Towards a conceptual framework for assessing the effectiveness of digital game-based learning

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ABSTRACT

In recent years, interest has grown in the systematic assessment of the effectiveness of digital game-based learning (DGBL). A conceptual framework describing what effectiveness means in the context of DGBL and which are its subcomponents has hitherto been lacking however. Hence, the goal of this paper is to propose a conceptualization and operationalization of effectiveness rooted in social-cognitive theory. In order to identify desired outcomes and be able to operationalize effectiveness, focus groups were organized with three stakeholder groups following a user requirements analysis methodology. Results indicate that three categories of desired outcomes can be distinguished: learning, motivational and efficiency outcomes. For the different outcomes, different subcomponents can be extracted which can be organized hierarchically. Learning outcomes that are seen as relevant to the effectiveness of DGBL are 1) increased interest in the subject matter, 2) improvement in objective performance (e.g., in a test), and 3) transfer, referring to the player's ability to apply acquired knowledge or skills to real-world situations. Relevant motivational outcomes concern 1) enjoyment, the extent to which playing the game evoked an enjoyable experience, and 2) increased motivation to learn using DGBL. Efficiency outcomes relevant to DGBL effectiveness, finally, are related to 1) time management and 2) cost-effectiveness. Overall, it can be stated that a DGBL intervention is effective when it achieves similar or higher scores compared to other instructional methods in relation to any of the above mentioned outcomes without significantly (in the common, not the statistical sense) diminishing any of the others.

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1. Introduction

Digital game-based learning (DGBL) is increasingly being used in a range of sectors including defense, communication, education, health and corporate training (Backlund & Hendrix, 2013; Michaud, Alvarez, Alvarez, & Djaouti, 2012). Whereas initial research into the topic was exploratory in nature, aiming to demonstrate potential uses, in recent years interest in more systematic assessment of its potential benefits has been growing. An oft-heard argument thereby is that, in order to be considered worthy of investment, research into the effectiveness of digital games as instructional tools is required (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013; Clark, 2007).

Typically, in experimental research on medical treatments, a distinction is made between efficacy and effectiveness (Brook & Lohr, 1991; Flay et al., 2005; Hunsley, Elliott, & Therrien, 2014). Efficacy refers to the attainment of intended goals under idealized conditions, meaning that experimental control is kept high in order to maximize internal validity (i.e., the interference is an actual result of the treatment and not due to other observed and unobserved variables). Effectiveness also refers to the attainment of intended goals, but under real-world conditions and thus maximizing external validity (i.e., results of an experiment are generalizable to different subjects, settings, experiments and tests), still maintaining an adequate level of internal validity (Brook & Lohr, 1991; Flay et al., 2005; Hunsley et al., 2014). Whilst efficacy studies of DGBL interventions are theoretically possible, some flexibility with regard to experimental control will generally be required. Moreover, it is unclear to what extent these studies would provide valuable insights as actual learning generally takes place in less controlled contexts. Hence our primary focus in this paper is on effectiveness rather than efficacy research whilst some observations may also be relevant in the context of highly controlled effect studies.

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DGBL generally aims to leverage the entertaining nature of games in order to pursue educational outcomes (Bellotti et al., 2013). Consequently, with regard to DGBL effectiveness, both learning and player engagement are considered as relevant factors.

1.1. Defining effectiveness

Effectiveness of DGBL can be defined as the successful attainment of its intended goals in a real-world context. This implies that its desired outcomes should be clearly defined and made explicit (Calder, 2013). This is, however, an issue in DGBL effectiveness research as different indicators are being used for determining whether DGBL is effective in different contexts (O'Neil, Wainess, & Baker, 2005). Hence, there is a need for a conceptual model that provides a general evaluation framework for assessment of DGBL which can be applied flexibly across contexts (Mayer, Bekebrede, Warmelink, & Zhou, 2013). In order to move towards a more systematic approach and, consequently, facilitate the comparison of results of different instructional methods across studies, the current study uses social cognitive theory (SCT) as a theoretical framework (Bandura, 1986) to conceptualize and operationalize effectiveness of DGBL. SCT was chosen because it provides a framework of effectiveness evaluation linked to actual behavioral intention as a result of this evaluation. This is in line with previous results stating that proven effectiveness of DGBL will stimulate its implementation (Bardon & Josserand, 2009).

According to social cognitive theory (SCT), motivation for exhibiting a certain behavior is the result of an interaction between personal determinants (cognitive, affective and biological events), behavioral determinants and environmental determinants (Bandura, 1986). However, influence of environmental determinants on behavior is not of a direct nature, but is an indirect influence via psychological mechanisms of the self-system. The self-system influences people's aspirations, self-efficacy and personal standards. Or as Bandura states 'What people think, believe and feel affects how they behave' (Bandura, 1986, p. 25).

Bandura's concept of agency provides insight into how effectiveness of human behavior can be evaluated. Agency refers to humans' ability to influence their own behavior through intentionality, forethought and self-regulation by self-reflectiveness and self-reactiveness about their behavior (Bandura, 2001). This means that individuals are capable of evaluating their own behavior (i.e., self-evaluation, self-reflectiveness) through observation of that behavior and the associated outcomes (i.e., self-observation). Based on this evaluation, behavior is (dis)continued or altered (i.e., self-reactiveness). This evaluation of behavior occurs based on goal setting which refers to objectives one wished to attain by performing a certain behavior. Hence, outcomes one desired to attain through a particular behavior serves as a benchmark against which to judge effectiveness (Bandura, 2001). If we apply this to digital game-based learning, the evaluation of its effectiveness will be against outcomes one desired to attain by implementing DGBL. Hence desired outcomes of DGBL are considered as the cognitive component influencing behavior, which is implementation of DGBL. Thus desired outcomes of the implementation of DGBL serve as a benchmark for evaluating its effectiveness.

As mentioned before, people's aspirations, self-efficacy and personal standards and consequently, goal setting are indirectly influenced by environmental determinants (Bandura, 1986). Thus, the benchmark against which to judge effectiveness will partly depend on the sector in which it will be implemented and its disciplinary preconceptions (Calder, 2013; Mayer, 2012) which are considered environmental determinants in the present study. Therefore, all relevant stakeholders should be taken into account when aiming at developing an effectiveness definition of DGBL (Calder, 2013).

Developing a conceptualization of effectiveness based on desired outcomes of DGBL, indirectly relates it to use. More specifically, if DGBL succeeds in generating outcomes considered relevant for the stakeholders and in validating these outcomes empirically, this will support adoption and usage of DGBL.

Note, however, that not only expected outcomes but also self-efficacy (i.e., perceived capability to perform a certain behavior) influence motivation to perform a certain behavior (Bandura, 1986). Considering that the focus of this paper is effectiveness evaluation and not motivation to use or implement DGBL, (see De Grove, Bourgonjon, and Van Looy (2012) and Bourgonjon et al. (2013) for literature on motivations to implement DGBL in a school context), we will focus on outcome expectations in this study.

1.2. Defining stakeholders

In order to conceptualize and operationalize DGBL effectiveness, a user requirements analysis with regard to desired outcomes of the implementation of DGBL was conducted. Typically, three types of stakeholders can be distinguished: the operational working area, which refers to stakeholders who will have direct contact with the product, the containing business which refers to stakeholders who benefit from the product in some way, even though they are not in the operational working area and the wider environment, which refers to other stakeholders who have an influence on or an interest in the product (Robertson, 2006). The operational working area was defined as DGBL researchers and game developers, considering that these groups are directly involved in effectiveness assessment whereby the former will conduct the research and the latter prepare the material. The containing business was defined as (potential) adopters of DGBL (e.g., teachers, principals, HR managers, etc.), considering that they would have an interest in the degree of effectiveness of particular interventions they wish to implement. Whilst we considered integrating students, employees, etc., the people who actually play the games, to get an indication on which outcomes they expect from DGBL, we have decided to put our main focus on intermediaries as adoption of DGBL largely depends on intermediaries such as teachers (Bourgonjon et al., 2013), considering that the adoption or implementation decision is typically made on a higher level (Boyle, Connolly, & Hainey, 2011; Mayer et al., 2013).

The wider environment was defined as stakeholders on a governmental level, considering they can have an influence through funding for development of and research on DGBL, of which both DGBL developers and DGBL researchers are mostly dependent on.

2. Method

A user requirements analysis aiming to identify anticipated or desired outcomes of DGBL was conducted. For this purpose, three focus groups were organized; one for each stakeholder group. We conducted focus groups given that it is a cost-effective technique for conducting a user requirements analysis (Maguire, 2003). In total, 33 stakeholders participated in the focus groups (13 in the operational working area,