Information & Management 53 (2016) 504–516

Contents lists available at ScienceDirect

Information & Management

journal homepage: www.elsevier.com/locate/im

E-learning continuance: The impact of interactivity and the mediating role of imagery, presence and flow

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ARTICLE INFO

Article history:
Received 5 February 2014
Received in revised form 24 November 2015
Accepted 29 November 2015
Available online 11 December 2015

Keywords:
Interactivity
Imagery
Flow
Spatial presence
Copresence

ABSTRACT

This paper empirically examines the impact of the interactivity elicited by e-learning environments for higher education. By considering the underlying processes of imagery, spatial presence, copresence and flow, we analyse how interactivity affects users' responses towards the learning environment, including their actual continuance behaviour. We validate our conceptual model by using survey and registrar data obtained from 2530 students of an open, distance university in the European Higher Education Area. The results suggest that the interactivity elicited by an e-learning environment unleashes imagery that in turn facilitates spatial presence and copresence as well as flow. Significant paths are also found from interactivity to flow and from flow to e-learner response variables (attitude, intention to continue and actual continuance behaviour). The paper provides a novel account of the presence and flow-enabling mechanisms in e-learning and offers novel knowledge on how higher education institutions can facilitate e-learners' continuance behaviour.

1. Introduction

Since 1960, when the University of Illinois launched the first computer-based teaching initiative, significant advancements have been made in e-learning. At present, most higher education institutions have devised ways of providing e-learning services. Moreover, e-learning is no longer a novelty for tech-savvy students; it has become a mainstream essential for all kinds of individuals with higher education needs [18].

E-learning lets individuals fulfil their educational needs via a large range of digital technology-supported services. As these systems offer interaction opportunities [151,11,137], e-learners customise their learning–teaching processes according to their specific wishes, building on their knowledge. Examples of these interactive features include multi-blog learning applications, wikispaces for collaborative project learning, software programmes, hypermedia didactic materials, simulators, real-time communication and project video presentations.

As the demand for e-learning grows, higher education institutions face increasing pressure to understand the mechanisms underlying the interactivity features of e-learning. This is because they need to be able to take advantage of the interactivity possibilities of novel education systems to provide students with compelling learning experiences and to promote e-learner continuance [62]. As a consequence, interactivity has emerged as a key player to be considered carefully under the empirical lenses.

Over the years, studies examining e-learning interactivity have increased, although several important subjects are yet to be covered. Firstly, the effects of interactivity that have been studied to date largely relate to attitude or learning performance, but they do not connect with e-learner retention. A number of papers have examined the links between interactivity and positive attitudes and satisfaction (e.g., Refs. [52,86,94]), while many others have assessed the impact of interactivity on e-learning quality and effectiveness (e.g., Refs. [11,90,182,170,93,65,115]). By contrast, at the time this paper was being prepared, these researchers located only one study paying attention to the behavioural effects of interactivity on e-learning continuance [25], and no investigation has considered its possible impact on actual continued usage. Secondly, very little notice has been taken of the underlying processes that intervene when individuals are exposed to interactive e-learning initiatives. Instead, previous research has mainly analysed the direct impact of interactivity on e-learning outcomes [39,172,98,122]. While some studies have assumed the existence of internal processes (e.g., Refs. [11,86,94,25]), such presumptions have not been always validated (e.g., Refs. [115,73,127]).

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http://dx.doi.org/10.1016/j.im.2015.11.005
0378-7206/

Therefore, this paper aims to fully elucidate and provide further insights into the effects of interactivity on e-learning. For this purpose, we acknowledge the role of imagery, spatial presence, copresence and flow as central underlying mechanisms, and we study their impact on individuals' responses. Despite the scarcity of studies on imagery processes in e-learning, imagery preferences have been noted as crucially important in laying the groundwork for understanding e-learners' experiences [34,61,79]. It has been alleged that, when interacting with a virtual environment, imagery processes come into play [77] and, through imagery, individuals feel immersed in the environment [132] and experience intrinsic enjoyment [63]. Furthermore, spatial presence and copresence have been identified as important psychological processes in e-learning (e.g., Refs. [94,15,66]). Through these experiences, users feel that the imagined (virtual) terrain depicted by technology is now their actual reality [9,140] and that they are with the other individuals [10]. Similarly, the mediating role of flow within interactive virtual environments has been suggested [161], and this translates into states of deep focus on the tasks being carried out and an intrinsic interest in the activities for their own sake [56,29]. With this approach, we seek to perform the following:

- Examine the influence of interactivity on affective and behavioural e-learners' responses.
- Analyse the interaction between underlying processes (imagery, spatial presence, copresence and flow) unleashed by interactivity.
- Build a comprehensive conceptual model of the direct and indirect effects of interactivity, including actual continuance behaviour.
- Find empirical support for the causal paths in the model.

2. Theoretical considerations

In this section, we present the theoretical considerations that lead us to propose our conceptual model on the effects of interactivity and imagery within e-learning (see Fig. 1). Similar to many other studies on human behaviour online (e.g., Refs. [59,89,135]), we situate our model within the widely accepted SOR (stimulus–organism–response) framework [100]. Accordingly, interactivity in our model is considered as an *input* variable that influences an individual's organismic reactions or *experiences* (i.e., imagery, spatial presence, copresence and flow). The experience variables in turn influence the individual *responses*: attitude, behavioural intention and actual continuance.

2.1. Meaning and connections of interactivity and imagery

Studies have identified e-learners' interactivity as a critical success factor in virtual learning environments [65,117,145,168]. This is because e-learners do not relate face to face with instructors, university staff and classmates [122,97]. Rather, teaching and learning processes are mediated by digital technologies. In addition, within the specific territory of e-learning, a number of studies have explored interactivity manifestations, which include interactivity with didactic resources (e.g., Ref. [157]) and interactivity with and among peers and instructors (e.g., Refs. [11,122]).

Steuer conceived interactivity as 'the extent to which users can participate in modifying the form and content of a mediated environment in real time' (1992, p. 84). Moreover, many studies have used this definition as their starting point to define interactivity (see Refs. [17,104]). Despite this, two main, differing views about the nature of interactivity have emerged [14,184,153]: a more technical or feature-oriented approach and a perceptual approach. The technical view of interactivity conceives it as a structural capacity of the virtual environment, which reflects its functionalities and design. This type of interactivity can be objectively assessed by considering the number and type of interactive elements in the virtual environment [166], such as real-time feedback, network interaction or sensitive images [86,182,127]. In this research, by contrast, we adopt a perception-oriented approach. This is because the 'actual' interactivity level of a virtual environment does not necessarily correspond with final users' subjective evaluations – as observed for both marketing-oriented websites [166,154] and virtual education environments [156]. In addition, a number of analyses framed around the perception-oriented view support three core dimensions of interactivity (e.g., Refs. [164,104,166,30]): perceived two-way communication (reciprocal communication within the institution), perceived receptiveness (simultaneity or speed of the responses) and perceived control (user's capability to instrumentally modify the communication environment). Taking these into consideration, we understand interactivity as the extent to which the e-learners perceive that their communication or interaction in the virtual education environment is bi-directional, responsive to their actions and controllable.

Imagery, as a synonym here for mental imagery, has received scarce attention within the particular context of e-learning. This contrasts with the importance of imagery as a human behaviour construct, which is well credited in the fields of psychology and

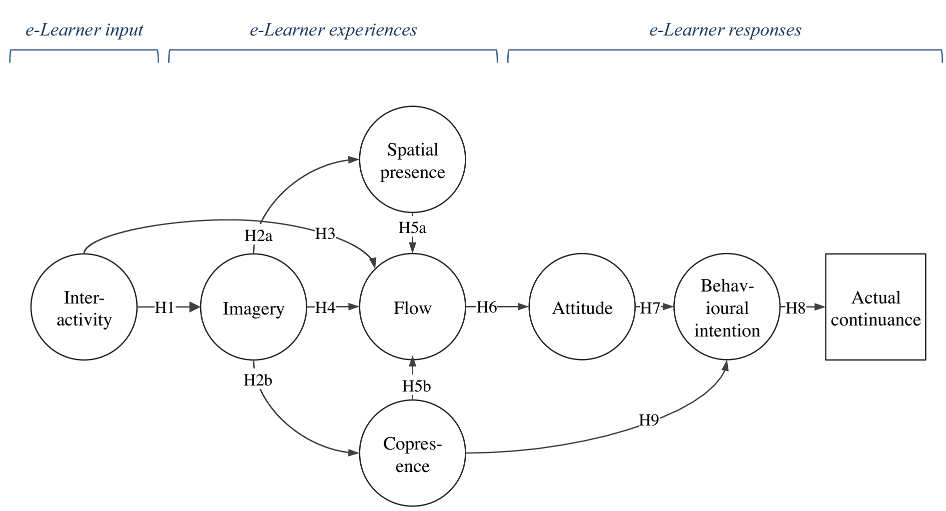

Fig. 1. Mediated model of the effects of interactivity.

consumer behaviour (for a review, see Refs. [123,134]). Imagery is acknowledged as a quasi-perceptual experience through which people recreate sensory information in their minds and produce fresh thoughts [132]. The lines between perception and imagery are vague [48,126]. Both perception and imagery can not only be prompted by incoming external stimuli [42,130] but also share 'the same system of conscious processing' [99]. Moreover, they generate results that are often functionally similar [42,160].

The role of imagery as an underlying process is not fully clear [123]. Cognitive elaboration theories of dual-coding hypothesis [118,119] and availability–valence hypothesis [75] have been used to claim that the information generated via imagery is superior in retrieval and accessibility, has a greater impact on attitudes and behaviours and leads to longer-lasting attitudes and behaviours. However, although this cognitive elaboration perspective is assumed in a number of studies [16,22,76,116], there is a lack of consistency in the results about the exact role of imagery [124,169,177]. More recent studies have found that the effects of imagery are not necessarily ruled by cognitive elaboration, and that other underlying processes also play a part [169,37,141]. In particular, the narrative transportation theory [50] sheds light on the underlying mechanisms raised by imagery [123,38]. Following narrative transportation rationale, individuals direct all their mental systems and capacities to the contents that are presented to them and do not consider their own knowledge structures [50], and they connect and elaborate the contents similar to formulating a story [111]. Under these conditions, they build lasting thoughts that reflect the arguments [51]; ultimately, they feel fully 'immersed' in the alternative environment presented to them [132].

Yet in the particular context of e-learning, imagery has been mainly understood either as a sort of 'storage room' for images and sensory information or as an individual's willingness to elaborate on visual information. On the one hand, some studies have dealt with imagery-eliciting didactic content. These studies infer their existence from the effects of imagery-eliciting didactic strategies on learning criterion variables [163,144,105] instead of focusing on imagery experiences. On the other hand, some other studies examine the learning effects of the individual's preference for processing visual information [34,41,161], which they differentiate from the individual's inclination to elaborate abstract or verbal information. However, evidence shows that e-learner preference for imagery-eliciting content does not predict actual elaboration of imagery [79]. This is because imagery evoked by a piece of communication results from both the individual's ability to process it and the stimulus itself [36]. For instance, if the teaching strategies implemented in the virtual education environment do not fit the e-learner's disposition towards imagery processing, he or she might not perform the learning process as had been anticipated.

The connections between interactivity with imagery processes have been underexplored. Besides, only Huang et al. [61] proposed the existence of a link between visual e-learning styles and online interaction, which they found to be insignificant. But imagery was pigeonholed as a general tendency; hence, results must be interpreted with caution. In fact, the human behaviour literature strongly supports the causal effect of perception on imagery (see Ref. [173]); in the context of consumer behaviour, mounting evidence suggests that interactive online content prompts higher levels of imagery [77,141]. These findings lead to the rationale that content that allows higher levels of reciprocity, responsiveness and active control enables individuals to gather information in the best suitable way; as a result, this makes information elaboration more compelling. Content will be more meaningful and thrilling, and thus it will stimulate more mental imagery resources to process information. Therefore, we presume that interactivity elicits imagery:

H1. Interactivity positively affects imagery.

2.2. Presence experiences

The sense of presence covers a wide range of sensory feelings associated with the individual's temporary suspension of disbelief in the reality of the virtual world [152], as if the experience of the virtual environment was not generated by technology [91]. Two primary and separate concepts related to presence have emerged from presence theorists [10,91,142,101,183,82]: the concept of spatial presence and the concept of copresence. In line with this, we present spatial presence and copresence as distinct teams, with both wielding influence on the individual's experiential immersion in an (educative) virtual environment.

The concept of spatial presence is widely used to describe the experiences through which individuals believe they have been transported elsewhere and are actually 'there', that is, inside the concrete virtual terrain suggested by technology cues, and not in their immediate physical surroundings (e.g., Refs. [140,176]). Researchers into 'presence' use various terms to label these feelings, including telepresence [155,103], virtual presence [147] and spatial presence [174,143]. Moreover, although there are slight differences between the specific meanings associated with these terms (see [83]), we will consider them to be interchangeable for the purpose of this study.

There is no consensus on the nature of spatial presence experiences. Yet, although it is outside the scope of this article to provide an in-depth review of spatial presence research, it is worth distinguishing two research streams that respectively defend an external and an inner view of spatial presence. Conceptualisations under the external perspective define spatial presence as how the individual perceives the stimuli that technology sends out [9,103,120,109]. Consistent with this, imagery is categorised as opposite to presence, and spatial presence experiences are relegated to a non-internal domain. By contrast, more recent studies have noted an important shortcoming in these previous conceptualisations and have recognised a mental domain for the spatial presence concept [143,12,138,178]. The reasoning behind this is that individuals cannot infer that the perceived external stimuli are part of their external (virtual) world, unless the inner processes related to imagery occur. As shown by Saunders et al. [140] and Schubert [143], the only consumers who can feel in an virtual environment are those who have mental representations of that non-physical or non-real place. This is because spatial dimensions in virtual domains are conceptual, not physical. Hence, consumers use their perceptions to fashion spaces in their mind to try and develop a meaningful understanding of the virtual environment [132]. In line with these researchers, we suggest that spatial presence is not merely a perception; it is triggered by the type of internal processes responding to perceived, external stimuli. Consequently, we propose an inner view of spatial presence. This view is further in line with empirical tests that have observed a positive relationship between how successfully the individual can engage in imagery and spatial presence [69,139,162,171].

The concept of copresence or social presence [91,146] is used to refer to feelings of 'being with others' [142,101,183]. It is about the individual's sense of being connected to other people's minds [114], and it translates into the awareness of other people within the virtual environment and the psychological connections with them [146]. In the particular context of e-learning, copresence has been found to be a facilitator through which participants experience total educational submersion in the learning process

[35,47] as well as an important construct in understanding the experiences of e-learners online [73].

Studies that have explored the role of the individual's imagery ability in presence have largely focussed on spatial presence experiences, and only Keng and Lin [69] have described the impact on copresence. Nevertheless, and bearing in mind that copresence shares spatial presence dimensions related to the suspension of disbelief with regard to incoming stimuli's authenticity and the individual's immersion in the virtual environment [91,101], it seems reasonable to posit that similar to spatial presence experiences imagery also mediates the development of copresence. In other words, it is plausible to consider that content and interface designs that contain social cues (for instance, self-presentations by other university community members) and online responses to individual's actions lead e-learners to evoke social realities for creating complete, vital learning communities.

Consistent with this, we suggest that the individual's interaction within the educative virtual arena can lead him or her to feel immersed in these alternative spatial and social worlds by imagery.

H2a. Imagery positively affects spatial presence.

H2b. Imagery positively affects copresence.

2.3. Flow experience

Flow experiences were first conceptualised by Csikszentmihalyi [26,28] to study optimal states in people's daily routines, including learning. In contrast to a predominant line of research on motivation at the time, which adopted a utility-centric perspective of people's motivations, Csikszentmihalyi defended the importance of flow experiences as the internal triggering forces of an individual's behaviour [27]. He understood flow as an extremely positive experience people have when they voluntarily push their mind to the limit in an effort to undertake a complex, challenging task. While doing so, people experience such joy that the task is a reward, in and of itself: they do not seek conventional rewards. They simply continue the task because they enjoy it [29]. Hoffman and colleagues [56,112] were among the first researchers to study flow experiences within virtual environments. They conceived flow as a psychological state that might occur when (a) the navigation provides a match between the individual's skills and the perceived challenges presented by the concrete online activity that he or she is undertaking, and (b) the individual is fully concentrating on that particular activity.

The concept of flow has important implications in research that aims to understand how e-learning environments influence individuals' behaviours. Flow is seen as directly associated with the intrinsic motivation of e-learners [40,55,128]. It emerges from achieving realistic goals and overcoming prescribed challenges [121]. In addition, it manifests itself in a sense of pleasure [40], a feeling that the activity at hand is worthwhile and interesting for its own sake. Moreover, the individual going into flow can be so completely focussed on the stimulus field that the e-learning realm has configured, that their conscious awareness of the activity might merge with a loss of self-consciousness, with their sense of time diminishing or sinking into nothingness [136,70].

An emerging research thread has started to develop around flow-subjective experiences in virtual education environments [55,68,131,21] that are based on previous conceptualisations. This group of studies conceives flow as a construct that mediates between the learner's exposure to the virtual environment and the e-learner's attitudes and behaviours. Besides, the flow and the experiences of presence are considered to be distinct (e.g., Refs. [88,60]). This is due to the fact that although the flow and presence concepts include the suppression of external distracters [175], in flow, the emphasis lies on the individual being engrossed in the concrete, challenging task he or she is undertaking online [121] rather than on the individual's immersion 'in' the virtual environment – which is characteristic of the (spatial and co-) presence feelings [183,174].

Again, interactivity can be influential in e-learning experiences – now facilitating users' flow states. This is in agreement with the studies by Cheng et al., Choi et al., Coursaris and Sung, Davis and Wong and Rha et al. [25,128,23,24,33,20], who observed a positive effect of interactivity on flow. This is because e-learning systems that are perceived as interactive tend to provide a greater perceived control and freedom, and are envisaged as more attractive and enjoyable [150]. This is also due to the timely and understandable feedback and the higher controllability of interactive systems, which help individuals to remain focussed on the task at hand [164]. Therefore, we hypothesise that when e-learning environments boost interactivity, they are more capable of eliciting flow:

H3. Perceived interactivity positively affects flow.

Narrative transportation delivers a theoretical foundation to embed imagery in the framework of flow. This occurs when imagery enhances the value proposition and presents itself to be enjoyable [63]. It is also because individuals under imagery conditions are compelled to use extensive mental resources [96]. This creates greater distance from their own knowledge structures, to the extent that they switch all their mental capacities to the activity they are undertaking in the 'other' (virtual) environment. Relative to this, Munroe et al. [107] have suggested the utility of imagery in sustaining concentration on the current task. However, although there is no evidence supporting the connection between imagery and flow in the particular context of e-learning, a handful of studies have reported a positive relationship in dance and sports training [78,110,64]. Based on these findings, we hypothesise:

H4. Imagery positively affects flow.

Presence experiences are frequently used as constructs in the few investigations dealing with flow's antecedents in e-learning (e.g., Refs. [88,60,33]). However, findings are mixed across these previous studies. Contrary to expectations, Davis and Wong [33] did not uncover support for the relationship between spatial presence and flow, whereas Faiola et al. [40] and Huang et al. [60] did observe a strong positive connection. Moreover, Joo et al. [67] and Leong [88] detected a significant effect of copresence on flow. Similarly, Franceschi et al. [46] reported the effective contribution of both spatial presence and copresence to flow.

Despite this, both spatial presence and copresence have the potential to facilitate flow experiences [101,181,108,54]. This is due to the fact that (spatial and co-) presence experiences clearly transport e-learners to alternative domains, where they can feel in tune with the initiatives and social actors available [91,72,113] and be more likely to feel absorbed in the activities therein. Spatial presence and copresence bring a suspension of disbelief in the virtual realm and make the e-learner forget their immediate surroundings, such that e-learners might attach their mental capacities to the cues and activities coming from the virtual environment [13,49,125]. We thus propose the following hypotheses:

H5a. Spatial presence positively affects flow.

H5b. Copresence positively affects flow.

2.4. Effects on e-learner's responses

Flow experiences are often depicted as a state of optimal pleasure that occurs when people are completely involved in an activity [59,80,19]. Because flow brings pleasure to the activity itself, it can intrinsically motivate individuals online to feel more attracted to, or to develop affective attitudes towards, the virtual environment [164,149,58]. In comparison with other relevant subjective experiences online (i.e., imagery, spatial presence and copresence), which contribute to the formation of flow, flow experiences play a more significant role. This is because flow might be the closest definition of the quintessence of a positive experience in a personal sense [81], or a 'cognitively pleasant state' [149].

Following the rationale of the theories of reasoned action [2,44] and planned behaviour [1], we further consider the links between positive attitude, favourable behavioural intention and actual behaviour. Therefore, we will presume that attitude constitutes an affective response that promotes an e-learner's intention to continue using e-learning, which in turn influences his or her actual continuance behaviour.

There is some, although not much, evidence regarding the role of flow in predicting an e-learner's affective and intentional responses. It has been found that flow facilitates the formation of affective attitudes within the particular context of e-learning [68,131,67,158,84], and that these attitudes promote an e-learner's behavioural intention to continue e-learning [68,131,67,158,84]. However, and despite the predominant point of view that states intentions are good predictors of actual behaviour [2], there is no previous evidence to validate the causal connection between stated intention to continue e-learning with actual continuance. Besides, the empirical testing of this relationship raises a challenging question regarding the measurement of an individual's behaviour. It has been noted that self-reported answers to stated intention questions do not necessarily correlate with actual usage behaviour [32,6]. This is because intention is captured through scales of positively worded statements [180,5]. These scaled items can produce a halo effect that encourages respondents to over-report behaviour in which they might not actually engage. This can also lead to an inflated level of reported continuance behaviour that is inconsistent with actual behaviour. In order to avoid these issues and understand the continuance intention–behaviour link, we will objectively assess continuance behaviour. For this purpose, we will consider real data that correspond to the period immediately after the decision-making process [165]. This will allow us to examine the effective impact of continuance intention on the immediate post-decision stage.

H6. Flow positively affects attitude towards the e-learning environment.

H7. Attitude positively affects behavioural intention.

H8. Behavioural intention positively affects actual continuance.

The potential influence on behavioural intention of other factors that are different from attitude has been indicated by previous studies into the acceptance of new media products. When the attitude–intention–behaviour linkages for instant messaging acceptance were tested, Lu et al. [92] reported an explained variance of behavioural attitude of 60% and claimed that other variables should intervene. In concordance with this, Lee et al. [87] found that copresence is a significant predictor of behavioural intention for virtual simulator usage. Similarly, Joo et al. [67] confirmed a significant effect of copresence (operationalised as instructor's presence) on e-learning persistence intention.

A plausible explanation for copresence directly triggering behavioural intention (while also influencing the individual's behaviour mediated by flow and attitude) stems from Fishbein's model [2,44]. In contrast to flow, imagery and spatial presence – which can be seen largely as subjective feelings generated by certain properties of, or stimuli from, the online environment – copresence could represent not only a sense triggered by attributes of the virtual environment but also the 'power' perceived in other people being online. Moreover, on the basis of Fishbein's rationale, this latter type of component might directly influence the user's behaviour. Another alternative explanation could be that the user's behaviour may result not only from attitude evaluation, but also from feelings of a hedonic nature [57] such as copresence [74,31] which might urge the user to adopt certain behaviours. Consequently, the learners who feel they are not alone and are part of a humanised educative environment see the value in attaining their desired goals and are more prone to continue using e-learning [66,148]. In line with this, we suggest the following hypothesis:

H9. Copresence positively affects behavioural intention.

3. Method

3.1. Data collection

The data used in this study were collected from two sources. The first is an online survey sent to students of an open, distance university within the European Higher Education Area. We correlated the data gathered in the survey with the actual data from our second source namely the registrar's office at the same university. Registrar data refer to the educational programmes and courses in which every student was enrolled within the university for the next academic term. The online survey was e-mailed from the university's registrar and included the unique numeric key for each of the university's students. We used this number to match the data collected through the survey against the registered data from the students' enrolment. The combination of the two data sets produced a sample of 2530 valid observations. This sample size was smaller than the number of online questionnaires that had been filled in, as we eliminated 1332 questionnaires that were only partially finished.

The sample comprised students enrolled in the university during the survey. The university follows a purely online educational model; hence, in order to undertake their learning processes, students are required to access a specific virtual education environment and use it regularly and consistently through a variety of online educational resources, all embedded in that particular environment. It is worth noting that in applying the principles of the Bologna Process, universities operating within the European Higher Education Area implement transparent and comparable degree structures (including the European Credit Transfer System) and work to facilitate the recognition of degrees and courses among them. This minimises the 'switch cost' for students when changing from a purely online university, equipped with a particular virtual education environment, to other higher education institutions implementing alternative learning systems (online-based, blended or traditional). Therefore, it is improbable that students are 'captive' at a specific purely online university or prone to continue in that particular education environment merely because it is expensive or laborious to change to a better, alternative learning system.

51.86% of respondents were women, and their average age was 36. They came from 35 undergraduate and post-graduate university programmes in a wide range of academic disciplines (including Economics and Business Sciences, Law and Political

Science, Psychology and Educational Sciences, Arts and Humanities, IT and Telecommunications Sciences, Health Sciences, and Information and Communication Sciences). Before entering the university, 5.97% of students had previously studied at another distance university, 82.66% at a conventional face-to-face university and 0.96% at a university with a blended learning system. Following the term in which they participated in the survey, 70.1% of them effectively continued studying at the university.

Data were collected according to the code of ethics as well as the university's code of practice for research and innovation. The sample was obtained through the students' voluntary participation in the survey; hence, the existence of self-selection bias was examined. Difference of mean tests on the three classification variables considered (gender, age and degree programme studied) indicated that the participant's profile did not differ significantly from that of the general profile of the university. Therefore, non-response bias is unlikely.

3.2. Measurement

Except for e-learning continuance, all variables of our model were included in a questionnaire. The scale items were selected from the existing appropriate literature on interactivity, imagery, flow and presence. Moreover, the items were adapted to fit with the specific e-learning system at the university where data had been collected. The items were also translated into the main native languages used by the students. Apart from F2, each item was scored on a seven-point Likert scale, with 1 denoting 'strongly disagree' and 7 'strongly agree'. Answers to F2 were measured on a seven-point scale ranging from 'never' to 'very frequently'.

The measure of interactivity consisted of five items in total: three customised items from the scale proposed by Novak et al. [112]; one from Richard and Chandra [129]; and one from Wu and Chang [179]. E-learners' imagery processes were captured by adapting three items from the study by Walters et al. [167], who in turn developed them from Phillips et al. [124]. Then, five items were included from the study by Novak et al. [112], for investigating spatial presence, as well as three to measure flow. The copresence scale included four items: three from Kim's scale of copresence in distance higher education [71] and one from Arbaugh and Hwang's teaching presence scale [4]. The attitude measure was derived from Taylor and Todd's scale [159]. In order to study behavioural intention to continue e-learning, two items were adapted from Lee et al. [85] and Roca et al. [131], who originally elaborated them based on Bhattacherjee [8] and Davis [32].

E-learning continuance was captured using a dichotomous registrar variable, with values of 0 (if the student did not enrol in any subject at the university in the next period) and 1 (if they effectively enrolled in at least one course at the university).

4. Results

We used structural equation modelling (SEM) methodology to test the model. Firstly, we tested the reliability and the validity of the measures obtained from the data in the survey with the objective of consistently building the latent variables in the model. Secondly, we estimated the model through the maximum likelihood approach to check the causal relationships stated in the hypotheses.

4.1. Measurement model

We used Cronbach's α and item-to-total correlations to explore the internal reliability of the scales employed to measure constructs in the model (see Table 1). The Cronbach's α values

Table 1
Results for internal reliability, convergent validity and discriminant validity.

Construct	Variable	Cronbach's α	Item-to-total correlation	Factor loading	CR[a]	AVE[b]	MSV[c]	ASV[d]
Interactivity	IA1	0.726	0.487	0.693	0.728	0.350	0.303	0.212
	IA2		0.560	0.754				
	IA3		0.508	0.714				
	IA4		0.422	0.627				
	IA5		0.461	0.664				
Imagery	IMG1	0.877	0.708	0.864	0.881	0.713	0.373	0.227
	IMG2		0.806	0.902				
	IMG3		0.777	0.856				
Spatial presence	SP1	0.811	0.588	0.744	0.812	0.464	0.432	0.183
	SP2		0.630	0.783				
	SP3		0.591	0.745				
	SP4		0.608	0.762				
	SP5		0.588	0.749				
Copresence	CP1	0.881	0.777	0.880	0.883	0.653	0.306	0.174
	CP2		0.700	0.829				
	CP3		0.722	0.845				
	CP4		0.775	0.881				
Flow	F1	0.870	0.729	0.879	0.878	0.707	0.432	0.199
	F2		0.816	0.924				
	F3		0.726	0.879				
Attitude	AU1	0.936	0.876	0.937	0.939	0.794	0.306	0.200
	AU2		0.888	0.943				
	AU3		0.786	0.875				
	AU4		0.864	0.924				
Behavioural intention	BI1	0.953	0.911	0.978	0.954	0.912	0.194	0.082
	BI2		0.911	0.978				

[a] Composite reliability.
[b] Average variance extracted.
[c] Maximum shared squared variance.
[d] Average squared variance.

for scales are all above the required level of 0.70. Similarly, we obtained good results for the item-to-total correlation, as almost all values are >0.60. Values for the items associated with *interactivity* and *spatial presence*, however, did not reach the required lower threshold. Nevertheless, considering the two good Cronbach's α values (of 0.73 and 0.81, respectively), we deemed both scales as internally consistent.

In order to assess convergent validity, we considered factor loading, composite reliability (CR) and the average variance extracted (AVE) measure. As shown in Table 1, all factor loadings exceeded the recommended value of 0.60. By performing a confirmatory factor analysis for the constructs of the model, we obtained the composite reliability and the AVE. The CR is greater than the recommended value of 0.70 in all cases. Concerning the AVE, all values are greater than the recommended lower threshold of 0.50 except for *interactivity* and *spatial presence*. Nevertheless, every case satisfies the condition that CR is greater than AVE, which in turn is another desired condition concerning convergent validity [53]. In light of these results, we accept that convergent validity is also accomplished in these two cases.

Discriminant validity has been tested by comparing the maximum shared squared variance (MSV) and the average shared squared variance (ASV) of a construct (with respect to all the other constructs) with the corresponding AVE. In all cases, AVE is clearly greater than MSV and ASV (see again Table 1). Hence, we acknowledge that the measures of the constructs examined are robust in terms of their discriminant validity.

4.2. Structural model

Upon assessing the reliability and the validity of the research instruments, we tested the overall fit of our model (a summary of the fit indices is shown in Table 2). The χ^2 test indicated that we had to reject the null hypothesis, that is, the reduced model does not fit the data well when compared to the full (saturated) model ($p = 0.00$). Nevertheless, we considered that if the sample is sufficiently large, even the fit of a well-fitting reduced model will be significantly different from that of the full model. This is because the chi-squared statistic is sensitive to sample size, which means that the test nearly always rejects the model when large samples are used [7]. With our sample size being 2530, it was evident that this exceeded the minimum recommended sample size of 100. When the χ^2/d.f. fit index is considered, the same negative effect is produced: the value is greater than the desired upper threshold of 5.00. Therefore, we shifted our focus to other fit indexes.

The goodness-of-fit index (GFI) surpasses the recommended value of 0.80 for an acceptable fit, thus demonstrating a good fit. We found that 90.6% of the variance in the sample variance–covariance matrix was accounted for by the model. We also obtained good results while adjusting GFI to the number of parameters in the model (AGFI), with the value being >0.80. Regarding GFI adjusted by the number of paths in the model (i.e., parsimonious GFI, or PGFI), PGFI was observed to be above the recommended level of 0.50 [106]. Moreover, the standardised root mean square residual (the standardised square root of the difference between the residuals of the sample covariance matrix and the hypothesised covariance model) was lower than the acceptable upper threshold of 0.08. Moreover, the root mean square error of approximation, which explains how well the model would fit the population covariance matrix, showed a good fit value, that is, less than the recommended value of 0.08 [95].

The normed fit index is greater than the minimum required value of 0.90, indicating a good fit of the model compared to the null model. Similar indices such as the Tucker–Lewis index and the comparative fit index yielded values greater than the suggested lower threshold of 0.90. Besides, the parsimonious normed fit index and the parsimonious comparative fit index were both >0.50 and approximately 1.00, thus indicating a good fit of the model [106].

We thus conclude that GFIs for the structural model are acceptable. This implies that we can proceed with the analysis of the estimation of the parameters and its implications for the hypotheses presented. Table 3 shows the hypothesised relationships between constructs, the values of the regression weights between them, and their significance in the structural model. All estimated coefficients are positive and significantly different from zero, for a level of significance equal to 0.05. These results indicate that the proposed causal links are statistically different from zero, and the hypothesised relationships are all supported (see Fig. 2). *Interactivity* has a significant and positive effect on *imagery* ($\beta = 0.77$, $p = 0.00$); and *imagery*, in turn, has a direct effect on *spatial presence* ($\beta = 0.53$, $p = 0.00$) and *copresence* ($\beta = 0.39$, $p = 0.00$). In addition, *interactivity* positively influences *flow* ($\beta = 0.27$, $p = 0.00$). *Flow* is influenced by *imagery* ($\beta = 0.15$, $p = 0.00$), *spatial presence* ($\beta = 0.65$, $p = 0.00$) and *copresence* ($\beta = 0.09$, $p = 0.00$), all elements that are consistent with our hypotheses. Moreover, *flow* has a significant and positive impact on *attitude* ($\beta = 0.27$, $p = 0.00$), which in turn reinforces *behavioural intention* ($\beta = 0.44$, $p = 0.00$); and *behavioural intention* triggers *actual continuance* ($\beta = 0.05$, $p = 0.00$). Finally, *copresence* has a direct impact on *behavioural intention* ($\beta = 0.12$, $p = 0.00$).

Table 2
Fit indexes for the model.

Fit index	Value	Recommended cut-off values
Absolute fit measures		
χ^2	3487.454	The lower the better
d.f.[a]	314	
p-value	0.000	>0.050
χ^2/d.f.	11.107	<5.000
GFI[b]	0.906	>0.800
SRMR[c]	0.075	<0.080
RMSEA[d]	0.063	<0.080
AGFI[e]	0.886	>0.800
Incremental fit measures		
TLI[f]	0.913	>0.900
NFI[g]	0.915	>0.900
CFI[h]	0.922	>0.900
Parsimonious fit measures		
PGFI[i]	0.752	>0.500
PNFI[j]	0.818	>0.500
PCFI[k]	0.825	>0.500

[a] Degrees of freedom.
[b] Goodness-of-fit index.
[c] Standardised root mean square residual.
[d] Root mean square error of approximation.
[e] Adjusted goodness-of-fit index.
[f] Tucker–Lewis index.
[g] Normed fit index.
[h] Comparative fit index.
[i] Parsimonious goodness-of-fit index.
[j] Parsimonious normed fit index.
[k] Parsimonious comparative fit index.

4.3. Common method variance

We undertook Harman's single-factor test to validate the absence of common method bias due to data collection through a self-reporting questionnaire. From the factorial analysis with all items in the model, we obtained seven components with eigenvalues >1. The percentage of variance explained for the first component is 33.21%, with the aggregate variance explained being 71.48%. As the majority of the variance cannot be explained by a

Table 3
Hypotheses and model path coefficients.

	Hypotheses			β[a]	SE[b]	CV[c]	p
H1	Interactivity	→	Imagery	0.772	0.040	19.385	0.000
H2a	Imagery	→	Spatial presence	0.538	0.022	24.639	0.000
H2b	Imagery	→	Copresence	0.395	0.020	19.938	0.000
H3	Interactivity	→	Flow	0.270	0.040	6.663	0.000
H4	Imagery	→	Flow	0.153	0.035	4.381	0.000
H5a	Spatial presence	→	Flow	0.657	0.037	17.562	0.000
H5b	Copresence	→	Flow	0.095	0.025	3.829	0.000
H6	Flow	→	Attitude	0.271	0.014	18.892	0.000
H7	Attitude	→	Behavioural intention	0.443	0.023	18.990	0.000
H8	Behavioural intention	→	Actual continuance	0.057	0.008	7.445	0.000
H9	Copresence	→	Behavioural intention	0.120	0.020	6.131	0.000

[a] Estimates.
[b] Standard error of the regression weight.
[c] Critical ratio value for regression weight.

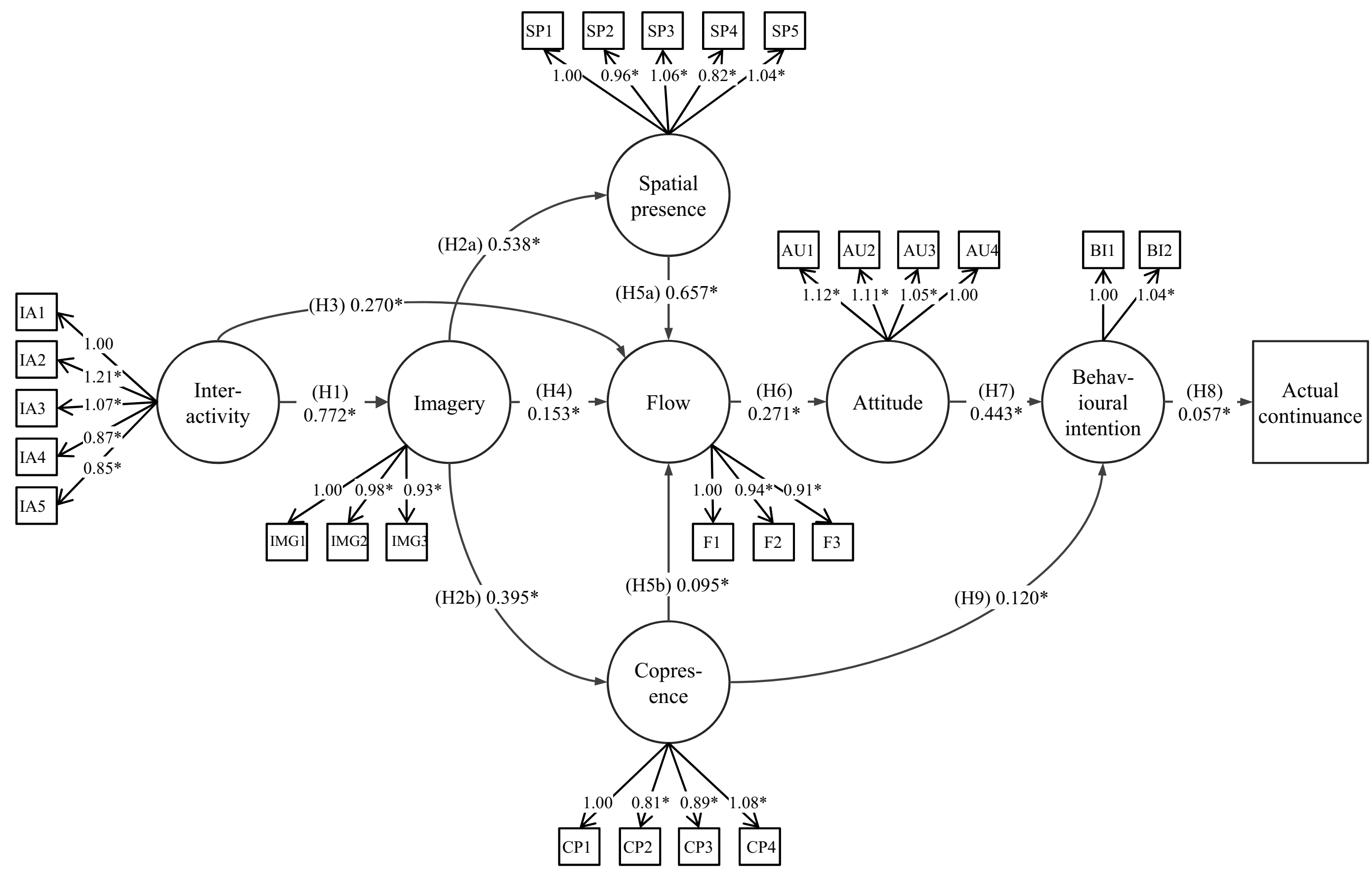

Fig. 2. Structure model diagram with estimations of parameters ($^{*}p < 0.01$).

single factor, we understand that there is no evidence to suggest that the common method bias affects the interpretation of the results. Furthermore, e-learners' continuance behaviour is measured objectively and in a different period of time, which allows us to discard a systematic response bias for this particular variable.

5. Concluding discussion

Lee et al. [86] called for research into the effects of interactivity in virtual education environments; in this respect, our paper strives to provide a better understanding of e-learning interactivity and its behavioural consequences on continuing to e-learn. With that aim in mind, we examine the underlying mechanisms that could explain the effects of e-learning interactivity. Grounded in the theories of imagery, presence research and flow theory, we define a conceptual model that considers imagery processes, experiences of spatial presence and copresence and flow states as the mediators of the impact of e-learning interactivity on continuance behaviour. The results confirm all the expected mediating effects and strongly support the model proposed.

5.1. Contributions to research on information systems

The insights garnered from this research represent a milestone on the path to understanding how interactivity works, and they do so in four ways. First, the paper defines and validates a mediated model that has not been found in the information system (IS) literature to date. To the best of the authors' knowledge, this is the most comprehensive model that explains the impact of interactivity (e.g., Refs. [164,104,43]), as it combines explanations about how imagery, spatial presence feelings, copresence and flow mediate the effects of interactivity, as well as how all these underlying mechanisms interact.

Secondly, this paper provides a missing link in the existing IS knowledge, as the study of the mediating role of quasi-perceptual experiences in elaborating information online and their links with other subjective experience is often neglected. Recently, Rodríguez-Ardura and Martínez-López [132] proposed an explicit connection between imagery and spatial presence in new media. This research goes a step further by suggesting that mental imagery facilitates the formation of both presence and flow experiences, and presenting the first findings on these connections. This suggests that the elaboration of interactive content triggers inner processes through which learners produce collections of representations that are related to imagery forms. Findings indeed give credence to differentiate the illusion mechanisms that generate experiences of immersion (i.e., imagery) from the immersion experiences themselves. Moreover, the acknowledgement of spatial presence and copresence feelings resulting from mental imagery lets us hone in on the inner facet of these phenomena, rather than focus on the perceptual and external view of presence experiences. Interestingly, imagery does not always seem to be an antecedent of flow. As a consequence, the users might be completely involved in their online activities, bound by the virtual environment, even if they do not 'visualise' the virtual domain as a spatial or social reality.

Third, this paper offers novel insights into the outcomes of interactivity. While past IS research on interactivity was largely based on experiments (e.g., Refs. [45,102]), which have very limited external validity, we match a direct measure of actual behaviour with answers to an online survey. This also avoids the risks of overestimating actual behaviour or making claims about the impact of interactivity on behaviour inconclusive. Besides, in contrast to most empirical studies in the particular domain of e-learning, the results are not connected to a particular educational programme or the subject taught. Rather, they are obtained from a large sample of university students across a range of undergraduate and graduate programmes and subjects.

Fourth, this study emphasises the fact that experiencing spatial presence, copresence and flow has crucial consequences on an individual's behaviour. Previous IS studies primarily focussed on presence and flow experiences and their consequences for intentional responses (e.g., Refs. [3,133]). However, we have now shown that presence and flow effectively influence the individuals' continuance behaviour.

5.2. Limitations and future research

This study has two major limitations. The first limitation is the focus on the inner processes of imagery, presence and flow; hence, other relevant elements may have been ignored. Although actual continuance behaviour has been well clarified by the determinants included in our analysis (90.6% of variance in the sample is accounted for by the model), other relevant predictors can still be considered. The second limitation stems from having collected data from a single, purely online educative environment. Therefore, there are limitations to the generalised application of the findings to other e-learning environments. As a result, further investigation is suggested to test the proposed model on other independent educative environments (purely online and blended) and ensure cross-sample validation.

Another interesting area for future research would be the investigation of factors that potentially moderate the relationship between interactivity and e-learners' imagery processes such as the familiarity with the digital resources being used and the learner's processing style. Furthermore, researchers might wish to consider affective valence responses as potential criterion variables.

5.3. Practical implications

Our study offers scholars and higher education institutions useful insights into helping e-learners pursue their education activities online. It suggests that higher levels of e-learning interactivity are desirable, as they strongly prompt learners' inner imagery and positive subjective experiences (spatial presence, copresence and flow). These experiences also unleash outcomes of paramount importance for e-learning institutions: favourable attitudes towards the e-learning virtual environment, positive intentions to continue e-learning in the future and effective continuation in the e-learning environment. The first implication from these findings is that interactivity is valuable in e-learning. Hence, it is advisable for lecturers and practitioners involved in the design of e-learning–teaching processes to ensure that didactic strategies and initiatives are offered with exceptional levels of interactivity from the e-learner's standpoint. By providing didactic content, educative resources and communication systems that are flexible and customisable and allow e-learners to manage their communications with peers and faculty, educational institutions can enhance the e-learners' sense of interactivity in the education environment. This in turn increases their willingness to continue with e-learning.

A second implication stems from experiential benefits that are derived from interaction. An interactive setting lets e-learners immerse themselves in these experiences, thus supporting positive attitudes and behaviours. These experiential benefits include the e-learner's feelings of 'being placed' in and 'being part' of a true educational realm, as well as giving them full engagement in their learning tasks. The experiences considered – influential as they are – play different roles in the e-learner's outcomes. Spatial presence has a considerable impact (even greater than that of copresence) on flow states. Flow, however, unambiguously determines the formation of positive attitudes. This suggests the importance of feeling the vibe and bliss of learning. By managing the interactions within the e-learning environment, lecturers and practitioners should be able to draw the learners' interest to learning and provide them with interactive elements that will engage them in e-learning tasks. Regardless of the e-learner's attitude to the education environment, if the e-learner feels part of a university community that thrives in a mediated environment instead of reality, they will be more willing to continue e-learning. This suggests that lecturers and practitioners should implement activities that generate social cues online, facilitate relationships and ensure that e-learners feel they are active members of a university community.

Acknowledgements

The authors gratefully acknowledge the support of the Open University of Catalonia (*Universitat Oberta de Catalunya*) in gathering the data used in the study.

Appendix. Measures

Construct	Source	Items
Interactivity	[112,129,179]	(IA1) When I use the campus, there is very little waiting time between my actions and the computer's response (IA2) Interacting with the campus is slow and tedious (R[a]) (IA3) Pages on the campus usually load quickly (IA4) The range of what can be manipulated on the campus is narrow (R) (IA5) On the campus, I can easily obtain the detailed information that I want
Imagery	[167]	(IMG1) The campus makes me fantasise (IMG2) When I use the campus, I feel unimaginative (R) (IMG3) When I use the campus, I feel creative
Spatial presence	[112]	(SP1) I forget about my immediate surroundings when I use the campus (SP2) Using the campus makes me forget where I am (SP3) After using the campus, I feel like I come back to the 'real world' after a journey (SP4) When I use the campus, I feel I am in a world created by the technology (SP5) When I use 'the campus', the world generated by the technology is more real for me than the 'real world'
Copresence	[71,4]	When I use the campus: (CP1) I enjoy engaging in the exchange of ideas with other students (CP2) I feel I am part of a learning community (CP3) I enjoy sharing (with other participants) what I learn (CP4) I engage in productive dialogue with instructors
Flow	[112]	(F1) I have (at some time) experienced 'flow' on the campus (F2) In general, how frequently would you say you have experienced flow when you use the campus? (F3) Most of the time when I use the campus I feel that I am in flow
Attitude	[159]	(AU1) Using the campus is a good idea (AU2) Using the campus is a wise idea (AU3) I like the idea of using the campus (AU4) Using the campus is pleasant
Behavioural intention	[131,85]	(BI1) I am going to regularly use the campus next semester (BI2) I am going to use the campus next semester for learning purposes

[a] Reversed.

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