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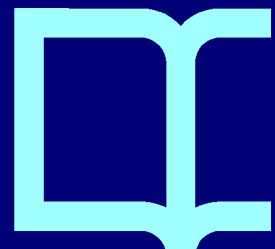
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Flow experiences in personalised e-learning environments and the role of gender and academic performance

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Abstract: The successful move to a new generation of technologies that provide students with personalised e-learning environments is connected to their ability to facilitate flow experiences – through which e-learners feel fully engaged in the educational activities at hand. However, little is known about the heterogeneous influence of subjective and education-related elements intervening in the formation of flow experiences and the moderating effects of gender and academic performance. This paper contributes to the existing literature by building an integrative model that captures the formation of flow in personalised e-learning environments. The results yielded by a study to test this model have largely

confirmed that subjective and education-related constructs significantly predict flow and show the moderating impact of gender and academic performance.

Keywords: e-learning; flow; professor competency; resource quality; academic performance; gender

Introduction

Personalised virtual education environments are equipped with enriched digital resources, tutoring applications and collaborating services, which infuse more interactivity into the learning process and offer a diversity of ways to adapt to the learner's needs and the context in which they are studying. In these advanced virtual education settings, students are empowered so that they can meet their educational goals, customise the learning process to their specific requirements, and construct their own knowledge (H. C. Wang & Huang, 2013). Unlike conventional education environments, in personalised virtual education environments, professors do not necessarily carry out their teaching activity with small groups of students. This is because personalisation settings allow lecturers to dynamically adapt the didactic resources to students' varying needs, thus mirroring the individual attention paid in small-group teaching (Ashman et al., 2014).

The viability and success of personalised e-learning settings is influenced by their ability to facilitate flow experiences. In e-learning, flow experiences refer to those pleasurable feelings that students have when they engage, to the fullest capacity, in a highly demanding educational activity (Rodríguez-Ardura & Meseguer-Artola, 2017). When e-learners have studied with enthusiasm, they are considered to have been *in flow*; and this might also have positive consequences, like continuing in their work mode even when the experience of flow has finished. Far from decreasing, under current advances in personalised e-learning technologies, the interest in understanding flow is even higher. This is because flow experiences can contribute to increased profitability for investments in sophisticated e-learning systems (Rodríguez-Ardura & Meseguer-Artola, 2017).

Most research into flow in the context of e-learning attempts to identify the antecedents of flow. With that purpose in mind, they put the spotlight on certain subjective processes that potentially unleash flow, such as skill-demand balance or focused attention (Y.-C. Huang, Backman, & Backman, 2010). These potential antecedents largely coincide with those that have been explored by studies that offer a generic view of online user experiences (Novak, Hoffman, & Yung, 2000). However, there is a wide variety of online activities within which flow may arise, and as such it would be appropriate to go beyond general assessments of flow determinants (Novak, Hoffman, & Duhachek, 2003). Despite this fact, examinations of potential drivers of flow specifically connected to the online education setting are still scarce. Only a few studies have tackled these particular antecedents (Choe, Kang, Seo, & Yang, 2014; Rodríguez-Ardura & Meseguer-Artola, 2016c), leaving the education-related antecedents of flow in e-learning largely underexplored. Therefore, it could be argued that further research that considers the specific context of e-learning and appraises the education-related elements that might elicit flow is required.

Previous research has pointed out that individual differences might play a part in people's experiences online (Bourgonjon, Valcke, Soetaert, & Schellens, 2010); however, the results yielded so far are not only few in number, but also inconsistent. For example, although Sánchez-Franco found that gender differences exist with regard to flow

(Sánchez-Franco, 2006), Shin could not reach conclusive results with regard to gender differences in flow experiences for e-learning (Shin, 2006). Likewise, the connections between the individual's academic performance and flow are still unclear. On the one hand, students with a high level of academic performance might approach e-learning processes with greater confidence and hope of success, and thus feel motivated to experience flow for reasons different to those of students with a low level of academic performance (Schüler & Engeser, 2009). On the other hand, some studies have not detected any link whatsoever between the individual's academic performance and flow in e-learning (Young Ju Joo, Lim, & Kim, 2012; Konradt & Sulz, 2001).

Bearing this in mind, we aim to participate in the academic conversation about flow and address the void that has been detected in terms of the knowledge held on personalised e-learning situations. Therefore, the main goals of this paper are: 1) to examine the interplay among education-related and subjective elements intervening in the formation of flow in a personalised e-learning context; and 2) to provide evidence on the moderating role of the individual's differences in gender and academic performance.

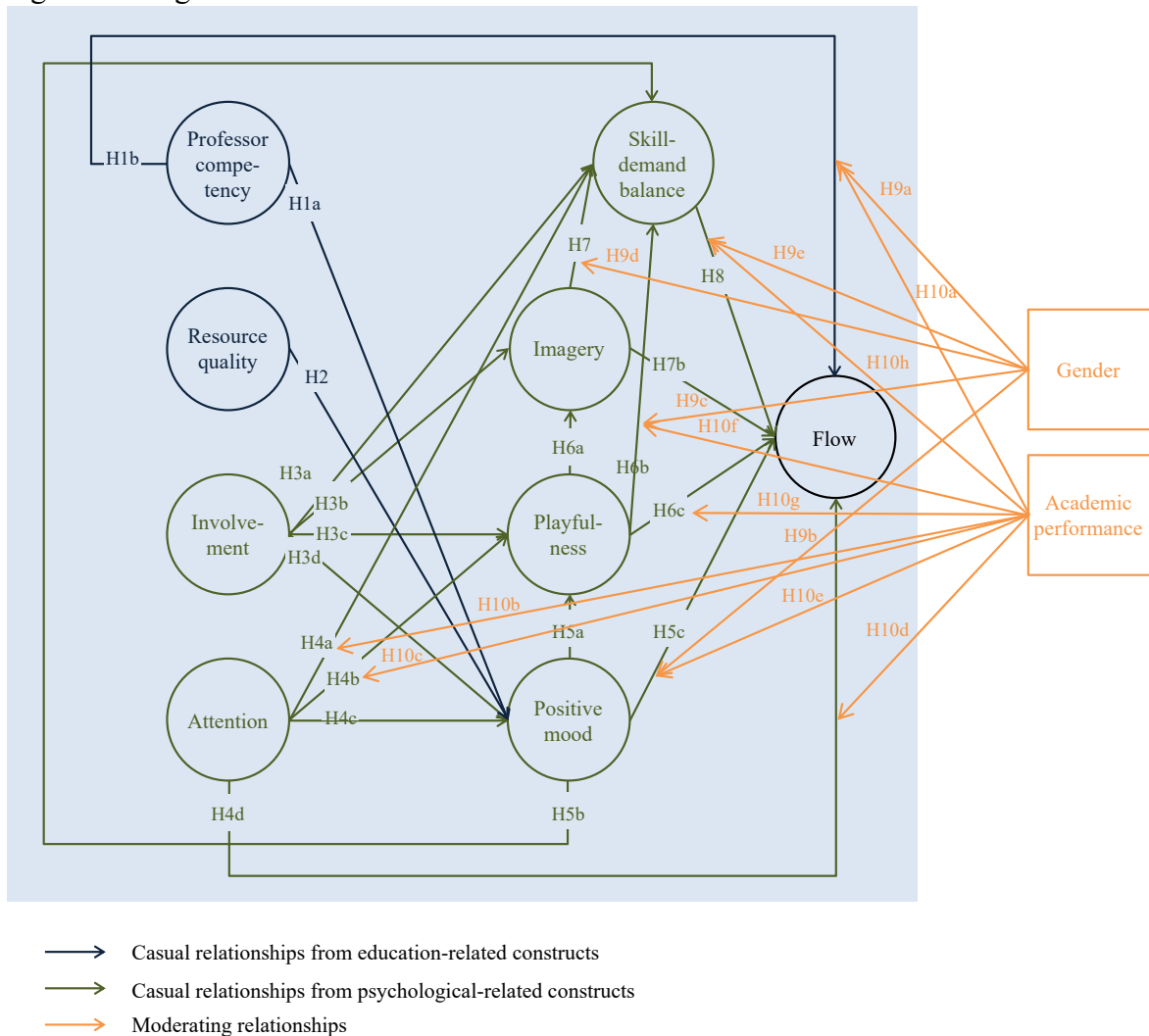
Theoretical background and research hypotheses

Personalised e-learning involves a range of educational technologies and pedagogical approaches that consider differences among individual students (Essalmi, Ayed, Jemni, Graf, & Kinshuk, 2015) and which can tailor the generic virtual education environment to their particular needs (Christudas, Kirubakaran, & Thangaiah, 2018), giving students the feeling that their individual learning requirements are being met (Ashman et al., 2014). One highly sought-after milestone among universities involved in personalised e-learning activities, public authorities, and society in general is being able to provide e-learners with opportunities in which to experience flow (OECD, 2007). There is clear agreement among the literature on the concept of flow (Engeser & Schiepe-Tiska, 2012). Flow experiences are described as pleasant psychological states under which individuals are entirely engrossed in an ongoing activity that has well-defined objectives and offers immediate feedback (Csikszentmihalyi, 1975). When experiencing flow, individuals plunge themselves into the task at hand with such intensity that they themselves merge with the task. As such, they forget themselves and self-referential thoughts disappear (Csikszentmihalyi, 1975) as they feel time fly (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2005).

Despite some of the potential antecedents of flow being noted at some length in the context of e-learning, so far their integral and effective impact is not well understood. In an attempt to provide a clearer picture, we develop a coherent framework that considers the interplay of flow states with both education-related and subjective constructs (see modelling in Figure 1). The model contends that flow is prompted by two important drivers related to the specific e-learning setting (i.e. the professor's competency, and the quality of the didactic resources), plus a wide range of constructs related to psychological processes experienced by the e-learner. We choose three psychological processes (i.e. focused attention, skill-demand balance, playfulness) that have been considered by numerous researchers of flow (Hoffman & Novak, 2009), and three other subjective constructs (i.e. involvement, imagery, positive mood) whose connection with flow, despite having been suggested, has been examined empirically to a much lesser degree (Chang, 2017; Koehn, Morris, & Watt, 2013; Peifer, Schulz, Schächinger, Baumann, & Antoni, 2014). We study the interplay of the education-related and experiential elements

selected for a personalised education environment, under the presumption that they will help to explain the flow episodes that emerge in those particular contexts. Furthermore, the model considers a potential moderating role played by individual differences in gender and academic performance.

Figure 1. Integrative model of flow



Antecedents of flow

Professors' competency and didactic resources' quality are elements of critical importance in e-learning programmes (Rodríguez-Ardura & Meseguer-Artola, 2016c). A professor's competency becomes apparent through the "instructor's personal approach, teaching style and their advice/help" within the online education setting (Choi, Kim, & Kim, 2007, p. 230). Competent professors help students build their own knowledge by motivating them, guiding them across their individual learning processes, designing pertinent learning initiatives, and giving advice in a continuous, customised and efficient fashion (Choi et al., 2007; Edwards, Perry, & Janzen, 2011). Furthermore, e-learners need to use advanced interactive didactic resources and collaborating tools to deploy their learning processes and gain knowledge (Udo, Bagchi, & Kirs, 2011). In e-learning, quality interactive didactic resources are a major source of information as well as being a mainstream study tool. Quality didactic resources encompass learning materials and

tools in an array of formats (such as wikis, theme repositories, video books, databases, study guides, and so on), which are needed to adequately carry out the learning activities.

On the basis of control-value theory (Pekrun, 2006), it seems reasonable to expect that professors and didactic resources can have a positive influence on e-learner's emotions – and subsequently trigger flow (Artino Jr, Holmboe, & Durning, 2012). This is because both professors and didactic resources can contribute to the fostering of education environments that are warm and responsive to e-learners' particular needs, so that they feel in control of learning activities that are of value to them. Furthermore, by way of crossover and emotional contagion (Bakker, 2005; Hatfield, Cacioppo, & Rapson, 1993), we might expect that professors who show a high degree of competency in the virtual class (e.g. they exhibit enthusiasm, work motivation and absorption) are more capable of generating flow experiences among their students. This potential direct link between professor competency and flow is in line with findings from the contexts of sports training (Bakker, Oerlemans, Demerouti, Slot, & Ali, 2011) and on-the-job training (Choi et al., 2007). Consistent with this, we presume that:

H1a. Professor competency has a positive influence on positive mood.

H1b. Professor competency has a positive influence on flow.

H2. Resource quality has a positive influence on positive mood.

Flow literature has mainly focused on attention, skill-demand balance and playfulness as subjective experiences that trigger flow. However, there is evidence from flow studies in the field of digital marketing (Koufaris, 2002; Novak et al., 2000) and human-computer interaction (L.-T. Huang, Chiu, Sung, & Farn, 2011) that suggests the potential usefulness of examining the mediating role of involvement as an indirect driver of flow. Involvement is a motivational construct, well-recognized for its ability to exert a positive influence on the individual's internal process and responses, even online (Jiang, Chan, Tan, & Chua, 2010). Individuals involved in an ongoing (e-learning) activity are those who are interested in such activity and, on the basis of their personal needs and values, they perceive it as worthy (Zaichkowsky, 1994).

Students' involvement in the learning activity might be a good predictor of their perception of their own skills (Schiefele & Csikszentmihalyi, 1994) and also activate various internal experiences, including mental imagery (Polyorat, Manoa, & Kim, 2007) and playfulness (Chung & Tan, 2004). This is because motivated e-learners perform the tasks at hand out of interest, in such a way that they meet the essential need of feeling competent or skilled (Ryan & Deci, 2000). Also, motivated e-learners are more likely to put effort into the educational tasks (Deci, Vallerand, Pelletier, & Ryan, 1991), so they are more active in exploring information and finding alternatives – which in turn fosters creative performances that require imagery and playfulness (Runco, 2014). Moreover, involvement is potentially connected to emotion because it triggers a person's positive mood and the feelings associated with this (Zaichkowsky, 1994). We therefore hypothesise that:

H3a. Involvement has a positive influence on skill-demand balance.

H3b. Involvement has a positive influence on imagery.

H3c. Involvement has a positive influence on playfulness.

H3d. Involvement has a positive influence on positive mood.

Attention can be conceived as the individual's focus on the (e-learning) activity taking place within the virtual environment (Anderson, 2005), which is a very different situation from those in which the individual is engaged in distinct tasks so that their attention is "divided" (Pace, 2004, p. 348). It seems reasonable to presume that the greater the individual's attention to the activity, the more effort he or she will put into it, thus finding that they can adequately meet the demands posited by the virtual (education) environment (Weber, Tamborini, Westcott-Baker, & Kantor, 2009). Furthermore, concentrating on the activity can trigger the individual's cognitive spontaneity or playfulness (Chung & Tan, 2004; Webster & Martocchio, 1992) and, as some studies have observed, selective attention on a subset of stimuli can influence the individual's affective responses (Raymond, Fenske, & Westoby, 2005; H. Zhou, Wan, & Fu, 2007).

Through a qualitative assessment, Pace observed that, to emerge, episodes of online flow require the individual's full attention on only one activity (Pace, 2004). However, previous quantitative research has yielded various results when examining this potential connection: while in the studies of L.-T. Huang and colleagues, and Jin the indicators of focused attention were found to exhibit a reliable causal relationship with flow (L.-T. Huang et al., 2011; Jin, 2011), Novak et al. (2000) could not provide evidence of their hypothesised direct link between attention and flow online (Novak et al., 2000). However, some recent empirical studies could reveal the influence of attention on flow in the more particular context of e-learning (Rodríguez-Ardura & Meseguer-Artola, 2017; Rodríguez-Ardura, Meseguer-Artola, & Ammettler, 2016). Considering the above discussion, we suggest:

H4a. Attention has a positive influence on skill-demand balance.

H4b. Attention has a positive influence on playfulness.

H4c. Attention has a positive influence on positive mood.

H4d. Attention has a positive influence on flow.

Emotion mediates between the upcoming stimuli from the (e-learning) environment and the individual's cognitive processes and responses (Clore & Palmer, 2009). Individuals in positive emotional states are more likely to perceive positive feelings (Gray, 1990) and display more effective academic behaviour (Proyer, 2011). Thus, they are more inclined to be playful, spontaneous and inventive (Proyer & Ruch, 2011). Conversely, an individual's negative emotional states, such as anxiety, negatively influence playfulness (H. Y. Wang & Wang, 2008). Furthermore, the emotion elicited by the stimuli from the environment is associated with the individual's perceived capacity to deal with challenging demands from the environment (Watson & Spence, 2007).

The positive affective consequences of flow have been fairly well explored (Landhäuser & Keller, 2012; Rodríguez-Ardura & Meseguer-Artola, 2017), but much less has been studied on how the individual's emotional state intervenes in flow formation. Nevertheless, as recent research has observed (Hong, Tai, Hwang, & Kuo, 2016; Peifer, Schächinger, Engeser, & Antoni, 2015; Peifer et al., 2014), the most appropriate

environments in which to experience flow are those without high levels of stress or anxiety, and to which individuals can feel positively connected emotionally. In other words, stressful e-learning environments can be perceived by students as threatening and become detrimental to cognitive functioning (Young, Drevets, Schulkin, & Erickson, 2011). By contrast, those environments that heighten positive emotions might facilitate a pleasurable immersion in the learning activity – a key element in flow experiences. All of this leads us to expect:

H5a. Positive mood has a positive influence on playfulness.

H5b. Positive mood has a positive influence on skill-demand balance.

H5c. Positive mood has a positive influence on flow.

E-learners in a playful state of mind show more inventiveness, curiosity and spontaneity in their academic endeavours (Chiang & Lin, 2010). As noted by Singer and Singer (Singer & Singer, 2006), the internal states of playfulness might evoke mental imagery processing. This is because they lead the individuals to distance themselves from conventional solutions, explore alternatives (Runco, 2014) and tackle new issues “with an open mind” (Guitard, Ferland, & Dutil, 2005, p. 21) – which are common facets of imagery experiences (Howe, 1989).

Proyer offered the first evidence of a positive connection between playfulness and working at full capacity (Proyer, 2011). The reasoning underlying this finding stems from the assertion that, in a playful mode, individuals might be more willing to go the extra mile and work beyond what is needed, thus being able to better face increasing demands (Guitard et al., 2005). To put it another way, playfulness is associated with the individual’s tendency to light-heartedly engage in activities (Rodríguez-Ardura & Meseguer-Artola, 2018b). Therefore, when e-learners adopt a playful way of coping with academic tasks, they are more likely to address properly the demands behind the tasks. Moreover, playfulness is connected with optimal psychological functioning, finding joy in learning experiences (Proyer & Ruch, 2011) and a greater likelihood of reaching states of flow (Hsu, Chang, & Chen, 2012; Jin, 2012). Therefore, we hypothesise:

H6a. Playfulness has a positive influence on imagery.

H6b. Playfulness has a positive influence on skill-demand balance.

H6c. Playfulness has a positive influence on flow.

Mental imagery, understood as the inner production of mental representations and sensory thoughts (Rodríguez-Ardura & Martínez-López, 2014), can be useful in developing a person’s own skills (Mousa, Halaweh, & Al-Taieb, 2013) – so they should match well with the demands delivered by the (e-learning) environment. In line with this, imagery has been observed as having a positive effect on the amount of effort and individual devotes to a task (Callow, Roberts, Hardy, Jiang, & Edwards, 2013). Similarly, studies in sports psychology show that individuals who are more inclined to experience imagery have more realistic expectations about their personal capabilities and train longer hours (Martin & Hall, 1995; Weinberg, 2008).

Research also suggests that imagery is a subjective experience that prompts flow (Koehn

et al., 2013; Rodríguez-Ardura & Meseguer-Artola, 2016a). Narrative transportation theory (van Laer, de Ruyter, Visconti, & Wetzels, 2014) offers a rationale about this potential link: a person engaged in mental imagery uses their intellectual capacity to a larger extent, and this leads them to detach from their own perspective and facilitates their utmost immersion in the ongoing (e-learning) activity – which is a core facet of flow experiences. Based on this reasoning, we suggest:

H7a. Imagery has a positive influence on skill-demand balance.

H7b. Imagery has a positive influence on flow.

A notion central to the flow theory is that individuals who feel confident that their skills will allow them to face highly demanding situations are more prone to experience flow (Buil, Catalán, & Martínez, 2017). That is to say, flow states occur when e-learning activities require the student to stretch his or her abilities to new levels. Additionally, as the student's skills improve, in order for him or her to experience flow, the educational demands should go beyond what has previously been easily achievable and become more acute. This engages the e-learner's cognitive system in the activities and makes him/her feel competent performing the tasks (Rodríguez-Ardura & Meseguer-Artola, 2017). We therefore presume that, in personalised e-learning environments, a match between the skills and demands required by an activity might lead the e-learner to fully immerse him- or herself in this activity:

H8. Skill-demand balance has a positive influence on flow.

Interaction effects of gender and academic performance on the relationships between flow and its antecedents

The relationships between flow and its antecedents may be related to gender differences. However, there is little research that has introduced the gender perspective into the study of flow and, so far, the findings are mixed. Konradt found, for a small sample of business students using a digital training tool, that flow experiences were independent of gender (Konradt, Filip, & Hoffmann, 2003); contrary to expectations, Shin could not detect a correlation between gender and flow for a convenience sample of e-learners at the undergraduate level (Shin, 2006). Nevertheless, a handful of studies have observed that boys are more prone than girls to experience flow in game-based e-learning (Hsieh, Lin, & Hou, 2016; J. C. Yang & Quadir, 2018); the results obtained by Sánchez-Franco, in the broader context of human-computer interaction, suggest that men and women may go through flow states for different reasons (Sánchez-Franco, 2006).

Furthermore, gender differences might exist when it comes to several antecedents of flow, particularly in perceived teaching performance, emotion, playfulness, imagery and perceived compatibility between skills and demands. There is considerable evidence supporting the existence of gender differences in terms of the degree to which individuals view themselves as connected to others (Guimond, Chatard, Martinot, Crisp, & Redersdorff, 2006). This implies that females might be more oriented interpersonally and display higher relational interdependence, giving more importance to the professor's positive attitude and participation in the e-learning process than their male peers (Horvat, Dobrota, Krsmanovic, & Cudanov, 2013; Y. Yang, Cho, & Watson, 2015). By contrast, males might tend to adopt a more individualistic-motivational orientation and seek to fulfil self-centred goals (Sánchez-Franco, 2006), so they will value a stronger, more

masterful approach in their professors (Y. Yang et al., 2015).

H9a. Professor competency's positive influence on flow is stronger for males than for females.

Gender differences are also believed to interact with a positive mood in personalised e-learning settings (Rodríguez-Ardura & Meseguer-Artola, 2016b). Women might exceed men in assigning emotional traits to elements of the virtual environment (Dittmar, Long, & Meek, 2004), show a higher level of emotional awareness (Barrett, Lane, Sechrest, & Schwartz, 2000) and emotional reactivity (Domes et al., 2009), and value and experience emotions more intensely than men (van Middendorp et al., 2005). Thus, it seems plausible to presume that females might be more eager to experience flow when the virtual education environment rouses positive emotions and vice-versa: perceived absence of positive emotions can be a less important reason in men than in women when explaining why they do not enter flow states.

H9b. Positive mood's positive influence on flow is stronger for females than for males.

Selectivity hypothesis (Meyers-Levy & Maheswaran, 2004) offers a useful foundation for suggesting that playfulness and imagery have greater importance for women when it comes to drawing up information, producing knowledge and fulfilling educational demands. According to this theory, males are not as likely as women to involve themselves in the comprehensive elaboration of all accessible information in order to support judgements and learning. Instead, they tend to rely on a subset of cues, which are readily available and prominent in the immediate environment – and often relate to objective signals (Kempf, Lacznik, & Smith, 2006). Conversely, women typically engross themselves in more demanding, wide-ranging or systematic information processing (Zhang, Cheung, & Lee, 2014). In contrast to men, they not only might elaborate information more thoroughly, but also could give more equal consideration to objective analytical information and sensory information – typically elicited via playful and imagery-evoking (learning) initiatives (MacInnis & Price, 1987). Considering the proceeding arguments, it is reasonable to hypothesise:

H9c. Playfulness' positive influence on skill-demand balance is stronger for females than for males.

H9d. Imagery's positive influence on skill-demand balance is stronger for females than for males.

When it comes to e-learning, it has been reported that women hold more humble opinions of their own capabilities (M. Zhou, 2014), and this female propensity to underestimate accomplishments might have no relation whatsoever to their actual academic performance. For example, Ehrlinger & Dunning found hard evidence in conventional learning settings that female students – even though they performed as well as their male peers – were prone to undervalue their academic achievements (Ehrlinger & Dunning, 2003). It has been argued that this stems from women's higher predisposition to exhibiting relational interdependency, while men have proven to be more independent and thus are more motivated by self-enhancement and self-assertion (Guimond et al., 2006). Because of these tendencies, men more than women might value those e-learning initiatives that enhance their capabilities and challenge them to face educational demands and meet their personal education goals. Therefore, it seems reasonable to expect skill-

demand balance to have a stronger effect on flow among males than among their female peers (Sánchez-Franco, 2006).

H9e. Skill-demand balance's positive influence on flow is stronger for males than for females.

Achieving a high level of academic performance is an important aspiration not only for many students but also for their professors and higher education institutions. Although much effort has been put into explaining inter-individual variability in academic performance (Richardson, Abraham, & Bond, 2012), as well as the beneficial effects of flow on students' achievements (Bressler & Bodzin, 2016; Rodríguez-Ardura & Meseguer-Artola, 2017; Yoo, Sanders, & Cervený, 2018), to the best of the authors' knowledge, no previous study has ever examined the potential moderating role of students' differences in performance in the formation of flow.

In e-learning environments, the professor's role is different from that of conventional, face-to-face settings. Successful e-learning initiatives largely rely on student-centred approaches (Cheawjindakarn, Suwannathachote, & Theeraroungchaisri, 2012), where there is little lecturing (Ahmed, 2010) and instead a deep emphasis on guiding and advising students throughout their learning processes (EL-Deghaidy & Nouby, 2008). That is to say, in productive e-learning environments, the professor's role shifts from lecturer to facilitator. And because student-centred e-learning environments stimulate learners to be active and self-sufficient (EL-Deghaidy & Nouby, 2008), and autonomy is associated with optimal self-regulation and learning (Niemic & Ryan, 2009), academic performance might be a meaningful negative moderator between perceived professor competency and flow.

H10a. Academic performance weakens the positive influence of professor competency on flow.

Research in learner comprehension has observed two main learning styles – surface vs. deep learning – that involve different levels of self-regulatory learning strategies across education activities (Pintrich, 2004). Particularly, it is believed that students engaged in deep learning deploy self-regulatory learning strategies, which imply paying constant, focused attention to the learning activity (Richardson et al., 2012). In turn, self-regulatory abilities have been associated with greater effort regulation in order to persevere when challenged by demanding tasks (Standage, Duda, & Ntoumanis, 2006). This is because, once a learning goal has been set, a student's self-regulatory processes intervene to decide how much effort should be implemented to achieve the educational demands, and where and how to best deploy this effort (Boekaerts & Corno, 2005). Furthermore, those students who do well academically might have higher aspirations and like the challenge behind the educational goals. As such, they are willing to pay more attention to and interact more intensely with online activities in order to enter into a playful mode, in such a way that they experience joy in learning (Proyer & Ruch, 2011). Based on the above reasoning, we hypothesise the following relationships:

H10b. Academic performance strengthens the positive influence of attention on skill-demand balance.

H10c. Academic performance strengthens the positive influence of attention on playfulness.

In comparison with low-level academic performers, their academically high-achieving peers are more capable of experiencing flow when they focus their cognitive efforts on the learning activities (Young Ju Joo, Joung, & Kim, 2014). Previous research has reported that, when high-level performers in e-learning concentrate on the learning tasks, they are more inclined to deploy self-regulatory abilities, be active participants and perform higher-order thinking (Y J Joo, Bong, & Choi, 2000), so they make particularly good use of the online education environment (Kofoed, 2004), which, in turn, facilitates pleasurable experiences of flow (Young Ju Joo et al., 2014). In addition to this, there is neurophysiological evidence that the emotional centres of high-level performers' brains are barely activated when they implement training activities (Milton, Solodkin, Hlušík, & Small, 2007); the reverse would be the case for lower-level performers. This is because higher-level performers might be more likely to develop psychological skills that self-regulate emotions in order for them to enhance other psychological abilities, such as staying focused, that lead them to become fully immersed in the learning task at hand (Eccles et al., 2011).

H10d. Academic performance strengthens the positive influence of attention on flow.

H10e. Academic performance weakens the positive influence of positive mood on flow.

Students who do not perform as well are less willing to adopt the self-regulatory learning strategies that facilitate deep learning, such as critical thinking and analytical elaboration (Richardson et al., 2012). Interestingly, research has found that these individuals are more keen to perform playful learning activities and spend more time in *play* mode (Ford, Ward, Hodges, & Williams, 2009; Nandagopal & Ericsson, 2012). By doing so, however, they are less capable of enhancing their skills and facing highly demanding academic situations (Nandagopal & Ericsson, 2012), so they do not become as well-equipped as high-level performers in going through flow experiences (Moneta & Csikszentmihalyi, 1996). Following Ericsson, Krampe and Tesch-Römer's deliberate practice theory (Ericsson, Krampe, & Tesch-Römer, 1993), higher performers are more willing to invest time and effort in deliberate practice activities, which are learning tasks that trigger deep learning. Unlike playful activities, deliberate practice activities are not primarily entertaining or enjoyable by themselves, but they are more appropriate vehicles for developing skills and attaining higher levels of expertise (Ward, Hodges, Williams, & Starkes, 2004), which is indeed more strongly connected to flow.

H10f. Academic performance weakens the positive influence of playfulness on skill-demand balance.

H10g. Academic performance weakens the positive influence of playfulness on flow.

Flow is the bread and butter of optimal intellectual functioning because students are prone to experience flow when both skills and demands are at personally high levels (Csikszentmihalyi, Rathunde, & Whalen, 1997). Even though flow can occur in low-performance situations, and an individual not in flow can achieve excellent outcomes (Stavrou, Zervas, Karteroliotis, & Jackson, 2007), within contexts of high performance, the optimal mental functioning that is flow tends to be connected with high levels of skills and demands and outstanding results (Jackson, 2000).

H10h. Academic performance strengthens the positive influence of skill-demand balance on flow.

Research method

Sample and data collection

To validate our research model about antecedents and moderators of flow in e-learning, we used survey and register data from students in a purely online university operating in the European Higher Education Area (EHEA). It is an established higher education institution, recognized within the EHEA as a pioneering and leading player in the context of e-learning¹. The university offers a customisable and student-centric virtual education environment that empowers students to learn actively, constantly accompanied by their professors, and with support from enriched didactic resources and collaboration tools. The university's e-learning environment combines automated e-learning personalisation instruments (with which students tailor the teaching language, the format of the interactive learning resources and collaborative tools, the media through which to receive advice and guidelines from the professors, etc.) with communication and learning analytic services that allow lecturers to design individual academic pathways for students and provide them with personalised attention and feedback.

Fieldwork was performed in accordance with the code of ethics for research established at the university. The survey was addressed to all the students at the university. To avoid any missing-data issues, we dropped from the resulting database all questionnaires with empty fields (1,332 questionnaires); this yielded a final sample of 2,530 completed questionnaires. Next, participants' responses to the survey were matched dynamically with their academic and demographic information via register data exploitation.

We compared the demographic profile (gender and age) and the programmes taken by the population of students at the university with those of the participants in the survey who completed the questionnaire. As we observed no significant differences, we deemed that the representativeness of the sample was high, and the probability of non-response bias minimal.

Measurement

The constructs of professor competency, resource quality, involvement, attention, positive mood, playfulness, imagery, skill-demand balance, and flow were all measured by scales previously validated in the literature, which furthermore had been previously used for those purposes in the context of e-learning. A preliminary exploratory factor analysis with all the items was carried out (items finally included in the measurement model are detailed in Table 1). Except for item F2, the response categories for these items were a seven-point Likert-type scale, from "strongly disagree" (1) to "strongly agree" (7). Response options to F2 were coded with a scale anchored at "never" (1) and "very frequently" (7).

Table 1. Measures of constructs

¹ 1997 Bangemann Challenge Award, of the European Union, for the best European distance education initiative; 2001 Prize of Excellence of the International Council for Open and Distance Education; 2009 Learning Impact Award, of the IMS Global Learning Consortium, for the Best Learning Portal; 2015 IMS Learning Impact Award; 2016 European Distance and E-learning Network (EDEN) Award of Institutional Excellence.

Constructs	Measures	Source
Professor competency	(PC1) The professor effectively resolves my questions (PC2) The professor makes sure that I understand what is being dealt with (PC3) The professor masters the contents of the course	(Choi et al., 2007)
Resource quality	(RQ1) The campus provides up-to-date resources and content (RQ2) The campus provides resources and content that exactly fit my needs (RQ3) The campus provides sufficient resources and content	(Y.-S. Wang, 2003)
Involvement	(IN1) Using the campus is important (IN2) Using the campus is worthwhile	(Zaichkowsky, 1994)
Attention	(A1) When using the campus, I am able to block out most other distractions (A2) When using the campus, I am totally absorbed in what I am doing (A3) When using the campus, I have a feeling of concentration	(Agarwal & Karahanna, 2000; Shin, 2006)
Positive mood	(PM1) When I use the campus I feel happy (PM2) When I use the campus I feel satisfied (PM3) When I use the campus I feel contented	(Novak et al., 2000)
Playfulness	(P1) When I use the campus I feel uninventive ¹ (P2) When I use the campus I feel playful (P3) When I use the campus I feel spontaneous	(Webster & Martocchio, 1992)
Imagery	(IM1) The campus makes me fantasize (IM2) When I use the campus I feel unimaginative ¹ (IM3) When I use the campus I feel creative	(Walters, Sparks, & Herington, 2012)
Skill-demand balance	(SD1) Using the campus challenges me to perform to the best of my ability (SD2) Using the campus provides a good test of my skills (SD3) Using the campus stretches my capabilities to the limit	(Novak et al., 2000)
Flow	<i>[Definition of flow and instructions]</i> (F1) I have (at some time) experienced <i>flow</i> 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	(Novak et al., 2000)

¹Reversed scale item.

Academic performance and gender were both register variables. Academic performance reflected the mean of all the final marks earned by each student in the courses they took during the term. The scores for each course ranged from “unsatisfactory” (0) to “excellent work” (5).

Preventative strategies to avoid common-method biases

We used register variables to capture academic performance and gender. This allowed us to avoid the common method variance that can appear when all measures are obtained from a single source. Also, the use of registrar's office data to measure academic performance prevented a potential bias from occurring due to individuals' tendency to maintain consistency between their beliefs and their behaviours (McGuire, 1966); and their need to show socially desirable behaviours (Ganster, Hennessey, & Luthans, 1986), such as learning performance (Bakker et al., 2011).

Minor changes in the wording of the scales were made to adapt them to the virtual education environment in which the survey was distributed. Furthermore, all the items were translated into the two languages most used by the students (Table 1 provides the English translation). These measures sought to prevent respondents from misinterpreting scale items (Gioia & Sims, 1985) and reduce random responses (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Analysis and results

We tested the proposed model and hypotheses using the partial least squares (PLS) technique and R software. PLS is particularly suited to testing complex modelling systems and data with no multivariate normal distribution (Hair Jr, Sarstedt, Hopkins, & G. Kuppelwieser, 2014). This is our case, since the structural model includes 26 items (associated with 9 distinct constructs) and, as shown by the Shapiro-Wilk test ($W=0.102$, p -value = 0.000), the data does not accomplish the multivariate normal property.

Measurement model

All Cronbach's alpha values and Dillon-Goldstein's rho values exceeded the minimum required value of 0.70 (Vinzi, Trinchera, & Amato, 2010). The first eigenvalues of the correlation matrix of each set of items were greater than 1, and the second eigenvalues clearly less than 1 (Table 2). These results of these analyses led us to state that the internal reliability of the constructs was established in our measurement model.

Table 2. Internal reliability and convergent validity of the constructs

Constructs	Variables	Cronbach's α	Dillon-Goldstein's ρ	First eigenvalues	Second eigenvalues	AVE ¹	Weights	Loadings	Communalities
Professor competency	PC1	0.832	0.899	2.241	0.441	0.748	0.389	0.886	0.785
	PC2						0.400	0.874	0.764
	PC3						0.366	0.834	0.695
Resource quality	RQ1	0.854	0.912	2.322	0.421	0.775	0.371	0.863	0.746
	RQ2						0.414	0.920	0.847
	RQ3						0.349	0.856	0.732
Involvement	IN1	0.710	0.873	1.553	0.450	0.772	0.493	0.845	0.715
	IN2						0.640	0.911	0.830
Attention	A1	0.737	0.851	1.974	0.623	0.652	0.285	0.702	0.501
	A2						0.462	0.835	0.697
	A3						0.473	0.876	0.768
Positive mood	PM1	0.876	0.924	2.415	0.377	0.802	0.357	0.892	0.795
	PM2						0.398	0.878	0.770
	PM3						0.363	0.917	0.840

Playfulness	P1	0.846	0.907	2.296	0.411	0.764	0.409	0.901	0.812
	P2						0.379	0.876	0.768
	P3						0.355	0.844	0.713
Imagery	IM1	0.878	0.925	2.417	0.371	0.804	0.353	0.862	0.742
	IM2						0.369	0.918	0.842
	IM3						0.392	0.910	0.828
Skill-demand balance	SD1	0.871	0.921	2.388	0.355	0.794	0.368	0.894	0.800
	SD2						0.344	0.892	0.796
	SD3						0.411	0.886	0.786
Flow	F1	0.875	0.923	2.409	0.373	0.800	0.367	0.881	0.776
	F2						0.404	0.929	0.862
	F3						0.345	0.873	0.762

¹AVE: average variance extracted.

The loadings of the items on the associated constructs exceeded the accepted threshold of 0.70 (Hair Jr, Black, Babin, & Anderson, 2010), so communalities were all greater than 0.50. In most cases, more than 70% of the variability of the items was captured by their associated latent variables (Table 2). Additionally, the AVEs of all constructs were over the minimum value of 0.50 (Hair Jr et al., 2010). These results indicated that the convergent validity of the multi-item constructs was acceptable.

To examine the discriminant validity of the measures, we considered the cross-loadings of the items and Fornell and Larcker's criterion (1981). The loadings of each item on the corresponding construct exceeded the cross-loadings on other constructs (Table 3); the AVE of each construct (Table 2) was above the highest squared correlation of that construct with any other construct (Table 4). Consequently, the discriminant validity was deemed to be also acceptable.

Table 3. Items' cross-loadings

	Profess- or com- petency	Resour- ce qual- ity	Involvement	Atten- tion	Positive mood	Playful- ness	Imagery	Skill- demand balance	Flow
PC1	0.886	0.470	0.257	0.238	0.330	0.277	0.256	0.223	0.224
PC2	0.874	0.466	0.244	0.235	0.327	0.281	0.267	0.252	0.243
PC3	0.834	0.452	0.296	0.228	0.308	0.242	0.212	0.210	0.214
RQ1	0.444	0.863	0.310	0.235	0.372	0.328	0.333	0.291	0.255
RQ2	0.510	0.920	0.316	0.271	0.415	0.374	0.371	0.331	0.294
RQ3	0.456	0.856	0.286	0.224	0.349	0.310	0.291	0.250	0.221
IN1	0.274	0.322	0.845	0.273	0.335	0.292	0.282	0.319	0.247
IN2	0.267	0.293	0.911	0.315	0.401	0.387	0.386	0.418	0.289
A1	0.206	0.197	0.211	0.702	0.223	0.232	0.204	0.181	0.280
A2	0.196	0.194	0.254	0.835	0.334	0.368	0.341	0.347	0.441
A3	0.255	0.279	0.335	0.876	0.378	0.360	0.333	0.348	0.440
PM1	0.299	0.339	0.353	0.333	0.892	0.703	0.627	0.483	0.391
PM2	0.374	0.457	0.425	0.392	0.878	0.646	0.581	0.516	0.425
PM3	0.321	0.356	0.348	0.335	0.917	0.702	0.623	0.491	0.397
P1	0.269	0.354	0.358	0.354	0.664	0.901	0.855	0.598	0.473
P2	0.266	0.340	0.333	0.342	0.702	0.876	0.730	0.535	0.420
P3	0.276	0.314	0.336	0.373	0.635	0.844	0.642	0.482	0.400
IM1	0.248	0.344	0.334	0.335	0.554	0.660	0.862	0.590	0.448
IM2	0.249	0.333	0.354	0.327	0.619	0.775	0.918	0.567	0.426
IM3	0.266	0.343	0.350	0.342	0.655	0.855	0.910	0.596	0.456
SD1	0.214	0.250	0.381	0.326	0.474	0.542	0.564	0.894	0.415

SD2	0.199	0.237	0.338	0.301	0.445	0.505	0.547	0.892	0.385
SD3	0.287	0.387	0.410	0.373	0.555	0.597	0.623	0.886	0.458
F1	0.241	0.282	0.284	0.441	0.397	0.433	0.424	0.410	0.881
F2	0.250	0.274	0.300	0.480	0.443	0.480	0.478	0.456	0.929
F3	0.214	0.229	0.237	0.394	0.372	0.410	0.421	0.402	0.873

Table 4. Squared correlation between constructs

	Profess- or com- petency	Resour- ce qual- ity	Involvement	Attention	Positive mood	Playful- ness	Imagery	Skill- demand balance	Flow
Professor competency	1.000	0.286	0.094	0.073	0.138	0.095	0.081	0.070	0.069
Resource quality	0.286	1.000	0.120	0.077	0.187	0.148	0.144	0.110	0.086
Involvement	0.094	0.120	1.000	0.113	0.177	0.154	0.149	0.181	0.094
Attention	0.073	0.077	0.113	1.000	0.158	0.165	0.139	0.142	0.241
Positive mood	0.138	0.187	0.177	0.158	1.000	0.582	0.464	0.309	0.205
Playfulness	0.095	0.148	0.154	0.165	0.582	1.000	0.729	0.382	0.244
Imagery	0.081	0.144	0.149	0.139	0.464	0.729	1.000	0.424	0.244
Skill-demand balance	0.070	0.110	0.181	0.142	0.309	0.382	0.424	1.000	0.225
Flow	0.069	0.086	0.094	0.241	0.205	0.244	0.244	0.225	1.000

Techniques for controlling common-method biases

We performed two tests so we could discard any possible effect of the common method variance on the results: Harman's one-factor test and the Bagozzi method. First, the factorial analysis showed that there were 9 components with eigenvalues greater than 1, with an explained aggregate variance of 69.86%. Second, the highest correlation among constructs was 0.85 (for *playfulness* and *imagery*), which is less than the recommended cut-off value of 0.90 (Bagozzi, Yi, & Phillips, 1991). From this we could infer that there were no significant common-method biases in our study.

Main structural model

The R^2 values of the five regressions included in the main effects model exceeded the required value of 0.30 for a moderate predictive accuracy; one of them had an R^2 higher than 0.60, which implied a high accuracy (Table 5).

Table 5. Regressions in the main effects model

Dependent variable	R^2	Independent variable	Estimates	Standard error	t -value	p -value
Positive mood	0.328	Intercept	0.000	0.0163	0.00	1.000
		Professor competency	0.120	0.0197	6.10	0.000
		Resource quality	0.225	0.0199	11.30	0.000
		Involvement	0.232	0.0182	12.80	0.000
		Attention	0.224	0.0177	12.60	0.000
Playfulness	0.598	Intercept	0.000	0.0126	0.00	1.000
		Involvement	0.063	0.0142	4.41	0.000
		Attention	0.111	0.0140	7.88	0.000
		Positive mood	0.692	0.0146	47.50	0.000
Imagery	0.733	Intercept	0.110	0.0103	0.00	1.000
		Involvement	0.061	0.0112	5.41	0.000

Skill-demand balance	0.482	Playfulness	0.831	0.0112	74.30	0.000
		Intercept	0.000	0.0143	0.00	1.000
		Involvement	0.156	0.0163	9.59	0.000
		Attention	0.093	0.0161	5.78	0.000
		Positive mood	0.107	0.0228	4.71	0.000
Flow	0.381	Playfulness	0.091	0.0315	2.89	0.004
		Imagery	0.406	0.0278	14.6	0.000
		Intercept	0.000	0.0157	0.00	1.000
		Professor competency	0.048	0.0171	2.80	0.005
		Attention	0.304	0.0177	17.20	0.000
		Positive mood	0.059	0.0252	2.33	0.020
		Playfulness	0.078	0.0345	2.28	0.023
		Imagery	0.152	0.0316	4.81	0.000
		Skill-demand balance	0.166	0.0214	7.77	0.000

As the data did not follow a multivariate normal distribution, the significance of each path coefficient was tested with bootstrapping (300 resamples). After p -values were calculated for all the statistics, we used the Benjamini-Hochberg method (Benjamini & Hochberg, 1995) to correct the alpha error ($\alpha = 0.05$) for multiple hypothesis testing. For a level of confidence of 95%, no confidence intervals included 0 (Table 6), which indicated that the path coefficients were significantly different from 0. Based on these results, we could assert that the proposed causal links in the main effects model were all statistically different from 0, and therefore that the relationships proposed in H1-H8 were supported (Figure 2).

Table 6. Bootstrapping results for path coefficients

Causal hypotheses	Original	Bootstrapping mean	Standard error	p -value	Benjamini-Hochberg α adjustment
H1a (+) Professor competency \rightarrow Positive mood	0.120	0.122	0.020	0.000	0.028
H1b (+) Professor competency \rightarrow Flow	0.048	0.048	0.019	0.013	0.043
H2 (+) Resource quality \rightarrow Positive mood	0.225	0.224	0.021	0.000	0.018
H3a (+) Involvement \rightarrow Skill-demand balance	0.156	0.156	0.017	0.000	0.020
H3b (+) Involvement \rightarrow Imagery	0.060	0.061	0.011	0.000	0.033
H3c (+) Involvement \rightarrow Playfulness	0.063	0.064	0.016	0.000	0.040
H3d (+) Involvement \rightarrow Positive mood	0.232	0.231	0.020	0.000	0.013
H4a (+) Attention \rightarrow Skill-demand balance	0.093	0.094	0.017	0.000	0.030
H4b (+) Attention \rightarrow Playfulness	0.111	0.110	0.015	0.000	0.025
H4c (+) Attention \rightarrow Positive mood	0.224	0.225	0.020	0.000	0.015
H4d (+) Attention \rightarrow Flow	0.304	0.305	0.020	0.000	0.008
H5a (+) Positive mood \rightarrow Playfulness	0.692	0.694	0.013	0.000	0.035
H5b (+) Positive mood \rightarrow Skill-demand balance	0.107	0.109	0.023	0.000	0.003
H5c (+) Positive mood \rightarrow Flow	0.059	0.060	0.030	0.047	0.048
H6a (+) Playfulness \rightarrow Imagery	0.831	0.831	0.008	0.000	0.005
H6b (+) Playfulness \rightarrow Skill-demand balance	0.091	0.091	0.037	0.019	0.045
H6c (+) Playfulness \rightarrow Flow	0.078	0.074	0.038	0.049	0.050
H7a (+) Imagery \rightarrow Skill-demand balance	0.406	0.406	0.034	0.000	0.010
H7b (+) Imagery \rightarrow Flow	0.152	0.156	0.037	0.000	0.038
H8 (+) Skill-demand balance \rightarrow Flow	0.166	0.166	0.020	0.000	0.023

Multi-group analyses

We examined the possible moderating effects of individuals' differences in terms of *gender* and *academic performance* using a multi-group comparison analysis (Sarstedt, Henseler, & Ringle, 2011). This led us, firstly, to divide the sample into four subsamples,

namely the female subsample, the male subsample, the subsample of high-performing students (those whose final marks' mean was equal to or greater than 4), and the subsample of low-performing students (final mark mean of below 4). Significant differences for *age* were discarded after an exploratory ANOVA analysis.

We tested the significance of the individual's differences in *gender* using the bootstrap *t*-test, also tagged as the parametric approach (Henseler, 2007). Table 7 shows the *t*-statistic values for the difference of the coefficients and the associated *p*-values after running 300 resamples, and with the Benjamini-Hochberg α -error adjustment verified. The results revealed that moderating hypotheses H9a-H9e are supported.

Table 7. Gender multi-group analysis

Moderation hypotheses	Global	Females	Males	Absolute value of the difference	<i>t</i> -statistic	Degrees of freedom	<i>p</i> -value	Benjamini-Hochberg α adjustment
H9a Professor competency → Flow	0.048	0.010	0.088	0.078	2.538	2528	0.006	0.010
H9b Positive mood → Flow	0.060	0.111	0.024	0.087	1.690	2528	0.046	0.050
H9c Playfulness → Skill-demand balance	0.091	0.110	0.030	0.080	1.847	2528	0.032	0.040
H9d Imagery → Skill-demand balance	0.406	0.481	0.358	0.122	1.923	2528	0.027	0.030
H9e Skill-demand balance →Flow	0.166	0.093	0.213	0.120	2.526	2528	0.006	0.020

Likewise, we used the bootstrap *t*-test approach to confirm interaction of inter-individual variability in *academic performance* (see Table 8). After the Benjamini-Hochberg α -error adjustment, results showed significant differences in the paths considered in H10a-H10h.

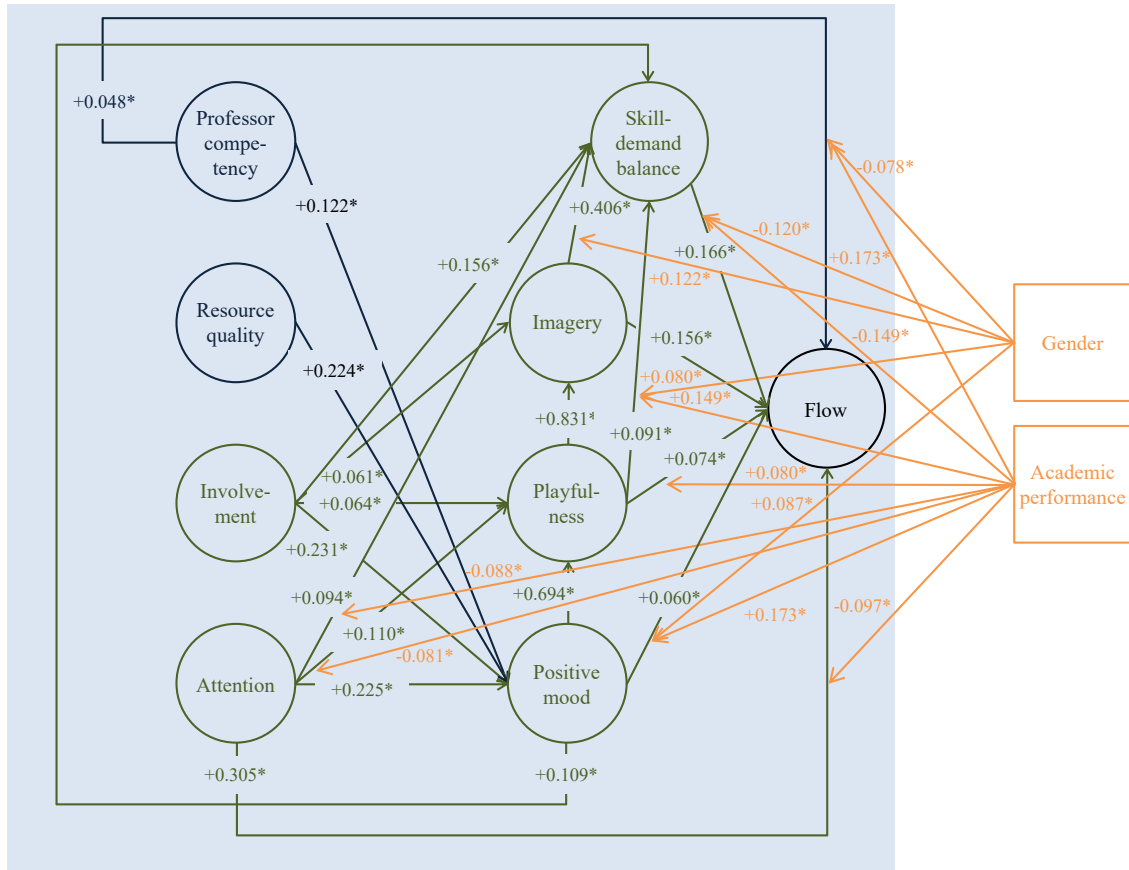
Table 8. Academic performance multi-group analysis

Moderation hypotheses	Global	Low-performing students	High-performing students	Absolute value of the difference	<i>t</i> -statistic	Degrees of freedom	<i>p</i> -value	Benjamini-Hochberg α adjustment
H10a Professor competency → Flow	0.048	0.240	0.067	0.173	2.239	2528	0.012	0.013
H10b Attention → Skill-demand balance	0.093	0.085	0.173	0.088	1.690	2528	0.046	0.050
H10c Attention → Playfulness	0.111	0.101	0.181	0.081	1.847	2528	0.030	0.031
H10d Attention → Flow	0.304	0.291	0.388	0.097	1.776	2528	0.038	0.044
H10e Positive mood→ Flow	0.059	0.265	0.092	0.173	2.239	2528	0.001	0.006
H10f Playfulness →Skill-demand balance	0.091	0.154	0.005	0.149	2.184	2528	0.015	0.025
H10g Playfulness →Flow	0.078	0.090	0.009	0.080	1.847	2528	0.033	0.038
H10h Skill-demand balance →Flow	0.166	0.145	0.294	0.149	2.184	2528	0.015	0.019

Figure 2 depicts the results corresponding to the path coefficients of the main effects model and the moderating effects of *gender* and *academic performance*. Values for the moderating effects indicate the differences between the groups. The positive signs show that casual relationships are significantly stronger among females (in the case of *gender*) and low-performing students (in the case of *academic performance*). Conversely,

negative signs indicate that the causal path are stronger for males or for high-performing students.

Figure 2. Main and moderating effects model results



*Significant with Benjamini-Hochberg correction at 0.05 level.

Positive signs in the moderating effect values indicate stronger causal relationships for females (vs. males) and low-performing students (vs. high-performing students).

Conclusions

Contributions to research

From the viewpoint of human-computer interaction issues, the relevance of research in the specific context of e-learning could be questioned. Put another way, if personalised e-learning is *only* a particular online setting for individuals' activities, is it of interest to study flow in this specific environment? However, online flow is connected particularly to the activity that is performed. This implies that assessments focused on specific types of online activities can better tackle flow.

Our study has various meaningful implications for researchers. We provide evidence that, in e-learning, flow is prompted by the simultaneous effect of educational elements, strictly related to the specific context in which flow occurs (i.e. a professor's competency, didactic resources' quality), as well as psychological factors emerging during the learning process. On the one hand, these findings lend support to the abovementioned idea that models of flow centred on the particular context of online education can capture correctly the phenomena in play. On the other hand, our results are aligned with the predictive

power that previous studies of flow have accredited to the psychological constructs of attention (Rodríguez-Ardura & Meseguer-Artola, 2017; Rodríguez-Ardura et al., 2016), skill-demand balance (Engeser & Rheinberg, 2008; Rodríguez-Ardura & Meseguer-Artola, 2017), imagery (Rodríguez-Ardura & Meseguer-Artola, 2016a, 2018a), and playfulness (Hsu et al., 2012; Jin, 2012).

The present research fills a gap in the e-learning literature, which has placed special emphasis on explaining the affective effects of flow (Rodríguez-Ardura & Meseguer-Artola, 2017), but which has not considered that the direction of the causality can be the other way around, too. We offer evidence of positive mood being a direct driver of flow and show that mood also has remarkable potential for fostering playful modes, which in turn facilitate mental imagery and e-learners' feelings of compatibility between their skills and the educational demands, thus unleashing flow.

We extend to the domain of flow previous findings about the explicative value of involvement in attitude formation. Flow literature usually conceives flow states as a powerful intrinsic motivational force that channels the individual's behavioural intention (Csikszentmihalyi & Rathunde, 1993), yet it has not examined sufficiently how the importance that the individual places on the ongoing task influences the formation of flow. This study has detected empirically this connection and has shown that it is mediated by imagery, playfulness, positive mood, and skill-demand balance.

Another important contribution of this research is the examination of the interaction effects provoked by individuals' differences in gender and academic performance. Although some previous studies have investigated the role of gender, they have not determined whether the effects of gender emerge when the role of academic performance is also considered. We do precisely that, giving evidence that flow modelling should consider the moderating effects provoked by gender and academic performance, which are both interaction drivers.

First, we observed a few yet relevant differences between female and male e-learners regarding the formation of flow. While some studies have assumed that females and males experience flow for similar reasons (Russell, 2001; Stavrou et al., 2007), we have found sufficient grounds to suggest that gender differences exist for certain key relationships related to flow. Given our results, flow states, in females, are comparatively more driven by positive emotions and subjective processes, such as playfulness and imagery, which are related with non-analytical elaboration (Thompson & Hamilton, 2006). This finding would appear to agree with previous literature, based on psychology and consumer behaviour, which portrays women as being more inclined to engage in relational, imagery-laced interpretations; as a result, they process multiple pieces of information and deploy subjective and more comprehensive processing (Meyers-Levy & Loken, 2015; Putrevu, 2001). By contrast, in males, competence factors – such as professor competency and skill-demand balance – carry relatively heavy weight in flow formation. This is further in sync with examinations of the behavioural intention to use e-learning (Padilla-Meléndez, del Águila-Obra, & Garrido-Moreno, 2013), which have reported that functional, analytical factors are relatively more significant for males while, for females, it is playfulness that accounts for them having more positive attitudes.

Second, the findings regarding the moderating effects of academic performance lead us to assert that high-performing e-learners are less dependent on the professor's support, so, for them, self-enhancement learning strategies play a more important role in flow

formation. They are relatively more capable of concentrating deeply on the learning activities, and effectively use their own capabilities to address the demands raised by the education environment. By contrast, low-performing e-learners tend to experience flow to a greater extent with the help of their professors and via less self-regulatory strategies. Added to this, academic performance moderates the effects of positive emotions and playfulness on flow, so much so that emotions have a stronger impact on flow at lower levels of academic performance.

Practical implications

Apart from supporting and extending theory, our findings are useful to scholars and practitioners in e-learning as well as public authorities that are willing to promote initiatives aimed at creating opportunities of flow in personalised education environments. This is a key consideration, as earmarking resources might be wasteful if they fail to unleash effectively higher levels of flow experiences.

This study presents professors, higher education institutions, and public authorities involved in online education with a clear picture of the states of flow and their determinants for personalised e-learning settings. Particularly, it shows that professors' competence and the quality of the didactic resources provided to students, along with psychological processes that come about during the teaching-learning process (the student's involvement, attention, positive emotions, playfulness, imagery and a balance of the student's skills and the demands of the education environment), are all major determinants of the e-learner's flow experiences in personalised online education.

Based on this, public authorities and higher education institutions looking to carry out initiatives to facilitate students' experiences of flow should keep the following suggestions in mind:

- Invest in up-to-date and quality didactic resources that are well-adapted to students' needs.
- Improve faculty members' teaching competency with the aim of making them more effective in solving students' queries and in mastering the courses' contents.
- Promote learning environments that enhance students' involvement, attention and satisfaction, and that also facilitate their perceptions of playfulness and imagery.

Professors' teaching initiatives and didactic resources are often designed to promote deep learning, be it through intense concentration, critical thinking or analytical elaboration. However, this study shows that there are multiple drivers, not necessarily related to self-regulatory learning strategies, that facilitate flow. To put it differently, our model provides statistically significant paths and a variance explanation for each gender and academic performance grouping, which indicates that the model is relevant for both females and males and high- and low-performing students. This is important since, whatever the individual differences may be among students, mental imagery, playfulness and emotion play a key part in the emergence of flow experiences. Therefore, a potential strategy for university leaders and professors is to promote imagery, playfulness and emotion as compatible with the achievement of optimal learning experiences. Consistent with this, e-learners should be provided with resources and instruments that enable this.

Our study also shows that the relative importance of some education-related and subjective determinants of flow varies among female and male students, and at low and high levels of academic performance. Some drivers of flow are more crucial for women (e.g. imagery and skill-demand balance, playfulness and skill-demand balance, positive mood and flow) and low-performing students (e.g. playfulness and skill-demand balance, playfulness and flow, positive mood and flow). Furthermore, the importance of the professor's role as an expert advisor varies among e-learners, being more relevant for male students and for lower-level performers. To put it simply, those e-learners relatively best able to maximize episodes of flow through strategies that encourage deep learning are men and high-performing students.

Precisely because the digital technology that makes possible the personalisation of e-learning environments can adapt the teaching-learning process to the students' various characteristics and needs, it can be of great help in facilitating the variety of ways in which students experience flow. Therefore, personalised e-learning technologies should be used by both professors and practitioners in e-learning to provide students with the most appropriate teaching methods and resources in each case. Key protagonists of e-learning teaching should be aware of the range of ways in which flow is elicited, and be furnished with information related to the e-learners' gender and academic performance. Based on this information, they should ensure that the activities and learning resources adapt to the student's diverse needs and elicit flow.

Specific practices and venues to facilitate episodes of flow, especially among women and lower-performing students, are those that enhance the learning process and make it appealing and enjoyable and create positive feelings. To foster flow among members of these collectives, university leaders and professors might take advantage of training methods capable of increasing the e-learner's imagination and producing imagery and playfulness (e.g. integrating didactic novels, complex animated films, audiovisual narratives, simulations and didactic games in the set of educational tools).

Limitations and further research

This paper has two major limitations that, in turn, offer opportunities for further research. First, this is non-longitudinal research, so it cannot be known if the relationships reported here will change over time, encompassing the evolution of new e-learning technologies for personalisation. Hence, future studies could gather information over a longer timeframe and tackle whether causal and moderating paths considered in our model could be extended to the completion of the entire university degree.

Second, this study is restricted to one purely online university. Even though we used a sample of sufficient size and representativeness, which includes students involved in a wide range of programmes, it would be desirable that further research contribute to the improvement of this model and the generalization of the results.

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