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Integrating Games as a Means to Develop e-learning: Insights from a Psychological Perspective

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3 **Title: Integrating Games as a Means to Develop e-learning: Insights from a Psychological**
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20 **Short Biographies**

21
22 Dr Melody M Terras is a Chartered Psychologist, Associate Fellow of the British Psychological
23 Society and Lecturer in Psychology at the University of the West of Scotland, UK. Her research
24 interests include the psychology of mobile and e-learning, and the inclusion of individuals with
25 learning difficulties and disabilities in educational and health contexts.
26

27 Dr Elizabeth Boyle is a Reader in Psychology at the University of the West of Scotland, UK. Recently
28 her main research interests have been in learning and motivation in e-learning, digital games and
29 social media.
30

31
32 **Abstract**

33
34 Although the Education sector has pioneered the use of technology, the pace of technological change
35 has outstripped the slower processes of theoretical development and critical reflection, so the field is
36 highly fragmented and lacks a comprehensive evidence base to support future development. In this
37 paper we consider how the insights offered by games and a psychological perspective can address the
38 current challenges. Both games and e-learning specialists are facing similar challenges and would
39 therefore benefit from adopting a more integrated approach in the future. We demonstrate how this
40 integration can best be achieved by viewing the challenges through a psychological lens which
41 informs theory, research and practice in user-centred design, supports the development of more
42 widely applicable theories of learning and pedagogy, recognises of the complexity of the contexts in
43 which learning occurs, and offer an established evidence-based framework to aid integration at the
44 theoretical level by emphasising the continued importance of classic concepts such a transfer,
45 cognitive load and the increasing blurred boundaries between formal and informal learning, but also
46 in terms of methodology and as a catalyst for future debate and discussion.
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1. Introduction

The Education sector has enthusiastically embraced technological advances to deliver and support learning. The early use of radio, TV and videos to support distance learning has evolved to maximise the opportunities afforded by the internet and the development of e-learning with the use virtual learning environments (VLEs) such as Moodle to support online assessment submissions and feedback, discussion groups and a range of educational resources such as traditional learning materials, open educational resources such as massive open online course (MOOCS) and more learner generated content such as Blogs and Wikis. Serious games, game-based learning and gamification approaches are increasingly being used as their benefits become recognised. The widespread availability and sophistication of mobile technology is enabling delivery of education via mobile platforms. The use of social networks such as Facebook, Twitter and YouTube to support education and advances in the areas of Virtual Reality (VR) and increasing promise of increased personalisation and learning analytics of Web 3 are currently being explored. Such pioneering use of technology should always be encouraged but, by its very nature, there are bound to be errors, inconsistencies and limitations in its initial application. These are par for the course and, as a field develops, critical review and reflection are essential for it to move forward. The recent flurry of reviews and the publication of this special issue of this journal itself, dedicated to developing critical and theoretical approaches to educational technology research and practice, indicates that the field has recognised that it has reached this important milestone.

Historically the use of Serious Games has emerged as a relatively distinct field from e-learning and educational technology generally. Interest in games initially focused on the perceived disadvantages of entertainment games, such as increased violence and aggression (Anderson & Bushman, 2001) and concerns about addiction to games (Kuss & Griffiths, 2012) and this deflected attention away from consideration of their educational potential. However demonstrations that brain training games could increase accuracy and speed of processing in children (Robertson & Miller, 2009), and research showing improved attentional and visual perceptual skills of video gamers suggested that even entertainment games could support learning (Green & Bavelier, 2006). This ignited interest in the potential of designing games purposely to support learning and skill acquisition.

Despite their separate origins, recent reviews in the areas of Serious Games (Boyle et al., 2016; Tsekleves, Cosmas, & Aggoun, 2016), and Gamification (Subhash & Cudney, 2018; Koivisto, & Hamari, 2018) illustrate that research on serious games is grappling with many of the same challenges identified in the literature on e-learning. Games offer coherent learning experiences and many of the advances in games research are attributable to the rigorous and detailed analysis of how games support learning by looking at: the game, the players, pedagogy and context. In this paper we argue that the decompositional approach taken in the design of serious games can help inform and address the challenges currently present in the area of e-learning. Furthermore, this paper aims to inform the process of critical reflection by advocating the need for greater integration within the field and does so by viewing relevant issues through a psychological lens. It should be emphasised that we are not suggesting that a single discipline perspective is the way forward, in fact we advocate the contrary-integration will only be achieved by increased multi-disciplinary working. The advantages of viewing many aspects of technology enhanced learning from a psychological perspective are discussed elsewhere (Terras & Ramsay, 2012; Ramsay & Terras, 2015; Terras et al., 2018). This paper will focus primarily on using a psychological perspective to integrate the growing evidence base concerning the development of serious games and game-based learning within the wider framework of e-learning. In doing so we will explore the similarities between the criticisms directed at games-based learning and e-learning, the reasons why, and consider the advantages of integrating games into the more general e-learning approach.

2. Current Challenges: Insights from a Games Perspective

The key challenges in the area of e-learning are well documented in the literature: existing work tends to be atheoretical and lacks explicit and detailed consideration of theories of learning generally (Castañeda & Selwyn, 2018; Mayer, 2018). Similar criticism applies at the level of pedagogy

(Bartolomé, Castañeda, & Adell, 2018). A lack of consideration of the emotional and motivational state of the learner and difficulties around translating the concepts of individualisation and personalisation of learning into practice, are widely noted and urgently need to be addressed, as the increasingly active and self-directed approaches of e-learning necessitate the need to explicitly consider the role of self-regulation and motivation (Castañeda & Selwyn, 2018). In this section we will discuss these challenges and consider the insights that can be derived from the games-based literature.

2.1 Theories of Learning and Pedagogy

The provision of technology enhanced learning must be underpinned by evidence-based theories of how people learn using different technological mediums and identification of the most effective mechanisms and strategies. The increasing use of active learning approaches entails consideration of motivation and self-regulation, areas which have been relatively neglected in the provision of e-learning opportunities to date (Castañeda & Selwyn, 2018). However such considerations have been explicitly considered in the games literature. Learning through games is consistent with current perspectives on effective learning which view learning as active, situated (Whitson, 1997), constructivist, self-regulated (Zimmerman, 2002), and cooperative (de Corte, 2011), and games provide opportunities to address these characteristics (Dondlinger, 2007; Arnab et al, 2015). In aiming to ground games design in pedagogical theory Gee (2003) identified 36 principles of learning in games, while Gentile and Gentile (2008) provided interesting insights into how entertainment games systematically incorporate basic principles of effective learning into their design, such as setting clear objectives, adapting to the prior knowledge, skills and pace of each learner, presenting tasks in well-sequenced levels of increasing difficulty. Originally developed to explain effective learning in child development, Vygotsky's zone of proximal development also specifies the conditions that e-learning and games should be trying to simulate, where the more able facilitator or teacher presents the learner with information that is just a little in advance of what they already know.

Pedagogy is related to theories of learning, but framed from the perspective of how the instructor presents the information and skills to be learned. Research on games makes a useful contribution to understanding pedagogy by extensively analysing the different ways in which games can support learning. Consideration of the learning outcomes that games support has helped to inform our understanding of how games can assist learning and emphasised the importance of identifying learning outcomes. Learning outcomes address what a learning task or activity aims to achieve. Although developed over 40 years ago, Bloom's (1975) taxonomy has been highly influential in providing useful guidance about the different categories of learning objectives that activities can support. In their literature review of games, Boyle et al. (2016) categorised the learning outcomes of the games as: knowledge acquisition, skills, affective and motivational, perceptual and cognitive, behaviour change, physiological and social/soft skills and physiological outcomes. While games potentially provide innovative methods of learning it was disappointing that 58% of the papers in this study of games for learning reported knowledge acquisition outcomes. This may be attributable to the fact that the specification of the precise learning outcomes for a specific game also requires close consideration of the game content. For example the *Youth@work* game aimed to support young people in career decision making, but the precise learning outcomes of promoting "career awareness and career adaptability" were only agreed after much discussion (Hummel et al., 2018). Research also suggests that games for learning that intrinsically integrate information and learning outcomes into game activities will lead to better learning since "the benefits of the flow are directed toward educational goals" (Habgood & Ainsworth, 2011, p. 174).

When considering the links between games and e-learning, it is useful to reflect on the activities that games support; since many of these activities are similar to those used in e-learning. Games research has developed several different classification systems for categorising game activities including game genres, game features, game elements and game mechanics. By focusing on the nature of the activities, games research can help to bridge the gap between games and e-learning. Game genre offers a higher-level classification of games based on the broader activities, challenges and interactions that take place during gameplay. While game genres was originally developed to guide

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3 players in choosing preferred entertainment games, adapted versions of game genres have been
4 applied to games for learning. A recent literature review of games used in primary education found
5 that strategy games, role playing games and simulations were the most popular (Hainey et al., 2016).
6 Many activities that are presented as games for learning are very similar to quizzes or multiple choice
7 questionnaires (MCQs) that are widely used in e-learning. E-learning platforms such Moodle f allow
8 the presentation of MCQs to test knowledge of a subject area. For example Kahoot! is a game-based
9 learning platform that can be used to create multiple choice questionnaires (MCQs) across different
10 content areas that include videos, images and diagrams. Although quizzes are popular, they have been
11 widely criticised for testing only surface knowledge (memory retention) rather than deep knowledge
12 (comprehension). To examine whether game features added to the learning experience over and above
13 the MCQ, Chaiyo & Nokham (2017) compared Kahoot, Quizizz and Google forms and found that the
14 gamified features in Kahoot and Quizizz led to better concentration, engagement, enjoyment,
15 motivation and satisfaction. Research on game mechanics which focuses on how specific game
16 features, such as game turns, movement and feedback can support learning (Arnab et al., 2009) may
17 also inform the design of e-learning opportunities, especially the provision of feedback and
18 consideration of the nature of the learning context.
19

20
21 Gamification is another area that highlights the advantages of greater integration between games and
22 e-learning. Gamification refers to the application of engaging game-design elements and game
23 principles in non-game contexts to increase engagement and improve task performance. The well
24 recognised engaging and motivational aspects of entertainment games that are exploited by serious
25 games have recently been harnessed for e-learning with the use of games-based features being
26 integrated into e-learning courses in the form of gamification. Two recent reviews (Koivisto, &
27 Hamari, 2018; Subhash, & Cudney, 2018) have illustrated the increasing interest and use of
28 gamification across a number of disciplines. The most frequently used game features applied in
29 gamification draw upon the psychological dimensions of games and tap into user experience and
30 perception, enjoyment/fun, motivation and social aspects, especially social influence, and are
31 generally implemented through the main gamification techniques of points, leader-boards and badges,
32 with success often being judged on academic performance via assessment grades. To date,
33 gamification, like games-based learning, has tended to draw upon a rather limited number of game
34 features, with less attention being given to the use of more immersive techniques such as role play and
35 narratives so it is essential that these aspects are explored in future. It is also essential that
36 gamification research keeps in step with more technological developments in the area of games such
37 as VR, immersive and reality augmenting techniques.
38

39
40 Games and gamification are often presented as interventions that can support learning or behaviour
41 change and, like other interventions, their effectiveness should be judged on how well they achieve
42 these goals compared with a carefully chosen control group in a before and after study. However,
43 evaluations of both games and gamification typically focus on the gamification process as a whole
44 (based on multiple game-based features), so it is difficult to determine unambiguously which aspect of
45 gamification is the source of any improvement. Other methodological concerns, such as relatively
46 small sample sizes, lack of well-designed experimental studies, the use of rigorous, poorly matched
47 experimental controls and variability in outcomes measures and their assessment methods, undermine
48 the conclusions that can be drawn from the evaluations (Hamari et al., 2014); interestingly similar
49 criticisms apply to evaluations of e-learning.
50

51 **2.2 The Human Dimension: Emotion and Motivation**

52
53 Castañeda & Selwyn (2018) highlight that the area of e-learning needs to consider human affect and
54 emotion in more detail. In recognising that “Computer and videogames are potentially the most
55 engaging pastime in the history of mankind” (Prensky, 2001, Pg. 05-1), researchers have adopted a
56 structured and in depth approach to analysing just why players like games so much which draws
57 heavily on established psychological theories. This research has distinguished between players’
58 motives for playing games and the subjective experiences that players feel while they play as
59 important theoretical explanations for the popularity of entertainment games. Motivational theories
60 have made an important contribution to our understanding of why people enjoy games. Deci and

Ryan's (1985) self-determination theory is a generic motivational theory that proposes that basic human needs for competence, autonomy and relatedness underlie human activities. Ryan, Rigby, and Przybylski (2006) applied this theory to examine players' motives for playing games and their findings confirmed that the need for challenge, the freedom to act in a virtual world, and opportunities to develop relationships are important contributors to game player enjoyment. Research has also addressed the pleasurable, subjective experiences that are central to media enjoyment (Vorderer et al., 2004). Flow (Sweetser & Wyeth, 2005), immersion (Jennett et al., 2008) and presence (Weibel, Wissmath, Habegger, Steiner, & Groner, 2008) are at the heart of explanations of user experience in games and help to explain why players find games so engaging. These constructs have slight differences in focus, with flow relating more to the activity, immersion relating to player involvement with the game, and presence relating more to the technology. The distinctive feature of flow is that it occurs when there is an optimal match between the abilities an individual possesses and the challenges presented by the activity. It is interesting that challenge is a key component of this theory of enjoyment, reflecting the human need to take part in demanding and testing activities as described in motivational theories. Similar engagement attributes, e.g., aesthetics, challenge, feedback and interactivity have been identified in the context of e-learning (O'Brien & Toms, 2008). This research has focused on engaging game features in entertainment games, but can engagement attributes also help players to learn? Wilson (2009) reviewed several games studies, mapping out which games and game attributes are most effective for which kinds of learning and learning, but acknowledged the need for greater precision in such studies. Whilst enjoyment is the most widely explored emotion in game play, interest is receiving increased attention (Tan, 2009) as it may play an important factor in engagement as it relates to novelty of stimuli, and surprise and uncertainty about what happens next, all important features of games. Both games and e-learning technologies increasingly offer learning analytics, the capacity of the learning management system or game to collect and analyse users' interaction and performance data, and provide personalised feedback. Given the importance of emotional and motivational influences on learning these aspects constitute a key element of personalisation. An interesting example of this is the *Youth@work* career game which used data collected about players' interests, values, personalities and strengths (Hummel et al., 2018) to predict players' preferred careers.

3 Addressing the Common Challenges: Insights from a Psychological Perspective

We have outlined the common challenges faced by games and e-learning and how games-based theory and research can offer insight to overcome them. However, to gain a full understanding it is essential to consider why such similarity exists and why games-based approaches are helpful in addressing them? When viewed through a psychological lens, the reasons for these commonalities becomes clear- they are attributable to psychological factors and individual differences. This explains much of the utility of the games literature presented: the majority of games design has explicitly considered the role of psychological factors, especially motivation and emotion from the outset which has not always been the case for e-learning.

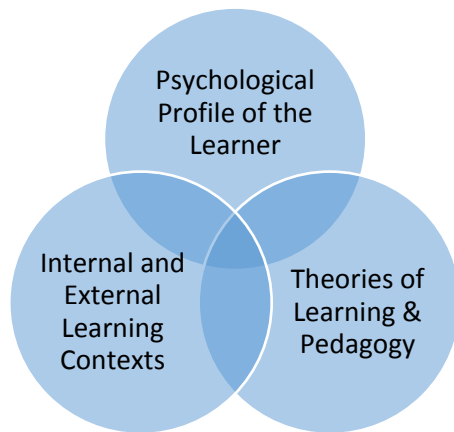


Fig 1 Common Challenges from a Psychological Perspective

Fig 1 above illustrates the main areas that should be considered and illustrates the interrelationships between them. It is essential to consider the psychological profile of the learner. Theory and practice should be user-centered, not technology centred, driven by the cognitive and socio-emotional profile of the learner and how it influences the use of learning technology. In the age of personalisation, user centred design takes on increased importance and requires more explicit reconsideration and recognition. User centred design ensures that learning experiences are not only physically, but also *psychologically accessible*. It reflects consideration of both the cognitive and socio-emotional profile of the learner and how the unique psychological attributes of the learner interact with the context and the pedagogical framework (Terras, et al., 2018).

Therefore, it is essential to consider theories of learning and pedagogy when designing games and e-learning materials. However, it is important to remember that it is “the instructional method not the media that is important” (Mayer 2018, Pg 2). Although we fully endorse this, we further propose that we must not only move beyond the delivery medium but also the instructional method, and consider in detail the psychological mechanisms that enable, support and sustain technology enhanced learning i.e. we must develop comprehensive and evidence-based theories of learning and pedagogy to inform the design of more effective learning materials that may encourage transfer across different contexts and mediums. We propose that this can best be achieved by taking a psychological perspective underpinned by psychological theory, research and scientifically rigorous methodologies. Psychology has greatly influenced our understanding of learning, be it in the form of behaviourism, cognitivism, constructivism, and more recently via the general science of learning (Mayer, 2018) and is ideally placed to do so in future. A psychological approach which focuses on the mechanisms and processes that support learning is by its very nature generic enough to encompass and integrate all aspects of learning regardless of the medium. Like theory, pedagogical considerations must also be sensitive to the psychological profile of the learner. For example, the increasing use of networked and collaborative learning brings different degrees of challenge for learners depending on individual differences in preferences, motivation and regulation and theories of learning, pedagogy and instructional materials must be sensitive to and flexible enough to accommodate these differences.

Learning is situated, it does not occur in a vacuum; it is affected by range of contextual influences. These influences may be external such as the nature of the online environment, the mechanics of the game, the nature and timing of feedback, or internal reflecting the learner’s socio-emotional state. Contextual influences are complex and multifaceted and can be determined by the theory and pedagogical approach taken as well individual differences in the psychological profile of the learner. So future research and practice must consider the *learner in context* (Boyle et al., 2017).

Although it is informative to examine these three areas individually, a detailed understanding of how and why they overlap is required. It is essential that theory, research and practice embodies an understanding of how these three elements are related in order to have full insight into the process of learning and the structures necessary to support it. Currently the field is highly fragmented and these

important connections are often unrecognised and undervalued. It is essential to consider not only two-way interactions e.g., how theories of learning and pedagogy are surfaced in different learning contexts? and how individual differences in the psychological profile of the learner interact with different learning contexts?; but also the three way interaction between theories and pedagogy, contexts and the psychological profile of the learner. Such understanding is essential to maximising the benefits of Game-based mobile learning (GBML) and related learning opportunities. GBML uses Global Positioning System) technology to provide information about the on location of the user and learner resources and has immense potential to support contextualized real world learning.

4. Concluding Remarks and Future Directions

4.1 Integrated Models and Multidisciplinary Working

Integration is required at a theoretical level to ensure that the latest understandings concerning games design and mechanics, pedagogical approaches to game-based learning and psychologically-based theories of engagement and games use are applied not only to the design of serious games but also gamification and e-learning in general. Adopting a trans-disciplinary perspective is essential for the development of guidelines for the complex process of pedagogically-informed design of technology enhanced learning in the future. Typically theories of how games support learning consider the characteristics of the games and players, the activities offered and the context to clarify how games can be used most effectively in learning. An early model that attempted integration was the Input-Process-Outcome model (Garris et al., 2011) which emphasised the need to clarify how game characteristics are integrated with the relevant instructional content to provide productive player experiences that lead to the specified learning outcomes. Another influential transdisciplinary model is the Learning Mechanics-Game Mechanics (LM-GM) model that describes how game features such as game turns, movement and feedback, are mapped into clearly specified learning outcomes (Arnab et al., 2015). These models strongly advocate the clear identification of learning outcomes and consideration of how they can be realized from the outset in a principled manner and such an approach could inform the effective design of e-learning activities.

Despite the advantages, it is important to remember that games and gamification may not be the catch all solution to developing and improving e-learning in the future. Many games and learning packages with a high degree of gamification tend to be purpose designed and are thereby both content and context specific; so neither the process nor the outcomes may transfer well or even transfer at all into other domains (Hamari, 2015). The difficulties associated with transfer are well recognised within educational contexts and greater sharing of relevant knowledge, especially psychologically informed knowledge, to support the process across domains would greatly assist this process. Interestingly some of the strongest evidence for skills transfer from playing entertainment games indicates playing action video games supports faster reaction times and improved ability to track multiple objects (Dye, Green, & Bavelier, 2009; Green & Bavelier, 2006) which is most likely attributable to the enhancement of executive functioning (Boyle et al., 2015). Future research is required to identify the psychological mechanisms that assist transfer within and across a range of technological mediums.

4.2 Revisit and Revise Classic Concepts and Controversies

Many classic concepts and approaches lie at the core of the successful use of technology to support education and learning, but some have been neglected in the rush to embrace technological advances and modernise educational delivery to make it more appealing to and consistent with the experiences of millennials. However, the widespread use of technology does not necessarily entail that learners will automatically know how to use technology to learn or wish to learn using the technology they primarily use for social purposes, and despite their familiarity with technology in everyday contexts, learner may require training in *how to use* learning technologies most effectively (Ramsay & Terras, 2015). Therefore, user-centered design is as essential now, and possibly even more so in the future. Although technology is developing at a rapid pace, the human information processing system remains

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3 unchanged. It has the same finite cognitive resources (especially attention and working memory) to
4 support learning, be it game-based or otherwise, and learning opportunities must be sensitive to these
5 cognitive constraints. Therefore it is as essential to consider the cognitive load imposed at the levels
6 of theory, pedagogy and implementation. Cognitive load refers is a highly influential concept in the
7 area of instructional design that is sensitive to the limitations of the cognitive system and attempts to
8 avoid cognitive overload by minimising the extraneous cognitive load imposed by the nature of the
9 learning material to help maximise the processing of content (Sweller, 1988). The idea of minimising
10 cognitive load has also been applied in the Theory of Multimedia Learning (Mayer and Moreno,
11 2003) and it is essential that this concept is developed to keep a-pace with the demands of technology
12 in future.
13

14 The use of social technology and games for learning raises some interesting questions about the
15 relationship between enjoyment and learning and the distinction between formal and informal
16 learning. The increasing use of mobile technology, mobile gaming and casual games that have an
17 educational purpose (Price et al., 2016) is rapidly making this distinction less useful and, in the future,
18 potentially redundant. This shift is predominantly technology-led; the increasing use of mobile
19 devices is growing across all contexts in life and opening up new informal, mobile contexts for
20 learning. Future research and practice will benefit from a user-centred approach that looks at user
21 needs is taken to maximise all these learning opportunities. The blurring of the boundaries between
22 work and leisure activities places more responsibility on the learner to manage and regulate their time
23 more effectively. Many digital technologies are highly compelling and there is a danger that failure to
24 manage our time and regulate our digital behaviours will lead to less time available to spend on
25 essential learning tasks (Boyle et al., 2017). For example Kirschner and Karpinski (2010) found that
26 Facebook® users reported having lower GPAs and spending fewer hours per week studying than
27 nonusers. The educational use of games creates tensions both practically and theoretically, concerning
28 the extent to which enjoyment and learning are compatible. While games can provide highly engaging
29 learning experiences, there is also increased recognition of the negative consequences of games and
30 gamification such as increased competitiveness and lack of focus on games to promote co-operation
31 (Koivisto, & Hamari, 2018). While competition is a key element of many games, it has less of a role
32 to play in education and this represents a major challenge and research direction for the future.
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37 **Conclusion**

38 In this paper we have outlined how consideration of the insights offered by research on games may
39 help to address some of the challenges currently experienced in the areas of games and e-learning. We
40 argue that despite being relatively distinct fields, games and e-learning face similar challenges and
41 would benefit from adopting a more integrated approach grounded in psychological theory. We have
42 demonstrated how this integration can best be achieved by viewing the challenges through a
43 psychological lens as it informs: (1) user-centred design by supporting a detailed consideration of the
44 cognitive and socio-emotional profile of the learner; (2) identification and application of relevant
45 theories of learning and pedagogy; (3) selection of appropriate game features and mechanics, or e-
46 learning functionality more generally, to support desired learning outcomes; (4) consideration of both
47 the internal context of the learner and the external context of the learning environment; (5) the
48 importance of understanding the complex and often transactional nature of the interactions between
49 the learner, the context and the theoretical and pedagogical framework in which learning occurs and
50 (6) the provision of an established evidence based framework to aid integration not only in terms of
51 theory and research concerning human behaviour, but also in terms of research methodologies such as
52 eye-tracking and neurological imaging (fMRI) to gain insight into the cognitive process that underpin
53 learning and help develop a more nuanced understanding of the increasing use of learner analytics.
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5 Statements:

6
7 Conflict of Interest: None

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9 Ethical Approval and Open Data: N/A as not empirical research

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Structured Practitioner Notes

What is already known about this topic

- The evidence base concerning e-learning is rather fragmented and lacks integration at the theoretical and pedagogical level.
- Serious games can provide enjoyable and effective learning experiences.
- Aspects of game-based learning are increasingly being integrated into e-learning based delivery.
- Despite their increasing use both games-based and e-learning have a number of limitations.

What this paper adds

- Identification of the similar challenges facing games-based learning and e-learning.
- Demonstrates how games-based research concerning learning, pedagogy and motivation can inform the future development of e-learning.
- Illustrates how the common challenges can be understood by taking a psychological perspective.
- Illustrates how a psychological perspective can aid integration by providing an evidence based framework to support integration at the levels of both theory and practice.

Implications for practice and/or policy

- Future research and practice should be supported by greater integration and multidisciplinary working between games developers and e-learning specialists.
- Despite technological advances, learners' psychological resources are finite and the design of all learning resources should remain user centred and be sensitive to the cognitive and socio-emotional profile of the learner.
- Future research should address existing methodological issues such as small sample size, avoid confounding variables to allow systematic evaluation.
- Future provision and development of e-learning opportunities should be more explicitly driven by theoretical and pedagogical considerations that clearly specify learning outcomes, are sensitive to the cognitive load imposed and the preferences and skills of the learner and maximise informal learning opportunities.