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Flow in e-learning: What drives it and why it matters

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Abstract

This paper seeks to explain why some individuals sink further into states of flow than others, and what effects flow has in the context of a virtual education environment. Our findings—gathered from both questionnaire and behavioural data—reveal that flow states are elicited by the e-learners' senses of controlling the virtual education environment, their attention centred on the learning activity, and their feelings of physically being in such an environment. We bring evidence about three benefits from flow states: they facilitate e-learner's positive emotions, they enhance e-learners' academic performance, and they contribute to students' effective continuance in e-learning.

Introduction

Originally coined by best-selling author in the psychology of experience, Mihaly Csikszentmihalyi (Csikszentmihalyi, 1997), the term "flow" has been used to refer to those feelings people have when they plunge themselves (with great pleasure) into a high-demanding activity. The e-learning arena is not an exception when it comes to flow's relevance. This is because providing learning programmes that raise students' flow states is considered a key feature for academic success (OECD, 2007). But universities and public authorities involved in e-learning demand proof of how to achieve flow states and, even more importantly, what the precise effects of flow are.

Research on flow for the context of e-learning is exiguous, and the minuscule investigation into the effects of flow is scattered across diverse papers which have explored single, separate outcomes. With this in mind, the main objectives of this paper are:

- to empirically test a conceptual model on flow's drivers and the effects in e-learning;
- to provide evidence on the compound effects of flow in e-learning—which include individual's affective, performance-related, and behavioural responses.

Background and hypotheses

There is noticeable accord on the definition of flow where it is conceived as a subjective state under which individuals are fully engaged with, and immersed in a task (Engeser &

Practitioner Notes

What is already known about this topic

- Scholars and practitioners involved in e-learning initiatives are frequently willing to trust their intuitive sense that e-learning programmes, capable of driving students' interest and effort, lead to higher learning outcomes. But universities and public authorities involved in e-learning demand proof of how to achieve flow states and, even more importantly, what the precise effects of flow are.

What this paper adds

- The paper proposes and tests a coherent framework of antecedents and consequences of flow in e-learning.
- Flow states unleash a compound of positive consequences in e-learning, affective and behavioural.
- Continuance in e-learning is determined by flow through the mediating effects of positive emotions, and academic performance.

Implications for practice and/or policy

- Flow states are a source of value in e-learning: when individuals plunge themselves in e-learning activities, they get a 'buzz' from their achievements, a desire to dedicate their energy further, and to develop increasing skills. The positive emotions and higher performance facilitated by e-learning lead individuals to keep studying and live up to their individual potential.
- Key protagonists involved in e-learning should push for scenarios where flow can be experienced as part of their strategies to raise both academic performance and students' retention.
- To ensure that e-learners are given the appropriate cues that foster the desired episodes of flow, e-learning practitioners should base their strategies on their knowledge of the e-learners. Therefore, practitioners should be equipped with tools that enable them to develop personal profiles of the e-learners while providing them with information regarding: the fit of the e-learner's cognitive resources and the learning-task demands; the degree of control the e-learner exerts over the e-learning environment; the attention he or she pays to the e-learning activity; and his/her use of communication tools that allow interaction within the virtual community and the shaping of his/her own digital identity. On the basis of this information, e-learning practitioners should determine how the learning resources and activities, and the structure and layout of the virtual environment, can all be arranged to facilitate flow.

Schiepe-Tiska, 2012). When the activity performed has clear goals and provides feedback, individuals immerse themselves in the activity to such an extent that they undergo it even though no extrinsic rewards are on offer. Whether the person starts the activity on his or her own behalf, or they are initially triggered by an external stimulus (eg an assignment in a course), he or she becomes intrinsically motivated as the activity is being performed (Schüler, 2009). Csikszentmihalyi (1975a, 1975b) suggested that merging oneself with the activity and the loss of self-consciousness are the most tell-tale signs that flow is being experienced. Associated with this is the individual's feeling that the activity is going smoothly and is fun; and time flies, insofar as the individual undergoes a distortion of the temporal experience of time (Nakamura &

Csikszentmihalyi, 2009). As a whole, the elements mentioned above configure a "holistic" state of immersion in an on-going activity (Csikszentmihalyi, 1975a, p. 36).

Approaches to configure (and operationalise) the mix of subjective elements related to flow can be largely categorised as indirect and direct (Hoffman & Novak, 2009; Landhäußer & Keller, 2012). With the understanding that flow results from the integration of its central "predictors", some authors do not distinguish flow from its antecedents and operationalise it with indirect, derived measures (eg Faiola, Newlon, Pfaff, & Smyslova, 2013; Jackson & Eklund, 2002; Moneta & Csikszentmihalyi, 1996). Yet a careful look at these studies reveals one point that falls short, which lies in a variety of constructs chosen to measure flow (including skill-demand congruence, concentration, immersion…), and a diversity of combinations of these constructs. As a result, the constructs used to (indirectly) measure flow, and the way in which flow is operationalised, can substantially differ from one study to another.

Other researchers measure flow directly, mainly through the self-report instrument designed by Novak, Hoffman, & Yung (2000). The underlying rationale here is that the constructs related to flow are antecedents (or consequences) of flow. And although this approach raises question marks about the presumption that all antecedents under consideration are detachable from flow (Hoffman & Novak, 2009), structural equation modelling and experimental designs make it possible to test whether they actually are drivers of flow. Also, it allows comparisons across studies, since researchers will have operationalised flow in a similar way.

Bearing in mind the advantages of the direct approach, we adopt this perspective and include in our model a set of antecedents of flow (see Figure 1). We select three subjective experiences (ie challenge, control, focus attention) whose role as flow's central predictors has been emphasised (eg Ghani & Deshpande, 1994; Luna, Peracchio, & de Juan, 2002; Nakamura & Csikszentmihalyi, 2009). In addition to those, we consider another potential driver (ie presence) consistently used in the literature to examine an individual's experiences online (Weibel & Wissmath, 2011).

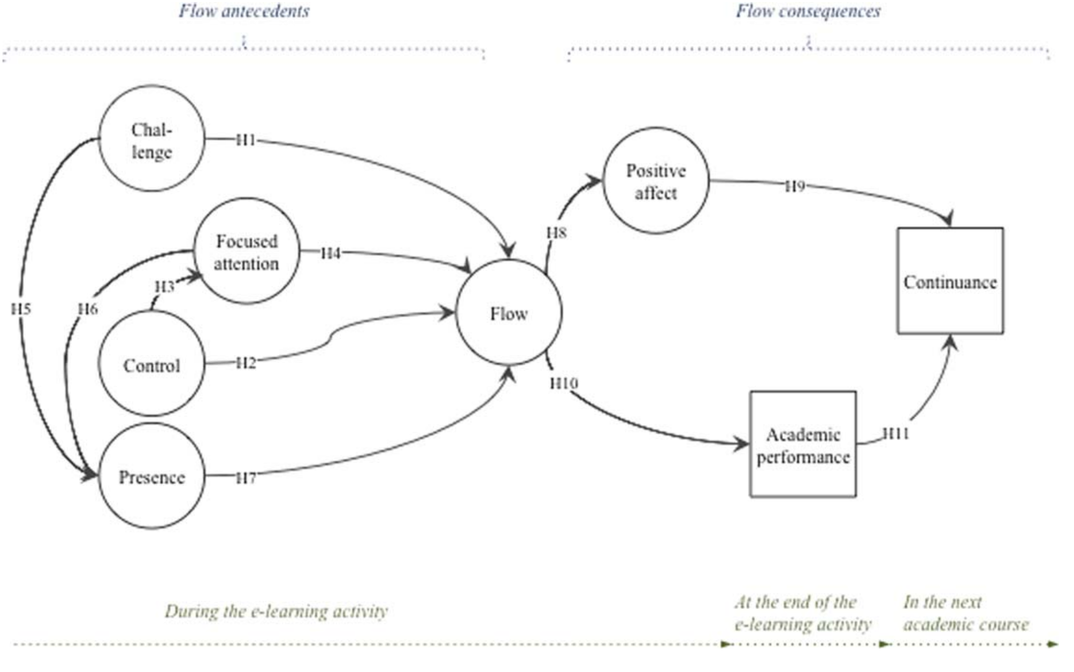

Figure 1: The conceptual model

Antecedents to episodes of flow

Flow theory essentially suggests that, when the individual engages in an activity that meets certain conditions (ie a learning initiative that has clear goals, and offers feedback), a combination of perceptual or psychological elements can emerge—such as, for example: a perception that the demands presented by the activity are in sync with one's skills, a feeling of control over the activity, and a sense of focusing attention on a limited field (Csikszentmihalyi, 1975a, 1975b). This compound of subjective elements leads the individual to go under the experiential states of flow, within which they feel holistically absorbed in the activity at hand. And, as a consequence of this, they feel genuinely and intrinsically motivated to pursue in such an activity (Csikszentmihalyi, 1975b; Landhäußer & Keller, 2012), which ultimately translates into affective and behavioural responses.

Common to the theoretical understandings of flow is the notion that the individual's perception of congruence between their skills, and the challenges that emerge in the activity, facilitates flow (eg Moneta & Csikszentmihalyi, 1996); and also that skills and challenges should surpass a certain threshold (Massimini & Carli, 1988) to trigger flow. However, from the perspective of motivational psychology, what the activity entails are "demands" rather than "challenges" (Engeser & Rheinberg, 2008); and challenge refers to the individual's subjective experience that emerge as a result of the congruence between their skills and the "demands" of the activity. On the basis of this we use the expression "challenge" to refer to this construct in our modelling.

A plausible explanation for the potential effect of challenge on flow has its roots in cognitive evaluation theory (Deci & Ryan, 1985): as long as individuals have a psychological need to feel competent, those activities that trigger positive challenge can conduce towards optimum experiences and intrinsic motivation—because they satisfy the individual's need for competence (Ghani, Supnick, & Rooney, 1991).

In the context of e-learning only one empirical study has examined the path from challenge to flow (Pavlas, 2010); and this study, focused on e-learning games, could not detect such causal path. However, this result must be interpreted with caution, as challenge was measured through gameplay data, so the indicator perhaps did not capture well whether the individuals actually perceived challenge. As stated previously, challenge refers to a subjective feeling that results from the interaction between the e-learner's skills with the e-learning environment's demands.

H1: Challenge has a positive impact on flow

The subjective experience of control is often referred to as a sense of competence or mastery over the person's environment (Baronas & Reis, 1988). In the field of educational psychology, control has been understood as a driver of the student's adaptation, and academic achievement: individuals who are feeling confident about their initiatives seem to be more willing to engage in intellectually high-demanding activities, develop resilient strategies, and remain focused on their learning activities (Skinner & Greene, 2008).

Although very scarce, there is empirical support documenting the association between control and e-learning flow (Liao, 2006). The explanation for this comes from locus of control literature and Rotter's social learning theory (Lefcourt, 1991; Rotter, 1966), which explain that the extent in which individuals experience personal control over their actions determines whether they act, willingly and successfully. Therefore, individuals who have a sense of full control over an activity "feel right" and intrinsically enjoy such activity (Keller & Blomann, 2008, p. 593).

H2: Control has a positive impact on flow

Focused attention is defined as a sustained and narrowed concentration on a subset of aspects of the current environment (Anderson, 2005); and it reflects in a kind of "tunnel-vision" (Landhäußer & Keller, 2012).

Ghani (1995) detected a control-focused attention connection in the use of e-learning artefacts. This study is in line with intrinsic motivation theories, which conceive control as a fundamental psychological need to be effective in the actions within the environment (White, 1959). This need to make things happen creates intrinsic impetus and provides direction to discover how the environment works. By so doing, control drives development of concentration capabilities that help to reach the desired goals.

H3: Control has a positive impact on focused attention

Previous research has revealed that there might be a reliable positive relationship between focused attention on the e-learning activity with flow (Kiili, 2005). The rationale for this connection has its roots in the notion of flow: when attention is strong, the individual becomes so completely invested in the activity that there is very little left to devote towards other mental processes outside of the fully-immersive activity itself (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2005).

H4: Focused attention has a positive impact on flow

A critical success factor of an e-learning environment is its ability to enable the students to be part of an actual education realm (Li & Akins, 2004; Welsh, Wanberg, Brown, & Simmering, 2003). This makes presence a critical component of an e-learner's experiences. In fact, the feeling of presence is recognised as an important driver of human behaviour online (Kim & Biocca, 1997; Lessiter, Freeman, Keogh, & Davidoff, 2001; Whitbred, Skalski, Bracken, & Lieberman, 2010), also in the specific interaction with e-learning artefacts (Cui, Lockee, & Meng, 2012; Joo, Lim, & Kim, 2011).

Presence has been described as the subjective illusion through which the non-factual or computer-based facet of the experience with the digital medium is not noticed (Lombard & Ditton, 1997; Rodríguez-Ardura & Martínez-López, 2014). This all-encompassing concept of presence, which refers to an individual's sense of being transported inside a true environment (depicted by the technology), has been used by the community of inquiry framework (Garrison, Anderson, & Archer, 1999; Garrison & Arbaugh, 2007) to theorise the e-learning process. A number of studies suggest that presence is generated by the spatial and social cues sent out by the digital medium (H.-G. Lee, Chung, & Lee, 2012; Nowak & Biocca, 2003; Schroeder, 2006). This results in a compelling feeling of being physically placed in the virtual or imaginary environment evoked by the medium, often in the company of "others"—intelligent entities—either real or fictional. Therefore, in this study, presence will be considered as the extent to which an individual using an e-learning environment feels that he/she is inside a "real" learning environment.

From a cognitive view, the major reasons why presence feelings happen are that: individuals naturally create a mental model of the environment portrayed by an IS artefact; and they accept this mental model as their reference frame (Wirth *et al.*, 2007). When this happens, individuals process the spatial and social cues from the simulated environment as if they were real, so they do not perceive their computer-based nature (K. M. Lee, 2004).

The spatial and social cues people perceive about what is happening in a virtual environment, such as large or dynamic images or sounds (K. M. Lee, 2004), are likely to be primitive cues that are also relevant when judging physical environments (Steuer, 1992). And these cues are more likely to yield alerts or demands, that challenge an individual's skills (Sas, O'Hare, & Reilly, 2004). Experimental studies by Jin (2011) with a medical simulator and a driving game have provided early evidence about this potential link, which though has not yet been explored in any other online context.

H5: Challenge has a positive impact on presence

Focused attention can be considered as a driver of presence (Schubert, 2009). This is because, to build a spatial situation model about a virtual environment, the individual should have previously allocated enough attentional resources to meaningful stimuli coming from that environment (Wirth *et al*., 2007).

Franceschi, Lee, Zanakis, & Hinds (2009) detected the influence on presence of focused attention, which they operationalised as engagement; and Jungjoo Kim, Kwon, & Cho, (2011), and JungJoo Kim (2011) found evidence about the positive effect of mutual attention in a social dimension of presence. Operationally, and following Wirth *et al*.'s (2007) cognitive framework, we could say that focused attention shifts the individual's attention onto the e-learning environment. When so doing, focused attention helps the individual to process increasing digital cues, which allows them to confirm the adequacy of the virtual environment as their reference frame.

H6: Focused attention has a positive impact on presence

The constructs of flow and presence share similarities. In the context of an individual's experiences occurring in IS usage, both involve episodes of complete immersion that capture the individual's attention, and each acts as an intermediate variable between the use of a virtual environment and the individual's attitude and behaviour (Weibel & Wissmath, 2011). However, there is a remarkable conceptual difference between them: while presence relates to a spatial immersion into an alternative environment, online flow can be rather described as the immersion in a digital activity (Weibel & Wissmath, 2011). Furthermore, as noted by Fontaine (1992), flow is connected to a perception of control while presence is not.

The relationship between presence and flow can also be relevant to an individual's experiences in a virtual environment (Faiola *et al.*, 2013; Rodríguez-Ardura & Meseguer-Artola, 2016). This is because presence prompts the disappearance of "awareness of one's surroundings" (Pace, 2004, p. 358)—and the feeling of entrance into an alternative environment instead. We therefore hypothesize that presence transports individuals into an alternative reality where they are more likely to become absorbed in learning activities and experience flow.

H7: Presence has a positive impact on flow

Consequences of flow

According to flow theory, flow is a pleasant and rewarding experience, which potentially makes us happier. But this positive valence can be seen as a consequence of flow, and not as flow itself (Engeser & Schiepe-Tiska, 2012). This is because, when the person is in flow their mental efforts are so centred on the activity at hand that there is no room for emotions. So positive emotional tones would prevent flow as they distract the individual's attention from the current task—which requires many mental resources—(Landhäußer & Keller, 2012). This leads to the idea that affect is a consequence (rather than a component) of flow.

Although fairly scarce, research in conventional university settings has observed a connection of flow with positive affect (Asakawa, 2010; Schüler, 2007). In e-learning research, findings have also yielded evidence that positive affect is raised by e-learning games (Chiang, Lin, Cheng, & Liu, 2011), and virtual environments (Davis & Wong, 2007), which gives rise to the notion that e-learning flow might precede positive affect.

H8: Flow has a positive impact on positive affect

Mediated by positive affect, states of flow might lead students to be likely to bond with the institution that is bringing e-learning services to them. Consistent with this, Joo, Joung, & Kim (2014) have found that, via affect, states of flow indirectly influence the intention to continue with e-learning.

Flow is a self-motivating state, and insofar as flow causes positive affect, individuals desire to reach flow again and again. As individuals create affective evaluations of the online activities that generate flow, these evaluations lead to behaviour in respect of these online activities (Zhang, 2013). This is because individuals tend to pursue pleasure, so they attempt to "perpetuate it when it occurs" (Russell, 2003, p. 156).

H9: Positive affect has a positive impact on continuance

Interestingly, a look at the e-learning literature reveals mixed findings with regard to academic performance as potentially beneficial outcome of flow. On the one hand, Rossin, Ro, Klein, & Guo (2009), in a small research sample, found support for the flow effect in self-reported learning, but did not observe a similar positive influence of flow on real academic performance. And contrary to expectations, Joo, Lim, & Kim (2012), Konradt, Filip, & Hoffmann (2003), and Konradt & Sulz (2001) did not detect any association between e-learning flow and students' academic achievement. On the other hand, Kiili's (2005) study on a small sample detected a significant correlation between flow and academic achievement. Likewise, Choi, Kim, & Kim (2007), Esteban-Millat, Martínez-López, Huertas-García, Meseguer, & Rodríguez-Ardura (2014), and Ho & Kuo (2010) observed a positive effect of flow on performance, this time measured through a subjective assessment by the respondent.

Since studies that documented the flow-learning link employed an insufficient sample size or self-reported measures of learning, it could be argued that flow boosts self-reported learning but does not trigger objective academic performance. Alternatively, it could be suggested that self-reported learning does not properly capture the outcome of the e-learning process, either because self-reported learning is concerned with the standard the e-learner feels they have reached but not with the likelihood that they have actually achieved a learning goal—which might go beyond the individual's control and depends on external factors; or because a common method variance (CMV) might exist when academic performance is operationalised through subjective measures. The CMV explanation (MacKenzie & Podsakoff, 2012) is based on the individual's tendency to maintain consistency between their beliefs and their behaviour, and their need to show socially acceptable behaviour, as well as on the fact that all the studies that used self-reported measures of e-learning measured both flow and e-learning at the same time point. As a result, respondents might over-report their learning progress—which is a desirable outcome. Consequently, it can be claimed that flow is related to subjective learning but does not necessarily cause it, or that spurious correlations between flow and e-learning were formed.

Nevertheless, a number of papers for conventional settings—that have not employed cross-sectional approaches—have established that flow: is related to better marks, and boosts academic performance (eg Engeser & Rheinberg, 2008; Schüler, 2007). The thoughts behind the flow-academic performance connection are threefold. First, flow is a highly functional state, so it leads individuals to operate at maximum capacity (Csikszentmihalyi *et al.*, 2005); and this brings about an enhancement in an individuals' performance (Engeser & Rheinberg, 2008). Secondly, because it entails full immersion in the activity, flow can transfer to situations that happen after the flow episode (Landhäußer & Keller, 2012). So flow states (insofar as they involve a high concentration on an e-learning activity) might boost the individual's general ability to concentrate. Thirdly, flow provides the incentives for personal growth (Engeser & Rheinberg, 2008). It fosters engagement in high-demanding e-learning activities. In order to maintain flow, the students have to raise their standards as their skills progress. Flow can be understood as a motivating force in and of itself. As flow episodes are perceived as rewarding, individuals might pursue repeat flow experiences. So to keep performing at a level that unleashes flow experiences, individuals should undertake e-learning activities with greater degrees of complexity. Therefore, a growth principle might be an implication of flow states (Csikszentmihalyi *et al.*, 2005).

H10: Flow has a positive impact on academic performance

Academic performance might also contribute to learners' continuance. For conventional university settings, it has been observed that academic achievement can provide good account for continuance (Allen & Robbins, 2008). However, continuance motives can differ in e-learning environments. This is because conventional settings usually compel students to meet mandatory minimum academic requirements to pass courses (Wintre & Bowers, 2007). Since e-learning institutions are more oriented to older, not traditional, students, who in many cases combine their studies with family and professional duties and take less courses per semester, academic requirements to continue in e-learning settings might take into consideration the individual's circumstances (Levy, 2007). Thus the connection of academic achievement and continuance is not necessarily so logical. Nevertheless, and keeping in mind reports about the influence of academic achievement for non-traditional university students' persistence in the university (Rosário *et al.*, 2014), we will presume a positive relationship between these two constructs.

H11: Academic performance has a positive impact on continuance

Methodology

An established pure-online University in the European Higher Education Area sponsored the research. An online questionnaire was distributed by the University's main office to every student in the undergraduate and graduate programmes (29,723 students in total). The average response rate was 12.59%, and 2,530 questionnaires were valid for analysis.

Assuming that flow occurs during the activity itself, the survey was made available during the term, while students were enrolled in their courses. By contrast, a student's academic performance was measured at the end of the term, and the e-learner's continuance was captured through a student's effective behaviour in the next academic course (see horizontal inferior section of Figure 1).

The questionnaire captured the constructs of flow, challenge, control, focused attention, presence, and positive affect. These constructs were measured through existing validated scales (see Table 1), which were modified to fit with the particular e-learning system employed at the University. Except for item F2, possible answers were scored using 7-point Likert scales, ranging from *strongly disagree* (1) to *strongly agree* (7). Answers to F2 were coded with a scale anchored at *never* (1) and *very frequently* (7).

To better detect causal inferences of flow—and avoid spurious correlations due to CMV problems—we used behavioural variables to measure academic performance and continuance. Therefore academic performance was measured with a variable that gathered all the final scores achieved in the courses that the student took in the semester. The marks for each course ranged from *unsatisfactory* (0) to *excellent work* (5). And continuance was measured through a dichotomous variable that captured the individual's actual behaviour in the next academic semester. It was equal to 0 (if the student did not enrol in any subject at the University in the next academic course) and to 1 (if he or she enrolled in at least one course).

Analysis and results

Measurement model

The results of the initial exploratory factor analysis showed that all the items loaded higher than the 0.70 cut-off with the expected construct. A confirmatory factor analysis was performed with the scales. Cronbach's α value for all the constructs surpassed the requested 0.70 level (see Table

Table 1: Questionnaire measurement scales

Constructs	*Scales of reference*	*Adapted questionnaire scales*
Challenge	(Novak *et al*., 2000)	(CH1) Using the campus challenges me (CH2) Using the campus challenges me to perform to the best of my ability (CH3) Using the campus provides a good test of my skills
Control	(Ghani & Deshpande, 1994; Novak *et al*., 2000)	(C1) When I use the campus, I feel in control over it (C2) When I use the campus, I feel influential (C3) When I use the campus I feel dominant
Focused attention	(Agarwal & Karahanna, 2000; Shin, 2006)	(FA1) When using the campus I am able to block out most other distractions (FA2) When using the campus I am totally absorbed in what I am doing (FA3) When using the campus I have a feeling of concentration
Presence	(Novak *et al*., 2000)	(P1) I forget about my immediate surroundings when I use the campus (P2) Using the campus makes me forget where I am (P3) When I use the campus, I feel I am in a world created by the technology
Flow	(Novak *et al*., 2000)	(Narrative description and instructions) (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 I use the campus I feel that I am in flow
Positive affect	(Novak *et al*., 2000)	(PA1) When I use the campus I feel happy (PA2) When I use the campus I feel annoyed[1] (PA3) When I use the campus I feel content

[1]Reversed scaled item.

2). Except for one item (P1), all values for item-to-total correlation were above 0.60. Yet the value of item-to-total correlation for the aforementioned item is just a bit lower than 0.60, and their associated Cronbach's α value is clearly greater than 0.70. Hence, we consider the internal reliability of all the self-reported constructs to be adequate.

Support for convergent validity is provided by factor loadings, which all surpass the 0.70 level. Additionally, the composite reliability is greater than the suggested minimum value of 0.70 for every construct, and the AVE is greater than the lower bound of 0.50 in all cases except for *focused attention* and *presence*. Since these latter values are pretty close to the minimum, and composite reliability is always greater than AVE, we finally accept that convergent validity is also completed.

Results further show that the AVE value for each construct is greater than its MSV and its ASV (see Table 2 and Table 3). Furthermore, the square root of the AVE of every construct is greater than all the correlations between that construct and all other constructs. All of these prove that the measures of the constructs in the model are robust in terms of their discriminant validity.

Table 2: Internal reliability and convergent validity of the constructs

Construct	*Variable*	*Cronbach's α*	*Item-total correlation*	*Factor loading*	*Composite reliability*	*AVE*[1]
Challenge	CH1	0.879	0.743	0.865	0.880	0.709
	CH2		0.789	0.861		
	CH3		0.767	0.857		
Control	C1	0.823	0.697	0.855	0.823	0.608
	C2		0.680	0.842		
	C3		0.655	0.817		
Focused attention	FA1	0.725	0.607	0.799	0.745	0.498
	FA2		0.627	0.798		
	FA3		0.642	0.782		
Presence	P1	0.739	0.594	0.747	0.741	0.492
	P2		0.650	0.847		
	P3		0.668	0.786		
Flow	F1	0.870	0.729	0.819	0.878	0.707
	F2		0.816	0.833		
	F3		0.726	0.819		
Positive affect	PA1	0.875	0.763	0.954	0.864	0.693
	PA2		0.706	0.950		
	PA3		0.813	0.722		

[1]AVE, average variance extracted.

Table 3: Discriminant validity of the constructs and bivariate correlations of latent constructs

Construct	*MSV*[1]	*ASV*[2]	*Challenge*	*Control*	*Focused attention*	*Presence*	*Flow*	*Positive affect*
Challenge	0.226	0.129	0.842†					
Control	0.094	0.061	0.092	0.780†				
Focused attention	0.348	0.181	0.397	0.307	0.706†			
Presence	0.348	0.164	0.464	0.141	0.474	0.701†		
Flow	0.348	0.211	0.475	0.307	0.590	0.590	0.841†	
Positive affect	0.089	0.052	0.195	0.298	0.281	0.110	0.202	0.833†

[1]MSV, maximum shared squared variance; [2]ASV, average squared variance; †, square root of AVEs.

Common method variance

We took four preventative measures to avoid CMV (MacKenzie & Podsakoff, 2012). First, we gathered data from two sources (a survey and a registrar's office). Secondly, we ensured a temporal separation between the measurement of two criterion variables (*academic performance* and *continuance*) and the rest of variables. Thirdly, we guaranteed anonymity for the survey's respondents. Furthermore, we improved the translation of the scale items, and adapted them to the respondents' particular e-learning environment.

In addition to these measures, we ran the Harman's single factor test and the Bagozzi method. The factorial analysis produced six components with eigenvalues greater than 1, with an aggregate variance explained of 75.26%; all the correlation among constructs were significantly less than 0.90. Therefore, we can infer that the potential existence of CMV does not significantly influence our analysis.

Table 4: Fit indexes for the model

Fit index	*Value*	*Recommended cut-off values*
Absolute fit measures		
χ^2	1997.548	The lower the better
d.f.[1]	160	
p-value	0.000	>0.050
χ^2/d.f.	12.485	<5.000
GFI[2]	0.928	>0.800
SRMR[3]	0.079	<0.080
RMSEA[4]	0.067	<0.080
AGFI[5]	0.905	>0.800
Incremental fit measures		
TLI[6]	0.907	>0.900
NFI[7]	0.916	>0.900
CFI[8]	0.922	>0.900
Parsimonious fit measures		
PGFI[9]	0.707	>0.500
PNFI[10]	0.771	>0.500
PCFI[11]	0.776	>0.500

[1]d.f, degrees of freedom; [2]GFI, goodness-of-fit index; [3]SRMR, standardized root mean square residual; [4]RMSEA, root mean square error of approximation; [5]AGFI, adjusted goodness-of-fit index; [6]TLI, Tucker-Lewis index; [7]NFI, normed fit index; [8]CFI, comparative fit index; [9]PGFI, parsimonious goodness-of-fit index; [10]PNFI, parsimonious normed fit index; [11]PCFI, parsimonious comparative fit index.

Table 5: Hypotheses, path coefficients, and results

*H*i	*Relationships*			β^1	SE^2	CV^3	*p*
H1 (+)	Challenge	→	Flow	0.213	0.021	10.274	0.000
H2 (+)	Control	→	Flow	0.198	0.026	7.596	0.000
H3 (+)	Control	→	Focused attention	0.286	0.023	12.633	0.000
H4 (+)	Focused attention	→	Flow	0.460	0.035	13.167	0.000
H5 (+)	Challenge	→	Presence	0.315	0.020	15.426	0.000
H6 (+)	Focused attention	→	Presence	0.433	0.031	13.754	0.000
H7 (+)	Presence	→	Flow	0.391	0.030	12.858	0.000
H8 (+)	Flow	→	Positive affect	0.175	0.018	9.939	0.000
H9 (+)	Positive affect	→	Continuance	0.054	0.007	7.345	0.000
H10 (+)	Flow	→	Academic performance	0.287	0.073	3.946	0.000
H11 (+)	Academic performance	→	Continuance	0.010	0.002	5.967	0.000

[1]β, estimates; [2]SE, standard error of the regression weight; [3]CV, critical ratio value for regression weight.

Structural model

The χ^2 test showed that we should reject the null hypothesis, that the reduced model fits the data just as well as the full model does ($p = 0.00$). This was an expected result, since we are working with a large sample. We therefore considered three other absolute fit measures (see Table 4). First, the GFI surpasses the recommended value of 0.80 for acceptable fit. We obtained that 92.8% of the variance in the variance-covariance matrix of the sample is represented by the model. Second, the SRMR is lower than the recommended upper bound of 0.08. In addition, the RMSEA remains below the suggested cut-off value of 0.08.

Compared with the null model, our proposed model has a good incremental fit result. First, the AGFI is clearly greater than 0.80. Secondly, the NFI surpasses the minimum required value of 0.90. Additionally, the TLI and the CFI are greater that the suggested lower bounds of 0.90 and 0.95, respectively. Parsimonious fit measures give similar good results. The PGFI is greater than the recommended 0.50 level; and the PNFI and the PCFI are clearly above 0.50. All these results show that the model has a good fit.

As shown in Table 5 all estimates are positive and significantly different from zero (the *p*-value is 0.00 in all cases), so that the associated hypotheses are fulfilled. The results show that the expected causal links between unobserved variables are statistically different from zero.

The results show that the expected causal links between unobserved variables are statistically different from zero: *control* has a positive and significant impact on *focused attention* ($\beta = 0.29$, $p = 0.00$), and *flow* ($\beta = 0.20$, $p = 0.00$). Consistent with our hypotheses, *flow* is also affected by *challenge* ($\beta = 0.21$, $p = 0.00$), *focused attention* ($\beta = 0.46$, $p = 0.00$), and, finally, *presence* ($\beta = 0.39$, $p = 0.00$), which, in turn, receives the influence of *challenge* ($\beta = 0.32$, $p = 0.00$) and *focused attention* ($\beta = 0.43$, $p = 0.00$). This implies that there is also a significant indirect effect of *control* on *flow*, mediated by *focused attention*, and on *presence*, mediated by *focused attention*. Furthermore, *flow* has a direct influence on *positive affect* ($\beta = 0.18$, $p = 0.00$) and *academic performance* ($\beta = 0.29$, $p = 0.00$). Likewise, *continuance* is directly affected by *positive affect* ($\beta = 0.05$, $p = 0.00$) and *academic performance* ($\beta = 0.01$, $p = 0.00$).

Conclusions

The goal of this paper was to extend the body of literature on online flow, and examine the applicability of flow theory to explain the individual's affective, performance-related, and behavioural responses in a particular online setting (ie an e-learning setting). It does this by developing a coherent framework that integrates key antecedents of flow with a compound of positive consequences (positive affect, performance, and effective continuance). The conceptual framework has its roots in extensive literature on flow in a range of contexts, including virtual environments. We further test our cognitive model by performing an empirical analysis with both questionnaire and behavioural data. As described, our empirical analysis supports the model.

Contributions to research

The concept of flow is especially worthwhile for education researchers seeking to understand what makes an e-learning experience optimal. The cognitive model presented here is especially relevant as it is well suited to a context (ie an e-learning context) in that it shows that it is possible that flow episodes are facilitated by studying online.

The study contributes three major insights to current knowledge of flow in education. The first is made by showing the driving role of challenge, control, focused attention, and presence in the formation of e-learning flow. Based on previous research into flow in both conventional and virtual environments, our study provides the first empirical demonstration of the simultaneous and direct impact of these four distinct subjective experiences on flow. Indeed, the findings are in line with the predictive value attributed to challenge, control, and focused experiences by flow theory; and the importance shown by presence in an individual's experiences online (Faiola *et al.*, 2013; Nah, Eschenbrenner, & DeWester, 2011; Weibel & Wissmath, 2011).

The second major contribution relates to a striking question pointed out by Faiola *et al.*'s (2013), which however has not been solved until now: do presence and flow share focused attention as a core predictor? Our findings clearly indicate so, which is further consistent with Draper & Blair's (1996) idea that presence and flow require the individual not to be distracted by any stimuli but those relevant to the online task at hand. This leads to where the individual loses awareness of self and feels fully immersed in the virtual education environment (presence), and in the e-learning task which is taking place "there" (flow).

The last major contribution solves a threefold gap in the understanding of the consequences of flow, and offers a more systematic view of how flow raises affective, performance-related, and behavioural responses. First, it is worth noting that the effect of flow on the spectrum of an individual's responses studied here has never been considered in any previous analysis. To the best of our knowledge, ours is the first study to explain how flow triggers positive emotion, performance, and continuance behaviour. More specifically, findings indicate that e-learning flow prompts both positive affect and performance-related outcomes; and that effective continuance is influenced by flow through the mediating effects of positive affect, and performance.

Secondly, actual behaviour online has not been appropriately studied through the lenses of flow principles. Despite it being acknowledged that individuals do not always behave in accordance with their intention, research that has tested the effect of flow on online behaviour has used measures of intention to gauge the individual's actual behaviour online. Moreover, behavioural intention has often been measured within research designs that do not separate it totally from its potential drivers in the respondent's mind, which might raise response bias. Rather, in our study we have used a design that does allow measuring actual behaviour and examining causal inferences, and so have been able to offer solid evidence about the flow-behaviour causal connection.

Thirdly, although previous research has attempted to examine the effects of flow on performance, the results have been inconsistent and often contradictory: while researchers have advocated the importance of online flow in raising individual's performance many failed to demonstrate it (Joo *et al.*, 2012; Konradt *et al.*, 2003; Konradt & Sulz, 2001; Rossin *et al.*, 2009). And the only studies that detected such role of flow neglected to use objective measures of performance (Choi *et al.*, 2007; Esteban-Millat *et al.*, 2014; Ho & Kuo, 2010), or employed too small a sample (Kiili, 2005). In the present research, we have strongly confirmed this causal relationship by using an objective measure of performance, and on the basis of a large sample.

Limitations and further research

The sample used in this study is representative of students in a premier e-learning higher education institution, who are scattered across a number of countries. Also, it refers to the variety of courses the students were taking when data was collected. However, it was extracted from a single pure-online University, thus making the generalisation of results to the entire population of e-learners difficult, and does not allow results to be compared among pure-online and blended programmes. Therefore, it is advisable for future research to employ data from a greater variety of universities that offer pure-online and blended e-learning programmes.

Although the current study provides important insights into the antecedents and outcomes of flow, it does little to further the understanding of how e-learning strategies could be addressed to improve flow. For example, a comparatively low level of flow among e-learners could prompt instructors and higher education institutions to alter didactic materials, communication initiatives, and teaching strategies. In turn that could unleash more feelings of flow antecedents (ie challenge, control, focused attention, and presence). As a knock-on effect this would facilitate flow experiences. Based on this, and to better understand the factors that influence change efforts directed at facilitating flow, it would be useful to undertake studies that centre on this change process.

Statements on open data, ethics and conflict of interest

Data was collected according to the code of ethics, and the Universitat Oberta de Catalunya's code of practice in research and innovation, and there is no potential conflict of interest.

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