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Enhancing e-learning in old age

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This study assesses the efficacy of e-learning content that has been adapted to cognitive styles in a sample of older adults. Since the personalisation of learning content has been generally associated with learning processes, it was hypothesised that intrinsic motivation, metacognition and self-regulated learning and learning strategies would interact in affecting learning outcomes. A sample of 106 older adults attending the University of the Third Age was divided into two groups on the basis of the learning approach (face-to-face vs. online). Participants were asked to fill out questionnaires that assessed cognitive styles, learning processes and learning outcomes. A factorial ANOVA and path analysis were used. Findings confirmed the efficacy of adapting e-learning content to older adults' cognitive styles, as well as the role played by intrinsic motivation, metacognition and self-regulated learning, and learning strategies in determining learning outcomes. Consequently, this research supports the benefits of e-learning environments in facilitating learning processes and in encouraging older adults to engage in learning activities.

Keywords: *e-learning, cognitive styles, learning processes, older adults*

Introduction

The rapidly growing older population has led researchers to further investigate the cognitive domains of intelligence, learning, memory and attention, which normally change during ageing, and their implications for maintaining a good quality of life (Simpson, Camfield, Pipingas, Macpherson & Stough, 2012; Williams & Kemper, 2010). Universities of the Third Age offer education programs aimed at promoting psychological and social wellbeing. There are a range of stereotypes about older people and their lifelong learning habits; for example, that they have low or no interest, experience anxiety or lack self-confidence (Chang, McAllister & McCaslin, 2014; Morrell, Mayhorn & Echt, 2004). These stereotypes are out of touch with reality. While there is general agreement in the literature that online educational programs can be effective interventions that foster intellectual stimulation and personal fulfilment (González, Ramírez & Viadel, 2012, 2015; Goodwin, 2013; Wandke, Sengpiel & Sönksen, 2012). Older people take more time to learn; make more mistakes and need more support.

When teaching technology to older people, teaching methods often draw on their other abilities and experiences in order to reduce their anxiety about using computers (Patsoule & Koutsabasis, 2014), especially in the first stages of learning (Kim, 2008). Consequently, even though e-learning seems to be an appropriate tool to support learning; for example, by allowing for individualised learning content and flexible delivery (Hernández-Encuentra, Pousada & Gómez-Zúñiga, 2009), an improvement in cognitive function is not enough to guarantee outcomes in terms of actual computer use for older adults. Other attitudinal variables must also be investigated (Chaffin & Harlow, 2005) such as cognitive styles, motivation, metacognition and self-regulated learning.

Background of study

Since the 1990s, an increasing number of studies have highlighted the beneficial effects of computer usage on personal and social factors such as social interaction, loneliness, self-esteem, self-efficacy, as well as on cognitive capacity for cognitive health in later life (Czaja, 1996, 1997; Jones & Bayen, 1998; McConatha, McConatha & Dermigny, 1994; Mead, Batsakes, Fisk & Mykityshyn, 1999; Morrell, Mayhorn & Bennett, 2000; Rajagopal & Thilakavalli, 2014). Investigations on intellectually engaging activities have shown that there is no prototypical "elderly computer user" but there is a heterogeneity of individual characteristics, from cognitive to motivational states. In terms of the different ways people process information, older people are said to be more internally motivated, problem-orientated and self-directed than adolescents and young adults (Knowles, Holton & Swanson, 2005; Straka, 2000). As a result, "it is important to develop contextual knowledge about the users for whom the system is being designed" (Dickinson & Hill, 2007, p. 616) in order to motivate and reduce the barriers (anxiety, lack of interest and negative attitudes towards technology) that hinder learning processes in old age (Savelsberg, Pignata & Weckert, 2017). Accordingly, as cognitive styles seem to be key factors that affect older people's learning patterns, they should be taken into account in the design of e-learning systems.

Cognitive styles are generally defined as individuals' habitual or typical ways of experiencing situations, perceiving, organising, retrieving, processing information, and solving problems (Chen & Liu, 2008; Messick, 1984; Riding & Rayner, 1998; Sternberg & Grigorenko, 1997). Clustered in a considerable array of dimensions, cognitive styles are often understood as opposing poles occupying opposite ends of a behavioural continuum, such as field-dependent vs. field-independent (Witkin, 1962); reflective vs. impulsive (Kagan, 1965); wholist vs. serialist (Pask, 1976, 1988); verbaliser vs. visualiser (Paivio, 1971). In the 1990s, two major hypotheses were formulated, one arguing a superordinate unified structure based on an analytical-intuitive (holistic) style in relation to the hemispheric lateralisation of the brain (Allinson & Hayes, 1996; Hayes & Allinson, 1998), the other affirming two principal orthogonal cognitive style families, wholistic-analytic and verbaliser–imager, grouped on the basis of the correlations among different cognitive styles, methods of assessment and effects on behaviour (Riding & Cheema, 1991).

Using the structure of government as a metaphor for describing individual differences in the regulation of intellectual activity, labelled as thinking style, Sternberg (1985, 1997) proposed a model including 13 styles. Among them, he distinguished the individuals who use a global thinking style from those who use an analytic thinking style.

Conceiving cognitive style as an individual's constant approach to organising and representing information, Riding (1991) developed the first computerised test to assess the wholist–analytic and verbaliser–imager cognitive style dimensions in an integrated manner. From this perspective, Cornoldi and De Beni (1997, 2001) confirmed the constant characteristic of cognitive styles, although they admitted a specific cognitive plasticity. Individuals fall on different positions along the style continuum and, when facing a task, can prefer a style other than their own (De Beni, Moè & Cornoldi, 2003). Cornoldi and De Beni's model of cognitive style foresaw four dimensions:

1. The global style that consists in a preference for organising and elaborating information as a whole;
2. The analytical style that refers to a tendency to analyse information into its parts;
3. The verbal style that concerns a preference for representing information initially verbally and then in mental pictures;
4. The visual style that involves a tendency to represent information as images and to learn best from visual displays.

As for e-learning environments, the personalisation of learning contents to students' cognitive styles may facilitate the memorisation of items and their recall, especially when learners are older adults. However, personalisation alone may not be enough. Further factors related to learning processes, such as motivation, metacognition and self-regulated learning are needed (Castel, Murayama, Friedman, McGillivray & Link, 2013; Kumar, Singh & Ahuja, 2017; Monacis, de Palo, Sinatra, & Berzonsky, 2016; Villar, Pinazo, Triado, Celdran & Sole, 2010; Villar, Triado, Pinazo, Celdran & Sole, 2010b).

Even though past studies have shown that motivation is a central component of personal health and wellbeing, as well as one of the key factors affecting learning in any environment (Lim, 2004; Miltiadou & Savenye, 2003; Schunk, Pintrich & Meece, 2008), it has not yet received enough attention in online learning (Fırat, Kılınç & Yüzer, 2017, p. 65; Jones & Issroff, 2005) because educationists and researchers have focussed more on the cognitive processes in these environments than on the affective and socio-emotional processes (Chen & Jang, 2010). In this regard, intrinsic motivation has been referred to as engaging in an activity for its own sake, for the enjoyment, interest or natural fulfilment of curiosity throughout life (Barry & King, 2000; Ryan, 1995; Ryan & Deci, 2000). It has been identified as the main source that triggers and maintains learning processes especially in e-learning environments (Cerasoli, Nicklin & Ford, 2014; Hartnett, George & Dron, 2014).

There has been general agreement that intrinsically motivated learners exhibit behaviour patterns including self-regulation, exploration, reflexion, deep level learning (i.e. understanding instead of learning by heart; Marton & Säljö, 1984), metacognitive regulation and strategy use (Boekaerts & Minnaert, 2003; Martens, Gulikers & Bastiaens, 2004; Ryan & Deci, 2000; Schunk & Ertmer, 2000; Zimmerman, 1995). Self-Regulated Learning (SRL) (Pintrich, 2000; Zimmerman, 2000) refers to an inclusive perspective that comprises cognitive, motivational, affective and social-contextual factors, through which individuals set their goals in relation to learning and ensure that these goals are achieved (Efklides, 2011). One of the components of SRL is metacognition, which has been generally defined as the knowledge of one's own cognitive process (Flavell, 1976), involving monitoring and control functions. Self-regulated learners consider learning as a controllable process and they tend to use various cognitive and metacognitive strategies, such as planning, organising, and monitoring (Zimmerman, 2000). Given their particular meaning, these learning processes have received much research attention in relation to academic achievement in traditional settings (Abar & Loke, 2010; Efklides, 2011; Mega, Ronconi & De Beni, 2014) and in online environments (Broadbent & Poon, 2015; Greene & Azevedo, 2010). As for age differences, the above-mentioned learning processes have been found to be similar in both younger and older adults (Castel et al., 2013; McGillivray & Castel, 2017; Price, Hertzog & Dunlosky, 2010).

The present study

The first aim of this study was to assess the effects of adapting learning content to cognitive styles on learning outcomes in a sample of older adults. The learning content was delivered by the Adaptive Hypermedia Learning Systems (AHLSs) and recorded by a Sharable Content Object Reference Model (SCORM).

As the adaptation of the learning content is believed to be associated with learning processes, it was hypothesised that intrinsic motivation, metacognition and self-regulated learning, and learning strategies would interact with learning content adaptation in affecting learning outcomes. More specifically, it was expected that:

1. e-learners would achieve better learning outcomes than face-to-face learners;
2. e-learners with higher levels of intrinsic motivation, metacognition and self-regulated learning, and learning strategies would achieve better learning outcomes than e-learners with low levels;
3. e-learners with higher levels of intrinsic motivation, metacognition and self-regulated learning, and learning strategies would achieve better learning outcomes than face-to-face learners with both higher and lower levels.

The second aim of this research was to assess the mediating role of metacognition and self-regulated learning and learning strategies between intrinsic motivation and learning outcomes using path analysis with observed variables. It was expected that:

1. Intrinsic motivation would have positive effects on learning outcomes and, in turn, would promote metacognition and self-regulated learning;
2. Metacognition and self-regulated learning would positively affect learning strategies and learning outcomes;
3. Learning strategies would improve learning outcomes.

Methods

Sample and procedure

The sample comprised 106 older adults (55 females; Mean age = 65.7, SD = 5.17) attending the University of the Third Age. They were divided into two groups on the basis of the learning approach (face-to-face vs. online). Twelve respondents were excluded from subsequent analyses because they did not complete the procedure. The final sample was composed of 94 participants (50 females and 44 males), who filled out a series of questionnaires in approximately 25 minutes during an ordinary lesson. E-learners received the online questionnaires, whereas face-to-face learners completed the paper–pencil version.

The experimental procedure consisted in the following steps:

1. Administration of questionnaires;
2. Presentation of the learning units: e-learners received the units tailored to their cognitive styles, whereas face-to-face learners received the same units without adaptation;
3. Final examination to verify the achievement of the learning outcomes.

The learning units were presented in an adaptive learning sequence system allowing the definition of a process able to build an interoperable learning object (LO) that could be used or adapted for use in multiple e-learning environments. The learning content was divided into different units given the high level of granularity of the SCORM standard. Each unit was implemented in a Shareable Content Object (SCO) for two reasons: it is the smallest unit that can be launched and traced by the Learning Management System (LMS); and the Sequencing and Navigation (SN) rules are able to choose among these components, thus offering different navigational paths. Two types of SCO (the unit and the reinforcement) were constructed for each topic and the learning content was presented according to four cognitive styles (global, analytical, verbal and visual). Consequently, a total of eight SCOs were built for each unit. The units were followed by a multiple choice test to verify the comprehension level of the learner. If the test failed, the same learning content was provided in the same cognitive style but using a different presentation mode. A second test followed. The navigation path supported by the same cognitive style continued if the learner passed the test. Differently, the same content was given by adapting the learning content to the second preferred cognitive style.

Measures

The *AMOS Cognitive Style Questionnaire* (CSQ) (De Beni, Moè & Cornoldi, 2003) was used to assess the cognitive style on the global–analytic and verbal–imagery dimensions. The test encompasses two parts, each containing nine items rated on a 5-point Likert scale (1 = *Strongly disagree*, 5 = *Strongly agree*). The first part measures the preference toward an analytic or a global approach. Respondents have to observe a figure inspired by the Rey-Osterrieth Complex Figure test for 30 seconds, then they are asked to reproduce the stimulus figure from memory. Subsequently, participants answer the nine items to indicate their preference for analytical (four items) or global (five items) style. In this study, the reliability of this dimension proved to be good (Cronbach's alpha = 0.798). The second part of the test refers to the preference toward verbal or visual cognitive styles: after viewing twelve words and twelve images, participants answer the nine items referring to their inclination toward imagery or verbal style. Also in this case, the reliability was good (Cronbach's alpha = 0.810). The completion of the questionnaire took approximately 25 minutes. The cognitive style was determined by assigning positive and negative scores to each item on the basis of the scheme suggested by the CSQ and then by calculating: (a) the total sum of the scores for each cognitive style (analytic vs. global and visual vs. verbal); (b) the standard deviation to estimate the amount of variance of the scores obtained from the sum; (c) the high values (HV; $x + \sigma$) and the low values (LV; $x - \sigma$). Visual and analytic styles were identified when the sum of the positive and negative scores was less than the LV, whereas verbal and global styles were identified when the sum was higher than the HV.

Intrinsic motivation, metacognition and self-regulated learning, and learning strategies were assessed by using the subscales of the *Questionnaire on the Processes of Learning* (QPL; Polácek, 2005), D-form, the Intrinsic Motivation Scale (IMS), the Metacognition and Self-Regulated Learning Scale (MeSRLS), and the Learning Strategies Scale (LSS). Each subscale comprises 18 items rated on a 5-point Likert scale (from 1 = *Strongly disagree* to 5 = *Strongly agree*).

The IMS measures individuals' interest, joyful involvement, perceived competence, usefulness, and concentrated attention considered as positive predictors of autonomy. Students who are intrinsically motivated tend to engage in activities for no reward other than interest and enjoyment (Deci, 1972; Lepper & Malone, 1987). The scale showed high reliability (Cronbach's alpha = 0.851).

The MeSRLS measures two components of a single factor: metacognitive ability and self-management of learning. Metacognition refers to the knowledge of one's own cognitive processes, whereas self-regulated learning is defined as the process by which learners activate cognitions, affects and behaviours orientated toward the achievement of learning goals. Cronbach's alpha of the scale proved to be high (α = 0.813).

The LSS assesses the techniques used by students to learn. They consist of choosing important information, taking productive notes and answering questions. The scale showed good levels of reliability (Cronbach's alpha = 0.786).

The *learning units*, each comprising a maximum of 7 chunks, were elaborated on the basis of the previously described cognitive styles. The topic of the units concerned psychology. As for the global style, the text consisted of 15 lines with keywords in bold to underline the most relevant parts. With regard to the analytic style, the content consisted of maximum 25 lines with a list of the main elements of the unit; the visual style foresaw the presentation of the content with coloured characters, drawings and cartoons. As for the verbal style, the written text was accompanied by an oral recording. Each unit included a total of 16 SCOs and the whole package amounted to 80 SCOs.

The comprehension tests involved 30 multiple-choice questions about the content of the units. After the presentation of each unit, participants had 30 minutes to complete the test. The scores ranged from 18 to 30: scores lower than 18 indicated the exam failure. Participants took a final exam after three weeks to evaluate their learning outcomes.

Data analyses

Statistical analyses comprised independent samples t-test to verify gender differences on the scores of the variables taken into account; a 2x2x2x2 factorial Analysis of Variance (ANOVA) to compare the main and interaction effects of Learning Objects Adaptation (LOA; adaptation vs. non adaptation), Intrinsic Motivation (IM; high vs. low), Metacognition and Self-regulated Learning (MeSRL; high vs. low) and Learning Strategies (LS; high vs. low) on learning outcomes. The scores of IM, MeSRL and LS were divided into high and low after calculating a cut-off value; (3) a path analysis with observed variables to test the indirect effects of MeSRL and LS between IM and learning outcomes. The model fit was examined using the chi-squared test ($\chi2$) and its degree of freedom, the Root Mean Square Error of Approximation (RMSEA; values of 0.08 or less) and its 90% confidence interval (90% CI), the Comparative Fit Index (CFI; values greater than or equal to

0.95), and the Standardized Root Mean Square Residuals (SRMR; values of 0.08 or less) (Browne & Cudeck, 1993; Hu & Bentler, 1999).

Analyses were carried out using SPSS 20.0 for Windows and MPlus 8.

Results

Gender differences were found in the scores of MeSRL and LS between males, t(92) = 3.125, *p* = 0.000, and females, t(92) = 2.147, *p* = 0.002. Specifically, females obtained higher scores than males in MeSRL (M = 26.32 and M = 25.63, respectively), whereas males obtained higher scores in LS (M = 24.28 and M = 23.12, respectively).

As for the cognitive styles, 24 learners were identified as global, 22 as analytics, 23 as verbalisers, and 25 as visualisers. The total sample was evenly divided into two groups: e-learners and face-to-face learners. Results of the factorial ANOVA revealed significant main effects of learning objects adaptation, F(1,64) = 14.636, *p* = 0.012, partial η2 = 0.250, metacognition and self-regulated learning, F(1,64) = 2.625, *p* = 0.001, partial η2 = 0.192, intrinsic motivation, F(1,64) = 13.324, *p* = 0.003, partial η2 = 0.270, and learning strategies, F(1,64) = 7.499, *p* = 0.020, partial η2 = 0.102, on learning outcomes. That is, statistically significant differences were observed in learning outcomes between e-learners and face-to-face learners, and between participants with high and low levels of intrinsic motivation, metacognition and learning strategies. Post-hoc analyses indicated that e-learners obtained higher scores (M = 28.49) than face-to-face learners (M = 26.59) in the final exam. Learners with high intrinsic motivation gained higher scores (M = 28.77) than those with low levels of intrinsic motivation. Learners with high levels of metacognition and self-regulated learning showed higher scores (M = 26.23) than those with low levels of metacognition (M = 24.36). Learners with high levels of learning strategies scored higher (M = 25.71) than those with low levels of learning strategies (M = 23.62).

Interaction effects were also observed. In particular, the interaction of learning objects adaptation with intrinsic motivation, F(1,64) = 5.724, *p* = 0.005, partial η2 = 0.178, and with metacognition and self-regulated learning, F(1,64) = 9.424, *p* = 0.015, partial η2 = 0.226, significantly affected learning outcomes. Differences in the scores were observed between e-learners and face-to-face learners with low levels of intrinsic motivation: e-learners obtained higher scores (M = 27.35) than face-to-face learners (M = 24.21) both with low levels of intrinsic motivation. Moreover, statistically significant differences in learning outcomes were found between e-learners and face-to-face learners both with high levels of metacognition and self-regulated learning: e-learners with high levels of metacognition obtained higher scores (M = 25.55) than face-to-face learners with high levels of metacognition.

Path analyses were performed to test the multivariate relationships between the variables. According to the hypothesised model, intrinsic motivation predicted metacognition and self-regulated learning, which, in turn, predicted learning outcomes. Moreover, the construct of metacognition and self-regulated learning was assumed as a predictor of learning strategies. Fit indices of the model indicated an excellent fit to the data, $\chi 2 = 2.263$, df = 1, $p = 0.132$; RMSEA = 0.056, 90% C.I. = 0.005 - 0.096; CFI = 0.987; SRMR = 0.026. As expected, intrinsic motivation positively predicted learning outcomes and metacognition and self-regulated learning which, in turn, positively predicted learning strategies and learning outcomes. Standardised beta coefficients are shown in Figure 1. With regard to the indirect effects, results suggested that learning outcomes were indirectly predicted by intrinsic motivation via metacognition and self-regulated learning ($\beta = 0.377$, $p = 0.003$), and by metacognition via learning strategies ($\beta = 0.285$, $p = 0.020$). Moreover, learning strategies were indirectly predicted by intrinsic motivation via metacognition and self-regulated learning ($\beta = 0.427$, $p = 0.003$). The model explained 48.2% of the variance of learning outcomes, 31.3% of the variance of metacognition and self-regulated learning, and 23.9% of the variance of the learning strategies.

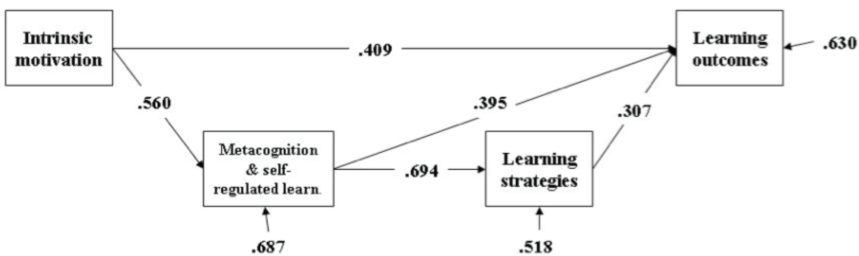

Figure 1: *Path diagram of the relationships between intrinsic motivation, metacognition and self-regulated learning, learning strategies, and learning outcomes with standardised parameter estimates (paths were significant at p < .05).*

Discussion

This research provided several key results that expanded the understanding of how individual differences in cognitive styles affect learning outcomes, even in old age. First, findings from factorial analysis of variance confirmed the efficacy of the adaptation of learning contents to older learners' cognitive styles on learning outcomes, together with intrinsic motivation, metacognition and self-regulated learning, and learning strategies. Consistently with previous studies carried out with young students (de Palo, Sinatra, Tanucci, Monacis, Di Bitonto, Roselli & Rossano, 2012; Di Bitonto, Roselli, Rossano, Monacis, & Sinatra, 2010; Monacis, Finamore, Sinatra, Di Bitonto, Roselli & Rossano, 2009), learning tailored according to cognitive styles and offered in an e-learning environment facilitates and improves academic performances. This is true in the sample of older adults who may require a learning environment that gives priority to specific information and activates effective control operations in learning. As for learning strategies, findings confirmed the role of intrinsic motivation, metacognition and self-regulated learning, and learning strategies in enhancing learning outcomes. Surprisingly, when considering the interaction effects, results indicated that older e-learners with low levels of intrinsic motivation showed better learning performances; that is, although they showed a decreased interest and involvement in learning, their learning outcomes were better when learning contents were adapted to the cognitive styles and provided in an e-learning environment. Conversely, learning outcomes were greater when learners with high levels of metacognition and self-regulated learning obtained the adaptation of learning contents in the e-learning environment. Hence, results further confirmed the efficacy of the AHLSs tailored to participants' cognitive styles in interaction with the knowledge of their own cognitive process and the control of their learning process. These findings corroborated the potential benefits of adaptive e-learning environments in enhancing assimilation of learning content, in reducing forgetfulness, in motivating and providing learners with the possibility to develop autonomous learning strategies (Al-Azawei & Badii, 2014). The increasingly heightened awareness of such benefits was also motivated by the difficulty of individualising learning at a "massive" scale through traditional approaches, especially because of the heterogeneity of the target population (i.e., younger and older adults) participating in lifelong learning activities (Paramythis & Loidl-Reisinger, 2003).

A further goal of the present research was to examine the relationships between specific learning processes, such as intrinsic motivation, metacognition and self-regulated learning, learning strategies, and learning outcomes in older adults. Results from the path analysis indicated, first, that higher levels of intrinsic motivation, i.e., the tendency to participate in learning activities for curiosity, interest and satisfaction purposes, determined better learning outcomes as well as increased metacognition and self-regulated learning, thereby confirming the specific literature: the rational and affective involvement in the learning process may foster students' use of cognitive and metacognitive strategies to plan, organise, and monitor the process itself (Boekaerts & Minnaert, 2003; Martens, Gulikers & Bastiaens, 2004). Second, learning achievement and the effective use of learning strategies depended directly and strongly on metacognitive processes. However, the weaker indirect effect observed between metacognition and learning outcomes through learning strategies indicated that knowledge and regulation of cognition were important sources of learning achievement, in accordance with the related literature (Zimmerman & Schunk, 2011). This relationship further confirmed that when students learn for themselves they display personal initiative, perseverance, and adaptive skills that allow them to achieve the desired learning outcomes.

In conclusion, the present research provided further empirical support for the effectiveness of e-learning environments structurally arranged in specific ways (instructional interactions, systems, tasks and texts). As a result, learning processes are facilitated, encouraging older adults to engage and persist in learning activities. As Findsen (2002) wondered: "What do older adults need education for?" There are lots of reasons. For example, Jenkins (2011) argued that lifelong learning can increase the wellbeing of the elderly, and Tornstam wrote that "human aging includes a potential to mature into a new outlook on and understanding of life" (Tornstam, 2011: 166). Indeed, research has begun to deal with the potential for older people to acquire new knowledge and fulfil learning needs, rather than dwelling solely on how can they meet their physiological and social needs (Boulton-Lewis, 2010).

Notwithstanding, much research is still needed to overcome some limitations of the present study. A broader and representative sample of older adult learners would allow a generalisation of the findings, as well as a comparison with a sample of younger learners, which may confirm the effectiveness of adaptive learning systems. In any case, e-learning programs offer undoubted opportunities for reshaping the place of older adults in society and promoting their wellbeing.

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