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The state of immersive technology research: A literature analysis

Ayoung Suh [a,*], Jane Prophet [b]

[a] School of Creative Media and Dept. of Information Systems, City University of Hong Kong, Hong Kong SAR
[b] Goldsmiths College, University of London, UK

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ABSTRACT

Despite the increase in scholarly attention paid to immersive technology, such as augmented reality and virtual reality, few studies have been conducted on the current state of immersive technology research, with no aggregation of findings and knowledge. To fill this gap, this study conducted a systematic literature review of immersive technology research in diverse settings, including education, marketing, business, and healthcare. The full range of SSCI journal articles that addressed issues related to immersive technology were searched. Based on rigorous inclusion and exclusion criteria, 54 articles were selected for the final analysis. This literature review analyzed the bibliometric data from the identified studies, their theoretical and methodological approaches, research themes, and contexts. Drawing on the stimulus–organism–response (S–O–R) framework, this study classifies and consolidates the factors associated with immersive technology use. Based on that classification, this study proposes a conceptual framework that accounts for the interplay between key elements associated with immersive technology use. The list of factors was then consolidated and mapped onto the S–O–R framework. As a result, this study identifies existing gaps in the current literature and suggests future research directions with specific research agendas.

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1. Introduction

Immersive technology is technology that blurs the boundary between the physical and virtual worlds and enables users to experience a sense of immersion (Lee, Chung, & Lee, 2013, Lee, Shan, & Chen, 2013). Immersive technology, including augmented reality (AR) and virtual reality (VR), is increasingly pervasive in our daily lives. Research in diverse fields, such as education (Frank & Kapila, 2017; Pribeanu, Balog, & Iordache, 2017), marketing (Huang & Liao, 2017), entertainment (Arino, Juan, Gil-Gómez, & Mollá, 2014), and healthcare (Zhao, Ong, & Nee, 2016), has shown that the use of immersive technologies enhances learning experiences (Huang, Chen, & Chou, 2016), fosters participation in collaborative activity (Fonseca, Martí, Redondo, Navarro, & Sánchez, 2014), and increases creativity and engagement (Huang, Rauch, & Liaw, 2010). Despite increasing scholarly attention paid to immersive technology, there is a lack of coherent understanding about what immersive technology is, the types of studies that have been conducted in the field of immersive technology, the methods that have been used in these studies, the results such research has yielded, and the conditions under which the studies were conducted.

Despite the increasing popularity of immersive technology and its influence on business and society (Huang & Liao, 2015), relatively little research has been conducted to better understand what we know and what we need to know about immersive technology and how users experience these technologies. A systematic review of the existing literature that synthesizes research findings and identifies gaps in our understanding can offer future research direction. Accordingly, this study systematically reviews the relevant immersive technology studies that have been conducted and analyzes research trends, topics, methodology, and contexts related to these studies. Specifically, the following questions are answered by the literature analysis.

1. What are the trends and focus of immersive technology literature?
2. What are the major theoretical foundations of previous immersive technology studies?
3. What are the research methods used in previous immersive technology studies?

* Corresponding author.
E-mail addresses: ahysuh@cityu.edu.hk (A. Suh), jane@janeprophet.com (J. Prophet).

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4. What are the research contexts and samples that appear in previous immersive technology studies?
5. What are the factors associated with immersive technology use?

By answering these questions, through a review of the existing body of empirical research, this study contributes to the understanding of user experience and performance in immersive environments and identifies current best practices in the study of such experiences and immersive technology performance.

This paper is organized as follows. First, the definitions of immersive technology and its related concepts are presented. Second, the search procedures for literature identification are described, and the results of the 54 identified studies are analyzed. The stimulus–organism–response (S–O–R) framework is used as an overarching theoretical platform to classify and consolidate the factors associated with immersive technology use. Drawing on this classification, an integrative framework is developed that takes into account user experience and performance in the context of immersive technology use. Finally, future research directions and the study's theoretical and practical contributions are discussed.

2. Definitions of immersive technology and its related concepts

Researchers have defined immersive technology from different perspectives. Some researchers have describe sensory information as a unique property of immersive technology; for example, Slater (2009) defines immersive technology as technology that offers a high quality or quantity of sensory information to the user. Other researchers emphasize users' immersive experiences while using the technology, such as Lee, Chung, et al. (2013), who define immersive technology as technology that blurs the lines between the physical and virtual worlds, creating a sense of immersion and enhancing the realism of virtual experiences (Soliman, Peetz, & Davydenko, 2017).

Immersive technology, as a term, is used to refer to several different technologies, such as VR, AR, and mixed reality (MR) (Handa, Aul, & Bajaj, 2012). To understand the concept of immersive technology and its scope, this study draws on the reality–virtuality continuum proposed by Milgram and Kishino (1994). In the reality–virtuality continuum, augmented virtuality (AV) and VR are used interchangeably because real objects are added to virtual environments in both AV and VR (Hsiao, Chen, & Huang, 2012). As shown in Fig. 1, real-to-virtual environments can be understood as a continuum, in which AR or VR is one area within the general area of mixed reality (MR). AR merges the real world with the virtual world, whereas VR allows users to control and navigate their actions in a virtual world that might simulate the real world (Zeng & Richardson, 2016). Accordingly, AR and VR could be understood as technologies that create certain degrees of MR and enable users to experience a sense of immersion in a synthetic environment where physical and virtual objects co-exist (Di Serio, Ibáñez, & Kloos, 2013). We are not suggesting that any particular part of the continuum is more, or less, immersive than another but that the sense of immersion is achieved differently along the continuum.

Table 1 summarizes the definition of immersive technology and related concepts, including AR, VR, and MR. AR refers to technology that blends computer-generated virtual objects and the real environment with the help of real-time interactivity and three-dimensional (3D) registration (Pribeanu et al., 2017; Rochlen, Levine, & Tait, 2017). AR enhances a user's visual, aural, and tactile senses by superimposing digital information onto the real world (Azuma, 1997). VR refers to technology that generates an interactive virtual environment that is designed to simulate a real-life experience (Lee, Chung et al., 2013). In the reality–virtuality continuum, VR can be categorized as non-immersive VR and immersive VR. Non-immersive VR is technology that displays virtual content via a computer screen without additional equipment to amplify the immersive experience. Users interact with non-immersive VR using traditional interfaces, such as keyboards and mice. Web-based virtual environments, such as Second Life and Minecraft, are examples of non-immersive VR (Zeng & Richardson, 2016). In contrast, immersive VR environments allow users to interact the technology via more complex tracking systems, such as head-mounted displays that track motion and provide deeper immersion because displays change in accordance with minute movements. Head-mounted displays block out visual cues from the users' physical environments to create a more controlled, restricted environment than that of non-immersive VR. Some of these tracking systems can also capture data while in use, providing richer information about user responses. The cave automatic virtual environment (CAVE) is an example of immersive VR. AR using the movement of a user's mobile device as an interface for tracking the user by displaying live images from the device's camera feed onscreen allows users to view blended environments. This type of reality is placed further away from immersive VR on the reality–virtuality continuum. While AR presents the user with virtual entities in addition to the components of the real environment in real time, VR enriches the virtual world with real objects. Since the main purpose of this study is to review immersive technology literature, papers that focused on non-immersive technology issues were excluded from the analysis.

3. Research methodology

To consolidate the extant knowledge on immersive technology, the literature review begins by identifying articles that address issues regarding immersive technology use. We follow the two-stage approach suggested by Webster and Watson (2002) and Boell and Cecez-Kecmanovic (2015). After relevant articles are

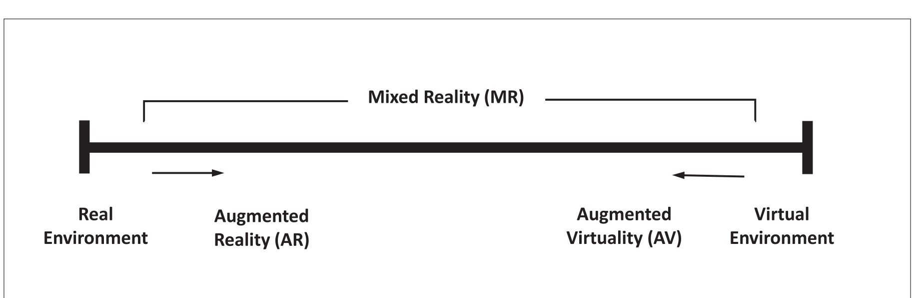

Fig. 1. Reality–Virtuality continuum (Milgram & Kishino, 1994).

Table 1
Definition of immersive technology and its related concepts.

Concept	Definition	Reference
Immersive technology	Technology that blurs the line between the physical, virtual, and simulated worlds, thereby creating a sense of immersion.	Lee, Chung, et al. (2013)
Augmented reality (AR)	Technology that enables users to engage with virtual information superimposed on the physical world. This mediated immersion places digital resources throughout the real world, augmenting users' experiences and interactions.	Dunleavy, Dede, & Mitchell (2009); Rochlen et al. (2017)
Virtual reality (VR)	Technology that generates an interactive virtual environment designed to simulate a real-life experience. **Non-immersive VR**[a] The VR content is displayed via a computer screen. Traditional media, such as keyboards and mice, are used for the interaction. Non-immersive VR does not require users to wear any equipment. Web-based virtual environments, such as Second Life and Minecraft, are examples of non-immersive VR. **Immersive VR** Users are required to wear a head-mounted display and are completely encompassed by the virtual environment. In an immersive VR environment, user responses can be observed and recorded in a controlled situation. Cave Automatic Virtual Environment (CAVE) is an example of immersive VR.	Lee, Chung et al. (2013), Wojciechowski and Cellary (2013)
Mixed reality (MR)	The space where the physical and virtual worlds co-exist. Within the reality–virtuality framework, a generic MR environment is a space in which real and virtual objects are presented together within a single display.	Milgram and Kishino (1994)

[a] This study excludes papers that addressed non-immersive VR from the analysis.

identified by a keyword search at the first stage, more rigorous inclusion and exclusion processes are applied to the selection of the articles at the second stage. The two-stage review methodology enables researchers to reduce potential biases in data collection (Chan, Cheung, & Lee, 2017; Tranfield, Denyer, & Smart, 2003). Fig. 2 presents the search and selection process for the literature review. In the first stage, research articles that addressed issues regarding immersive technology use were searched. At this stage, we only aimed to search for academic and peer-reviewed journal articles to ensure source credibility (Podsakoff, Mackenzie, Bachrach, & Podsakoff, 2005).

For the search, we used the Scopus database as our key data source and targeted peer-reviewed journal articles indexed in the Social Sciences Citation Index (SSCI) to ensure the quality of the searched papers. As suggested by Morschheuser, Hamari, Koivisto, and Maedche (2017), due to differences in search functions and algorithms, focusing the search on one database can ensure that the search procedure is replicable, rigorous, and transparent. A broad range of keywords representing "immersive technology," "augmented reality," "virtual reality," and "mixed reality" were used for searching for articles. Using the keywords, we found 926 relevant articles published in the period 2010–2017. Next, we refined the results by limiting the search to journal articles (document type) in social sciences (subject area). Given that we seek to understand immersive technology and user experience, we targeted our search for articles that incorporate human factors in research. After the refinement, 159 research articles were selected. To ensure that all major articles were included in the set of identified studies, we manually searched for articles from ten management information systems journals.

At the second stage, by applying the inclusion and exclusion criteria we previously set, we further selected relevant articles for the literature analysis. According to the inclusion criteria, we included studies that (1) used immersive technologies (including AR or VR) as the core systems that were the focus of the research and (2) addressed issues associated with immersive technology use. Further, according to the exclusion criteria, we excluded papers that had examined non-immersive VR (where the VR content is displayed via a computer screen), papers with no empirical results, and those in which no human factors were considered. In addition, we excluded papers that addressed engineering-related issues or purely focused on theory development. Based on these criteria, we identified 52 relevant research articles and used them for the literature analysis. Finally, we performed a forward search of the identified articles and found two additional studies. Accordingly, 54 relevant research articles were identified for the literature analysis.

After we selected research articles for the analysis, we coded the selected papers as suggested by Webster and Watson (2002) and

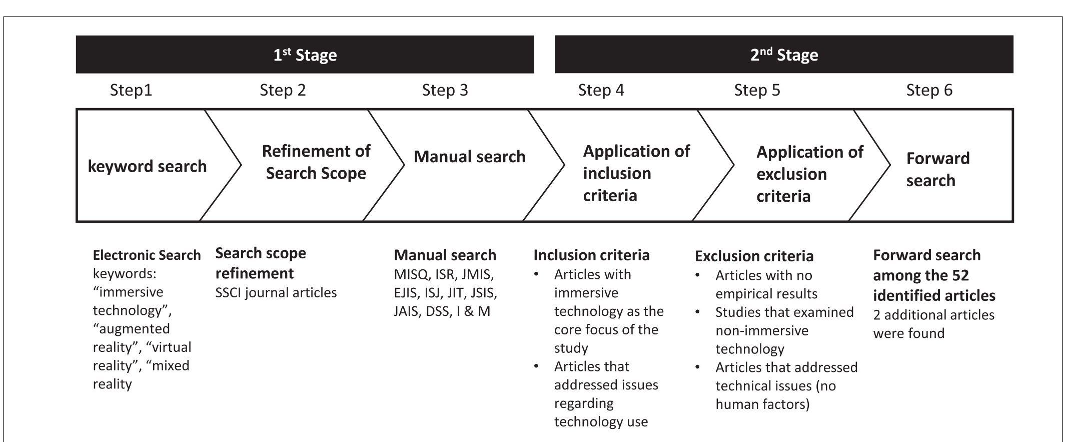

Fig. 2. Literature search and selection process.

Morschheuser et al. (2017). We gathered the following data: (1) bibliometric information (authors, publication years, and disciplines), (2) research approaches (quantitative, qualitative, or mixed), and (3) domain. Based on the coded data, we further analyzed the research themes, focus, theoretical framework, and research methods.

4. Results

4.1. Overview of research trends

First, we examined the bibliometric data of the 54 included papers. We deducted that the number of studies on immersive technology has been rapidly growing, because 43% of the studies (n = 23) were published in the period 2016–2017. We attribute the fast growth to the advancement of location-based sensing technology and the proliferation of mobile technologies. Fig. 3 shows the number of publications from 2010 to 2017. With regard to the domains under which research on the topic was conducted, 25 of the research papers (46%) had been published in journals related to education. In addition, 9 papers were in healthcare, 7 papers in entertainment (e.g., games), and 5 papers in marketing. Eight papers were categorized as “others” (no specific domain).

The literature analysis shows that two main research streams exist in the immersive technology literature. The first stream mainly places emphasis on the effects of the unique system features of an immersive technology on user experience. For instance, Jin (2013) examined how the visual, auditory, and haptic modalities of an immersive VR technology influence users' immersive experience. In addition, Huang and Liao (2017) examined how production of visual and tactile stimuli enabled by an AR technology designed for clothes fitting creates a sense of immersion while the user interacts via an avatar's body. The second stream of research examines how the use of immersive technologies enhances user performance (e.g., learning and teaching effectiveness, task performance, and pain management). For instance, Pribeanu et al. (2017) examined how a user's immersive experience is enhanced in an AR-based learning environment by improvement in perceived learnability and learning outcomes. Researchers have also provided evidence that the use of immersive technologies enhances task performance in terms of efficiency and accuracy (Munafo, Diedrick, & Stoffregen, 2017; Radkowski, Herrema, & Oliver, 2015; Zhao, You, Shi, & Gan, 2015). In another line of research, Hoffman et al. (2014) examined how users' immersive experiences while using a VR technology—designed for distracting patients from acute procedural pain—reduced their pain intensity and the unpleasantness of pain.

Finally, with regard to the methodologies employed, 78% (n = 42) of the 54 studies used a quantitative approach, 6% (n = 3) employed a qualitative approach, and 17% (n = 9) used a mixed approach.

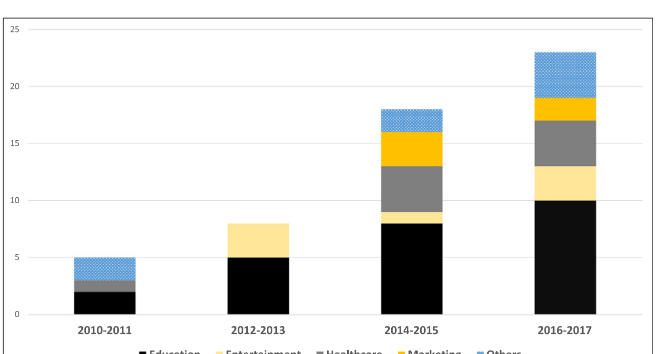

Fig. 3. Research on immersive technology use across domains.

4.2. Overview of theoretical foundations

Table 2 summarizes the theoretical frameworks employed in existing immersive technology studies. Flow theory, as defined by Csikszentmihalyi (1996) and others (Jackson & Marsh, 1996; Koufaris, 2002), was found to be the most popular framework used to understand the impact of technology on user behavior (Bian et al., 2016; Chang et al., 2014; Georgiou & Kyza, 2017; Hsu, 2017; Huang & Liao, 2017). Some researchers adopted other theoretical perspectives, such as situated cognition theory (Chang, Hsu, & Wu, 2016; Ke, Lee, & Xu, 2016), media richness theory (Huang & Liu, 2014), S–O–R model (Kourouthanassis, Boletsis, Bardaki, & Chasanidou, 2015), and the technology acceptance model (Huang & Liao, 2017; Wojciechowski & Cellary, 2013; Yilmaz, 2016).

4.3. Overview of research methods

As shown in Table 3 and Fig. 4, diverse methods, including case study, in-depth interview, survey, experiment, and system development, have been used to study immersive technology. Among them, the experimental method is the most popular, followed by the survey method. Of the selected studies, 22% (n = 12) employed a multimethod approach by combining more than one research method. Experimental studies were used to examine how the system features of immersive technology trigger users' cognitive and affective responses. For example, researchers have examined the effects of the information layout technique, label scaling (Polys, Bowman, & North, 2011), and navigation type (Di Serio et al., 2013). Some researchers used electromyography (EMG) to measure users' facial muscle activity and electroencephalogram (EEG) to detect electrical activity of the brain in their experimental studies (Bian et al., 2016). Alternately, researchers have used the survey method to measure unobservable constructs. For example, researchers have conceptualized interactivity (Huang et al., 2010), representation fidelity (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014), and usability (Frank & Kapila, 2017), and measured user perceptions of immersive system features. Surveys were also used to measure the psychological and behavioral outcomes of technology use. For instance, Pribeanu et al. (2017) measured the overall quality of an AR-based educational application by using a survey method; they found that hedonic quality is the most important dimension, followed by learning quality, and then, usability.

4.4. Overview of research sample and context

Of the selected studies, 65% (n = 35) used student samples. Among the 35 studies that collected data from student users, 20 papers used university students, 4 papers used primary school students, and 11 papers used secondary school students as their samples. 17% of the identified studies (n = 9) used a mixed sample with different age groups between 20 and 50 years old, whereas 2 papers include elderly people over 60 years old in their sample. 8 papers do not define sample characteristics. The studies that used student samples claimed that there were no serious problems in generating relevant empirical results because students are the dominant group among users of emerging technology (Parboteeah, Valacich, & Wells, 2009). With regard to the studies selected in the present review, 70% (n = 38) used AR applications and 30% (n = 16) used VR applications.

Table 2
Summary of theoretical foundations.

Theory	Description	References
Conceptual blending theory	The theory suggests that AR users need to move fluidly between the physical and virtual world. This creates a conceptual blend as users coordinate multiple, distinct conceptual spaces, or different source domains, which enhances learning performance.	Enyedy, Danish, and DeLiema (2015)
Cognitive load theory	The theory suggests that AR users may experience certain levels of cognitive load because AR requires users to process a large amount of information that they encounter in the learning context. Cognitive load is further increased by the multiple technological devices they have to use to complete the tasks.	Hsu (2017)
Constructive learning theory	This theory suggests that learners play an active role in their learning, since they not only absorb information, but also connect it with previously assimilated knowledge to construct their new knowledge.	Huang et al. (2010)
Experiential learning theory	This theory suggests that immersive technology can enhance learning performance by providing learners with meaningful experiences. The theory proposes four learning stages: (1) concrete experience, (2) observation and reflection, (3) formation of abstract concepts and generalizations, and (4) testing of new situations.	Huang et al. (2016)
Flow theory	This theory suggests that immersive technology enables users to immerse themselves in a flow state. When a user is immersed in a flow state, they have a high level of concentration, experience time passing by rapidly, create a balance between challenges and skills, and have a sense of positive enjoyment.	Bian et al. (2016), Chang et al. (2014), Georgiou and Kyza (2017), Hsu (2017), Huang and Liao (2017)
Media richness theory	The theory suggests that AR enhances the shopping experience of users by increasing media richness, which persuades consumers to purchase products or services.	Huang and Liu (2014)
Motivation theory	The theory suggests that an AR-based learning environment stimulates student motivation by increasing students' attention and satisfaction levels.	Di Serio et al. (2013)
Presence theory	The theory suggests that the perceived sense of presence in VR-based virtual learning environments fosters learners' motivation, learning engagement, and learning outcomes, by enabling focused and naturalistic interactions with learning materials and activities.	Ke et al. (2016), Von Der Pütten et al. (2012)
Situated cognition theory	The theory suggests that AR users are more likely to be engaged with authentic activities so that the learning is situated in socially and culturally meaningful contexts through practice, which leads to enhanced learning performance.	Chang et al. (2016)
Stimuli-organism-response (S–O–R) framework	The theory suggests that the technological stimuli used in immersive technology evoke individuals' cognitive and affective states, which in turn leads to behavioral changes (i.e., technology adoption behavior).	Kourouthanassis et al. (2015)
Technology acceptance model (TAM)	The theory suggests that users' intentions of using immersive technology are strongly affected by the perceived usefulness and ease of use of the technology.	Huang and Liao (2015), Wojciechowski and Cellary (2013), Yilmaz (2016)

Table 3
Summary of research methods.

	2010–2011	2012–2013	2014–2015	2016–2017	Total
Case Study			3	0	3
Experiment	4	3	8	15	30
Experiment & Case study	0	1	0	1	2
Experiment & Interview	0	0	1	0	1
Experiment & Survey	0	0	0	3	3
Experiment & Survey & Interview	0	1	0	0	1
Interview	0	0	2	0	2
Survey	1	1	3	2	7
Survey & Interview	0	0	0	1	1
Survey & Experiment & Interview	0	2	1	1	4
Total	5	8	18	23	54

5. A classification framework for immersive technology use

As mentioned in the previous section, many studies have employed flow theory to investigate user experience in immersive technology research, possibly because this theory allows researchers to assess the extent to which a user experiences a sense of immersion while using a technology. While studies that employed flow theory mainly focused on measuring users' psychological state as a cognitive response to an immersive technology, the antecedents and consequences of immersive technology use were often ignored in the studies. To develop a comprehensive framework that explores the interplay between factors including system features, user experience, and the outcomes of immersive technology use, this study adopts the S–O–R framework. This framework has been widely adopted for the examination of user experience and behavior while using information technologies (Mummalaneni, 2005). The framework posits that external or environmental cues trigger a user's internal evaluation, which in turn leads to user behavior (Jiang, Chan, Tan, & Chua, 2010). The S–O–R framework consists of three components: stimulus, organism, and response. Within this framework, stimulus refers to a trigger that arouses immersive technology users' cognitive and affective reactions, organism refers to an internal evaluation by immersive technology users, and response refers to an outcome of users' immersive technology use.

We extracted all the variables examined in the 54 identified studies and classified them based on the S–O–R framework to explore their relationships. Two researchers (one with a PhD in management information systems and the other with a Master's degree in media studies) independently coded. In case of any disagreement between the two coders, one of the authors facilitated the discussions till they reached a consensus. Agreement between the two coders was tested using Cohen's kappa, which was above 0.8 across all categories.

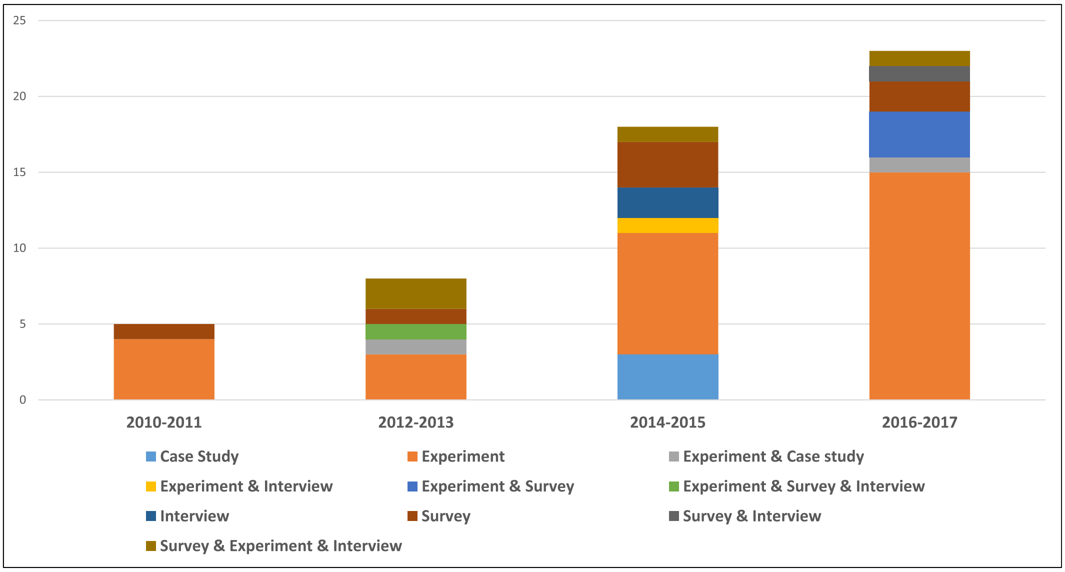

Fig. 4. Summary of research methods.

Table 4
Summary of the sensory stimuli.

Factor	System feature	Reference
Visual display	• Stationary display • Head-based display • Hand-based display	Datcu et al. (2015), Goh, Lee, and Razikin (2016), Polys et al. (2011), Zhao et al. (2015)
Auditory modality	Synthetic sound feedback to users interacting with the AR/VR environment • Stationary auditory modality (speaker-based 3D sound) • Head position-based auditory modality (headphones)	Hsiao et al. (2012), Lin (2017), Wojciechowski and Cellary (2013)
Haptic interface	Interface for tangible interaction • Provides users with the means to interact physically with virtual objects	Datcu et al. (2015), Jin (2013), Mateu et al. (2014)
Movement tracking	• Sensor-based tracking • Vision-based tracking • Marker-based tracking • Hybrid tracking	Chittaro, Sioni, Crescentini, and Fabbro (2017), Enyedy, Danish, Delacruz, and Kumar (2012), Enyedy et al. (2012), Enyedy et al. (2015), Mestre, Maïano, Dagonneau, and Mercier (2011), Park and Park (2010), Rovira and Slater (2017)

5.1. *Stimuli in immersive technology use*

The core of immersive technology is the affordances that engage users in the immersive environments, and thus provide the immersive experience. Researchers have reported that certain features of immersive systems elicit cognitive and affective responses from users. We have identified two major clusters in the system features of the papers we analyzed. The first stream of studies examined the effects of visual displays (Datcu, Lukosch, & Brazier, 2015), auditory modalities (Hsiao et al., 2012), haptic interfaces (Jin, 2013), and movement tracking (Mateu, Lasala, & Alamán, 2014). These studies posit that sensory stimuli are key to enhancing user experience in an immersive environment. Table 4 presents a summary of the sensory stimuli examined in the studies.

The other stream of research on system features focuses on user perception of features of immersive systems and examines the effects of perceptual stimuli on user experience. For example, Huang and Liao (2017) examined how an immersive technology creates a sensation of touch and transfers information content accurately while the user touches a virtual object to feel its texture in an AR environment. The study found that a high level of haptic imagery, imagery that transmits a sense of touch, enabled users to visually examine, search for, and manipulate objects. Moreover, Huang et al. (2010) conceptualized interactivity as a system feature for detecting a user's input (i.e., gesture) and responding to the new activity instantaneously. Table 5 presents a summary of the perceptual stimuli examined in previous studies.

In addition to analyzing the literature to reveal the technological features of immersive technology as stimuli, the content of immersive technology was found to elicit users' cognitive and affective responses. The major content topics appeared in the immersive technology research, including learning and training, psychotherapy, virtual journeys and tours, interactive simulation, and gaming (see Table 6). These content topics elicited cognitive and affective responses in different ways.

AR/VR content for learning and training includes tasks that can be solved through social interactions and collaborations, in which a learner feels connected to others (Enyedy et al., 2012; Mateu et al., 2014). Yilmaz (2016) argue that the content features of AR/VR should encourage learners to feel a sense of connectedness because such features facilitate learners' cognitive attainments and positive emotions while performing learning activities. Researchers have

Table 5
Summary of perceptual stimuli.

Factor	System feature	Reference
Interactivity	A system feature for detecting a user's input (i.e., gesture) and response to the new activity instantaneously	Huang et al. (2010)
Representational fidelity	The degree of realism of the objects or scenarios portrayed in an immersive environment Representational fidelity provides users with rich graphics, smooth temporal changes, and consistent object behavior, and as a result users are easily immersed in a mixed reality (synthesized) environment.	Merchant et al. (2014)
Imagination	A system feature that triggers the human mind's capacity to perceive and imagine in a creative sense about nonexistent things	Huang et al. (2010)
Haptic imagery	The ability to create a sensation of touch and to transfer information content accurately while touching an item of clothing in order to feel its texture	Huang and Liao (2017)
Perceived sense of self-location	The feeling that an online consumer's self is located inside their avatar's body	Huang and Liao (2017)
Media richness	Media richness makes an online simulation experience more authentic by various sensory stimulations and multiple cues.	Huang and Liu (2014)
Perceived usability	A user's overall perception of the system features of a technology, which refers to the extent to which a technology can be used to achieve certain objectives with ease, effectiveness, usefulness, efficiency, and satisfaction in an immersive environment	Frank and Kapila (2017), Pribeanu et al. (2017), Di Serio et al. (2013) Yilmaz Yilmaz (2016), Rochlen et al. (2017), Goh et al. (2016), Huang and Liao (2015), Arino et al. (2014)

Table 6
Summary of content stimuli.

Content topic	Content feature	Reference
Learning and training	Learners mentally process various information resources. To maintain learners' motivation and enable their conceptual blending, content features are highlighted that facilitate learners' social interaction with other learners, such as collaboration for problem solving and the stimulation of learner motivation and performance. Researchers have also suggested that providing various difficulty levels increases learners' motivation as they gain deeper understanding of a topic. Content topics for learning and training include the following: - Science and engineering - Medical training (central venous catheter insertion) - Painting appreciation - Cultural heritage Manufacturing assembly	Huang et al. (2010), Sylaiou, Mania, Karoulis, and White (2010), Mestre et al. (2011), Enyedy et al. (2012), Alelis, Bobrowicz, and Ang (2015), Ke et al. (2016), Radkowski et al. (2015), Mateu et al. (2014), Rochlen et al. (2017)
Psycho- and physiotherapy	Various psychological techniques using AR/VR environments are being employed to treat pain in the medical industry. In immersive environments, patients interact with virtual objects or characters that elicit emotional responses comparable to those produced by the real stimuli, which distract their attention away from pain, stress, and anxiety. Examples include the following: - Hypnosis therapy to reduce stress and anxiety - Psychotherapy for eating disorder patients - Pain management for burn patients - Food stimuli for obese patients	Mosso-Vázquez et al. (2014), Loreto-Quijada et al. (2014), Hoffman et al. (2014), Zhao et al. (2015), Mountford, Tchanturia, and Valmaggia (2016), Pallavicini et al. (2016)
Virtual journeys and tour	In a synthetic world, users are perceptually convinced that they are really "there." It has been found that navigating a cemetery elicits fear and anxiety, whereas navigating city streets, a metro, a lift, or the rooftop of a building stimulates users' sense of presence and special processing.	Kourouthanassis et al. (2015); Goh et al. (2016); Chittaro et al. (2017)
Interactive simulation	Through interactive AR technology, customers interact with simulated facial expressions, figures, and environments while trying on objects (e.g., clothes, glasses, and accessories). Content features that enable the creation and manipulation of product images arouse users' positive emotions. To stimulate users' narrative experiences, the content for interactive simulation should incorporate chronological logic into characters, events, images, and information content.	Huang and Liu (2014), Huang and Liao (2015), Huang and Liao (2017)
Gaming	AR/VR game content differs according to whether the game is designed so that players have a competitive or a collaborative experience. In general, collaborative games in AR/VR contexts were found to be more effective in facilitating users' cognitive involvement and spatial/social/temporal presence because collaborative AR/VR games allow multiple participants to share the physical and virtual spaces surrounding them and play together as opponents. Content for gaming include the following: - Single-person shooting games - Virtual sport games - Collaborative games - AR-based educational games (competitive/collaborative games)	Von Der Pütten et al. (2012); Lee, Chung et al. (2013), Bian et al. (2016), Hwang et al. (2016),

suggested that content features for learning and training should incorporate different stages of learning activities via a challenge to enable learners to accomplish more difficult tasks and experience a sense of self-progress (Enyedy et al., 2012; Ke et al., 2016).

AR/VR content for psycho- or physiotherapy focuses on how users' immersive experiences contribute to reducing stress, pain, and anxiety. For example, Zhao et al. (2015) found that hypnosis therapy using AR successfully reduced anxiety and stress. Mosso-

Vázquez, Gao, Wiederhold, and Wiederhold (2014) created VR environments that patients navigated, such as synthetic cliffs, an enhanced forest, a dream castle, and an icy cool world. Their results showed that psychotherapy using VR significantly reduced patients' pain and stress and increased positive emotions during treatment. Hoffman et al. (2014) also found that by giving patients the illusion of place, a VR application (i.e., SnowWorld) successfully focused burn patients' attention on interacting with virtual objects, such as snowmen, igloos, penguins, and flying fish, during wound cleaning and physical therapy, thereby reducing their pain and anxiety.

The content of virtual journeys and tours enables users to create their own narrative and fantasies while navigating a synthetic environment that represents a space they have never experienced before. Narrative refers to a content feature that enables users to create their own stories based on their experiences. Fantasy refers to a content feature that enables users to create mental images of objects that are not present to the senses or within the actual experience of a user involved. Chittaro et al. (2017) showed that such VR content elicits users' emotional responses (e.g., mortality salience and fear), for example, while navigating a cemetery with tombs and burial processes. In contrast, Kourouthanassis et al. (2015) identified that the content features of narrative and fantasy equally leveraged users' multi-sensory capabilities to be enacted in ways the user expects while navigating a synthetic environment. What researchers have commonly found is people perceive that they are really "there" in a synthetic world while navigating. Research finds that some people feel fear and anxiety, whereas some feel sense of presence while they tour virtual spaces.

The content for interactive simulation, such as AR for clothes-fitting and interactive online catalogs, incorporates features that transfer product information through customers' shopping experiences. Huang and Liu (2014) showed how haptic imagery enabled by AR elicits customers' cognitive and affective responses by enabling the creation and manipulation of product images.

AR/VR content for gaming uses game characters, events, narratives, and backstories to create player experiences, presence, enjoyment, and playfulness. The literature review revealed that AR/VR games elicit players' cognitive and affective responses in different ways depending on the type of game content. For example, survival horror games elicited emotions such as fear, suspense, and anxiety (Lin, 2017), whereas collaborative games increased cognitive involvement in solving problems, which led to enjoyment, pleasure, fun, happiness, and confidence among users (Von Der Pütten et al., 2012). Hwang, Wu, Chen, and Tu (2016) proposed a competitive AR-based education game for an ecology course and found the gaming approach to be effective for increasing learners' attitudes and performance.

5.2. Organism in immersive technology use

Researchers have identified cognitive and affective reactions to technology use in the S–O–R framework (Chan et al., 2017). In this study, organism refers to a user's internal evaluations as a reaction to immersive technology use. Cognitive reactions represent mental processes that occur when a user interacts with technological stimuli (Jiang et al., 2010). Table 7 presents the factors that were examined in previous studies to understand users' cognitive reactions while using immersive technology. The literature review reveals that immersion is a key construct that represents users' cognitive reaction to immersive technology use. Conventionally, immersion has been defined as a state of mind in which a user is deeply engaged within an immersive environment (Sherman & Craig, 2003). However, we found that immersive technology researchers currently tend to conceptualize immersion based on different dimensions. For example, Huang et al. (2010) categorize

Table 7
Summary of cognitive reactions.

Factor	Definition	Reference
Immersion	**Mental immersion**: a state of mind in which a user feels that he or she is deeply engaged within an immersive environment	Bian et al. (2016), Chang et al. (2014), Georgiou and Kyza (2017), Hsu (2017), Huang et al. (2010)
	Physical immersion: a state in which a user feels, physically and mentally, that he or she is engaged within an immersive environment. Physical immersion is achieved when a user interprets visual, auditory, and haptic cues to gather information and navigates and controls objects in the synthetic environment	Di Serio et al. (2013), Huang et al. (2010), Huang and Liao (2017)
Presence	A psychological state in which a user feels that he/she is in a certain place, even when he or she is physically situated in another place	Huang and Liao (2015), Huang and Liu (2014), Ke et al. (2016), Park and Park (2010), Stavropoulos, Wilson, Kuss, Griffiths, and Gentile (2017), Sylaiou et al. (2010)
	Physical presence: a psychological state in which virtual objects are experienced as actual physical objects	Jin (2013)
	Spatial presence: a feeling of being spatially located in the mediated space	Coxon, Kelly, and Page (2016), Jin (2013), Von Der Pütten et al. (2012)
	Social presence: the sense of being together with another or others	Lee, Chung, et al. (2013) Von Der Pütten et al. (2012)
	Temporal presence: a sense of being in the time of the perceived content	Lee, Chung, et al. (2013)
Flow	A subjective psychological state of control, attention focus, curiosity, and intrinsic interest, which is accompanied by a loss of self-consciousness and self-reinforcing conditions of human-computer interactivity	Chang et al. (2014) Bian et al. (2016) Huang and Liao (2017) Hsu (2017)
Illusion	**Place illusion**: the strong illusion of being in a place in spite of the sure knowledge that you are not there	Lin (2017)
	Plausibility illusion: the illusion that what is happening is real even though you know that it is not real	
Situated cognition	In an immersive environment (especially in a location-based AR context), users can cognitively blend virtual information and real context, which gives users the feeling that they are situated in authentic contexts and enhances their learning performance	Cheng Cheng and Tsai (2014)
Psychological ownership	Sense of body ownership: Users are concerned with possessing virtual objects (e.g., avatars) that appear similar to their actual physical body so that they can align their virtual selves with their actual physical selves	Huang and Liao (2017), Škola and Liarokapis (2016)
	Ownership control: sense of control (i.e., action, control, intention, action selection, and free will) over an artificial body in an immersive environment	Huang and Liao (2017)

immersion into mental and physical sub-dimensions. Georgiou and Kyza (2017) elaborate on the concept of immersion by using a hierarchical structure composed of (1) engagement, which refers to users' interest and usability; (2) engrossment, which refers to users' emotional attachment and their focus of attention; and (3) total immersion, which refers to mental absorption in the use of an immersive technology. Although researchers have proposed diverse constructs to capture users' cognitive reactions, we found that, in general, immersion has been defined as a psychological process of engagement and that it has a positive influence on flow and/or presence (Georgiou & Kyza, 2017).

Flow refers to a user's psychological state of mind in which he or she can feel a sense of control, attention, focus, curiosity, and intrinsic interest, which is accompanied by a loss of self-consciousness (Chang et al., 2014). Researchers have elaborated on this concept to capture the unique characteristics of immersive technology. For example, Jin (2013) and Von Der Pütten et al. (2012) conceptualized presence based on four sub-dimensions: (1) physical presence (a psychological state in which virtual physical objects are experienced as actual physical objects), (2) spatial presence: a sense of being located in virtual environments, (3) temporal presence: a sense of being in the time of the perceived content, and (4) social presence: a sense of being together or having an illusion of a shared physical space.

In the S–O–R framework, an affective reaction is the emotional response that arises when users interact with a technology (Chan et al., 2017). Research has found that the use of immersive technologies can evoke positive emotions (Huang et al., 2016), which in turn can influence user performance (e.g., learning outcomes). As shown in Table 8, in previous studies, researchers have identified enjoyment, fun, pleasure, arousal, and dominance as affective reactions to immersive technology use. While some studies found that immersive technology evokes positive emotions (Alelis et al., 2015; Huang et al., 2016), other studies found that enhanced illusions of place and plausibility in an immersive environment cause users to experience negative emotions, such as fear, anger, and rage (Lin, 2017).

5.3. Response in immersive technology use

In our framework, response refers to a consequence of immersive technology use. As shown in Table 9, learning performance, behavioral changes, pain reduction, and continuance intention were commonly cited as response variables. In the field of education, researchers found that the use of immersive technologies enhanced learning processes, student engagement, and outcomes (Cheng & Tsai, 2014; Frank & Kapila, 2017; Ibáñez, Di-Serio, Villarán-Molina, & Delgado-Kloos, 2016; Loup-Escande et al., 2017; Yoon, Elinich, Wang, Steinmeier, & Tucker, 2012). Researchers who view immersive technologies as persuasive tools argue that the use of immersive technologies can motivate users to change their behaviors, and they thus focus on user behavior as a consequence of immersive technology use. In the healthcare field, it has been found that the use of immersive technologies can help patients reduce the levels of perceived disease symptoms (Mountford et al., 2016). Additionally, in the entertainment field, researchers have found that the use of immersive technologies amplifies entertaining experiences by increasing the level of a pleasurable sense of flow and presence (Lee, Chung, et al., 2013).

Researchers have also reported negative responses to immersive technology use. For example, researchers found that some users experienced motion sickness when they used a head-mounted display (Coxon et al., 2016; Munafo et al., 2017). Moreover, it has been reported that certain design features required users to be in uncomfortable bodily postures that caused tiredness even after they used an immersive technology for a short period of time (Goh et al., 2016). Table 10 summarizes negative outcomes of immersive technology use examined in the previous studies.

5.4. Individual differences in immersive technology use

The literature analysis shows that individual differences play a

Table 8
Summary of affective reactions.

Factor	Definition	Reference
Pleasure	The degree to which the immersive technology evokes a pleasant (or unpleasant) emotion to users	Kourouthanassis et al. (2015)
Arousal	The degree of intensity of the pleasant or unpleasant emotion	
Dominance	The controlling and dominant nature of the emotion	
Positive/Negative Emotions	• Positive emotions: pleasure, fun, happiness, confidence, and hope • Negative emotions: boredom, anxiety, depression, tension, fear, anger, and rage	Alelis et al. (2015), Huang et al. (2016), Lin (2017)

Table 9
Summary of response in immersive technology use (positive outcomes).

Factor	Definition	Reference
Learning effectiveness	Improvements in learning processes and outcomes, including level of content knowledge, academic achievement, performance, skills, ability and others	Frank and Kapila (2017), Ibáñez et al. (2016), Yoon et al. (2012), Loup-Escande et al. (2017), Cheng and Tsai (2014)
Learning engagement	Increase in the amount of time spent focusing on AR/VR, a higher frequency of interactions	Ke et al. (2016), Chang Chang et al. (2014)
Learning attitude	Improvement in attitudes towards learning materials after experiencing the AR/VR	Hsiao et al. (2012), Hwang et al. (2016)
Task performance	Improvement in efficiency (i.e., less than average completion time for correct actions) and accuracy (i.e., than less average overall error rate/higher success rate for tasks)	Radkowski et al. (2015) Zhao et al. (2016), Munafo et al. (2017)
Reduced disease symptoms	Reduction in disease symptoms (e.g., pain, psychological stress, and mental diseases)	Mountford et al. (2016), Mosso-Vázquez et al. (2014), Hoffman et al. (2014) Pallavicini et al. (2016), Loreto-Quijada et al. (2014)
Intention to use	User's intention to use AR/VR	Huang et al. (2010), Wojciechowski and Cellary (2013), Yilmaz (2016), Lee, Chung, et al. (2013)

Table 10
Summary of response in immersive technology use (negative outcomes).

Factors	Description	References
Motion sickness	This is characterized by an aversive sense of discomfort, disorientation, nausea, vomiting, etc. Motion sickness is common in users of head-mounted display systems for immersive technology	Munafo et al. (2017), Coxon et al. (2016)
Physical discomfort	Some users report that using head-based displays causes physical discomfort. In the case of hand-based displays, some users report that they experienced discomfort in cases when they had to hold the device at eye level to view an immersive environment	Goh et al. (2016), Datcu et al. (2015)
Cognitive overload	When the size of the display screen is limited, it constraints the amount of information presented and overwhelms the user	Goh et al. (2016)
Distracted attention	Immersive technology often fails to balance a user's attention distribution between the virtual and the physical spaces, causing them to engage with the virtual information and technology excessively, and to ignore the real environment or learning process.	Chang et al. (2014)

role in determining users' responses to and subjective experience of immersive technology. For example, research has found that female users are more prone to have negative cognitive reactions to immersive technology use than male users (Munafo et al., 2017). While some researchers have found that younger users are more likely to be engaged with an AR environment than older users (Coxon et al., 2016), other researchers have found no difference between different age groups (Alelis et al., 2015). As previously noted, the tendency to use college students in studies, who typically have an age between 20 and 25 may result in less data on other age groups. It was also found that, regardless of age, users with a low sensation-seeking tendency experience a stronger sense of presence in an immersive environment than those with a high sensation-seeking tendency (Jin, 2013; Lin, 2017). Table 11 presents a summary of personal differences in immersive technology use.

6. Framework for immersive technology use

Although previous studies have examined the diverse aspects of immersive technology use, the current study revealed that no comprehensive framework has been used to explore the relationships between these aspects, including system features, users' cognitive and affective states, and the consequences of immersive technology use. By acknowledging the research gaps in existing immersive technology studies, this research builds on the S–O–R framework to propose an integrative framework for immersive technology use as shown in Fig. 5.

The literature analysis revealed that system features (sensory and perceptual stimuli) and content topics (learning and training, psycho- and physiotherapy, virtual journeys and tour, interactive simulation, and gaming) influence users' cognitive and affective reactions. Our findings signify the importance of having a comprehensive understanding of different types of stimuli that elicit users' cognitive and affective reactions. The fit between sensory and perceptual stimuli along with the content stimuli should be considered when an immersive technology is developed to provide users with engaging experiences. Our literature analysis reveals that prior literature has not emphasized the direct relationship between immersive system features and user performance (e.g., learning effectiveness, learning engagement, and intention to use). Rather, studies have shown that immersive system features lead to user performance through the mediation of users' cognitive and affective reactions (Merchant et al., 2014). Accordingly, the framework posits that immersive system features (stimuli) influence users' cognitive and affective reactions (organisms), which in turn influence the outcomes of immersive technology use (responses). Drawing on the previous findings (Arino et al., 2014; Coxon et al., 2016; Jin, 2013; Kourouthanassis et al., 2015; Lin, 2017), the framework posits that individual differences have moderating effects between (1) immersive system features and users' cognitive and affective reactions and (2) users' cognitive and affective reactions and the outcomes of immersive technology use. The direct relationships are presented as solid lines, and the moderating effects are depicted as dotted lines in the illustration of this framework.

7. Discussion

Recently, researchers and practitioners have paid increasing attention to immersive technology. However, little research has been done to systematically summarize and synthesize the existing knowledge. This study seeks to consolidate the factors examined in immersive technology studies into a classification framework, which can serve as a theoretical platform that researchers can test, verify, and revise to develop an understanding of immersive technology use. Based on the literature analysis, future research issues and directions are discussed in the following section.

Table 11
Summary of individual differences.

Factor	Findings	Reference
Gender	Women are more likely to have negative experiences (e.g., motion sickness) than men when they use head-mounted displays in an immersive environment. Men are more likely to accept AR technologies than women.	Munafo et al. (2017), Lin (2017), Arino et al. (2014)
Age	Younger users are more likely to accept immersive technologies than older users by creating a mental model when in an immersive environment.	Coxon et al. (2016), Arino et al. (2014)
Sensation-seeking tendency	Sensation seeking is a personal trait that characterizes a person who purposefully seeks novel, exciting, and intense experiences to satisfy his or her need for sensation. Users with a low sensation-seeking tendency experience a stronger sense of presence in an immersive environment than those with a high sensation-seeking tendency.	Lin (2017), Jin (2013)
Personal Innovativeness	This refers to an individual's propensity to experiment with new information technologies. When a user has a high level of innovativeness, he or she is more likely to have a high level of behavioral intention to use an immersive technology.	Kourouthanassis et al. (2015)

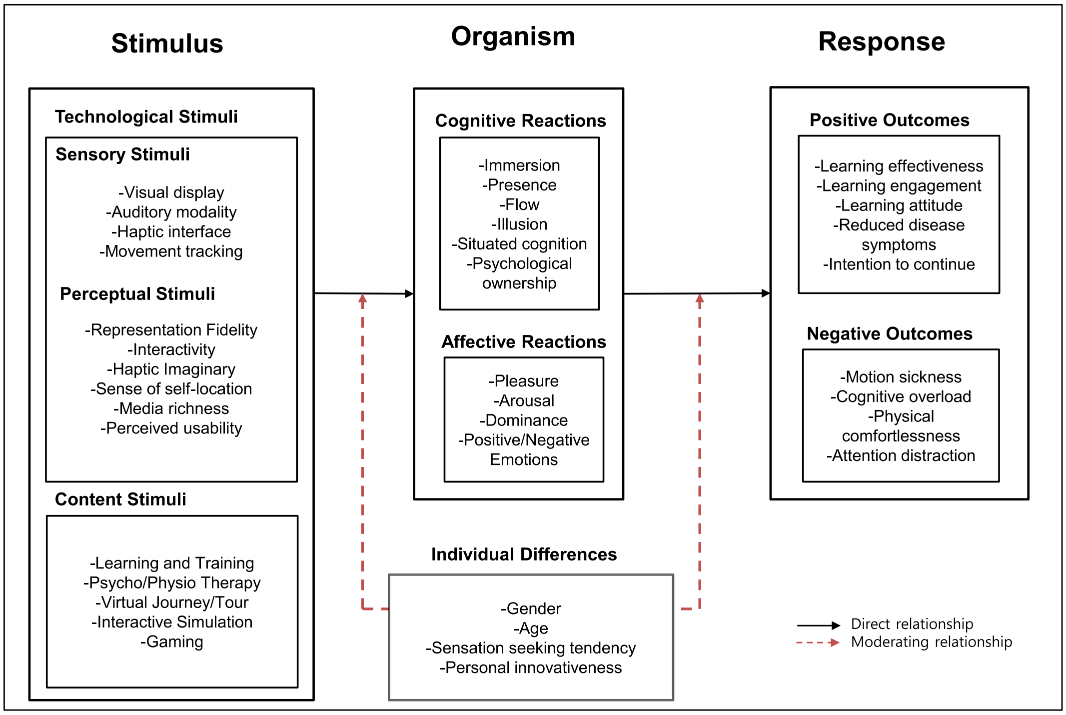

Fig. 5. Conceptual framework.

7.1. Future research agenda

7.1.1. Focusing on context-specific technological stimuli

The literature analysis shows that a technological stimulus influences user performance, such as learning effectiveness, through the mediation of user reactions to the stimulus cognitively or affectively. However, most studies have focused on a single or limited aspect of immersive technology, and very little research has examined the different effects of diverse technological stimuli on multiple aspects of user performance. Furthermore, the effects of particular and context-specific technological stimuli remain relatively understudied. Although some researchers have conceptualized the unique system features that are applicable to immersive technology (e.g., haptic imagery, representational fidelity, and perceived sense of self-location), their measures have not been well established and constructs that can exclusively capture the unique features of immersive technology are lacking in the literature. Thus, it would be meaningful to develop and conceptualize immersive system features and explore their influence on user experience and performance in a systematic way.

7.1.2. Elaborating on the concept of immersion

Conceptualization and operationalization of key constructs that can be used to evaluate a user's perception of technological features and his or her cognitive and affective responses to mixed or immersive environments are of value to academia. In this literature analysis, we found that researchers conceptualized immersion differently. That is, while some studies viewed immersion as a unidimensional concept (Bian et al., 2016; Chang et al., 2014; Georgiou & Kyza, 2017; Hsu, 2017), others considered it to be multi-dimensional (Di Serio et al., 2013; Huang & Liao, 2017; Huang et al., 2010). Despite the importance of conceptualizing users' immersive experiences, there is no accepted scale for measuring different aspects of immersion in the analyzed papers. Therefore, future studies could benefit from defining precisely what immersion is, how it interplays with other similar concepts, such as flow and presence, and how it contributes to enhancing user performance. The question of how different dimensions of immersion influence user performance remains unanswered. By elaborating on the concept of immersion and developing its measure, future studies can help researchers answer this question.

7.1.3. Understanding the mechanisms that explain how user experience and performance can be enhanced in an immersive environment

This literature review shows that immersive technology allows users to immerse themselves in virtual scenarios that otherwise cannot be easily envisioned. A result of this immersion is the ability to perceive, feel, and cognitively process information that would have otherwise been unavailable; in this way, immersion augments human cognition. The use of these technologies can enhance learning experiences, foster participation in collaboration, and increase creativity and engagement. However, despite the rise in popularity and increase in scholarly attention toward immersive technology, there is a significant lack of empirical research that explains systematically how and why these technologies improve or impair user performance. Although researchers have suggested that users' cognitive and affective reactions are influenced by diverse types of stimuli induced by technological features (i.e., sensory and perceptual stimuli) and content features (i.e., content stimuli), little research has systematically examined the joint effects of different stimuli on users' cognitive and affective reactions. Researchers might make important contributions by examining the effects of the fit/misfit between different types of stimuli influence user experience. For instance, empirical research on (1) how the fit between technological and content stimuli elicits positive user experience; (2) how the misfit between sensory and perceptual stimuli leads to negative user experience; (3) how technological stimuli offset or overweight the effect of content stimuli on user experience can contribute to understanding the mechanisms for user experience through immersive technologies.

7.1.4. Diversifying methodological approaches to capture the immersive user experience

This analysis shows that experimental and survey designs are the most widely adopted methods in immersive technology research. Although such quantitative approaches are relevant for providing empirical results for immersive technology use, we have identified limitations to measuring actual user experience and performance in the immersive technology literature. Specifically, experimental designs are limited in that the controlled settings may cause the subjects to act in accordance with what they believe the experiments are looking for (Chan et al., 2017). Survey designs to collect responses are also limited in that self-reported evaluation of system use and perceptions can be influenced by social desirability bias (Fisher, 1993). Therefore, conventional research designs, such as experiments and surveys, are arguably insufficient for precisely capturing immersive user experiences and performance. Researchers would benefit from considering method triangulation, for example, by employing neurophysiological measures. Electroencephalography (EEG) can be more actively adopted in research to detect a user's brain activity, which can help researchers to assess a user's mental state (e.g., relaxed or focused mental state) and the quality of user experience (Bauman & Seeling, 2017; Mercier-Ganady, Lotte, Loup-Escande, Marchal, & Lécuyer, 2014).

7.1.5. Understanding the negative consequences of immersive technology use

The literature review showed that immersive technology has great potential to create new value in creating user experience. However, it was also found that the use of immersive technology can engender negative consequences. For instance, some studies have reported that immersive technology use may cause cognitive overload (Hsu, 2017), and some researchers have also reported that using head-mounted displays to experience an immersive environment may cause motion sickness (Coxon et al., 2016; Munafo et al., 2017) and physical fatigue (Goh et al., 2016). However, relatively little research has addressed the negative consequences of immersive technology use. Future research should take these challenges, such as technical issues to be overcome and the negative consequences of technology use, into consideration to advance understanding of immersive technology use.

7.1.6. Diversifying samples and contexts

The majority of empirical research has used student samples for data collection. As immersive technology becomes more popular across different age groups, limiting samples to students may inhibit the generalization of the research findings. Future research should therefore incorporate more diverse samples to overcome this sampling issue. Furthermore, the majority of studies we reviewed used online learning systems incorporating AR or VR features as their research context to examine the influence of immersive technology use and learning performance. Given that immersive technology is becoming pervasive in many other fields apart from education, such as marketing, manufacturing, healthcare, and entertainment, more diverse research contexts with varying samples need to be used in future research.

7.2. Theoretical implications

This study set out to analyze the current state of immersive technology literature, including bibliometric information, research trends and contexts, theoretical foundations, and methodologies. This study makes several important key contributions to academia. First, because few systematic literature reviews of studies on immersive technology use have been conducted, this literature review can help researchers understand the state of immersive technology research in terms of theoretical and methodological approaches, research themes, and contexts. Second, we developed a comprehensive conceptual framework by consolidating the factors associated with immersive technology use into a classification framework. Based on the framework proposed here, researchers can work on new models that explain the interplay between immersive system features, user experiences, and the consequences of the use of immersive technology. Finally, we synthesized the findings in the literature and identified gaps in research. The list of factors we consolidated from the literature review and our suggestions for future research issues could benefit researchers who seek to conceptualize new constructs that reflect unique aspects of immersive technology use and who want to develop, test, and verify their theories in relation to immersive technology use.

7.3. Practical implications

The present study provides practical implications for system developers and managers who seek new ways to promote user engagement through immersive technologies. This literature review revealed the interplay between technological, content, psychological, cognitive, and behavioral factors in relation to successful technology implementation and user adoption of immersive technology. Additionally, AR/VR systems do not always create positive user experiences. The proposed framework revealed motion sickness, cognitive overload, physical discomfort, and distraction as factors that lead to negative user experiences. System designers should consider how to minimize the negative effects induced by immersive technology use on user experiences. It is noteworthy that individual differences shape the effects of technological and content stimuli on users' cognitive and affective reactions. Accordingly, understanding user characteristics might be a potential solution for overcoming the negative consequences of immersive technology use.

7.4. Limitations

This study has several limitations that should be considered when applying the study's findings. Because the articles included were selected based on our selection criteria, there might be important knowledge and findings that we have missed in our literature review. For example, information from industry reports, books, and magazines could provide additional insights. Second, immersive technology research is at its early stage, and many of the previous studies are still fragmented, which made it difficult for us to perform a quantitative analysis to consolidate the different effects of technological stimuli on user experience. Future research can go beyond these limitations and extend our findings by conducting replicative studies in different contexts with different technological applications.

8. Conclusion

The findings of the present systematic literature analysis indicate the number of studies on immersive technology is on the increase. Given that the use of immersive technologies is expected to become more widespread in the future, more empirical studies are needed to theorize the effects of immersive technology use on user experiences and performance. We hope that this literature review will help researchers understand the current state of immersive technology and develop research agendas for future investigation.

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Ayoung Suh is Assistant Professor of School of Creative Media and Department of Information Systems, City University of Hong Kong. Her research interests include virtual collaboration, virtual communities and teams, virtual identity, and the effects of emerging technology in the workplace. Her papers have been published in *Journal of Management Information Systems*, *Journal of the Association for Information Systems*, *Journal of Knowledge Management*, *Journal of Information Science*, *Computers in Human Behavior*, *Journal of Computer Information Systems*, *Internet Research*, and others.

Jane Prophet is Professor of Interdisciplinary Art and Computing, Goldsmiths College, University of London. Prophet's practice-based research and writing emerges through collaborations with neuroscientists, stem cell researchers, mathematicians and heart surgeons. Her papers position art in relation to contemporary debates about new media and mainstream art, feminist technoscience, artificial life and ubiquitous computing. Her current research includes the apparatus of contemporary neuroscience experiments, blended online/offline identities via augmented reality and ubiquitous computing.