviko, Janssen, de Jonge, Nouwens, Post, van der Ven, and Kester (2017) contend that while much research has been conducted in relation to the central and critical role teachers play in the integration of technology in the classroom, the focus of technology acceptance theories is primarily not on the teacher but rather on technology-related factors. However, over the last few decades, various technology acceptance theories founded on psychosocial principles (Taherdoost, 2018), have been developed to explore the relationships between beliefs, attitudes, and

technology use (Chien et al., 2014). The most well-known and utilised theories identified in the review and detailed in the next section, include: Theory of Reasoned Action (TRA) (Fishbein & Azjen, 1975; Azjen & Fishbein 1980); Theory of Planned Behaviour (TPB) (Azjen, 1991); Technology Acceptance Model (TAM) (Davis & Venkatesh, 1996); Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003); Task Technology Fit (TTF) (Goodhue & Thompson, 1995); and Will, Skill, Tool and Pedagogy (WSTP) (Knezek et al., 2000).

4.1.1 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) hypothesises that people act in a certain way once they evaluate a behaviour as being positive and they believe significant people in their life will expect them to behave in the given manner (Fishbein & Azjen, 1975; Azjen & Fishbein 1980). While TRA was originally developed as a general theory to predict, explain, and influence human behaviour (Azjen & Fishbein, 1980), it has become known as the earliest technology adoption theory to gain widespread acceptance (Samaradiwakara & Gunawardena, 2014; Mamoni et al., 2017). In TRA, Fishbein and Azjen (1975) and Azjen & Fishbein (1980) created three main cognitive constructs: *attitude to act*, *perceived social norms*, and *intentions* to predict and explain human behaviour. Furthermore, boundary intention factors, which include stability over time, measurement, and choice were included to test and evaluate the model (Taherdoost, 2018; Khan & Qudrat-Ullah, 2021). According to Sugar et al., (2004), attitude evolves from a person's individual disposition and evaluation of individual beliefs regarding the specific behaviour's effectiveness in producing desirable outcomes.

TRA has not only been criticised for being too general (Al-Mammary et al., 2016), but according Knabe (2009) its assumption that people have the power to choose to act or not to act in a certain manner i.e., volitional control, is erroneous. Madden et al., (1992) and Taherdoost (2018) contend volitional control is not always possible, and thus a separate measurement of beliefs is needed relative to the necessary resources and opportunities that people have or perceive they have, for accomplishing a specific behaviour.

4.1.2 Theory of Planned Behaviour (TPB) and Decomposed TPB (DTPB)

In response to the criticisms levelled at TRA, the Theory of Planned Behaviour (TPB) developed by Azjen (1991), addresses the social context and attitudes towards behaviour by incorporating both internal and external factors that influence a person's behavioural intention. Within TPB, measures of attitude are *subjective norm*, *perceived behaviour contro*l, and *attitude toward the behaviour* – with each measure related to a set of beliefs (Lai, 2017). While TPB captures the complexity of the relationship between beliefs, attitudes, intention, and behaviour, Chien et al., (2014) claim that TPB does not specify types of beliefs, which makes the categorisation of beliefs challenging. In addition, TPB is only relevant if suitable access to technology exists (Taherdoost, 2018).

In response to this criticism, Taylor & Todd (1995) combined TAM and TPB to form the Decomposed Theory of Planned Behaviour (DTPB) in which beliefs are categorised into *normative beliefs* (significant others' approval of one's behaviour); *control beliefs* (resources

and opportunities that facilitate or hinder the behaviour); and *behavioural beliefs* (personal beliefs one has towards the behaviour) (Taylor & Todd, 1995; Smarkola, 2008; Kriek & Stols, 2010; Chien et al., 2014; Khan & Qudrat-Ullah, 2021). The hierarchical nature of DTPB enables researchers to simultaneously identify external conditions and personal beliefs considered by teachers when choosing whether to integrate technology into their classroom (Smarkola, 2008; Chien et al., 2014; Khan & Qudrat-Ullah, 2021) claim DTPB is a powerful theory that can be used to explore teachers' past experiences with technology and the connections between different types of beliefs, which are constructed from a system and subsystem of people's attitudes and values (Pajares, 1992; Rokeach, 1968).

4.1.3 Technology Acceptance Model (TAM, TAM2, TAM3)

The Technology Acceptance Model (TAM) developed by Davis & Venkatesh (1996), which has been used to research technology adoption for the last thirty years, is an extension of TRA (Mamoni et al., 2017) and provides a framework to study how people's beliefs around perceived usefulness, ease of use, and their intentions to use, influence their technology use (Davis & Venkatesh, 1996; Lai, 2017; Wibowo, 2019). *Perceived usefulness* refers to the degree to which a person believes that using technology improves their job performance, while *ease of use* refers to the belief that using the technology will be effortless (Davis, 1989). Both factors are said to influence users' behavioural intentions and resulting technology use (Davis & Venkatesh, 1996; Lai, 2017; Wibowo, 2019; Khan & Qudrat-Ullah, 2021).

While TAM remains one of the most popular and influential research theories to predict individual users' technology adoption and acceptance (Al-Mammary et al., 2016) as it is easy to use and enables the study of technology adoption in multidisciplinary fields (Wibowo, 2019; Lai, 2017; Chien et al., 2014; Straub, 2009) contend that the omission of additional personal beliefs, the prescriptive nature of the model, and the non-consideration of particular contexts, severely limit its explanatory power. Furthermore, Taylor & Todd (1995) and Smarkola (2008) argue that other personal beliefs and external factors may influence technology use, and thus TAM is not comprehensive enough to study the effects of external variables or social factors.

In response to these limitations, Venkatesh and Davis (2000) refined their model to provide more comprehensive explanations of the reasons users find technology useful by developing TAM 2 (Wibowo, 2019; Al-Mammary et al., 2016), whilst keeping the original constructs of TAM in place (Lai, 2017). According to Lai (2017), Al-Mammary et al., (2016), Samaradiwakara & Gunawardena (2014), TAM 2 hypothesises that users' perceptions of the usefulness of any technology, depends on how much they believe their work goals are augmented by using the system, and thus TAM 2 adds *social* influence processes and *cognitive instrumental processes* with variables such as subjective norm, image, output quality, and result. Subsequently, Venkatesh & Bala (2008) further developed TAM, referred to as TAM 3, by adding *individual differences*, *system characteristics*, *social influence*, and *facilitating conditions* as determinants, and experience as a moderating variable (Wibowo, 2019; Lai, 2017). While Mamoni et al., (2017) claim TAM 2 and TAM 3 enhance the predictive power of the framework, Samaradiwakara & Gunawardena (2014) argue that the

original TAM framework is still being used extensively, as the extensions have made subsequent versions confusing and less parsimonious.

4.1.4 Unified Theory of Acceptance and Use of Technology (UTAUT, UTAUT2)

The Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh et al., (2003), is a synthesis of previous technology acceptance theories (Lai, 2017; Samaradiwakara & Gunawardena, 2014; Taherdoost, 2018; Al-Mammary et al., 2016; Khan & Qudrat-Ullah, 2021). According to Venkatesh et al., (2003), the four antecedents of IS acceptance are performance expectancy, effort expectancy, social influence, and facilitating conditions. *Performance expectancy* (degree to which using the technology will enable and benefit one's work success) (Venkatesh et al., 2003; Blackwell et al., 2013); *effort expectancy* (perceived ease of use of the technology) (Venkatesh et al., 2003); *social influence* (subjective norms related to technology use within a particular social context) (Blackwell et al., 2013) describing the degree to which significant others are perceived to influence technology use (Venkatesh et al., 2003); and *facilitating conditions* (perception of resources and support available to utilise the technology) (Venkatesh et al., 2003), including training and access to technology (Blackwell et al., 2013). In addition, according to Venkatesh et al., (2003) four moderating variables also influence technology use, namely gender, experience, age, and voluntariness of use.

While UTAUT can explain most behavioural intention variances in relation to technology use (Venkatesh et al., 2003), and has been used widely to explain technology integration (Samaradiwakara & Gunawardena, 2014; Blackwell et al., 2013) argue that it has not been applied extensively within an educational context. UTAUT has subsequently been extended by Venkatesh et al., (2012) to address personal limitations such as beliefs, perceived value, and comfort with technology (Blackwell et al.,2013), with *hedonic motivation*, *price value*, and *habit behaviour* being added (Faqih & Mousa, 2022; Khan & Qudrat-Ullah, 2021). According to Faqih & Mousa (2022), UTAUT 2 is a more powerful framework which is extremely useful in investigating and predicting individual adoption of technology within differing cultural and social contexts.

4.1.5 Task Technology Fit (TTF)

Task Technology Fit (TTF), which was derived from the Technology-to-Performance Chain (TPC), was developed by Goodhue & Thompson (1995) on the premise that technology can only positively impact performance when the tasks being performed fit with the technology being used. Goodhue & Thompson (1995) claim prior research into user attitudes and beliefs in relation to technology use is limited, as it focuses either on utilisation (Davis, 1989; Fishbein & Ajzen, 1975) or fit (Benbasat et al., 1986; Dickson et al., 1986; Lai, 2017; Faqih & Mousa, 2022). However, Goodhue (1988) and Goodhue & Thompson (1995) contend that utilisation is not always voluntary, is complex by nature, and performance improvements can only be realised once the technology is utilised, therefore a model addressing both fit and utilisation simultaneously and in parallel is needed to provide a richer understanding of technology use.

The primary components of TTF are *tasks* (actions carried out by people when transforming inputs), which vary according to routineness, interdependence, and time criticality); *technology* (tool used to carry out the task), which can be hardware or software (Lin & Huang, 2008); and *task-technology fit* (degree to which the technology utilised meets the needs of the tasks being performed by an individual), which includes eight factors that measure task-technology fit: quality, locatability, authorization, compatibility, training, production timeliness, system reliability, and relationship with users (Goodhue & Thompson, 1995). Lastly, *utilisation* (application of the technology to achieve objectives or goals) and *performance impacts* (an individual's belief that utilising the technology will change their task execution), with a positive perception of performance resulting from a high task-technology fit (Goodhue & Thompson, 1995).

According to McGill & Klobasb (2009), TTF has been used extensively in many different fields to research the key role technology-fit plays in individual performance and use of IS. In an educational context, TTF has also been used to study a variety of topics (D'Ambra et al., 2013; McGill & Klobasb, 2009; McGill & Hobbs, 2006; Khan et al., 2018; Faqih & Mousa, 2022). While TTF considers the relationship between task and technology, Rai & Selnes (2019) argue that TTF does not provide a clear explanation of how the task environment affects technology use in multifaceted and inherently complex contexts. Furthermore, TTF simply assesses how technology affects performance by matching the task and technology characteristics (Khan et al., 2018) without considering teachers' internal constraints, which may limit their technology use. According to Fuller & Dennis (2009) TTF is not appropriate for studies where there is ongoing exposure to, and extended use of technology, as the ability to predict performance wavers as people transform or acclimatise to technology use.

4.1.6 Will, Skill, Tool, and Pedagogy Model (WSTP)

Originally developed by Knezek et al., (2000), the model incorporated three factors: will, skill and tool. The model was then refined by Knezek & Christensen (2016) to enhance its ability to predict the level of classroom technology integration, by incorporating pedagogy to include teaching style and teachers' level of confidence in using the technology. The current version consists of four interdependent and equally-important constructs that influence technology use (Tondeur et al., 2021). According to Knezek & Christensen (2016) *will* (positive attitude towards technology use); *skill* (person's ability and experience with the technology), which includes self-efficacy; *tool* (access to and availability of technology); *pedagogy* (how effectively the technology is used in the classroom); and *technology integration* (level of adoption of technology by the teacher for educational purposes). According to Tondeur et al., (2021) even though WSTP only focuses on the teacher's perspective of technology integration, its broad scope and flexibility allows for different measures to be used as inputs for the four constructs, depending on the context of where it is being used. Furthermore, Sasota et al., (2021) contend that not only is the model parsimonious, but it also offers researchers a multi-dimensional approach to understanding technology integration as it incorporates both internal (will, skill, and pedagogy) and external (tool) factors.

WSTP emphasises that the effective and pervasive integration of technology is dependent on all the constructs within the model being present (Tondeur et al., 2021; Knezek &

Christensen, 2016). For example, even when teachers have the will to use technology, but have little or no access to the technology, they are unable to integrate it into their teaching (Tondeur et al., 2021). In empirical studies Morales (2006) and Knezek et al., (2003), and Farjon et al., (2019) found that the initial and refined models accurately predict the majority of teachers' integration of technology. While its simplicity can be seen as advantageous, the lack of specified relationships between the four constructs makes it difficult to understand the model as a whole and can result in inconsistencies (Tondeur et al., 2021). However, even though the strength of the constructs' influence on technology integration differs depending on contextual factors, Sasota et al., (2021) argue that the model offers a credible way to predict and explain teachers' technology integration.

A summary of the technology adoption/acceptance/use theories employed in education, is provided in Table 2.

Table 2 Summary of Technology Adoption/Acceptance/Use Theories/Models

Theory	*Description*	*Criticisms*
Theory of Reasoned Action (TRA)	Peoples' intention is constructed from attitude to act and perceived social norms (Fishbein & Ajzen, 1975; Azjen & Fishbein, 1980)	Assumes people have the power to choose to act or not to act i.e., volitional control (Knabe, 2009)
Theory of Planned Behaviour (TPB)	Addresses the social context by incorporating the internal and external factors that influence behavioural intention (Azjen, 1991)	Does not specify types of beliefs which makes the categorisation challenging (Chien et al., 2014) Only relevant when suitable access to technology exists (Taherdoost, 2018)
Decomposed TPB (DTPB)	Categorised beliefs into different components of normative, behavioural, and control (Taherdoost, 2018)	
Technology Acceptance Model (TAM)	Studies how peoples' beliefs around perceived usefulness, ease of use, and their intentions to use, influence technology use (Davis & Venkatesh, 1996; Lai, 2017)	TAM does not consider the personal beliefs and context of people (Chien et al., 2014)
(TAM2, TAM3)	TAM2 and TAM3 added additional constructs to address individual beliefs and differences (Wibowo, 2019)	TAM2 and TAM3 are confusing and less parsimonious (Samaradiwakara & Gunawardena, 2014)
Unified Theory of Acceptance and Use of Technology (UTAUT)	Synthesizes previous technology acceptance theories with performance expectancy, effort expectancy, social influence and facilitating conditions (Venkatesh et al., 2003)	Fails to consider beliefs, perceived value, and comfort with technology (Blackwell et al., 2013)
(UTAUT2)	Addresses personal limitations with hedonic motivation, price value, and habit (Faqih & Mousa, 2022)	
Task Technology Fit (TTF)	Based on the premise that technology can only positively impact tasks when they are a good fit (Goodhue & Thompson, 1995)	Does not explain how the task's environment affects technology use in complex and multifaceted contexts (Rai & Selnes, 2019)
Will, Skill, Tool, and Pedagogy (WSTP)	Offers a multidimensional model to understand technology integration (Sasota et al., 2021)	Hard to understand as relationships between constructs are not specified (Tondeur et al., 2021)

4.2 Social Theories

According to Schütz (1962), the form of social theories does not differ from that of natural science theories, rather they diverge in the way empirical work is conducted, with social researchers subjectively interpreting observed human behaviour as it relates to shared meanings, context, and history. Lee (2004) contends that for some researchers the term 'social' in relation to theory describes any theory that researches individuals, while for others 'social' means theories that explore shared, socially constructed institutions. Common social theories used in technology and educational research (which align to these conceptions of social), identified in the review and detailed in the next section, include: Activity Theory (AT) (Engeström, 1987, 2001); Diffusion of Innovation (DOI) (Rogers, 1995, 2003); Actor-Network Theory (ANT) (Callon, 1986; Law, 1987; Latour, 1992;1993); Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006); and Pedagogical Beliefs-Technology Model (PBT) (Tondeur, 2020).

4.2.1 Activity Theory (AT)

Activity Theory (AT), which was originally developed by Leont'ev (1978), later incorporated Vygotsky's (1978) work on human agency. The second and third generation of AT, constructed by Engeström (1987; 2001), advances previous generations of AT to develop a theoretical model that facilitates the exploration of an activity system along with the identification and explanation of inconsistencies and points of conflict within the system (Karasavvidis, 2009). According to Hasan & Kazlauskas (2014: 9), in simple terms, AT "is all about who is doing what, why and how". Karasavvidis (2009) claims that while most technology theories simply focus on the technology alone, AT is a unique theory as it enables researchers to holistically and systematically study teachers' concerns in relation to technology integration in the classroom. Furthermore, Hashim & Jones (2007) state that AT provides a powerful way in which human activity regarding technology can be explored through multiple dimensions.

Elements of the activity system, which are graphically represented in a set of interrelated triangles, are *subject* (individual or group of individuals involved in the activity); *object* (motivation behind the activity); *tools* (symbols, signs, and conceptual understandings that mediate the activity between the subject and the object), which can be physical or psychological and change over time (Anthony, 2012); *rules* (conditions that influence how and why individuals act in a certain manner) (Kaptelinin & Nardi, 2006); *community* (explicit rules or social norms within a subject's social context or culture that control and influence behaviour); and *division of labour* (description of how tasks are shared among the members of the activity system). In addition, there are *contradictions* (cumulative structural tensions that generate disruptions to bring about change), which are a fundamental principle of AT (Engeström, 2001) and exist continuously in all activity systems (Engeström, 1987, 2001).

According to Kaptelinin & Nardi (2006), AT enables researchers to focus on understanding technology in relation to human activity and shift away from the dominating technocentric approach to understand how technology promotes change within specific contexts (Bellamy, 1996; Bannon & Kaptelinin, 2000; Murphy & Rodriguez-Manzanares, 2008) state that in technology is not central in AT, rather it is just one of the tools that mediate the

relationship between humans and their environment. To date, AT has been used extensively in education and technology research for a variety of studies with teachers as the core focus (Buell, 2004; Lim & Hang, 2003; Russell & Schneiderheinze, 2005; Devane & Squire, 2012; Kizito, 2015; Kirby & Anwar, 2020).

While Toomela (2000; 2008) argues that the use of AT is limited as it assumes a unidirectional relationship between the individual and culture and primarily focuses on the activity rather than the individual involved, Engeström (2009) claims AT is not a static theory but rather an evolving theory of object-driven activity, characterised by change.

4.2.2 Diffusion of Innovation Theory (DOI)

Diffusion of Innovation Theory (DOI) aims to explore factors that influence an individual's adoption of new technology (Al-Jabri & Sohail, 2012; Khan & Qudrat-Ullah 2021). Developed by Rogers (1995:5), innovations refer to things perceived as new by an individual; while diffusion is the "process by which an innovation is communicated through specific channels over time within a particular social system". DOI is a mature theory that has been applied extensively to technological innovations (Halawi & McCarthy, 2006) to explain how and why innovations proliferate within a specific social context (Al-Jabri & Sohail, 2012; Khan & Qudrat-Ullah 2021).

The four critical elements that influence the extent of diffusion of any innovation are the *new idea* itself; about what and how the innovation is *communicated* from one individual to another; the *social system* in which is it being introduced; and the *time* over which the diffusion of the innovation takes place (Rogers, 1995, 2003; Taherdoost, 2018) claims that diffusion is an ordered process involving five steps: acquisition of knowledge about the innovation; formation of an attitude towards the innovation; decision whether to reject or make use of the innovation; implementing of the innovation in practice; and searching for support for the adoption decision (Sahin, 2006; Straub, 2009).

In addition to these elements, Rogers (2003) identifies various attributes of an innovation that influences adoption behaviour: *relative advantage* (extent to which an innovation is perceived to provide more benefits than its precursor) (Moore & Benbasat, 1991) - the greater the perceived relative advantage, the more likely it is to be adopted (McCloskey, 2006); *complexity* (how difficult or easy the innovation is to understand and utilise) (Cheung et al., 2000; Straub, 2009) - is negatively associated with diffusion of the innovation (Rogers, 2003); *compatibility* (extent to which the innovation is perceived consistent with existing beliefs, habits, and experiences) (Chen et al., 2004); *trialability* (ability to experiment with the innovation before adoption) (Al-Jabri & Sohail, 2012; Tan & Teo 2000); and *observability* (degree to which the benefits of the innovation are observed, communicated, and visible to the members of a specific social system) (Rogers, 2003; Al-Jabri & Sohail, 2012).

DOI has been used in education and technology research for a variety of studies. Examples include: Jwaifell & Gasaymeh (2013) who used it to evaluate and report on teachers' use of interactive whiteboards; Pinho, Franco and Mende (2020) whose study reinforced the theory through the characteristics of innovations, with regards to the implementation of the Moodle Learning Management System (LMS); and Goh & Sigala (2020) who used it as a lens

to understand educational change and to propose practical solutions to guide academics on the integration of ICT into their classrooms.

While DOI has been used extensively to study individual technology adoption, MacVaugh & Schiavone (2010) claim that its single focus on the reasons for adoption or non-adoption, without any consideration of the nature and influence that the relationships have on technology adoption, does not enable studying the social context. Furthermore, DOI's emphasis on the innovation itself, does not facilitate understanding and exploring the complexity of cultural norms (Deligiannaki & Ali, 2011) and socio-cultural differences (Meyer, 2010). Finally, Meyer (2010) claims that DOI's bias towards technology adoption and the blaming of individuals for non-adoption, assumes that the only valid choice for people is to adopt the innovation. Furthermore, Beal and Rogers' (1960) advocacy approach that all adoption is equal in benefit, limits DOI's ability to consider other external factors and internal barriers faced by teachers (Meyer, 2010).

4.2.3 Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK), developed by Mishra & Koehler (2006), draws on Shulman's (1986) model of Technological Content Knowledge (PCK) to offer a theory in which the essential components, needed to effectively teach with technology, can be explored (Hilton, 2016; Nelson et al., 2019). TPACK is a combination of the three different types of knowledge that motivate teachers to reassess their technology use in relation to their ability to deliver meaningful content through integration tasks (Cox & Graham, 2009; Bajracharya, 2021; Tondeur et al., 2021).

TPACK is circular and consists of three domains: *technology knowledge* (the teacher's knowledge of how to use the technology); *pedagogical knowledge* (the teacher's general pedagogic practice); and *content knowledge* (the teacher's knowledge of their subject matter) (Mishra & Koehler, 2006; Taherdoost, 2018; Bajracharya, 2021). These domains intersect to create *pedagogy and content knowledge* (the teacher's knowledge of the most effective way to teach their subject); *technology and pedagogy knowledge* (the teacher's knowledge of how best to integrate technology into their pedagogic practice); and *technology and content knowledge* (the teacher's knowledge of how the technology impacts and is used within their subject) (Koehler & Mishra, 2009; Hilton 2016; Tondeur et al., 2021). The centre of TPACK is the point at which the teacher's understanding emerges from intersections across, and within all three domains (Mishra & Koehler, 2006). Each of the domains function separately and in conjunction with each other, with all needed to ensure that teachers meaningfully and effectively integrate technology into the classroom (Archambault & Barnett, 2010; Tondeur et al., 2021).

TPACK has been used extensively to study education and technology integration as it is constructed exactly for that purpose (Hilton, 2016; Cox & Graham, 2009) contend that TPACK is an extremely important conceptual model that facilitates teacher's ability to effectively incorporate technology in the classroom, as it constantly shifts due to technology advances and innovative ways in which technology can be utilised. (Gellerstedt et al., 2018). However, according to Harris & Hofer (2011), TPACK is only effective in researching teachers who possess strongly defined pedagogic practices and well-developed content related to

their subject area. Hilton (2016) claims that this may be due to TPACK's preference for teacher-centred instruction. Furthermore, as TPACK suggests constant effort is required to integrate technology into the classroom, Hilton (2016) argues that TPACK does not fully reflect actual classroom practices in which daily routine dominates. In addition, Kim, Lee, Spector and DeMeester (2013) state that TPACK does not explain the varied utilisation of technology by teachers and is challenging to apply, as it lacks detailed structure, its boundaries are fuzzy (Kimmons et al., 2020), and within practical situations it has varied results depending on how it was employed (Harris & Hofer, 2011; Hilton, 2016; Gellerstedt et al., 2018; Bajracharya, 2021).

4.2.4 Actor Network Theory (ANT)

Actor Network Theory (ANT) which originates from the sociology of science discipline (Cressman, 2009) was developed by Callon (1986) and Law (1987), and later advanced by Latour (1992;1993) to understand the relationship between technology and individuals "the place where science and technology come into being" (Cressman, 2009:2). The focus of ANT is not the properties of human and nonhuman actors, but the emphasis of the theory is rather on the position of actors in the network and the power that emerges from the dynamic configuration of the network (Greenhalgh & Stones, 2010). While ANT is ontologically complex, Cressman (2009) states that ANT has been used across a wide range of disciplines. A possible reason for this is that ANT avoids technological determinism and social reductionism as it facilitates research without preconceived notions and pays attention to the formation, operation and dissolution of actor-networks structures (Monteiro, 2000). However, according to Fenwick & Edwards (2011), while ANT provides a powerful lens through which the complexity, diversity, and inconsistencies present in an educational context can be studied, it has not yet been used extensively for education and technology research. Law (1987) claims that ANT is a theory of performance and thus simply summarising its concepts or thinking about ANT in the abstract (Cressman, 2009), confuses those wishing to make use of it.

According to Latour (1996) *actors* are any object – human or nonhuman - that acts, or an object to which an activity is granted by other actors. The *actor-network* is attained through a collective process for actors enrolled in the network (McLean & Hassard, 2004; Law, 1987) states that an actor always exists within a network, due to the relationship that occurs between humans and objects. Callon (1986) proposes that actor-networks, which are dynamic and fundamentally unstable (Greenhalgh & Stones, 2010), can be stabilised to a degree when alignment between the different components of the actor-network is achieved. Stability within the actor-network occurs through 'black boxes' as actors in the network no longer question the ways things are, and simply accept it. Alignment, which is almost always some sort of negotiation or truce, is achieved through 'translation' (Greenhalgh & Stones, 2010). *Translation* involves a four-stage process of *problematisation* (problem is defined with a specific technology as a solution); *interessement* (requires getting other actors in the network to accept the proposed solution to the problem); *enrolment* (the crucial roles and practices of actors in the network); and *mobilisation* (engaging other actors in fulfilling their roles and connecting with other actors in the network) (Callon, 1986; Greenhalgh & Stones, 2010).

Some examples of using ANT in education include: Wright & Parchoma (2011) who draw on ANT to critically consider the formulation of mobile technology affordances, and to explore the way in which it positions and controls mobile devices as technologies for learning; Bleakley (2012) who explains the use of ANT in medical education; and MacLeod et al., (2019) who use ANT to understand how novel tools and educational spaces impact the way in which teaching and learning in medical education take place.

Criticisms of ANT relate to the lack of power considerations and inclusion of nonhuman actors. Greenhalgh & Stones (2010) claim that ANT is based on a flat ontology, as it assumes that actors within the network are equal and therefore power imbalances, for example, a lack of access to resources and knowledge constraints (which are present in almost any system) are not considered. Secondly, ANT has been criticised for assigning agency to nonhuman actors. According to Mutch (2002), this is not only ethically questionable, as it reduces humans to the same level as technology, but also limits ANT, as it does not account for motivation and other human traits.

4.2.5 Pedagogical Beliefs – Technology Model (PBT)

Pedagogical Beliefs-Technology (PBT) developed by Tondeur (2020) draws on the research by Ertmer (1999; 2005) on first- and second-order barriers and Tondeur et al.'s (2017) systematic review of the relationship between pedagogical beliefs and technology use within education to define the different factors one needs to consider when exploring teachers' technology use. According to Tondeur (2020), individual and institutional characteristics, as well as context, influence teachers' technology use. At an *individual level*, pedagogical beliefs shape teacher characteristics and are mediated by perceived barriers and enablers; while at an *institutional level* the belief profile of the school alongside the barriers and enablers of school culture, technology support, and the requirement to utilise technology, are used to construct the institutional characteristics, with the *school context* either supporting or hindering integration efforts (Tondeur, 2020).

Tondeur (2020) utilises a set of expanding circles for PBT to illustrate the multifaceted and bidirectional relationships that exist between individual and institutional characteristics and context (Tondeur et al., 2017). To encourage technology use, Tondeur (2020) states that schools need to develop a shared vision of meaningful integration and support 'good education', otherwise teachers may resist adopting technology as their pedagogical beliefs may be in conflict and challenge the incorporation of technology into the classroom.

While Tondeur's (2020) PBT model offers a valuable way to focus on the role teachers play in integration efforts through categorising and conceptualising the different factors and relationships that influence teachers' technology use integration, the composition of each factor and the relationships between them are not explicitly defined. As PBT is a new model (Tondeur, 2020) it has not yet been used to conduct primary data collection studies, and thus it is possible that these factors and relationships may become less conceptual and more specific when used to conduct empirical research.

A summary of the common social theories employed to address the use of technology within the field of education, is provided in Table 3.

Table 3 Summary of Social Theories

Theory	*Description*	*Criticisms*
Activity Theory (AT)	Concerned with how the social context and tools influence human activity (Hashim & Jones, 2007) with subject, object, and tools as areas of primary focus (Engeström, 1987)	Assumes relationship between individuals and culture is unidirectional; focus on activities not individuals (Toomela, 2000, 2008)
Diffusion of Innovation (DIT)	Explores factors that influence individual people's adoption of new technology (Al-Jabri & Sohail, 2012). Considers new technology, communications about the new technology, the social system, and time period (Rogers, 1995; Taherdoost, 2018)	Focuses on adoption or non-adoption, not social context (MacVaugh & Schiavone, 2010). Variations in socio-cultural contexts not considered, with advocacy or biased view of technology adoption (Meyer, 2010)
Technological Pedagogical Content Knowledge (TPACK)	Studies education and technology integration (Hilton, 2016); consists of 3 knowledge domains: technology, pedagogical, content; intersection describes teachers' understanding of technology use within their pedagogic practice (Mishra & Koehler, 2006)	Only effective for researching teachers that possess strongly defined pedagogic practices and well-developed content related to their subject area (Harris & Hofer, 2011)
Actor Network Theory (ANT)	Understands relationships between technology and individuals (Latour, 1992, 1993); focuses on power that emerges from the dynamic configuration (Greenhalgh & Stones, 2010)	Flat ontology not including power considerations (Greenhalgh & Stones, 2010); reduces actors to same level as technology (Mutch, 2002)
Pedagogical Beliefs-Technology (PBT)	Incorporates the relationship between pedagogical beliefs and teachers' technology use, with individual and institutional characteristics and contexts (Tondeur, 2020)	Relatively new model with focus on professional development, composition of factors and relationships not explicitly defined

4.3 Structuration Theories

Structuration theories, which originated from Giddens' (1984) work, aim to move past the single-phased and sequenced model approach (DeSanctis & Poole, 1994) to explain the inherent complexities in all social contexts. Gidden's (1984) Structuration Theory (ST), and its theoretical advancements of Adaptive Structuration Theory (AST) (DeSanctis & Poole, 1994), and Strong Structuration Theory (SST) (Stones, 2005) are presented [4].

4.3.1 Structuration Theory (ST)

Structuration Theory (ST) is a social theory developed by Anthony Giddens in response to extreme views of objectivism/functionalism and subjectivism (Stones, 2005), with a central focus on the relationship and linkage between individuals and society (Jones & Kartsen, 2008).

ST includes the concepts of structure and agency. Giddens (1984) developed the concept of *duality of structure* in which humans through their interactions draw on social structures, while at the same time transforming and reproducing the social structures (Walsham & Han, 1990). Structure, according to Giddens (1984), consists of three dimensions: *signification*, *domination*, and *legitimation*. For *agency*, Giddens (1984) proposes humans are purposeful agents that constantly reflect on the consequences of their actions in relation to their daily practices. Furthermore, agency consists of *communication*, *power*, and *sanction* which take place when agents follow or reject rules within a social system and exercise control over resources (Giddens, 1984). The relationships between structures and human agency are not static and are mediated via interpretive schema, facilities, and norms (Giddens, 1984; Walsham & Han, 1990; Feeney & Pierce, 2016).

According to Archer (1995) and Bostrom et al., (2009), even though ST offers a way in which the reproduction and transformation of social structures can be explored, it conflates the concepts of structure and agency. Furthermore, ST has been criticised as being too philosophical and challenging to implement empirically (Thrift, 1985; Stones, 2005). Notwithstanding these criticisms, the duality of structure defined in ST offers a powerful way in which society can be studied and has been used by DeSanctis & Poole (1994) in AST, and Stones (2005) in SST.

4.3.2 Adaptive Structuration Theory (AST)

To specifically study the application and use of technology – within groups and organisations in group decision support systems (GDSS) – DeSanctis & Poole (1994) (drawing on Giddens' (1984) structuration concepts of human agency and duality of structure and Orlikowski's (1992) structural model of technology), developed AST. According to Gopal et al., (1992), AST enables researchers to study changes to the nature of structures provided by technology as well as the structures that result from human actions when interacting with the technologies (Calloway, n.d.). Furthermore, AST facilitates an understanding of why identical technologies can enable similar interactions while resulting in dissimilar structural outcomes (Turner et al., 2019). According to Walsham (2002) shared meanings, power arrangements, and group norms need to be considered, otherwise structures embedded in technical systems could possibly be unsuitable for users within another social context.

Elements of AST include *the structure of the technology* (the organisation, the task, the social context, i.e., the group's internal system); *appropriation of structures and decision processes*, *emergent sources of structures* (the technology, task, and organisational outputs), and *decision outcomes and new social structures* (the rules and resources) (DeSanctis & Poole, 1994; Niederman et al., 2008).

According to Bostrom et al., (2009), because AST was originally constructed to study the introduction and use of technology within an organisational context, it is not an appropriate theory to study technology adoption amongst individuals. Kort & Gharbi (2013) claim that a further criticism of AST is that it does not utilise the power of Giddens' (1984) concepts of structuration and therefore cannot explain reality, as the analysis of the agents' unconscious actions is omitted, and the duality of structure is replaced with the narrow concept of appropriation of structures.

4.3.3 Strong Structuration Theory (SST)

SST advances Gidden's Structuration Theory (ST) to facilitate empirical research by retaining core elements while "incorporating conceptual and methodological links between the abstract and the particular" (Stones, 2005: 7). Firstly, Stones (2005) argues *ontology-in-situ* is needed because in reality structure and action are observed through concrete complexities of day-to-day activities and dispositions and practices of agents. Secondly, Stones (2005) adds a *sliding ontological scale* with conduct and context analysis on which researchers can position a specific study, which may vary from detailed and concrete to an abstract view of past phenomenon (Jack & Kholeif, 2007; Feeney & Pierce, 2016). Thirdly, Stones (2005) constructs the *quadripartite nature of structuration* to depict the duality of structure in (1) external structures, (2) internal structures, (3) active agency, and (4) outcomes.

While SST has not been used extensively in empirical studies, Stones (2005) contends that it provides a powerful and structured theory in which the depth and strength of Giddens' duality of structure and human agency can be explored. Although SST does not especially account for technology, according to Jones & Kartsen (2008) as structuration occurs in all social contexts, SST is an appropriate framework for technology studies and has recently been used to research technology use within an educational context (Sackstein, 2021).

A summary of the structuration theories employed in education is provided in Table 4.

Table 4 Summary of Structuration Theories

Theory	*Description*	*Criticisms*
Structuration Theory (ST)	Central focus is on the relationship between individuals and society (Jones & Kartsen, 2008) with key concepts of the duality of structure and agency and dimensions of signification, domination, and legitimation (Giddens, 1984)	Is too philosophical to implement empirically (Stones, 2005); conflates the concepts of structure and agency (Bostrom et al., 2009)
Adaptive Structuration Theory (AST)	Studies the application and use of technology within groups and organisations with the elements of structure of technology; appropriation of the structures and decision processes; emergent sources of structures; and decision outcomes and new social structures (DeSanctis & Poole, 1994)	Not appropriate to study individual technology use (Bostrom et al., 2009); the power of structuration concepts is not used, resulting in unconscious action being omitted (Kort & Gharbi, 2013)
Strong Structuration Theory (SST)	Retains core structuration concepts while including a sliding ontological scale and the quadripartite nature of structuration with external structures, internal structures, active agency, and outcomes (Stones, 2005)	While structuration occurs in all social contexts (Jones & Karsten, 2008), it has not been used extensively within educational contexts and does not specifically account for technology.

4.4 Education and Technology Models

As technology integration in education is a complex process, models play an important role as they provide a discourse and structure by which the different facets can be explained (Misirli, 2016). Even though most education and technology models are prescriptive (Hilton, 2016), technocentric (Cuban, 2012), and not grounded on solid academic theories (Hamilton et al., 2016; Hilton, 2016; Tondeur et al., 2021) claim that these models not only provide teachers with important ways to consider when and how to integrate technology, but also offer researchers structured frameworks to explore and describe teachers' levels and manner of technology integration and resulting technology activities.

The most common education and technology models which were identified in the review and detailed in the next section, include: Hierarchical Model of Technology Adoption (Hooper & Rieber, 1995); Apple Classroom of Tomorrow (ACOT) Model (Standholtz et al., 1997); the Substitution Augmentation Modification and Redefinition (SAMR) Model (Puentedura, 2006); Replacement, Amplification, and Transformation (RAT) Model (Hughes, 2000; 1999); and Levels of Technology Implementation (LoTi) Model (Moersch, 1995).

4.4.1 Hierarchical Model of Technology Adoption (HTMA)

The model proposed by Hooper & Rieber (1995) is a five-step hierarchical model in which teachers' stages of technology adoption are explained by the progressive integration of technology into their pedagogic practice. According to Hooper & Rieber (1995) teachers need to progress upward through each stage to effectively integrate technology into the classroom. Stages include *familiarisation* (teacher becomes acquainted with the technology); *utilisation* (teacher experiments with the technology); *integration* (teacher incorporates the technology into parts of their pedagogic practice); *reorientation* (teacher reassesses pedagogic practices in relation to technology); and *evolution* (teacher constantly evolves pedagogic practices to integrate technology).

In addition to the stages of technology adoption, Hooper & Rieber (1995) propose that teachers' conception of how technology can be used in the classroom determines whether technology is viewed as a product or idea technology. *Product* technologies describe contemporary uses of the technology, while idea technologies provide teachers with activities which were previously not possible (Hooper & Rieber, 1995).

4.4.2 Apple Classroom of Tomorrow (ACOT) Model

Research conducted by Sandholtz et al., (1997) resulted in the construction of the Apple Classroom of Tomorrow (ACOT) model. Initially, Apple™ placed desktop computers and other related hardware in ten classrooms, providing both learners and teachers with technology. Over time, as the study grew to incorporate more teachers in schools across the United States, Sandholtz et al., (1997) gathered evidence through observations and interviews with teachers and learners aimed at describing the process and stages of teachers' integration of technology into the classroom.

The progressive stages of integration in the ACOT model are: *entry* (teacher has little experience with the technology); *adoption* (teacher becomes more comfortable with the technology and are using it for traditional tasks); *adaptation* (teacher integrates the technology into their current pedagogy); *appropriation* (teacher is comfortable with using the technology which results in a shift of beliefs and attitudes); and *invention* (teacher begins to try novel ways of using the technology) (Dwyer et al., 1991; Sandholtz et al., 1997; Yucel et al., 2010; Cuban, 2012; Kimmons et al., 2020). According to Cuban (2021) while the model is dated, the descriptions of technology use defined in ACOT, and the related questions drawn from the model, are still relevant to current technology adoption research.

4.4.3 Substitution Augmentation Modification and Redefinition (SAMR) Model

SAMR is a four-level model developed by Puentedura (2006) to explain and assist teachers in integrating technology in the classroom (Bajracharya, 2021). Levels are: *substitution* (teachers do not change their pedagogic practice through their use of technology); *augmentation* (improvements in pedagogic practice are realised due to the use of technology); *modification* (teachers redesign activities in ways not possible without using technology); and *redefinition* (teachers use technology for new tasks that were not previously possible) (Puentedura, 2006; Nelson et al., 2019; Bajracharya, 2021).

According to Kirkland (2014), Hilton (2016), and Puentedura's (2006; 2013) SAMR model, *level of substitution* is where existing tools are simply replaced with digital tools; the *level of augmentation* is where technology is used by teachers to improve teaching and learning through an enhancement of tasks; and the *levels of modification and redefinition* provide the means through which tasks can be transformed, as new possibilities for teaching activities that are not easily attainable without the use of technology tools, can be created.

While Hilton (2016) contends the SAMR model is important as it provides a structured way by which teachers can consider technology integration and researchers can explore and describe technology activities within an educational context, its technocentric focus, prescriptive nature (Hilton, 2016), lack of solid academic grounding (Hamilton et al., 2016; Bajracharya, 2021), and lack of clarity around level boundaries (Kimmons et al., 2020), are limiting.

4.4.4 Replacement, Amplification, and Transformation (RAT) Model

RAT, originally developed by Hughes (2000; 1999), is based on a review of theories about technology in education and analyses of empirical evidence collected through observing and interviewing teachers about their enacted use of technology. RAT aims to understand how teachers' technology integration develops, as well as the role technology plays in an educational context (Hughes et al., 2006).

According to Hughes (2000) and Hughes et al., (2006) technology as *replacement* (simply changes the medium but established pedagogic practices or goals are replicated for the method, learning process, or content goal that already exists in the classroom); technology as *amplification* (tasks stay fundamentally the same, but the technology is used to extend teachers' pedagogic capabilities); and technology as *transformation* (used to reinvent an aspect of a teacher's pedagogic practice in new and novels ways).

Hughes (2000) claims RAT is not intended to chart a linear path for technology integration, as teachers possess an array of technology integration practices. According to Kimmons et al., (2020) RAT provides a simple but powerful way to describe the level of teachers' technology integration, with teachers new to the technology tending to use it to support current pedagogic activities i.e., replacement, while those at transformation using technology to enable pedagogic activities that cannot exists without technology.

Notwithstanding that RAT is a useful model to describe teachers' use of technology, Kimmons et al., (2020) contend that as teachers' descriptions of transformation are subjective and contextual, evaluating whether a teacher is truly using technology at a transformative level is hard to operationalise. Furthermore, due to its simplicity the model can be ambiguous when used for empirical research and therefore lacks substance (Kimmons et al., 2020. Lastly, Hughes (2000) cautions that RAT is more suited to teachers self-assessing their technology integration as contextual information about the technology is needed to use the model correctly, therefore if RAT is being used to research other teachers' technology integration, Hughes (2000) suggests in-depth qualitative interviews and observations to access the rich information known only by the teacher.

4.4.5 Levels of Technology Implementation (LOTI) Model

The LoTi model, developed by Moersch (1995) aims to provide a way in which the level of teachers' technology integration can be measured and evaluated (Stoltzfus, 2006; Moersch, 2009) states that LoTi draws on the theoretical foundations of the Apple Classroom of Tomorrow (ACOT) model (Dwyer et al., 1991) and the Concerns-Based Adoption Model (CBAM) (Fuller, 1969) for the experiences and concerns of educators when integrating technology.

To quantify teachers' technology use, LoTi consists of seven levels of integration from non-use to refinement. These levels are progressive, with higher levels shifting pedagogic practices and perceptions of technology (Moersch, 1995; Summaka et al., 2010). According to Moersch (1995), starting at the lowest level, the levels within LoTi are: *non-use level 0* (teachers perceive they lack access to technology and have insufficient time to integrate technology, with no digital technology being used); *awareness level 1* (there is some access to technology, but with little or no relevance to the teacher's pedagogic practices; *exploration level 2* (technology is used to support and complement existing practices, with teachers using technology for extension activities or enrichment); *infusion level 3* (technology being used to enhance isolated pedagogic activities); *integration leve*l 4 (technology is used in an integrative manner to provide rich content to provide authentic learning experiences); *expansion level 5* (technology access stretches beyond the classroom, with teachers actively seeking technology to expand learning experiences); and *refinement level 6* (technology is viewed as more than just a support tool and teachers integrate technology in a holistic and seamless manner). Waddle (2012) states that even though the framework includes six levels, level 4, in which technology is seamlessly integrated to support high-level thinking with the content, is the goal.

While Moses (2006) claims that the LoTi survey instrument accurately describes teachers' levels of implementation, exhibiting strong correlations between estimated LoTi levels and actual survey results (Waddle, 2012), LoTi has been criticised for having too many levels, with distinctions between levels seen as confusing (Kimmons et al., 2020). Furthermore, according to Mehta (2011) not only must the LoTi instrument be updated to reflect the pervasive use of technology within education, but the primary focus on teachers' progression to higher levels, discounts and minimises concerns about technology integration. Lastly, even though the original LoTi model has been used for multiple studies (Kimmons et al., 2020), Moersch's (2009) refreshed model, which now addresses teaching innovation rather than technology integration, does not appear to have been used widely for published academic empirical studies.

A summary of education and technology models employed in education are provided in Table 5.

Table 5 Summary of Education and Technology Models

Theory	*Description*	*Criticisms*
Hierarchical Model of Technology Adoption (HTMA)	Hierarchical model with five steps that teachers need to progress through. Steps are familiarisation, utilisation, integration, reorientation, and evolution (Hooper & Rieber, 1995)	Is a progressive model that prescribes levels of adoption (Sackstein, 2021)
Apple Classroom of Tomorrow (ACOT)	Progressive staged model of technology integration: entry, adoption, adaptation, appropriation, and invention (Dwyer et al., 1991)	Constructed solely with a technocentric focus (Cuban, 2012)
Substitution, Augmentation, Modification Redefinition (SAMR)	Four-level model that explains ways in which teachers integrate technology into the classroom, levels are: substitution, augmentation, modification, and redefinition (Puentedura, 2006, 2013)	Too prescriptive about the use of technology (Hilton, 2016); not grounded on solid academic theories (Hamilton et al., 2016); lack of clarity around level boundaries (Kimmons et al., 2020)
Replacement, Amplification, and Transformation (RAT)	Three stages of technology use are defined as: replacement, augmentation, and transformation, it is not intended to chart linear path of technology integration as teachers possess an array of technology integration practices (Hughes, 2000)	Evaluation at a transformative level is hard to operationalise; the model can be ambiguous and lacks substance (Kimmons et al., 2020); contextual information (only known by the individual) is needed to use the model correctly Hughes (2000)
Levels of Technology Implementation (LoTi)	Seven-levels of integration or teaching innovation, ranging from non-use to refinement, with level four being the goal, and focus being on teachers' progression to higher levels (Moersch, 1995, 2009)	Too many levels with distinction between levels seen as confusing (Kimmons et al., 2020)

5 Discussion

As stated previously, selecting a theory to conduct empirical research is a challenging task, as a vast number of models have been developed to study technology adoption within various contexts (Tarhini, 2015; Tondeur et al., 2020). While many studies provide reviews and/or comparisons of common and influential theories in the technology and education domain (Tarhini, 2015; Al-Mammary et al., 2016; Mamoni et al., 2017; Taherdoost, 2018; Samaradiwakara & Gunawardena, 2014; Sharma & Mishra, 2014; and Lai 2017; Omieno,

2022), objectives and aims differ. For example, Tarhini (2015), Al-Mammary et al., (2016), and Omieno (2022) aim to assist future researchers in comparing the strengths and weaknesses of selected positivist theories; Taherdoost (2018) provides an overview of technology driven theories so that researchers have a better understanding of each theory; Mamoni et al., (2017) outline how researchers can assess technology deterministic theories in regard to comprehensiveness and complexity; Samaradiwakara & Gunawardena (2014) utilise their review to develop an appropriate adoption theory for their particular context; Sharma & Mishra (2014) offer a review of the evolution of technology adoption theories; and Lai (2017) provides an understanding of underlying concepts in each technology focused theory so that future researchers can apply their selected theory to empirical work. Similarly, aims and objectives of reviews published specifically focusing on the adoption of technology within education also differ. For example, Tondeur et al. (2020) uses the review to develop and apply criteria to assess the quality and scope of specific educational technology models, while Bajracharya (2021) simply aims to highlight key features and challenges with educational technology models.

While this paper also offers a review of theories and models used to study technology adoption in educational contexts, various novel contributions are evident. Firstly, the paper offers researchers a holistic view of the theories and models employed to understand the adoption of technology in education from a variety of perspectives. Secondly, the detailed account of the hermeneutic review method can be used to guide future researchers wanting to pursue similar studies. Thirdly, the categorisation dimensions selected, the subsequent application of these dimensions, and the resulting categories provide readers with a clear overview of the different aims, perspectives and technology views of the theories presented.

5.1 Theory Categories

The theories and models have been classified into 4 categories and described in detail regarding specific constructs and application in education. Furthermore, a summary of each category is provided along with the name of the theory or model, a description, and listed criticisms. This categorisation not only provides coherence, but also enables researchers to select the most appropriate theory or model to make sense of their specific research problem - depending on their underlying research paradigm; their view of technology; the aim of their research; and whether they would like to describe or predict the phenomenon.

Technology acceptance/adoption/use theories and models constitute the first of these categories and seem to be fit for researchers who operate from the positivistic paradigm; have a technocentric view of technology that advocates for greater technology integration within educational contexts; aim to predict technology use; and follow a normative research strategy of regularisation and standardisation.

The second category of theories and models is *social* theories. Researchers who apply these models operate from the interpretivist paradigm; view technology as an enabler of education; aim to research the social aspects of technology integration within education by explaining, describing and understanding the social dynamics of technology with a focus on human behaviour; and follow a descriptive research strategy.

Table 6 Summary of categorisation of Theories and Models (can the theories column be made bigger and the aim and strtagy one a little smaller so the theories are all on one line?)

Category	Theories	Aim/Strategy/ Paradigm/ View of Technology
Technology Acceptance/ Adoption/ Use Theories & Models	Theory of Reasoned Action (TRA) Theory of Planned Behaviour (TPB)/ (DTPB) Technology Acceptance Model (TAM, TAM2, TAM3) Unified Theory of Acceptance and Utilisation (UTAUT, UTAUT2) Task Technology Fit (TTF) Will, Skill, Tool & Pedagogy (WSTP)	Positivist paradigm Technocentric view Prediction of technology use Normative research strategy
Social Theories	Activity Theory (AT) Diffusion of Innovation Theory (DOI) Technological Pedagogical Content Knowledge (TPACK) Actor Network Theory (ANT) Pedagogical Beliefs – Technology (PBT)	Interpretivist paradigm Technology as enabler Social aspect of technology Descriptive research strategy
Structuration Theories	Structuration Theory (ST) Adaptive Structuration Theory (AST) Strong Structuration Theory (SST)	Interpretivist paradigm Technology as enabler Complex interactions between humans, social context, and technology Descriptive research strategy
Education and Technology Models	Hierarchical Model of Technology Adoption (HTMA) Apple Classroom of Tomorrow (ACOT) Substitution, Augmentation, Modification, and Redefinition (SAMR) Replacement, Amplification, and Transformation (RAT) Levels of Technology Implementation/Teaching Innovation (LoTi)	Positivist paradigm Technocentric view Prescription and description of Levels of technology use Normative research strategy

The third category is *structuration* theories. Researchers applying these theories also operate from the interpretivist paradigm; view technology as a possible enabler; are primarily interested in understanding how the complex interactions between humans, people and their surroundings influence the use of technology; and follow a descriptive research strategy.

The fourth and last category is *education and technology* theories and models. These models and theories are fit for researchers operating from the positivistic paradigm; have a technocentric view of technology; aim to prescribe and describe the different levels of technology adoption, the stages of technology integration, and the way in which technology could assist with teaching and learning; and follow a normative research strategy. These models and theories are also fit to describe the way in which people use technology, for what they use it, and how their technology usage develops and matures over time. Table 6 provides a summary of the theory and model categorisation discussed in this section.

6 Limitations

Several limitations are present within this study. Firstly, search terms and words often have multiple meanings (Rights & Direct, 2019) and even though words and search terms were directly related to the research topic, it is still possible that other relevant theories and articles were missed, and different or other articles could have been found if alternative words and search terms had been used. Secondly, as a hermeneutic approach was followed, results may not be as comprehensive and reproducible as compared to when a systematic review method is used (Snyder, 2014; Xiao & Watson 2019). Thirdly, while supervisors provided input and guidance, as the initial research was carried out for degree purposes, only one researcher conducted the review, constructed the search terms, selected, and sorted the articles, defined categories, and assigned theories to specific categories. Therefore, it is possible that other theories were not included, relevant articles were missed, different or other categories could have been created, and that theories could have been categorised differently. However, to minimise bias and ensure trustworthiness of the results through inter-rater reliability (Boell & Cecez-Kecmanovic, 2014, 2015a), search terms, articles selected, categorisations created, and the assignment of theories to the defined categories were discussed, debated, and adjusted where appropriate, by two other academics with experience in the field of technology and education, when preparing this paper for publication. Notwithstanding these measures taken, Armstrong et al., (1997) claim that using more than one researcher from the outset ensures rigour and maximises inter-rater reliability. Therefore, it is noted that using a group of academics to initially decide on categorisations prior to the allocation of theories and models, could have enhanced inter-rater reliability.

7 Conclusion

Selecting the most appropriate theory to study the use of technology within an educational context can be extremely confusing and complex to navigate. This hermeneutic literature review was aimed at providing a list of the most well-known and useful theories and models in this regard, while accommodating methodological differences and cross-disciplinary dialogue. The most common theories and models used have been identified, structured, detailed and synthesised into 4 categories. These categories include technology acceptance/adoption/use theories and models; social theories; structuration theories; and education and technology theories and models. These categories can guide researchers in selecting the most appropriate theory for their particular study as they offer a systematic way of considering theory choices by aligning the theory's views on technology, strategies, paradigms to the intended research goals and objectives. For example, in quantitative

empirical technology adoption studies, researchers should consider the theories within the technology acceptance/adoption/use category, whereas for more interpretivist studies focusing on subjectively studying human behaviours and socially constructed realities, theories within the social and structuration categories are more appropriate. Consequently, researchers wanting to explore when and in which ways technology is incorporated within an educational context, theories and models within the education and technology model category are most suited.

Notes

1. While technology adoption generally refers to the acquisition, acceptance, and subsequent use of technology (Straub, 2009) the words 'use', 'integration' and 'acceptance' have been used interchangeably as they essentially refer to the same thing i.e., people adopting or using technology (Sovacool & Hess, 2017; Khan & Qudrat-Ullah, 2021).
2. While 153 papers were found based on the specified searches, only 129 papers were used to categorise the different theories, with the other 24 papers being used to provide background knowledge of the theory or descriptions of empirical use.
3. A description of why these particular criteria where selected and what each of the entail can be found in Sect.3.1.1.
4. While the theories in this grouping are also classified as social theories, they are all constructed using the foundational principles of structuration as defined by Giddens' (1984). A separate category for structuration theories has therefore been created.

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The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.