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Innovative pedagogical principles and technological tools capabilities for immersive blended learning: a systematic literature review

Najwa Amanina Bizami[1] · Zaidatun Tasir[1] · Kew Si Na[2]

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Abstract

Blended learning is widely known for its ability to improve learning, nevertheless little is still known about the best ways of designing effective blended learning environment which can support immersive learning such as greater learning experience and accessibility to education. In this respect, this study investigates the mapping of the principles of three Education 4.0 innovative pedagogies, namely, heutagogy, peeragogy, and cybergogy, with the capabilities of three technological learning tools, that is, Facebook (FB), Learning Management System (LMS), and Blog, via a systematic literature review technique. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used as the methodology, and the literature was further selected using Gough's Weight of Evidence criteria, resulting in 59 studies. The results show that cognitive factor is the most linked pedagogical principle to the four main capabilities of technological learning tools, that is, time, self-related, learning task, and learning community-related. This mapping is useful for instructors to plan learning and teaching by choosing the technological learning tools that match with appropriate Education 4.0 pedagogies for optimising the immersive blended learning practices.

✉ Zaidatun Tasir
p-zaida@utm.my

Najwa Amanina Bizami
najwabizami@gmail.com

Kew Si Na
snkew@utm.my

[1] Department of Science, Mathematics & Creative Multimedia Education, School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor Bahru, 81310 Johor, Malaysia

[2] Language Academy, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor Bahru, 81310 Johor, Malaysia

Keywords Heutagogy · Peeragogy · Cybergogy · Innovative pedagogical principles · Technological learning tools capabilities · Immersive blended learning

1 Introduction

Blended learning is widely recognised as an integration of classroom face-to-face learning experiences with online learning experiences. An increased use of blended learning environments in higher education has been an emerging trend in the twenty-first century (Mozelius & Rydell, 2017) due to the ever-changing world of technology and the need to guide twenty-first century learners to approach learning. Many studies have shown that blended learning can improve academic achievement (Kassab et al., 2015; Kazu & Demirkol, 2014). Through blended learning, technology is used to cater to multiple learning styles or needs, engage students, and support learning goals and values.

However, despite the continuous development of research on blended learning, they have not yet provided sufficient guidance on supporting the creation of an immersive blended learning environment, which is seen as an essential aspect to improve and contextualise learning experiences for twenty-first century learners. Since delivering sound immersive learning experience is hard due to time consuming, expensive and difficult to assess (Beckem and Watkins (2012), many professional educators have criticised the impersonal, sequential and disconnected elements of the current types of blended learning models (i.e., rotational model, flex model, self-blend model, and enhanced-virtual model), as they cover less of the immersive element of learning and teaching (Bidarra & Rusman, 2017; Lucke, 2011; Sobchenko, 2021; Whyte, 2018). Though blended learning has emerged as one of the most dominant delivery modes for various teaching contexts (Chen, 2022), a modern blended learning on the other hand should force for the integration of immersive learning since it appears useful and needed in today's dynamic learning environment to shake up learning for more excitement and innovation, and most importantly be applicable and relevant to contemporary life and transferable to 'real-world' situations (Bidarra & Rusman, 2017).

Before planning on what improvements can be made to construct a new immersive blended learning environment, there must be a deep understanding of pedagogic practice itself. Perhaps what is of utmost importance is a pedagogical approach that is flexible enough and can be changed according to learners' personal needs and learning context (Bidarra & Rusman, 2017). This pedagogical aspect is however often fraught with problems due to its complex series of relationships to produce actionable information (Colreavy-Donnelly et al., 2022). Additionally, several important aspects of the innovative learning pedagogy that involve new methods of interaction between 'instructor-student-resource' in the learning and teaching practice are often ignored in the discussion related to the immersive blended learning environment (Crawford & Jenkins, 2017). Hence, by reaching an understanding of the complex interaction relationship in the innovative learning pedagogy would be key to create an effective immersive blended learning experience.

Another problem that makes the adoption of immersive blended learning difficult is perhaps due to perception that immersive learning relies mainly on the advances in technology and involve only sophisticated and expensive technological tools, such as virtual, augmented, and mixed reality. Recent research by Chytas et al. (2021), Parong and Mayer (2018), and Checa and Bustillo (2020) however disagree that such technologies can provide immersive experiences to learners. Note that the use of digital technology per se may not able to enhance learning outcomes and should not be used for the sake of course repository. Considering that, there is a need to take into account the different types of technological learning tools and extract the capabilities to create a flexible immersive blended learning approach that will contribute to the greater learning experience and facilitate accessibility to education. To date, such technological capabilities were not spelled out clearly in the existing blended learning models to support the immersive learning experience.

From the above discussion, we can see that these two aspects, namely, innovative pedagogical principles and technological capabilities should be considered together in order to produce stimulating immersive learning environments through which robust learning can occur (Blaschke, 2018). This also fits with Kaufman's (2019) suggestion that, in redesigning transformative instructional blended learning, it is essential to have the involvement of both pedagogical elements and technological tools in order to promote active learning experiences and student-centred pedagogies. Without proper framework and limited knowledge on both technological capabilities and innovative pedagogical principles, it is difficult for educators to bridge the gap between technology and pedagogy, and successfully implement it in the learning and teaching practice despite realising its potential.

Thus, the focal point of this systematic literature is three-fold: (1) to ascertain about the principles of heutagogy, peeragogy, and cybergogy that are relevant for an immersive blended learning environment, (2) to identify the capabilities of the technological learning tools that appropriate to use in an immersive blended learning environment, and (3) to inform about how the principles of heutagogy, peeragogy, and cybergogy can be mapped with the capabilities of technological learning tools for the proper implementation of an immersive blended learning environment. FB, blogs, and LMS are the three types of technological learning tools that have been selected to be reviewed to ascertain their capabilities in supporting an immersive blended learning environment. FB is chosen because it is relevant for twenty-first century learning and is also a popular platform among millennials and Gen Z (Oomen-Early & Early, 2015). Similarly, blogs are often used to support active collaboration among students (Blaschke, 2018), whilst LMS is a common discussion platform for students (Twelves & Arasaratnam, 2012). These three technological tools also have the capability of supporting the learning community to complete a task, solve a problem, create a product, and share their thoughts (Craigg, 2020).

In brief, the techno-pedagogy mapping can provide a starting point for significant parties in education, such as curriculum designers, and faculty administrators, to have a good understanding of how to design preferred immersive blended learning experiences with much more confidence and competence. In terms of definition, the techno-pedagogy mapping is a mapping that intertwines the pedagogical

and technological elements to address explicit relationship of how technological tools are able to assist and support pedagogical aspects. This mapping is suitable for classroom teaching and learning if the following criteria/standards are met: (1) any teaching and learning environment that involve the use of online/virtual/remote/distance learning that requires the assistance of technological learning tools. The technological tools are within the use of Web 2.0 tools. Hence, this mapping might not be appropriate for classroom with application of augmented and virtual reality because of the uncovered capabilities, (2) any teaching and learning setting that involves both independent and/or collaborative learning methods as it takes into accountability of students' autonomy and collaboration aspects, (3) any teaching and learning pedagogy setting that align with the core principles of innovative pedagogies, that is Heutagogy, Peeragogy and Cybergogy, and (4) any teaching and learning components which consider the immersive learning features. In this case, immersive learning characteristics are (1) real-life like environment, (2) learning process focuses more on learning experience, and (3) supported by appropriate Web 2.0 technological tools.

Higher education educators may also utilise the techno-pedagogy mapping framework as a discourse opportunity to innovate their mainstream online curricular delivery by integrating innovative pedagogies with technological capabilities to prepare learners with twenty-first century skills/values in novel situations, such as creativity, independence, communication, self-determination, ability to work with others, critical thinking, capacity to learn and so on, since greater reliance has been placed on information technology as a result of the COVID-19 pandemic. Furthermore, as the three innovative pedagogies in the mapping support the shift from instructor-led teaching to student-centred learning, this can, in turn, prepare the students to take ownership of their learning, to survive, and to be competitive with regard to their knowledge and life-skills, which is in line with the 4th industrial revolution and digital transformation agenda. Plus, the mapping can also further inform the theorisation of the concept of innovative pedagogies and technologies in relation to an immersive blended learning environment in higher education, which remains insufficiently studied and substantiated.

2 Literature review

2.1 Blended and immersive learning environment

Blended learning is the mode of instruction most widely used by educational institutions owing to its apparent effectiveness in offering flexible, timely, and continuous learning (Rasheed et al., 2020). According to the Sloan Consortium, blended learning covers from 30 to 79% of online content delivery. To date, several individual and combination models of online learning with traditional face-to-face instruction, which are usually referred to as flex, self-blend, flipped, and rotation, among others, have been utilised in numerous studies. Some of these models are better than others and it is almost impossible in contrary, to design a perfect model (Azizan, 2010). For instance, Kudryashova et al. (2016) stated

that the rotation model can be considered as efficient for learning English since it makes it possible to improve the process of learning the subject under the conditions of class time deficiency and the differences in students' levels of training, motivation to study foreign language, and levels of information and communication technology competence. The implementation is further exemplified by Crawford and Jenkins (2017), who purposely combined the station rotation and flipped models to respond to the transitioning digital tertiary environment and the complexities linked to necessary pedagogical change.

As the implementations of blended learning are diverse, there appears to be a degree of unease among students and instructors regarding the inclusion of technology into learning and instruction. For example, blended learning requires students to equip themselves with self-regulation skills and technological competence in order to manage their learning at their own pace with less instructor facilitation. Instructors, meanwhile, are also required to be competent in utilising and merging both online resources and various pedagogies effectively into course design, and thereby can increase student engagement and performance (Rasheed et al., 2020). It is also observed that when learning technologies are introduced, the attention of blended learning is often paid to the technology implementation (Chen & Yao, 2016) rather than stressing the innovative pedagogies and learning objectives (Shand et al., 2016). Bidarra and Rusman (2017) also highlighted in their study that technology and pedagogy are the two main components in building a suitable blended learning environment.

While the values of technological tools and pedagogies are apparent in optimising blended learning (see Ayob et al., 2020; Mahalli et al., 2019; Mujacic et al., 2013), there has been little, if any, research into linking blended learning with the underlying principles of twenty-first century pedagogy and the capabilities of technology in learning and instruction. The existing blended learning models also put little emphasis on what constitutes immersion, thus present challenges for instructors to design instructions to improve and contextualise deep learning experiences for twenty-first century students through blended learning approach. Cheney and Terry (2018) describe immersive learning environment as the ideas of presence (being there) and co-presence (being there with others). Students in the twenty-first century desire immersive learning because it can give them the opportunity to immerse and interact actively in teams with fellow students by building a sense of identity and belonging in a low-risk environment (Bautista, 2013), and shift from content acquisition act to knowledge expression and creation act (Abdelaziz, 2014). It also equips them with an interactive learning environment and give them a sense of the realities of through the dynamics of learning. Nevertheless, the current focus of immersive learning is mainly relying on the technological driven and involve only advance and expensive technological tools such as virtual, augmented, and mixed reality. Hence, in this study, the researchers believe that a solid understanding of the mapping of innovative principles of different pedagogies, namely, heutagogy, peeragogy and cybergogy, with the capabilities of technological tools, even through the use of simple and accessible technologies such as Facebook

(FB), Blog, and Learning Management System (LMS) can provide rich opportunity to model effective immersive blended learning environment.

3 Education 4.0 innovative pedagogies

As outlined in the Framing Malaysian Higher Education 4.0: Future-Proof Talents, innovative pedagogies include heutagogy, peeragogy, and cybergogy (Ministry of Higher Education, 2018). Heutagogy is a student-centric learning and teaching strategy where students determine their learning independently (Blaschke & Hase, 2019; Kapasi & Grekova, 2018). This pedagogy was introduced as a response to the criticism that learning is dependent mostly on the instructors whereas, in reality, learning may occur independently in dynamic and complex form (Sumarsono, 2019). Until now, heutagogical practices have been applied in varied disciplines, such as social science (Snowden & Halsall, 2017), nursing (Bhoyrub et al., 2010), medicine (Abraham & Komattil, 2017), and engineering (Mohammad et al., 2019), because it is adaptable to the lifelong learning and workplace setting which is full of unpredictability and uncertain situations. The success of the heutagogical approach depends on reflective practice because it helps students to reflect on what they have learned and thus to control their learning and apply it to a practical situation (Canning & Callan, 2010). While heutagogy suggests that the ability to learn is a natural human condition, there is still a need to complement it with technological skill since technology can support learning outside the classroom where students can be creative and proactive in gaining knowledge and understanding independently (Blaschke, 2012). Therefore, the synergy of heutagogical principles and online technological tools is necessary in order to equip instructors and students with the technological competency of heutagogy learning and teaching approach.

Another form of collaborative learning, which is known as peeragogy or paragogy, has gained attention in higher education because of its unique concept. This peer-learning pedagogy focuses on co-creating and co-learning with peers, who share their learning situations and experiences in a social, active, and continuous process (Mulholland, 2019). It uses a co-creating learning environment where students are actively involved in a knowledge-building process (Jamaludin et al., 2020). The commitment of co-creating as suggested by Howard (2012), which includes "sharing power (empowering students), sharing interactivity & collaboration, sharing responsibility, sharing meanings and sharing knowledge", has led to significant flexibility and reflection in the peer-centred learning, and increased motivation for both students and instructor. However, when it comes to designing learning and teaching tasks that are techno-socially feasible, there might be a challenge "between a practical, action-oriented approach to learning and adaptation, and the whimsical, non-linear, non-coercive modality of peer production" (Corneli, 2012). In this regard, consideration of the principles underlying peeragogy is important to confront the problem of peer-producing in blended learning environments, as the pedagogy of the

twenty-first century differs from that of previous centuries (Mynbayeva et al., 2016). For peeragogical learning and teaching endeavours to be established, some serious questions need to be answered, such as (1) What technologies are suitable in peer learning?, and (2) How do the tools' features suit the role of co-learners in co-teaching and co-coaching work in the blended learning premise?

Cybergogy, meanwhile, is a pedagogy that focuses on engaging students in an online environment to advance their cognitive, emotional, and social learning (Wang, 2008). Engaging students on all three levels of presence simultaneously would result in the best learning outcomes. The cybergogy approach can be executed anywhere and anytime based on the availability of computers and the internet. Learning through communities is also supported by the cybergogical approach by activating students to engage in discussions, negotiate ideas, and devise solutions with the community (Bilfaqih & Qomarudin, 2015). This pedagogy is uniquely applicable to online instruction and has been intensively adopted by instructors who are educated about the usage of online computer systems (Yusuf & Yusuf, 2018). However, it has also been used in research on blended learning (Wang et al., 2009). As suggested by the previous research (see Ata, 2016; Salmon, 2009), the limited adoption of this pedagogy is caused by many factors including (1) digitally illiterate instructors, (2) limited time for exploring, tweaking, and creating heutagogical application, (3) a willingness to implement only if receiving a lot of help and support, and (4) the pedagogy being treated the same way as physical classes. Hence, there is a need to have detailed guidance on the ways to implement the cybergogy approach in the learning and teaching process which, in turn, enables the widespread adoption of this pedagogy. Besides, the framework of a future-ready curriculum for Malaysian public universities also did not provide any guidelines on how to use this pedagogy effectively.

In summary, the above-mentioned innovative pedagogies involve new methods of interaction between 'instructor-student-resource' in the learning and teaching practice. To be precise, this aspect is what is still lacking, and its innovative principles were not spelled out clearly in the existing blended learning models. If we can really understand how people learn best, then we can design educational experiences with much more confidence. Hence, we saw the possibility to contribute to the body of knowledge of the immersive blended learning environment, if all three fundamental aspects of innovative pedagogies are conducted integratedly, by taking into account the capabilities of several technological tools that are relevant to learning experiences from both theoretical and practical perspectives. The active use of innovative pedagogies (the three 'gogies') is also necessary in the Education 4.0 era to reshape and optimise immersive blended learning and teaching and prepare the students to survive and be competitive with regard to their knowledge and life-skills.

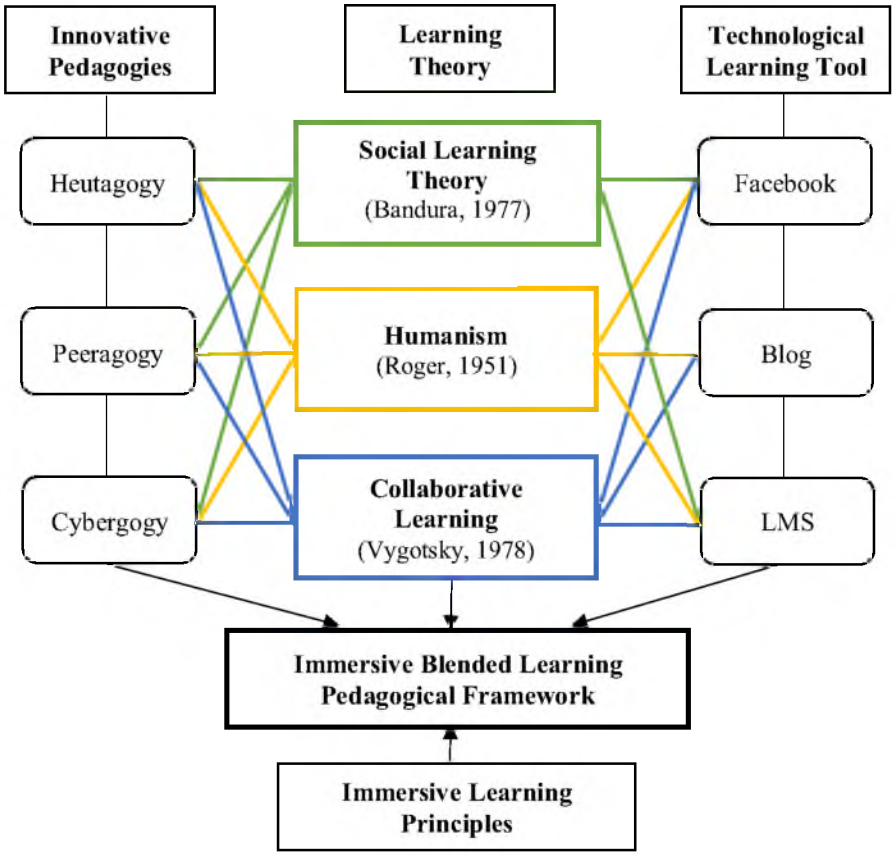

Fig. 1 Theoretical framework of immersive blended learning pedagogical framework

4 Theoretical framework

Based on Fig. 1, social learning theory, humanism, and collaborative learning are the appropriate underpinning theories for the three Education 4.0 pedagogies, i.e., heutagogy, peeragogy, and cybergogy, and three types of technological learning tools, i.e., FB, blogs, and LMS.

In social learning theory, Bandura (1977) explained that the learning process involves the process of observation and imitation of model figures. This theory also mentions that the cognitive factor mediates the learning process of students. In heutagogical learning, it is highlighted that students are responsible for exploring knowledge using their own approach, which involves their cognitive ability in planning their learning journey (Hase, 2016). It is similar to peeragogical learning, where students are actively producing knowledge, among themselves in an interactive community that would shift their perspective behaviourally or cognitively during the learning (Alexander et al., 2014). In contrast, in cybergogical learning, it is

outlined that students' learning will be affected by cognitive, social, and emotional factors which are interrelated with each other (Wang & Kang, 2006).

Next, the notion of humanism, which claims that students are positioning themselves at the centre of the learning process (Rogers, 1951; Sanmugarevathi & Lenin, 2020), is what connects this theory with heutagogy, peeragogy, and cybergogy. The self-determined strategy of the heutagogical approach focuses on students taking proactive action to decide what and how they will learn. Peeragogy, meanwhile, puts students at the heart of learning by giving them the autonomy to co-create knowledge and skills with peers in their own way, whilst, for cybergogy, the evolution of technological tools that can cater to students' cognitive, emotional and social aspects of learning has favoured educational offerings by creating huge opportunities for students to learn easily through the online environment.

Also, underpinning the Education 4.0 innovative pedagogies is the theory of collaborative learning. This is derived from Vygotsky's Zone of Proximal Development (ZPD), which argues that students are unable to learn everything on their own, and hence, guidance or facilitation must take place. In higher education, students are encouraged to collaborate in learning despite having full autonomy of the process. This would develop their personal and social skills as demanded by Fourth Industrial Revolution (4IR) (Collins et al., 2010; Ricaurte, 2016). Heutagogy is explained by Stoten (2020) to be collaborative in order to develop engagement skills to be applied in their future workplace. Peeragogy and cybergogy, on the other hand, are known as integrating collaboration in the learning process although their collaborative concepts are different, where peeragogical collaborative learning is able to happen in an offline environment (Mulholland, 2019) and happens through an online environment for cybergogy (Wang & Kang, 2006).

The three learning theories are also found to be underpinning the FB, blog, and LMS technological tools. According to Deaton (2015), social learning would happen only in an interactive knowledge exchange environment, which is apparently supported by the tools. For instance, a discussion forum on LMS enables students to review the opinions of others, which would later alter the students' prior belief on the subject. This type of interaction and engagement occurs on the social networking site and could reinforce or change students' behaviours as well as their beliefs, which is a fundamental view in social learning theory (Kilburn, 2013).

For humanism, this learning theory underpins the FB, blog, and LMS technological tools because of the centralisation on the elements of the students and cooperation. It is also highly affiliated with the experiential learning element (Wu et al., 2012). FB supports this, as it enables students to experience a real learning process in an online world (Harris, 2012). In another view of humanistic educational theory, it focuses on the autonomy of students in determining the process of learning and, simultaneously, accentuating students' feelings (Sanmugarevathi & Lenin, 2020). This is aligned by all the technological tools in this study, as they support self-explorative learning (Schindler et al., 2017; Yukawa, 2006). Based on inferences, collaborative learning theory is conspicuous in the three tools because of their collaborative capability in supporting the learning community to complete a task, solve a problem, create a product, and share their thoughts (Craigg, 2020). Empirical studies on FB (Duncan & Barczyk, 2016), blogs (Kilic & Gokdas, 2014),

and LMS (Vuopala et al., 2015) have contributed to this statement, which implies that collaborative learning theory underpins the technological tools. The theory promotes connectedness in a learning process that takes place in an online environment (Cavus et al., 2006; Irwin et al., 2012; McLoughlin, 2013). Ultimately, this will build students' readiness and capability to learn and work in an online environment, as demanded by 4IR.

Other than that, the immersive learning concept has been incorporated into this study as it deals with the real-life like engagement through technological tools. Three principles of immersive learning have been established through the literature review for achieving immersive learning, namely, (1) real-life like environment (Beckem & Watkins, 2012), (2) a learning process that focuses more on learning experiences, presence, and co-presence (Mynbayeva et al., 2018), and (3) support by the appropriate technological learning tools (Gregory & Bannister-Tyrrell, 2017). These principles are assimilated in the blended learning environment, as doing so helps to establish an engaging learning process to enable students to incorporate into the real-world knowledge they have acquired via online because of the focus on 'learning through experience'. In summary, looking at the theoretical framework, it could be inferred that a connection exists between the principles of innovative pedagogy and the capabilities of technological learning tools that are appropriate to be implemented in the immersive blended learning environment.

5 Research questions

(a) What are the principles of heutagogy, peeragogy, and cybergogy that are relevant for an immersive blended learning environment?
(b) What are the capabilities of technological learning tools that are appropriate to use in an immersive blended learning environment?
(c) How can the principles of heutagogy, peeragogy, and cybergogy be mapped with the capabilities of technological learning tools for implementing an immersive blended learning environment?

6 Research methodology

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline in conducting a comprehensive systematic literature review by (1) establishing inclusion/exclusion criteria for determining relevant studies, (2) carrying out a search strategy, (3) distinguishing potential studies through searching and screening for data collection, (4) describing and evaluating included studies for review purposes, and (5) analysing and synthesising the findings. Inclusion criteria were based on (i) the keywords used, and (ii) studies from the beginning of 2004, when the integration of Web 2.0 began, until the present. For exclusion criteria, we excluded studies that contained non-empirical data, were not peer-reviewed and studies related to K-12

educational settings because the scope of this study is higher education. Electronic databases such as Emerald, SpringerLink Journal, ScienceDirect Journal, SAGE, Taylor & Francis Online, and Wiley Online Library were searched based on the inclusion and exclusion criteria to locate relevant studies. The specific keywords used include the following:

(a) heutagogy*; heutagogy* AND higher education; heutagogy; heutagogy AND higher education; heutagogical; heutagogic; heutagogy AND technological learning tools; heutagogy* AND principles AND higher education
(b) peeragogy*; peeragogy* AND higher education; peeragogy; peeragogy AND higher education; peeragogical; peeragogic; peeragogy AND technological learning tool; peeragog* AND principles AND higher education
(c) cybergogy*; cybergogy* AND higher education; cybergogy; cybergogy AND higher education; cybergogical; cybergogic; cybergogy AND technological learning tool; cybergogy* AND principles AND higher education
(d) capabilities of technological learning tools; technological learning tool AND higher education; Facebook AND capability; blog AND capability; Moodle AND capability

This resulted in 1,337 studies being identified (heutagogy n = 425; peeragogy n = 246; cybergogy n = 45; technological tools n = 621). Potential studies were then screened by removing duplicate studies, titles, and abstracts, non-empirical studies, and non-peer reviewed studies, which affected 1,233 studies. This left only 104 studies which fit with this study purpose (see Figs. 2, 3, 4, 5), and these were further assessed using Gough's (2007) Weight of Evidence (see Tables 1 and 2).

This method of scoring is adopted in this study, as it offers meticulous judgement that can be applied in evaluating past literature to ensure that only compatible and relevant papers are chosen in the present study (Gough, 2007). Only papers that offer overall judgement with 'excellent' and 'good' criteria are included (see Table 6 in Appendix). Finally, only 59 studies, as tabulated in Table 2, were chosen for further analysis in order to answer this study's research questions.

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For data analysis, the specific process was performed as follows:

(1) Careful review of all 20 studies through two stages. The first stage (i.e. identify the main principles) involves a thematic analysis: deductive approach (Nowell et al., 2017) where the 20 studies are categorised through a process of deductive reasoning by trying to fit them into a pre-existing coding themes of principles of

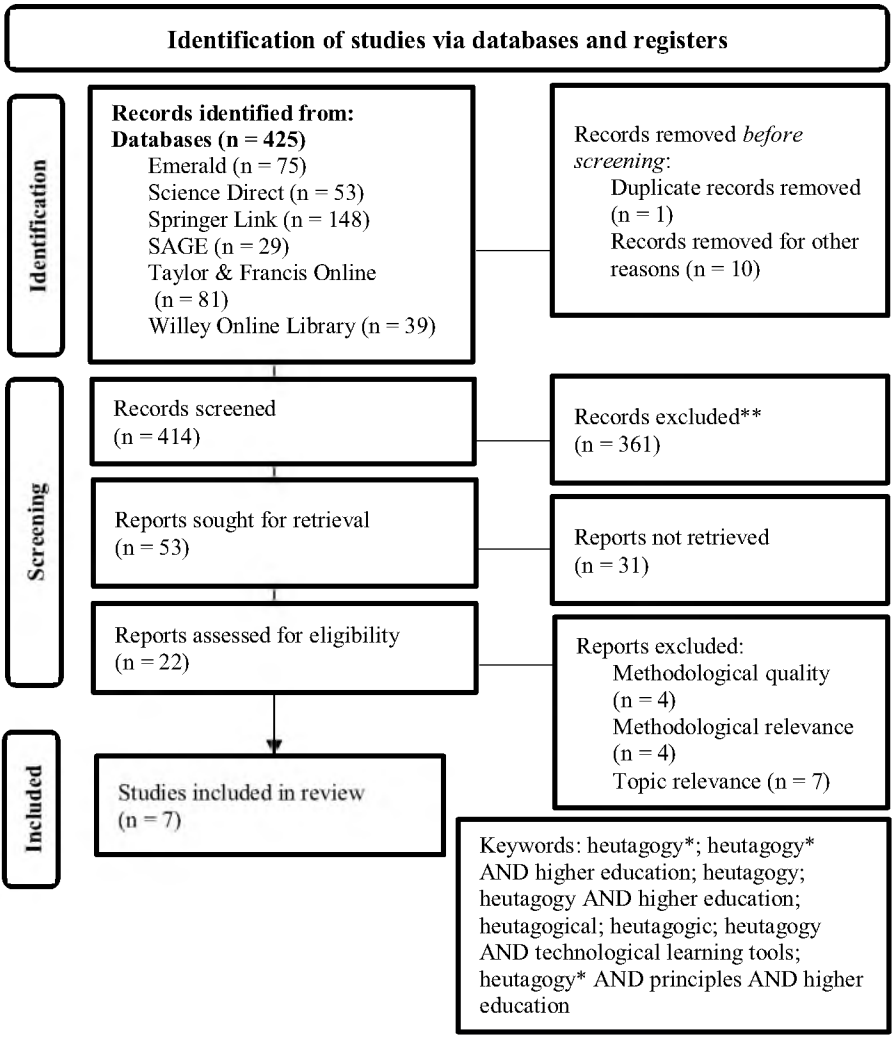

Fig. 2 Principles of heutagogy

heutagogy, peeragogy, and cybergogy. Those pre-existing coding themes can be found in the notable works by Blaschke (2012), Hase (2016), Corneli and Danoff (2011), and Wang and Kang (2006) (see Table 3 for the principles themes and its descriptions).

The second stage (i.e. identify the sub-aspects of the main principles) involves a constant comparative method (Maykut & Morehouse, 1994) by comparing and breaking down the raw data from the 20 studies through a process of inductive reasoning into specific sub-aspects themes that align with the main principles of

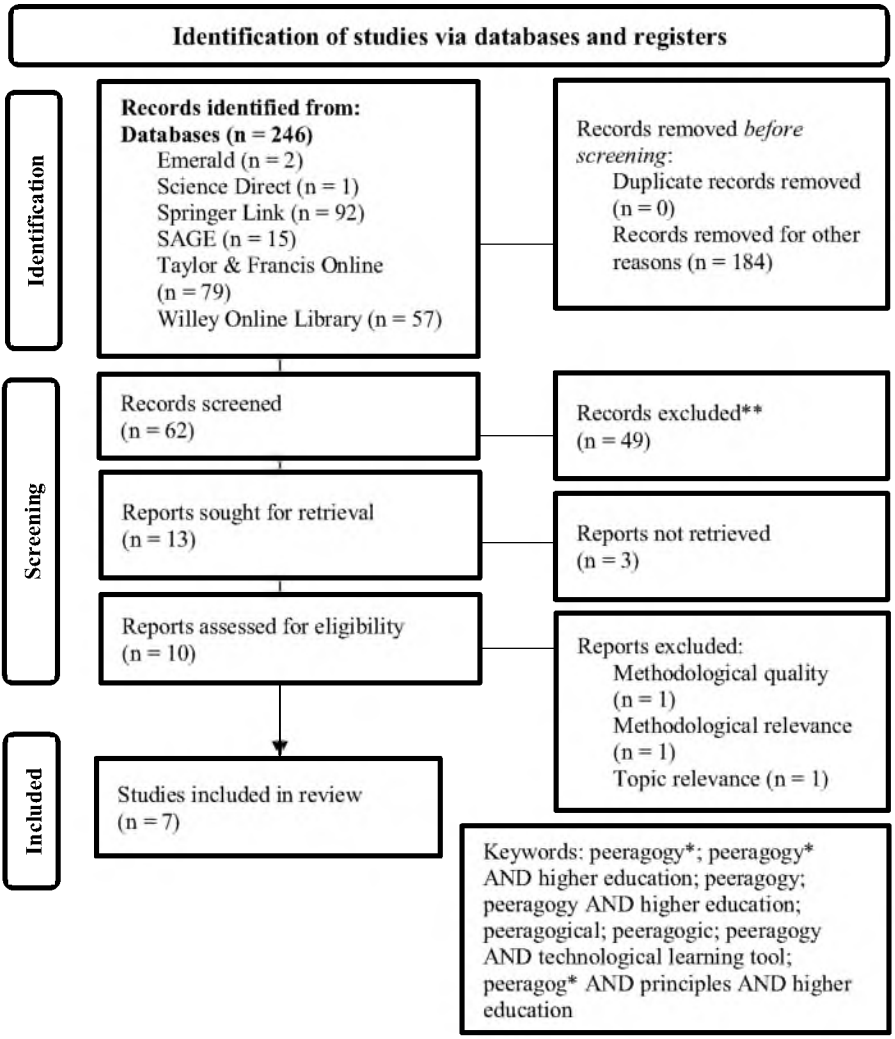

Fig. 3 Principles of peeragogy

innovative pedagogies (see Table 4 for the sub-aspects themes and its description).

(2) Careful review of all 39 studies via a constant comparative method: inductive approach (Maykut & Morehouse, 1994) by comparing and breaking down the raw data from the 39 studies through a process of inductive reasoning, in order to develop appropriate themes of capabilities of FB, LMS, and blog technologi-

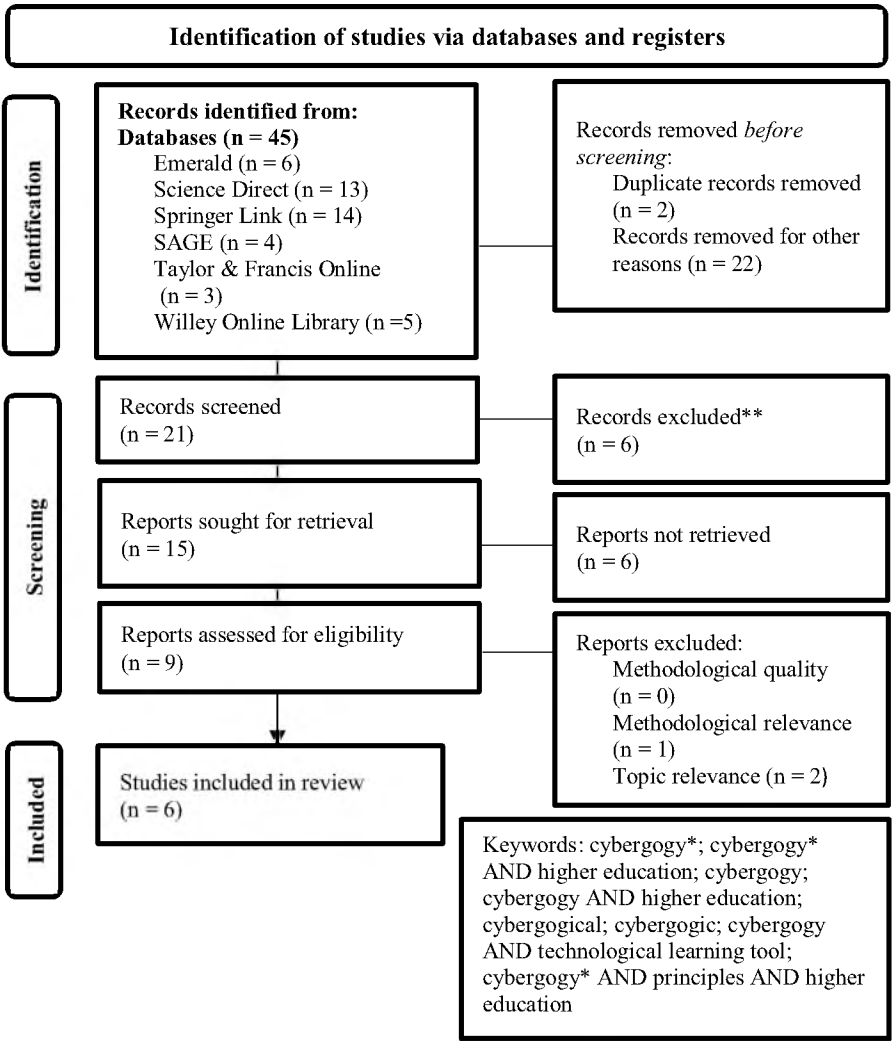

Fig. 4 Principles of cybergogy

cal learning tools. Inductive reasoning is a process of coding the data without trying to fit it into the researcher's analytic preconceptions but is data-driven instead (Nowell et al., 2017). See Table 5 for the capabilities' themes and its descriptions.

(3) Formulation of the mapping structure of innovative pedagogical principles, and technological learning tools capabilities by analysing and matching the similarity in characteristics from the findings in processes 1 and 2 above.

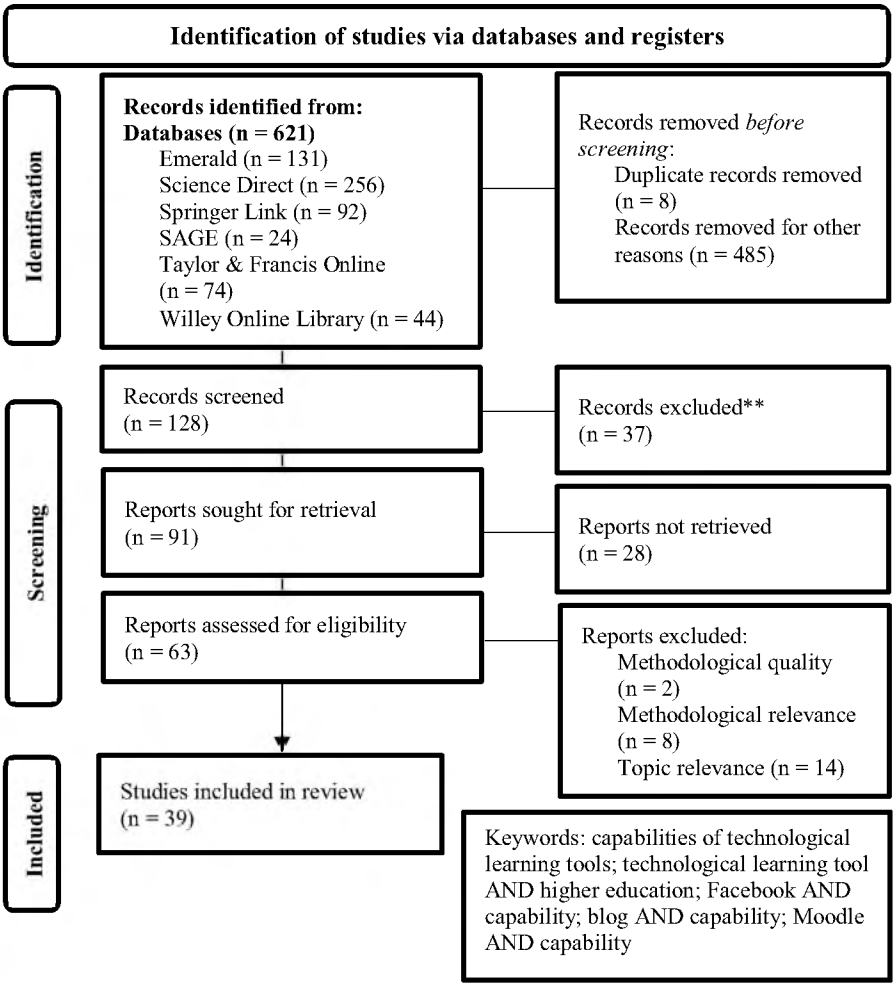

Fig. 5 Capabilities of technological learning tools

7 Results and discussion

7.1 Principles of heutagogy, peeragogy and cybergogy that are relevant for an immersive blended learning environment

Figure 6 presents the main principles and sub-aspects of Education 4.0 innovative pedagogies. The main principles are identified based on the typology proposed from the seminal works by Blaschke (2012), Hase (2016), Corneli and Danoff (2011), and Wang and Kang (2006). The sub-aspects of the main principles meanwhile have been systematically reviewed and derived inductively through a constant

Table 1 Weight of evidence (Gough, 2007)

Level/Criterion	Methodological quality	Methodological relevance	Topic relevance
Excellent	Excellent research design that justifies all decisions taken, e.g.: sample, instruments, analysis. Clear evidence of measures taken to maximise validity and reliability	Research questions is clearly stated Methodology is highly relevant to research questions and answers them in details	Study is very closely aligned to one of the key review questions and provides very strong evidence upon which to base future policy/action
Good	Research design is clearly stated with evidence of sensible decisions taken to provide valid and reliable findings	Research questions are explicit or can be deduced from text Findings address the research questions	Study is broadly in line with one of the key review questions and provides useful evidence
Satisfactory	Research design may be implicit but appears sensible and likely to yield useful data	Research questions implicit but appear to be broadly matched by research design and findings	At least part of the study findings is relevant to one of the key review questions
Inadequate	Research design is not stated and contains flaws	Research questions are not stated or not matched by design	Study does not address key questions

Table 2 Total included studies based on PRISMA guideline according to themes

Theme	Number of studies
Principles of heutagogy	7
Principles of peeragogy	7
Principles of cybergogy	6
Technological learning tools' capabilities (Facebook, blog & LMS)	39
Total	59

comparative method. The details descriptions of the themes and articles classification can be seen in Table 4 and at Table 7 in Appendix, respectively.

Four principles underlying heutagogy are involved in this study. The first is *human agency*, which deals with the student's intention to learn something voluntarily using their own preferred learning technique (Bandura, 2001; Blaschke, 2021; Blaschke & Hase, 2019). As an agent of their own learning journey, the student decides regarding their own method of how to learn and what to learn. Similar to the concept outlined by Christensen et al.'s (2013) models, Stoten (2020) and Patel (2018) reported that higher education students have full autonomy of their learning journey; this contradicts the traditional form of the knowledge-seeking process. This shift develops a substantial sense of responsibility and personal identity because of the personal competency awareness (Blaschke & Hase, 2019; Canning & Callan, 2010).

The second is *capability*, where students are able to integrate the knowledge and skills that they have learned in an unfamiliar context or situation (Blaschke & Hase, 2016). This could be achieved by implementing a curriculum that helps students engage with the real world (Stoten, 2020), which could assist in equipping them with essential twenty-first century skills. Moreover, as students of higher education are required to possess digital skills, Yusuf and Yusuf (2018) urged instructors to implement innovative pedagogies; these include integrating heutagogy in the process of teaching and learning, as it is aligned with the twenty-first century digital learning environment. This would consequently produce twenty-first century graduates known as digitalists, who can adapt to the future workplace and community because of their digital skills.

The third principle comprises *self-reflection and double-loop learning*. These two capabilities are closely linked to each other. Students should be reflective in their learning process to develop metacognitive and self-regulative skills (Gregory et al., 2018), and this is achievable whenever students are engaged in a thinking process during learning (Canning & Callan, 2010). The ability to reflect on their learning journey will lead to the second element of this principle, which is double-loop learning. This extension of andragogical single-loop learning obliges students to alter their personal beliefs and values by self-correcting their problem-solving skills and modifying their style of learning to be more efficient (Blaschke & Hase, 2016). This

Table 3 Description of themes of principles of heutagogy, peeragogy and cybergogy

Education 4.0 pedagogy	Principle	Description
Heutagogy (Blaschke, 2012; Hase, 2016)	Human Agency	Learner's intention to learn something voluntarily using their own preferred learning technique
	Capability	Learners' ability to integrate the knowledge and skills that they have learned in an unfamiliar context or situation into real situation
	Self-reflection & Double-loop learning	Learners are reflective in their learning process to develop metacognitive and self-regulative skills and alter their personal beliefs and values
	Non-linear learning	Learning is dynamic and flexible
Peeragogy (Corneli & Danoff, 2011)	Context as decentered center	Learner contributes on their own axis that changes the space or context
	Meta-learning as a font of knowledge	Learner's practice of awareness in their process of learning
	Peers provided feedback that wouldn't be there otherwise	A community (paragogues) that shares similar interests online that could alter each other's understanding of knowledge through interaction
	Learning is distributed and non-linear	The ability of peeragogues to co-create content in an open learning platform as a part of an online community
	Realize the dream and then wake up!	Knowledge community should be able to complete their learning objective at one point and move on to join the next knowledge community
Cybergogy (Wang & Kang, 2006)	Cognitive factor	Elements that could trigger the learners' ability in making sense of knowledge such as learners' (i) prior knowledge, (ii) achievement goals, (iii) learning activity and (iv) cognitive/learning style
	Emotive factor	Learners' psychological conditions and relationship within their learning community members;(i) self-efficacy, (ii) self-confidence, (iii) self-competence of learners, (iv)connection with community and (v) the built learning environment
	Social factor	Learners' (i) socio-background, (ii) identity in a community and (iii)sense of community which could be built through collaborative activities

Table 4 Description of main and sub-aspect themes of principles of heutagogy, peeragogy and cybergogy

Education 4.0 pedagogy	Principle	Aspect	Description
Heutagogy	Human Agency *Learner's intention to learn something voluntarily using their own preferred learning technique*	Autonominity	Learner self-determines how and what they are learning
		Personal identity	Learner is aware of their responsibility and personal competency
	Capability *Learners' ability to integrate the knowledge and skills that they have learned in an unfamiliar context or situation into real situation*	Curriculum to engage with world	Learner's knowledge and skills are adaptable to real-world because of flexible curriculum
		Having digitalist skills	Learner is trained of their research skill of internet which would optimise their higher order thinking skills (HOTS)
	Self-reflection & Double-loop learning *Learners are reflective in their learning process to develop metacognitive and self-regulative skills and alter their personal beliefs and values*	Reflective learning environment	Learner's metacognitive and reflexive skills assists their understanding of knowledge
		Thinking process leads to reflection	Learner involves emotions and thinking on experiences, values, critical/creative thinking when reflecting of reflection (meta-reflection)
	Non-linear learning *Learning is dynamic and flexible*	Dynamic process	Learner learns in a flexible and non-static process

Table 4 (continued)

Education 4.0 pedagogy	Principle	Aspect	Description
Peeragogy	Context as decentered center *Learner contributes on their own axis that changes the space or context*	Contributing on personal axis	Learner understands the self-concept in a co-production learning environment which requires them to contribute as an individual
	Meta-learning as a font of knowledge *Learner's practice of awareness in their process of learning*	Deciding on syllabus	Learner determines and plans their own syllabus/ curriculum within their learning community
		Analysis on the knowledge	Learner is able to develop analytical skill while discussing on background knowledge
	Peers provided feedback that wouldn't be there otherwise *A community (paragogues) that shares similar interests online that could alter each other's understanding of knowledge through interaction*	Feedback from paragogues	Learner receives feedback from peers and instructor regularly for reflection
		Involvement of experts	Learner benefits from the expert's view on key concept and guidance
	Learning is distributed and non-linear *The ability of peeragogues to co-create content in an open learning platform as a part of an online community*	Open knowledge production	Learner utilised an open online platform to co-create knowledge within learning community
		Flexibility	Learning objective might be changing during semester in accordance to course/program
		Asynchronous knowledge production	Learner works collaboratively using asynchronous media (platform)
	Realize the dream and then wake up! *Knowledge community should be able to complete their learning objective at one point and move on to join the next knowledge community*	Disbandment of knowledge production team	Learners should know when act and move on when learning is complete or unable to be finished

Table 4 (continued)

Education 4.0 pedagogy	Principle	Aspect	Description
Cybergogy	Cognitive factor *Elements that could trigger the learners' ability in making sense of knowledge such as learners' (i) prior knowledge, (ii) achievement goals, (iii) learning activity and (iv) cognitive/learning style*	Critical thinking	Learner is equipped with critical thinking for a more advanced thinking
		Problem solving	Learner is able to find appropriate solution for conflicts based on their knowledge
		Self-formative	Learner self-acquires knowledge in finding solution
	Emotive factor *Learners' psychological conditions and relationship within their learning community members;(i) self-efficacy, (ii) self-confidence, (iii) self-competence of learners, (iv)connection with community and (v) the built learning environment*	Autonominity	Learner's independency
		Satisfaction	Learner's satisfaction affects their participation in their learning
		Cultural	Learner's cultural background affects their confidence level
	Social factor *Learners' (i) socio-background, (ii) identity in a community and (iii)sense of community which could be built through collaborative activities*	Collaborative	Learner's networking is able to be developed
		Engagement	Learner engages in online environment through learning activities
		Personal preference	Learner's preference in their working environment (autonomous or collaborative) affects learning effectiveness
		Enlarging social and business environment	Learner consciously and unconsciously learn when exposed to social and working environment through learning task

Table 5 Description of sub-capabilities themes for technological capabilities of FB, LMS, and blog

Capability	Sub-capability	Description
Management *Manage learning for a more organised learning process*	Resource	Learning materials are accessible directly from learning tools
	Personalisation	Customisable and able to be personalised based on learner's needs
	Flexible & Convenient	Easing the process of learning management
	Efficient	Accelerate the learning process because of the comprehensive functions
Communication time *Support real-time and flexible learning*	Synchronous	Real-time learning that provides opportunity for learners to interact directly for discussion and teaching and learning
	Asynchronous	Online or independent learning time where learners have the responsibility to learn at their own time according to guidelines provided by instructors
Self-related *Assist learners in developing their behaviour, skill or emotion*	Autonomous	Allow students to decide and determine their own syllabus and method of learning
	Explorative	Explore knowledge without restriction
	Reflective	Provide platform to reflect their learning experience
	Critical thinking	Achieve deep insight through interaction and discussion
	Self-expression & self-confidence	Build prior knowledge and provide opportunity to communicate with genuine audience
Learning task *Participate in or complete task without time restriction issue*	Creating idea	Create individual showcase projects, ideas and information
	Sharing idea	Brainstorm and deliver the ideas during asynchronous learning
Learning community-related *Support learning that involves a group of students with similar learning concerns / objectives or who are enrolled in a similar course*	Communicative & Interactive	Assist two-way interactions (e.g.: feedback & monitor)
	Connective & Collaborative	Connect learners for collaborating their knowledge through learning activities
	Engaging	Engage learners of a learning community emotionally, behaviourally and cognitively
Experiential learning		Experience of immersive virtual learning when adopting appropriate technology

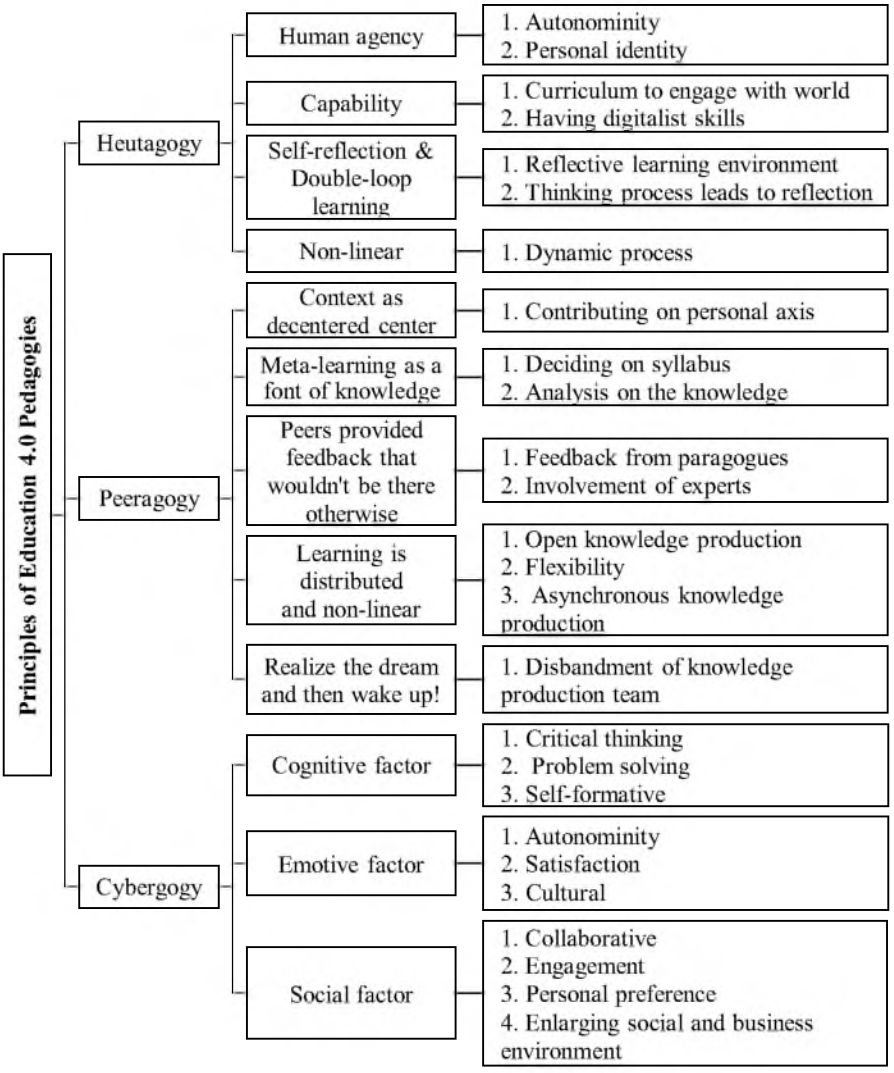

Fig. 6 Principles and sub-aspects of Education 4.0 innovative pedagogies

is possible because heutagogy offers a high-quality reflective environment (Stoten, 2020).

Fourth is *non-linear learning*. In the traditional teaching and learning approach, instructors have full authorisation/top down direction of knowledge delivery. However, for twenty-first century learning, the ultimate decision of a learning process is taken by the students by exploring the variety of learning paths in pursuit of dynamic and flexible learning (Gregory et al., 2018; Hase, 2016). This non-linear learning might also include collaboration, communication, and connection with others because that is how students attain knowledge from both inside and outside the classroom (Facer & Selwyn, 2010).

The systematic literature review on peeragogy studies in higher education settings also comprised the five peeragogy principles outlined by Corneli and Danoff (2011). The first principle is *changing context as a decentred centre*. This principle is heavily influenced by the concept of 'basho', which means a shared context in motion: while interacting, every student is responsible for contributing based on their own axis, which changes the space or context (Corneli & Danoff, 2011). This concept is introduced to emphasise that there is no specific centre in this learning mode.

The second principle is *meta-learning as a font of knowledge*. Meta-learning is a substantial concept in peeragogy, which relates to students' metacognition. It could be defined as the peeragogues' (students in peeragogical classroom) practice of awareness of their process of learning (Corneli & Danoff, 2011). In other words, paragogues need to be conscious of what and how they are learning to be able to grasp knowledge. According to Raw (2014), students are more conscious of their learning process when they are deciding their course syllabus. In addition, to improve peeragogues' meta-learning, analysis could be conducted of knowledge in a peeragogical classroom discussion (Ouhrir et al., 2019). This, in turn, will lead to the formation of critical students who are aware about the learning content as well as how they acquire the content.

Third, the principle of *peers provide feedback that would not be there otherwise* points out that a community that shares similar interests online could alter each other's understanding of knowledge through interaction (Corneli & Danoff, 2011). This alteration could happen if paragogues provide regular and constructive feedback to each other (Raw, 2014). Also, the involvement of experts or prominent figures will be valuable, as their feedback will be constructive and contributive for beginners (Yusuf & Yusuf, 2018). Although peeragogy emphasises learning in an informal environment, this supportive and collaborative environment is appropriate and could be implemented in formal and physical settings as done by Mulholland (2019).

The fourth principle is *learning is distributed and nonlinear*. The distributed and non-linear learning aspect in peeragogy refers to the ability of peeragogues to co-create content in an open learning platform as part of an online community (Corneli & Danoff, 2011). Usually, peeragogical technique is used to build, share, and primarily, learn from others in a similar field (Ricaurte, 2016). This principle is suggested to relate directly to the first principle of peeragogy because the peeragogues should realise they are individuals who work independently in an asynchronous and distributed environment, although they collaborate in one knowledge community (Mulholland, 2019). In this learning environment, they are allowed to contribute flexibly based on their capability and knowledge (Raw, 2014) because of the distributive nature of peeragogy.

The fifth principle is *realize the dream ıf you can and then wake up!*. This last peeragogical principle suggests that every knowledge community should be able to complete their learning objective at one point and move on to join the next knowledge community (Corneli & Danoff, 2011). The term 'knowledge community' or 'learning community' refers to a network of peeragogues that contributes to co-producing knowledge (Mulholland, 2019). When adapting peeragogy in learning, a knowledge community should establish a set of objectives to be achieved by the end of the co-producing process. This differs from the concept of Wikipedia despite it

having a similar essence of peer production. This is due to the free-access editing concept where the articles could be modified/re-edited publicly by individuals that do not belong to any learning community.

The principles of cybergogy are reviewed based on Wang and Kang's (2006) suggestions. The first principle is the *cognitive factor*. 'Cognitive factor' refers to the elements that could trigger the students' ability to make sense of knowledge, such as students' prior knowledge, achievement goals, learning activity, and cognitive/learning style in a cybergogical classroom (Muresan, 2014; Thanh Tran & Van Nguyen, 2020; Wang & Kang, 2006). In addition, critical thinking and problem-solving ability are listed as additional cognitive factors because they are the generic skills required in today's 4IR (Chaka, 2020; Yusuf & Yusuf, 2018). By emphasising these factors in a cybergogical classroom, students' level of cognition can be improved.

The second principle is *emotive factor*. This principle emphasises students' psychological conditions and the relationship among their learning community members; therefore, the self-efficacy, self-confidence, and self-competence of students are incorporated throughout the learning process (Wang & Kang, 2006). Students who are able to navigate their own learning process in an informal and less restricted learning environment are thought to be more satisfied with their learning process (Muresan, 2014). Wang et al. (2009) also revealed that students' cultural background may affect their emotional state of participating in class. For example, students with an Asian background tend to feel less confident in taking part in classroom activities or expressing themselves, as they view themselves as inferior to the instructors. This indicates that the emotional state of students could greatly affect their learning process; thus, instructors could be more attentive in dealing with students from different backgrounds.

The third principle is *social factors*. This relates to the social background of the students' identity and sense of community, which could be built through collaborative activities (Wang & Kang, 2006). These activities usually take place in online that are guided by instructors to support engagement among students (Yusuf & Yusuf, 2018). Collins et al. (2010) supported this by mentioning that collaboration and engagement can be achieved among students after completing a task together in a cybergogical classroom. Hence, as social factors are triggered by collaboration and engagement within the learning community, teaching and learning should instill a strong sense of community (Wang & Kang, 2006). From this, it is summarised that these cybergogical principles are highly related in creating an immersive blended learning environment, as it considers comprehensively the cognitive, emotive, and social aspects of the student.

Relating these innovative pedagogical principles to blended learning, Christensen et al. (2013) mentioned that their models focus on altering and redesigning the learning process by shifting to a student-centred concept in a combination of face-to-face and online learning. As heutagogy, peeragogy, and cybergogy are listed as student-centred pedagogies, this implies they are applicable in a blended learning environment. It could also be noted that certain principles of these Education 4.0 pedagogies correspond to the immersive learning principles. Mynbayeva et al. (2018) outlined that the learning process should focus more on learning experiences, meta reflection, and group tasks to achieve immersive learning. This fits into human agency, self-reflection and double-loop learning, context as decentred centre, peers provide feedback that would not be there otherwise, and emotive and social factors where it prepares learners to be

completely engaged with and immersed in the given scenario or situation as well as contextualised learning activities that encourage students to approach a meaningful student-centred learning experience from both the theoretical and practical perspectives, which can prepare them for the skills they will need in the workplace (Beckem & Watkins, 2012). Another claim is made by Gregory et al. (2018) where a deeper connection with peers will result in an immersive learning environment; thus, considering the two reflection-related principles of heutagogy, peeragogy, and emotive cybergogical factors that could occur in both face-to-face and online learning sessions, students could achieve an immersive session with their learning community members.

7.2 Capabilities of technological learning tools that are appropriate to use in an immersive blended learning environment

Figure 7 depicts the capabilities of FB, blogs, and LMS, which are classified inductively into six main categories through a constant comparative method. The capabilities found through the systematic review include (1) management, (2) communication time, (3) self-related, (4) learning task, (5) learning-community-related and (6) experiential learning. The descriptions of sub-capabilities can be seen in Table 5. See Table 8 in Appendix for details articles classification of the capabilities.

The first capability is *management*. Technological learning tools that possess this capability are able to manage learning for a more organised learning process (Ghilay, 2019). The sub-capabilities listed under management are *resources, personalisation, flexibility and convenience*, and *efficiency*. Resource management is shown when students are able to access learning materials directly from their learning tools. For instance, FB has been used to compile and share learning resources (Bateman & Willems, 2012). Meanwhile, Kassab et al. (2015) and Poncela (2013) mentioned that LMS assists instructors in managing materials such as lectures, course note documentation, examination timetables, and assessment details. Next, for the sub-capability personalisation, Haworth (2016) stated that Web 2.0 tools and social media are customisable during the design phase of instructional design and can be personalised based on students' needs in order to support the self-learning direction for attaining specific learning outcomes. The sub-capability flexible and convenient meanwhile works by easing the process of learning management. For example, by using LMS, time and effort are greatly reduced because the platform is able to provide quick access to the texts, audio files, and other materials uploaded by the instructors. A similar sub-capability is also noted in FB where it could assist in providing quizzes and presentations, and in sharing links among the learning community although it is known as a social media platform (Pimmer et al., 2012).

The second capability is *communication time*. Technological learning tools should be flexible in supporting students in their communication process in which they can exchange information/knowledge/discussion and so on, instantly (*synchronous*) or with transmission delays / lags (*asynchronous*). Based on the systematic review conducted on the previous literature, FB and LMS are found to support the synchronous interaction feature. For instance, Bateman and Willems (2012) study addressed how FB is equipped with a synchronous chat function with a notification

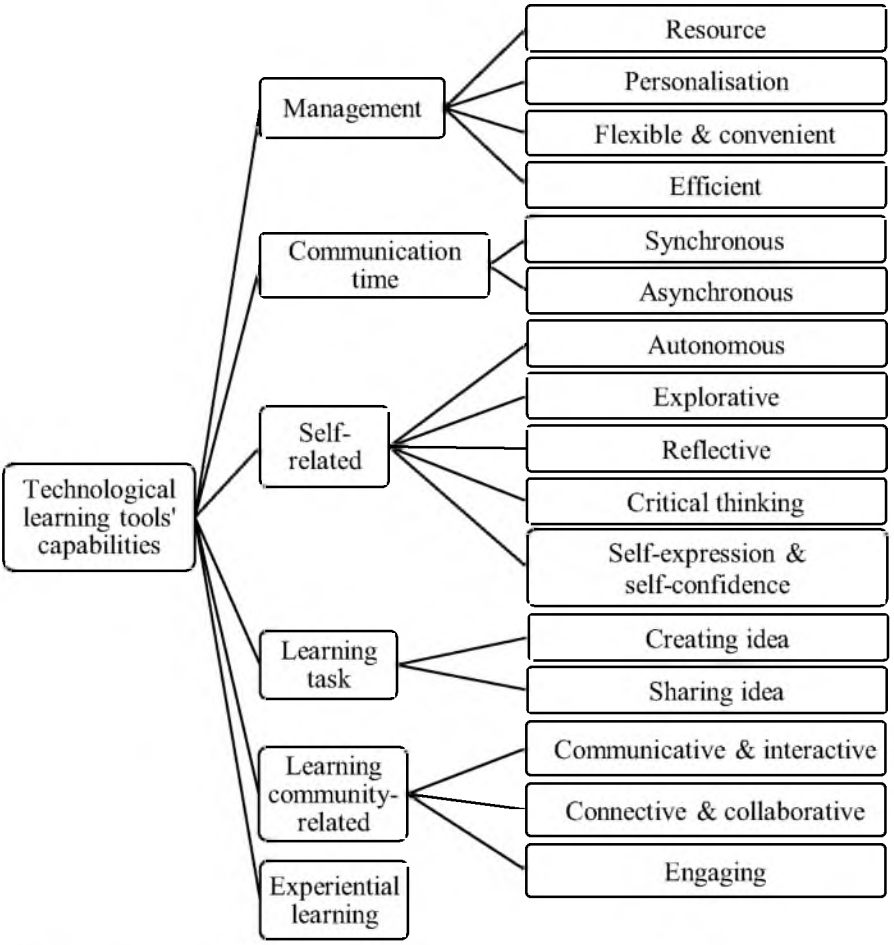

Fig. 7 Capabilities of technological learning tools

alert that enables students to engage simultaneously and receive rapid replies from their learning community. They added that students are able to share their knowledge simultaneously by using this synchronous function. Likewise, LMS has this sub-capability to help the instructor to present and manage the course assignment in a synchronous manner (Kasim & Khalid, 2016). Additionally, de Jong et al. (2014) mentioned that the addition of an asynchronous environment is important, as it complements the blended learning process, which is found in FB, blogs, and LMS. Asynchronous learning usually takes place in an online environment where learners have the responsibility to learn in their own time and at their own pace according to guidelines provided by instructors (Azmi et al., 2012; von der Heidt & Quazi, 2013), and this helps to reinforce more in-depth learning when students are reflecting on their knowledge-learning process. To conclude, the tools are appropriate for

a blended learning environment where synchronous and asynchronous sessions are supported.

The third capability is *self-related*, which relates to technological learning tools that can assist students in developing their behaviours, skills, or emotions. As twenty-first century learning is student-driven, tools that can provide an opportunity to promote students' *autonomy* and self-determination should be adopted. The systematic literature review reveals that FB (Blaschke & Hase, 2019; Gregory et al., 2018; Kayri and Cakır, 2010), blogs (Fattah, 2016), and LMS (Ntshwarang et al., 2021) are capable of cultivating autonomy among students. Autonomy allows students to decide and determine 'what and how to learn' (Hase, 2016). For instance, students can independently search for a learning community that will provide assistance regarding additional resources on FB without depending on their instructors (Gregory et al., 2018). This is compared to blogs, where students develop autonomy when managing their blogging documents, transferring knowledge learned in face-to-face or synchronous lectures, and *reflecting* their learning experience when posting in their blog (Fattah, 2016). Also, students are found to benefit from LMS (Yukawa, 2006) in *exploring* knowledge on their own without restrictions. Meanwhile, students' *critical thinking* can be improved by adopting LMS and blog in their learning process. This issue is addressed by Kassab et al. (2015) where the use of interactive online sessions of a blended classroom using LMS has achieved deep insight among students. Moreover, Lujan-Mora and de Juana-Espinosa (2014) mentioned how a blog serves as a critical thinking platform where exchanges of opinions and experiences can occur among students. Lastly, the sub-capability *self-expression and self-confidence* is discovered when the selected tools provide a platform for students to self-reflect, which boosts their self-confidence. Research by Kabilan et al. (2010) reported that students' self-confidence improved after they were given the opportunity to communicate with a genuine audience by writing and reading more on FB. Other than that, instructors can utilise FB as a pre-learning platform for blended learning by uploading videos, as this helps students to build prior knowledge because they are seen to be more prepared and confident to participate in the discussion during the face-to-face session (Thanh Tran & Van Nguyen, 2020). In summary, it can be agreed that the technological learning tools help in developing self-related aspects, such as behaviour, skills, and psychological state.

The fourth capability is *learning task*. Other than assisting students' personal development and their management of learning materials, technological learning tools are also proven to help students in their learning tasks (Blaschke & Hase, 2019; Tasir et al., 2005). By having this capability, students can *create*, build, and *share* the knowledge in their learning community. In Blaschke and Hase's (2019) heutagogical study, FB was described as assisting in creating individual showcase projects, ideas, and information. This is supported by studies such as Bateman and Willems (2012) and Irwin et al. (2012) where in the higher education context, FB is used to share ideas and information via online participation in their learning community. On the other hand, LMS has been utilised by students to brainstorm and deliver the resulting ideas during asynchronous learning (Tasir et al., 2005). Through these tools, students are able to participate in or complete their task without time restriction issues compared to face-to-face sessions.

The fifth capability is *learning community-related*, in which technological learning tools are said to support learning that involves a group of students with similar learning concerns/objectives or who are enrolled in a similar course (Gregory et al., 2018). The *communicative and interactive* sub-capability is confirmed in the systematic literature review because the tools are capable of assisting two-way interactions (between learner-peer and learner-instructor) (de Mattos, 2014; Prescott et al., 2013). Studies by de Jong et al. (2014) and Kayri and Cakır (2010) demonstrate that Web 2.0 tools, such as social media and blogs, train students to communicate and interact in a community-based environment. This interaction happens via the feedback-giving process. In addition, while giving feedback, instructors are able to monitor the students indirectly. This implies that a learning community consists not only of students and peers but also of their instructors, who are considered experts in their field of study (Alexander et al., 2014). Interestingly, FB has an added value where students can communicate with individuals outside their learning community in private or public settings (Irwin et al., 2012), which could expand their social circle. Nonetheless, the instructor is still necessary in online learning to steer the learning process (Kayri and Cakır 2010).

The next sub-capability is *connective and collaborative*, where it focusses on connecting students for collaborating regarding their knowledge through learning activities (Blaschke & Hase, 2019; McLoughlin, 2013). It is different to the sub-capability communicative and interactive where students are only communicating to receive feedback and notifications and to interact during peer mentoring (Duncan & Barczyk, 2016). By answering forum discussions on FB and LMS, students are cognitively connected and might collaborate to solve a problem within an online learning community (Bateman & Willems, 2012; McLoughlin, 2013). This is similar to when Alexander et al. (2014) mentioned making use of the collaborative infrastructure of FB for activities such as posing questions.

Lastly, *engaging* is acknowledged as part of the learning community-related capability, as the tools have the ability to engage the students of a learning community emotionally, behaviourally, and cognitively (Collins et al., 2010; Schindler et al., 2017). Kilic and Gokdas's (2014) finding shows the students are not only engaged with their learning community to share their knowledge content but also to share their experience as well, which will encourage a deeper involvement in learning about using a blog. Additionally, Schindler et al. (2017) highlighted that students' behaviour engagement could be enriched by using blogs when they are completing the tasks that are assigned to them. Callaghan and Fribbance (2018) further argued that engagement in the higher education context can build networking with a wider audience in an authentic online environment on FB that is not restricted to one learning community. Consequently, it helps students to have an immersive engagement in their process of learning in a real-life like environment, which is assisted by appropriate technological learning tools (Beckem & Watkins, 2012; Gregory & Bannister-Tyrrell, 2017).

The sixth capability is *experiential*. This capability is defined as immersive online learning that could be experienced by students when adopting the appropriate technological learning tools in the learning process (Harris, 2012). Harris (2012) further explained that students who are able to experience a online

learning environment that feels similar to the traditional classroom setting tend to acquire knowledge better, as the vivid experience helps them to focus. Nonetheless, a deep learning issue has been addressed in Callaghan and Fribbance (2018) when implementing FB, as overabundant distraction and simulation in the open learning space might halt students' capacity for in-depth processing of the knowledge. Nevertheless, social media can provide authentic engagement because of the tool's ability to situate students in authentic and genuine real-life like contexts, such as collaborating with instructors and learning communities (Narayan et al., 2019). Kabilan et al. (2010) also stated that authentic learning could happen not only through real-time communication but also via online discussion, comment, or reading activity.

To summarise, these identified main and sub-capabilities of technological learning tools inform how specific tools possess capabilities similar to those held by others and how they differ from one another. According to Beckem and Watkins (2012) and Gregory and Bannister-Tyrrell (2017), immersive learning could take place by engaging in real-life like environments as well as with the assistance of the appropriate technological learning tools; if deep engagement happens, the application of FB and LMS can support online synchronous sessions, or blogs can function as a deep reflective platform. Hence, it is possible to achieve an immersive blended learning environment in the learning and teaching process by utilising and considering the capabilities of the selected familiar twenty-first century technological learning tools discussed in this study.

7.3 Mapping of the principles of heutagogy, peeragogy, and cybergogy with the capabilities of technological learning tools for immersive blended learning implementation

Figure 8 shows the basis for mapping elements to indicate the suitable implementation of an immersive blended learning approach. The capabilities of the technological learning tools are mapped with the selected ten innovative pedagogical principles to find the relevance of the two elements in creating an immersive blended learning environment.

Initially, there are 12 innovative pedagogical principles discussed in this study; however, the second and fifth principles of peeragogy are not included in the mapping because of their unimportance to being adopted in a blended learning environment. This is because (1) the two principles require no technological learning assistance when learners need to halt/take a step back in order to observe their learning process. Note that technological usage is necessary for the scope of this study, and (2) the independent learning concept that can be found in both second and fifth principles has been covered in the first and fourth principles; therefore, it is appropriate to omit the second and fifth peeragogy principles to avoid duplicated results in the mapping.

Based on Figs. 9, 10, and 11, the obvious pattern that can be seen from the mapping is that each capability of all types of technological tools, i.e., FB, blogs, and LMS, is associated with at least one aspect of the principles of Education 4.0

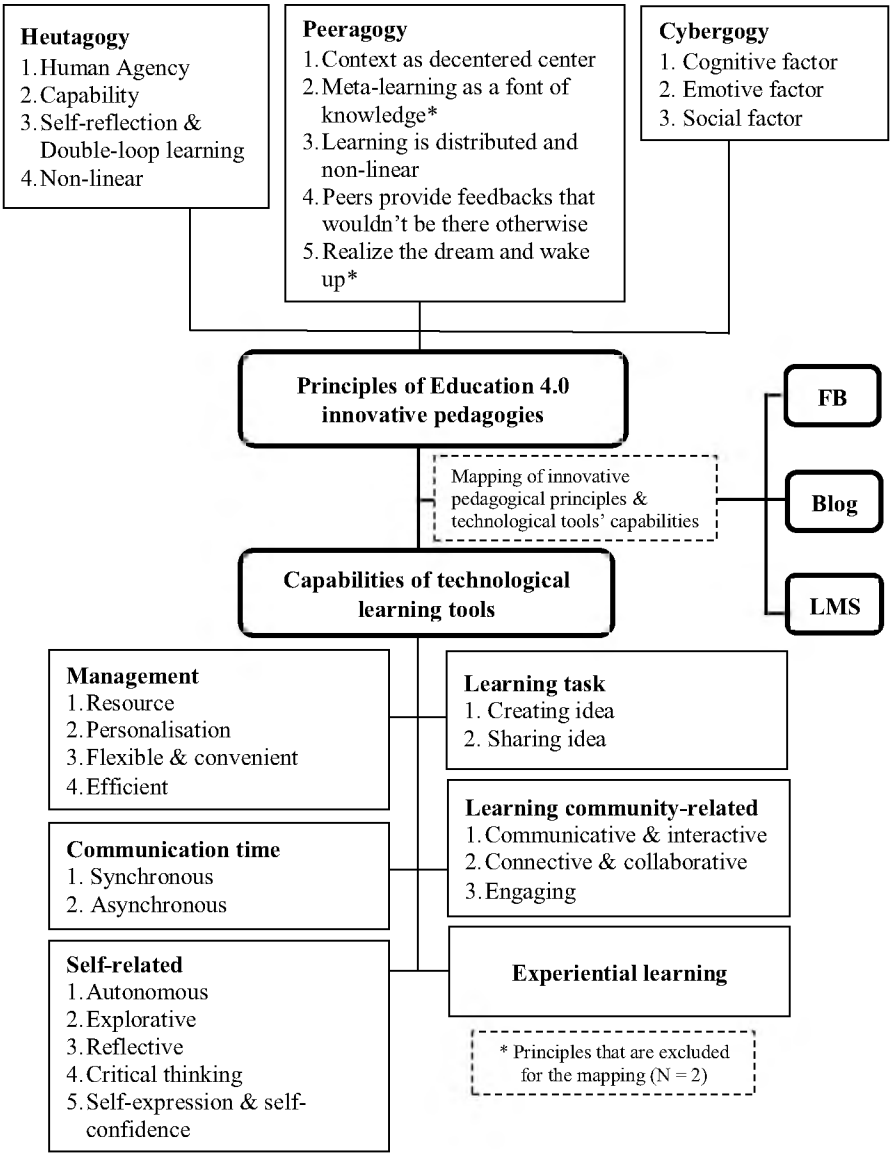

Fig. 8 Framework of mapping Education 4.0 innovative pedagogical principles and the capabilities of technological learning tools

innovative pedagogies. This could mean that establishing an immersive blended learning environment is possible, as the learning process could be optimised by integrating comprehensive pedagogical elements and technological tools that are directly linked to each other. This is also congruent with Kaufman's (2019) suggestion that in redesigning a transformative instructional model of blended learning, it

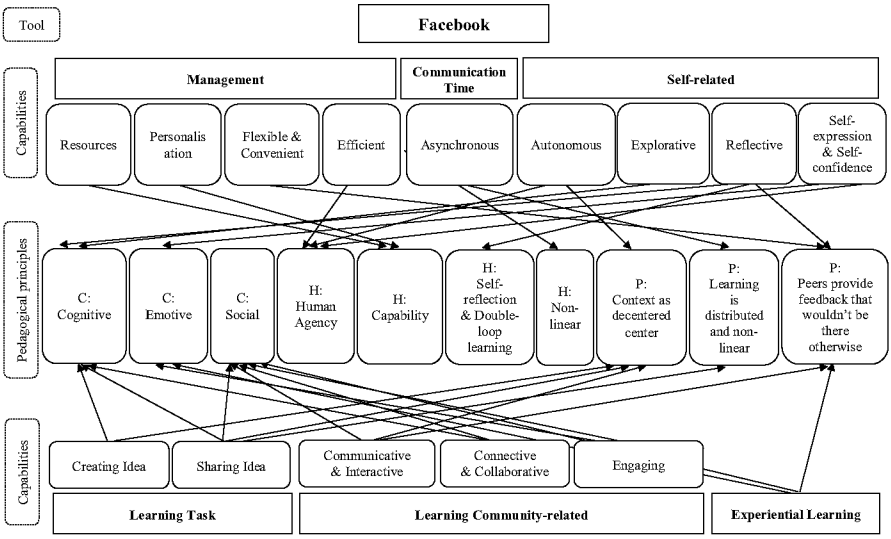

Fig. 9 Mapping of principles of Education 4.0 pedagogies with Facebook

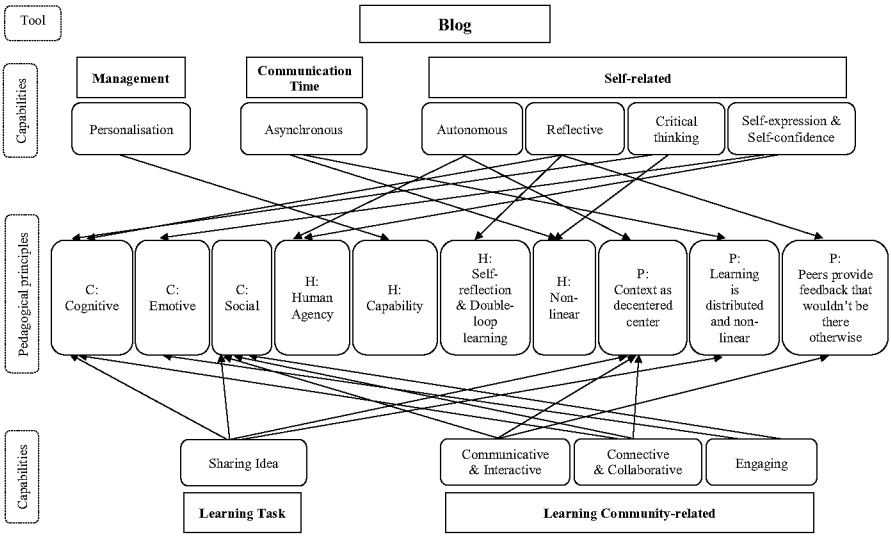

Fig. 10 Mapping of principles of Education 4.0 pedagogies with blogs

has to involve both technology and pedagogy and thus can promote active learning experiences and student-centred pedagogies.

Analysing the technological learning tools individually, FB has the most connections (n = 30 links) between the capabilities and pedagogical principles compared to blogs (n = 24), and LMS (n = 23). This proves that although FB starts off as a social media tool, it is relevant to be categorised as one of the most influential

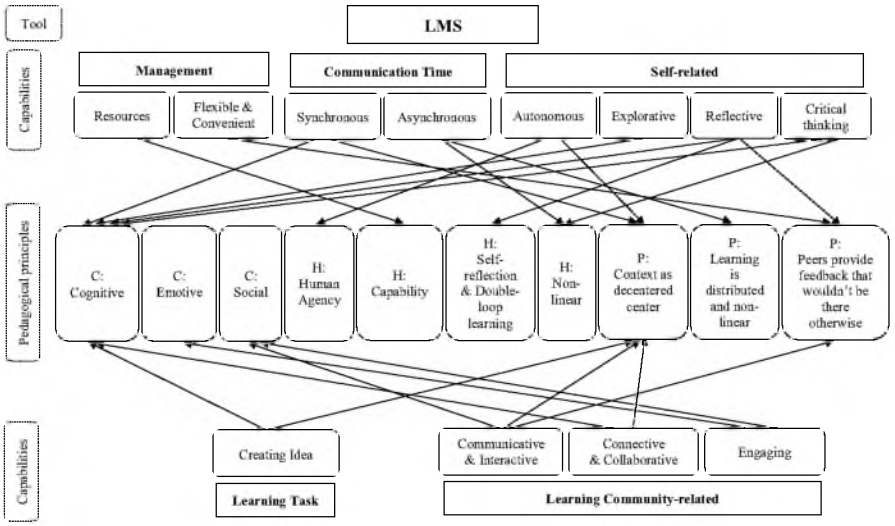

Fig. 11 Mapping of principles of Education 4.0 pedagogies with Learning Management System

technological learning tools (Gregory & Bannister-Tyrrell, 2017). This also implies that FB is able to support different kinds of aspects in a learning process, as it holds all six capabilities of technological learning tools and supports all the sub-categories except two sub-capabilities, namely, synchronous (communication time) and critical thinking (self-related) although the latter is still debatable, as Blaschke and Hase (2019) mentioned briefly how social media could help learners to think critically.

Additionally, FB is found to be the only tool to possess the experiential learning capability, in contrast to LMS and blogs, to support the blended learning environment. Kabilan et al. (2010) reported that FB can successfully assist a group of English language students to engage in an authentic situation by interacting with native speakers via the learning tool. This type of interaction would position students in a real situation of knowledge application. In Bateman and Willems's (2012) study, they found that the implementation of FB is an alternative to LMS after students demanded a learning space with open access beyond their course enrolment semester, which is also a success in one of the case studies presented. An open FB group was created and linked with their LMS, and the admin students exclusively invited teaching staff within similar educational fields into their learning space to contribute with additional learning resources. Harris's (2012) study meanwhile suggests that FB could support immersive learning since students are found to be reflective while using the learning tool, and this leads to knowledge building.

Closer inspection of the pattern of the mapping reveals that the most linked principle of innovative pedagogy is cognitive factor (n = 15) across all the technological learning tools. The cognitive factor has been linked with communication time, self-related, learning task, and learning community-related, and it mostly influences students' explorative, reflective, and critical thinking. In other words, students'

cognitive skill development can be supported in all three technological learning tools. Nevertheless, LMS is a more suitable platform for that purpose since, as this mapping shows, the cognitive factor somehow demands the use of synchronous discussions/meetings in order to be developed in an immersive blended learning environment. According to Blaschke (2021), synchronous learning is important if students are not able to engage well in self-directed learning; hence, they might insist on quick and real-time intensive support from the instructors to avoid any learning frustrations. In regard to functions, LMS can support synchronous exchanges of communication from three aspects, namely, content-related, planning of tasks, and social support (Hrastinski, 2008) compared to blogs and FB. Furthermore, synchronous sessions will help ease the feeling of isolation during the learning process, which is a crucial factor to be taken into consideration when it comes to blended learning (Hrastinski, 2008). Besides, as Education 4.0 requires students to be responsive to technological learning tools, instructors need to bear in mind that synchronous communication works effectively in larger classes (Zydney et al., 2019).

Another significant finding from the mapping is the self-related capability. It has been reported to be the only capability to be successfully linked to the three innovative pedagogies (i.e., heutagogy, cybergogy, and peeragogy). Apart from that, reflective is the sole sub-capability of the self-related capability which has a connection to heutagogy, cybergogy, and peeragogy across all three technological learning tools, compared to the other sub-capabilities, such as autonomy, explorative, critical thinking skills, and self-expression and self-confidence levels. Through reflection, students are able to practise analytical and critical thinking and to engage in complex reasoning, problem-solving, and emotions (Blaschke, 2021). To make it practical, instructors can provide instructional support for students to have the opportunity to self-assess their learning process using a single or double loop reflection in order to implement self-determination and peer production effectively. As blended learning allows students to take more time to reflect or allows them to do it instantaneously via online tools, the choice of the tools depends on students' access to computers and the internet. In this case, students can simply choose whether to utilise FB, blogs, or LMS for that purpose since these technological learning tools are found to support the reflection process.

Notable differences could also be seen in the learning task capability. It is revealed that LMS aids the creating idea capability whereas a blog links to the sharing idea capability. FB, on the other hand, has been noted to support both the creating ideas and sharing ideas capabilities. In Blaschke and Hase's (2019) heutagogical study, FB has been listed as being able to assist in creating individual showcase projects, ideas, and information. This is supported by Bateman and Willems (2012) and Irwin et al. (2012) where in the higher education context, students share ideas and information via online participation within their FB learning community. In contrast, LMS is mentioned only as being utilised in brainstorming and delivering ideas during asynchronous learning sessions (Tasir et al., 2005). It is interesting to examine how the LMS capability of creating ideas is also linked to the same principles in the mapping, which indicates the students are independent but simultaneously connected and engaged in a community in their learning process. Blogs meanwhile allow for idea sharing and dissemination when participating in posts or in the forms

of essay writing, drawing, or videos (Alexander et al., 2014; Kilic & Gokdas, 2014). In addition, a blog's sharing function deeply engages peers in their learning session, such as their reflective post, which will help immerse students by allowing them to express their thoughts and experiences (Sulcic, 2008). Based on the notable differences between the technological learning tools, instructors should consider utilising FB more in order to have a higher rate of achieving immersive blended learning because of its comprehensive learning task capability to support learning creation and sharing.

The descriptions in Table 9 in Appendix provide a clear example of how to translate the mapping framework into teaching and learning practice in an immersive blended learning environment. From the descriptions, we can see that for FB, only two sub-principles of heutagogy, one sub-principle of peeragogy, and four sub-capabilities tools are suitable to be used for this specific example. Meanwhile, for a blog, only one sub-principle of heutagogy, and two sub-capabilities tools are appropriate to be utilised. It should be noted that it is not compulsory to include in the teaching and learning all the elements in the techno-pedagogy mapping. This is (1) to make the learning less difficult and allow students ample time to adapt to a new innovative pedagogical activity, and (2) to ensure students have sufficient time to complete the activity and grasp the basic learning objective. More useful practical scenarios need to be constructed to inform further theorisation of the concepts of heutagogy, peeragogy, and cybergogy, and the capabilities of technological learning tools.

8 Conclusions

The Education 4.0 era requires both instructors and students to change the learning and teaching paradigm by implementing and experiencing innovative pedagogies, such as heutagogy, peeragogy, and cybergogy. The techno-pedagogy mapping developed through this systematic review could offer helpful guidance for providing an immersive blended learning environment to fit the mission of twenty-first century learning. As emphasised by Bidarra and Rusman (2017), the focus on both technology and pedagogy, as done in this present systematic review, is crucial in building suitable immersive blended learning environment. This is because, it is observed that when learning technologies are introduced, the attention of blended learning is usually concentrated on the technology implementation per se (Chen & Yao, 2016) rather than stressing the innovative pedagogies and learning objectives (Shand et al., 2016). As there has been little, if any, research into linking blended learning with the underlying principles of twenty-first century pedagogy and the capabilities of technology in learning and instruction, despites it values (see Ayob et al., 2020; Mahalli et al., 2019; Mujacic et al., 2013), this techno-pedagogy mapping could be useful in reducing the pressure in adopting right merging of technology and pedagogy for immersive blended learning. According to Ata (2016) and Rasheed et al. (2020), the challenges for instructors to adopt immersive blended learning is due to digitally illiterate, and limited time for exploring, tweaking, and creating immersive

Table 6 The weight of evidence of the included and excluded studies according to themes

No	Author(s)	Methodology quality	Methodology relevance	Topic relevance	Overall	Action
Principles of Heutagogy						
1	Sumarsono (2019)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
2	Annamalai (2019)	Excellent	Good	Inadequate	Satisfactory	Excluded
3	Narayan et al. (2019)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
4	Yusuf and Yusuf (2018)	Satisfactory	Good	Excellent	Good	**Included**
5	Northcote and Boddey (2014)	Excellent	Satisfactory	Satisfactory	Excellent	Excluded
6	Patel (2018)	Satisfactory	Good	Excellent	Good	**Included**
7	Narayan and Herrington (2014)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
8	Blaschke and Hase (2019)	Excellent	Excellent	Excellent	Excellent	**Included**
9	Canning and Callan (2010)	Good	Good	Excellent	Good	**Included**
10	Blaschke (2012)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
11	Blaschke (2018)	Satisfactory	Satisfactory	Good	Satisfactory	Excluded
12	Richardson et al. (2017)	Satisfactory	Excellent	Satisfactory	Satisfactory	Excluded
13	Blaschke and Hase (2016)	Good	Satisfactory	Excellent	Satisfactory	Excluded
14	Hase (2016)	Good	Good	Excellent	Good	**Included**
15	Tajudin et al. (2020)	Satisfactory	Satisfactory	Excellent	Satisfactory	Excluded
16	Gregory and Bannister-Tyrrell (2017)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
17	Blaschke (2018)	Satisfactory	Inadequate	Excellent	Satisfactory	Excluded
18	Haworth (2016)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
19	Gregory et al. (2018)	Excellent	Excellent	Excellent	Excellent	**Included**
20	Majanja (2020)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
21	Stoten (2020)	Good	Satisfactory	Good	Good	**Included**
22	Kapasi and Grekova (2018)	Excellent	Good	Satisfactory	Satisfactory	Excluded

Table 6 (continued)

No	Author(s)	Methodology quality	Methodology relevance	Topic relevance	Overall	Action
Principles of Peeragogy						
1	Yusuf and Yusuf (2018)	Good	Satisfactory	Good	Good	**Included**
2	Ouhrir et al. (2019)	Excellent	Excellent	Satisfactory	Good	**Included**
3	Terrell (2016)	Satisfactory	Good	Satisfactory	Satisfactory	Excluded
4	Corneli et al. (2015)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
5	Corneli and Danoff (2011)	Good	Good	Excellent	Good	**Included**
6	Mulholland (2019)	Good	Excellent	Excellent	Excellent	**Included**
7	Raw (2014)	Good	Satisfactory	Excellent	Good	**Included**
8	Alexander et al. (2014)	Good	Good	Excellent	Good	**Included**
9	Ricaurte (2016)	Good	Excellent	Excellent	Excellent	**Included**
10	Corneli (2012)	Satisfactory	Excellent	Inadequate	Satisfactory	Excluded
Principles of Cybergogy						
1	Sumarsono (2019)	Good	Good	Satisfactory	Satisfactory	Excluded
2	Yusuf and Yusuf (2018)	Satisfactory	Good	Excellent	Good	**Included**
3	Muresan (2013)	Good	Good	Excellent	Good	**Included**
4	Muresan (2014)	Good	Good	Good	Good	**Included**
5	Guzzetti and Stokrocki (2013)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
6	Scopes (2011)	Good	Good	Inadequate	Inadequate	Excluded
7	Wang and Kang (2006)	Good	Good	Excellent	Good	**Included**
8	Wang et al. (2009)	Excellent	Excellent	Good	Excellent	**Included**
9	Collins et al. (2010)	Good	Good	Excellent	Good	**Included**
Capabilities of Technological Learning Tools						
1	Alda et al. (2020)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
2	Annamalai (2019)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded

Table 6 (continued)

No	Author(s)	Methodology quality	Methodology relevance	Topic relevance	Overall	Action
3	Kabilan et al. (2010)	Excellent	Good	Good	Good	**Included**
4	Ouhrir et al. (2019)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
5	Terrell (2016)	Satisfactory	Satisfactory	Excellent	Satisfactory	Excluded
6	Patel (2018)	Satisfactory	Good	Excellent	Good	**Included**
7	Blaschke and Hase (2019)	Excellent	Excellent	Excellent	Excellent	**Included**
8	Hase (2016)	Good	Good	Excellent	Good	**Included**
9	Haworth (2016)	Good	Good	Excellent	Good	**Included**
10	Gregory et al. (2018)	Excellent	Excellent	Excellent	Excellent	**Included**
11	von der Heidt and Quazi (2013)	Satisfactory	Satisfactory	Excellent	Good	**Included**
12	Majanja (2020)	Excellent	Good	Excellent	Excellent	**Included**
13	Muresan (2013)	Good	Good	Excellent	Good	**Included**
14	Tasir et al. (2005)	Excellent	Excellent	Good	Excellent	**Included**
15	Kayri and Cakır (2010)	Excellent	Excellent	Satisfactory	Good	**Included**
16	Prescott et al. (2013)	Good	Good	Satisfactory	Good	**Included**
17	Pimmer et al. (2012)	Excellent	Satisfactory	Good	Good	**Included**
18	Duncan and Barczyk (2016)	Excellent	Excellent	Good	Excellent	**Included**
19	Irwin et al. (2012)	Excellent	Satisfactory	Good	Good	**Included**
20	Wise et al. (2011)	Excellent	Satisfactory	Inadequate	Satisfactory	Excluded
21	Alawawdeh and Kowalski (2015)	Satisfactory	Satisfactory	Good	Satisfactory	Excluded
22	Vance (2013)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
23	Harris (2012)	Excellent	Excellent	Good	Excellent	**Included**
24	Bateman and Willems (2012)	Excellent	Good	Good	Good	**Included**
25	Callaghan and Fribbance (2018)	Excellent	Excellent	Satisfactory	Good	**Included**
26	Kilic and Gokdas (2014)	Excellent	Excellent	Good	Excellent	**Included**

Table 6 (continued)

No	Author(s)	Methodology quality	Methodology relevance	Topic relevance	Overall	Action
27	Lujan-Mora and Juana-Espinosa (2014)	Satisfactory	Excellent	Good	Good	**Included**
28	Schindler et al. (2017)	Excellent	Good	Good	Good	**Included**
29	Can and Ozdemir (2006)	Satisfactory	Good	Satisfactory	Satisfactory	Excluded
30	de Mattos (2014)	Good	Satisfactory	Excellent	Good	**Included**
31	Sulcic (2008)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
32	Fattah (2016)	Good	Good	Excellent	Good	**Included**
33	Kasim and Khalid (2016)	Good	Good	Good	Good	**Included**
34	Azmi et al. (2012)	Good	Good	Satisfactory	Good	**Included**
35	Adzharuddin and Lee (2013)	Satisfactory	Good	Satisfactory	Satisfactory	Excluded
36	Ghilay (2019)	Excellent	Excellent	Good	Excellent	**Included**
37	Cavus et al. (2006)	Satisfactory	Excellent	Inadequate	Satisfactory	Excluded
38	Embi et al. (2012)	Good	Excellent	Good	Good	**Included**
39	Al-Rahmi et al. (2015)	Excellent	Satisfactory	Inadequate	Satisfactory	Excluded
40	Twelves and Arasaratnam (2012)	Satisfactory	Satisfactory	Good	Satisfactory	Excluded
41	Vuopala et al. (2015)	Excellent	Excellent	Good	Excellent	**Included**
42	Birzina et al. (2012)	Good	Good	Satisfactory	Satisfactory	Excluded
43	Catherall (2008)	Good	Satisfactory	Good	Good	**Included**
44	Ntshwarang et al. (2021)	Good	Satisfactory	Good	Good	**Included**
45	Oomen-Early and Early (2015)	Good	Good	Inadequate	Good	Excluded
46	Blanco and Ginovart (2012)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
47	Burke and Fedorek (2017)	Good	Good	Satisfactory	Satisfactory	Excluded
48	Dogoriti et al. (2014)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
49	McLoughlin (2013)	Good	Good	Good	Good	**Included**
50	Priluck (2004)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded

Table 6 (continued)

No	Author(s)	Methodology quality	Methodology relevance	Topic relevance	Overall	Action
51	Kuljis and Lines (2007)	Good	Satisfactory	Satisfactory	Satisfactory	Excluded
52	Yukawa (2006)	Excellent	Excellent	Satisfactory	Good	**Included**
53	Montelongo and Eaton (2020)	Satisfactory	Good	Satisfactory	Satisfactory	Excluded
54	Alammary et al. (2014)	Excellent	Good	Inadequate	Satisfactory	Excluded
55	Graham (2006)	Good	Good	Satisfactory	Satisfactory	Excluded
56	Kassab et al. (2015)	Excellent	Excellent	Good	Excellent	**Included**
57	Poncela (2013)	Excellent	Good	Satisfactory	Good	**Included**
58	Thanh Tran and Van Nguyen (2020)	Excellent	Excellent	Good	Excellent	**Included**
59	de Jong et al. (2014)	Good	Excellent	Excellent	Excellent	**Included**
60	Atmacasoy and Aksu (2018)	Excellent	Satisfactory	Satisfactory	Satisfactory	Excluded
61	Collins et al. (2010)	Good	Good	Excellent	Good	**Included**
62	Alexander et al. (2014)	Good	Good	Excellent	Good	**Included**
63	Narayan et al. (2019)	Excellent	Satisfactory	Excellent	Satisfactory	**Included**

Table 7 Systematic literature review table of education 4.0 innovative pedagogies

No	Principle	Aspect	Author(s)
Heutagogy			
1	Human agency	Autonominity	Stoten (2020); Patel (2018)
		Personal identity	Canning and Callan (2010); Blaschke and Hase (2019)
2	Capability	Curriculum to engage with world	Stoten (2020); Hase (2016)
		Having digitalist skills	Yusuf and Yusuf (2018)
3	Self-reflection & Double-loop learning	Reflective learning environment	Stoten (2020)
		Thinking process leads to reflection	Canning and Callan (2010); Gregory et al. (2018)
4	Non-linear learning	Dynamic process	Hase (2016); Gregory et al. (2018)
Peeragogy			
1	Changing context as a decentered center	Contributing on personal axis	Alexander et al. (2014); Corneli and Danoff (2011)
2	Meta-learning as a font of knowledge	Deciding on syllabus	Raw (2014)
		Analysis on the knowledge	Ouhrir et al. (2019)
3	Peer provide feedback that wouldn't be there otherwise	Feedback from paragogues	Raw (2014)
		Involvement of experts	Alexander et al. (2014); Yusuf and Yusuf (2018)
4	Learning is distributed and non-linear	Open knowledge production	Ricaurte (2016)
		Flexibility	Raw (2014)
		Asynchronous knowledge production	Alexander et al. (2014); Mulholland (2019)
5	Realize the dream and wake up!	Disbandment of knowledge production team	Alexander et al. (2014); Mulholland (2019)
Cybergogy			
1	Cognitive	Critical thinking	Yusuf and Yusuf (2018); Wang and Kang (2006)
		Problem solving	
		Self-formative	Muresan (2014)

Table 7 (continued)

No	Principle	Aspect	Author(s)
2	Emotive	Autonominity	Yusuf and Yusuf (2018); Wang and Kang (2006); Muresan (2014)
		Satisfaction	
		Cultural	Wang et al. (2009)
3	Social	Collaborative	Yusuf and Yusuf (2018); Collins et al. (2010)
		Engagement	
		Personal preference	Wang et al. (2009)
		Enlarging social and business environment	Muresan (2013); Collins et al. (2010)

Table 8 Systematic literature review table of capabilities of technological learning tools

No	Capability		Author(s)	Technological learning tool
1	Management	Resources	Bateman and Willems (2012); Catherall (2008); Ghilay (2019); Harris (2012); Kassab et al. (2015); Ntshwarang et al. (2021); Pimmer et al. (2012); Poncela (2013)	LMS, Facebook
		Personalisation	Haworth (2016)	Web 2.0
		Flexible & Convenient	Azmi et al. (2012); Duncan and Barczyk (2016); Kasim and Khalid (2016); Muresan (2013); Pimmer et al. (2012); Yukawa (2006)	Web 2.0, LMS, Facebook, Wiki-based
		Efficient	Kayri and Cakır (2010); Muresan (2013)	Web 2.0, Facebook
2	Communication time	Synchronous	Azmi et al. (2012); Bateman and Willems (2012); Kasim and Khalid (2016)	Facebook, LMS
		Asynchronous	Azmi et al. (2012); Kasim and Khalid (2016); Patel (2018); von der Heidt and Quazi (2013)	Blog, Web 2.0, social media, Moodle
3	Self-related	Autonomous i. Self-determined ii. Human agency iii. Training	Blaschke and Hase (2019); Gregory et al. (2018); Hase (2016); Kayri and Cakır (2010); Ntshwarang et al. (2021); Fattah (2016)	Social media, Facebook, LMS (Moodle), blog,
		Explorative i. Inquiry learning	Blaschke and Hase (2019); Hase (2016); Yukawa (2006)	Social media, LMS
		Reflective	Blaschke and Hase (2019); de Mattos (2014); Harris (2012); Hase (2016); McLoughlin (2013); Kasim and Khalid (2016); Sulcic (2008); Yukawa (2006)	Social media, Blog, Facebook, LMS
		Critical thinking	Kassab et al. (2015); Lujan-Mora and de Juana-Espinosa (2014)	Moodle, blog
		Self-expression & Self-confidence	Kabilan et al. (2010); Sulcic (2008); Thanh Tran and Van Nguyen (2020)	Blog, Facebook

Table 8 (continued)

No	Capability		Author(s)	Technological learning tool
4	Learning task	Creating idea	Blaschke and Hase (2019)	Social media, Moodle
		Sharing idea	Alexander et al. (2014); Bateman and Willems (2012); Blaschke and Hase (2019); Irwin et al. (2012); Kilic and Gokdas (2014)	Social media, Facebook, Weblog
5	Learning community-related	Communicative & Interactive i. Peer teaching ii. Feedback iii. Notification	Alexander et al. (2014); Bateman and Willems (2012); de Jong et al. (2014); de Mattos (2014); Irwin et al. (2012); Kayri and Cakır (2010); Majanja (2020); McLoughlin (2013); Prescott et al. (2013)	Web 2.0, Facebook, social media, Blog, LMS
		Connective & Collaborative	Alexander et al. (2014); Blaschke and Hase (2019); de Jong et al. (2014); Duncan and Barczyk (2016); Kilic and Gokdas (2014); McLoughlin (2013); Vuopala et al. (2015)	Social media, Weblog, LMS, Moodle, Facebook, Web 2.0
		Engaging i. Behaviour ii. Emotion	Callaghan and Fribbance (2018); Collins et al. (2010); McLoughlin (2013); Schindler et al. (2017); Vuopala et al. (2015)	Blog, Facebook, LMS
6	Experiential learning		Callaghan and Fribbance (2018); Harris (2012); Kabilan et al. (2010)	Facebook

Table 9 Description on the practical aspect of the mapping

No	Practical Scenarios
1	First, the course instructor needs to create an appropriate learning problem and context, for instance, *How to develop a company website?* The direction of the website development needs to be aligned with the requirements set by the company, that is (1) supports thousands of items of data, (2) has shorter time to load website pages, and (3) needs only a small budget allocation for website development Let us assume that the course instructor would like to apply heutagogical learning as the main pedagogy, where, in the end, his/her students are able to achieve goals such as (1) able to learn with only the limited provision of learning materials and guidance from the course instructor, and (2) achieve a good cognitive level based on the problems that often concern the real work-based context. One thing to emphasise when developing the heutagogical learning activities is that the course instructor has to re-balance the activities towards self-determination and autonomy instead of favouring only knowledge acquisition (which reflects the cognitive aspect) because those two are core characteristics of the heutagogical method. Furthermore, the three principles of immersive learning, that is, (1) real-life like environment, (2) a learning process that focuses more on learning experiences, presence, and co-presence, and (3) support by the appropriate technological learning tools, must also be considered. Its application can be seen in the next stages
2	Second, students are given full authority on how they would want to proceed with the learning activity that has been designed at the second stage above, because self-determined learning is crucial in the heutagogical learning approach. Nonetheless, despite being given full authority to execute the learning activity, the course instructor may at least make it compulsory for students to focus specifically on the *reflection* activity when they solve the problem. This is to avoid the students from getting lost and having no sense of direction regarding what to focus on when solving the problems. This also can be used as proof of students' cognitive development. What is more important is that, based on the mapping, it shows that reflection is associated with heutagogical learning practice
3	Third, let us consider that there might be two situations that emerged due to the students being given full authority to create their own learning journey, that is, (1) students who prefer to solve problems alone, and (2) students who prefer to co-learn with peers when solving problems. Note that, from the mapping framework, students who prefer to co-learn with peers when solving problems and doing reflection are actually applying peeragogical learning. This is where we can see how more than two innovative pedagogies can be applied in one learning activity. Mapping for FB, blogs, and LMS shows that reflection favours not only heutagogy but peeragogy as well
4	Fourth, for students who prefer to do the activity alone, perhaps blog is an appropriate tool for them to choose because when working alone, they are more inclined to share ideas instead of welcoming others' ideas to build upon further. As shown in the mapping, blogging supports *sharing ideas* instead of creating ideas
5	Fifth, for students who want to co-construct knowledge with peers, FB is a suitable tool to use because, as shown from the mapping, it allows for both *creating ideas* and *sharing ideas* actions. In addition, *communication* and *interaction* processes from peers are easier to perform through FB due to the notifications and tagging function, which allows for a quick response. Besides the user-friendly interface, the threaded messages are also organised; hence, the searching for related messages will be easier when there is a large number of messages in the comments section. LMS also allows for creating ideas, nevertheless, for communication and interaction purposes, it might not be sufficiently convenient since students are required to log in to the system every time they want to have a discussion. Plus, the system tends to log the user out if it remains idle for a period of time even though the students might in fact be reading at that moment
6	Sixth, if the course instructor feels that students who learn on their own do not reach a certain standard of knowledge and comprehension when assessing their reflection, he/she can redirect the students to peers or professional experts. This can be done because blogging also supports the *communication* and *interaction* capabilities. In innovative pedagogical learning, the course instructor could act only as a coach rather than spoon-feeding the students with facts and controlling the learning

blended learning application. Furthermore, the techno-pedagogy mapping which have been identified and aligned in detail including some suggestions in order to make it more practical could provide an input to other significant parties in education, such as curriculum designers and faculty administrators and complement the transformation of learning and teaching course design, curriculum and delivery as the framework of a future-ready curriculum for Malaysian public universities is yet to provide any guidelines on how to use this pedagogy and technology effectively.

The techno-pedagogy mapping presented in this study is limited in its scope and involves only three types of innovative pedagogical approaches and three forms of technological learning tools. Hence, the mapping can be further expanded using other important online technological learning tools, such as WhatsApp, Webex, Zoom, Google Meet, Padlet, Google Drive, and YouTube, among others, in order to help make immersive blended learning and teaching effective in the real sense and to vary the ways of learning and teaching transactions. Moreover, the mapping output is still in the conceptual form; hence, it needs to be validated empirically so that a proper framework of innovative pedagogies and technological learning tools can serve as a feasible source of reference for instructors to design an immersive blended learning environment and visualise its practical aspect.

Appendix

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Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare that they have no competing interests.

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