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Playing educational micro-games at high schools: Individually or collectively?

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ABSTRACT

The effectivity of learning by playing serious games is increasingly subject to research, but information about how these games should actually be used in classes is limited. In this explorative study with between-subject design ($N = 166$; high school students), we investigated the effectivity of playing two different micro-games in two different ways. After an expository lecture, either students played a game individually at computers ("individual play"), or the teacher played it, while showing it to the class on a projector and prompting the students on how to proceed with the game ("collective play"). Results indicated that the two modes of play were nearly comparable as concerns immediate and one month delayed learning gains, as well as subjective evaluation of educational experience. There were only two notable differences. First, immediate test scores for factual questions, but not transfer questions, for one of the games were higher for the individual play (medium effect size). Second, this difference was accompanied by a higher enjoyment in the better performing group (small to medium effect size). The results support the idea that collective play, which is easier to implement in schools, is a method that should be considered in educational design and future research.

1. Introduction

Some schools have gradually adopted educational digital games for use (Huizenga, Admiraal, & Ten Dam, 2013; Proctor & Marks, 2013; Wastiau, Kearney, & den Berge, 2009; Williamson, 2009) but these and also other educational institutions reported multiple issues (De Grove, Bourgonjon, & Van Looy, 2012; Kenny & McDaniel, 2011; Ketelhut & Schifter, 2011; Sisler & Brom, 2008; Wastiau et al., 2009, Ch. 7). Therefore, the games' acceptance is not always guaranteed and the issue of how to integrate them effectively into formal education remains an important question.

In a well-equipped school, with a committed teacher, students, parents, and school board, it is often possible to play games for educational purposes even over prolonged periods of time (Watson, Mong, & Harris, 2011; see also Gjedde, 2013; Wastiau et al., 2009). However, in many cases, in a moderately-equipped school, with an average teacher somewhat interested in game-based learning (but with other stakeholders who are largely uninformed), certain problems can emerge. Besides scepticism on the part of some of these stakeholders (Bourgonjon, Valcke, Soetaert, De Wever, & Schellens, 2011; Bourgonjon, Valcke, Soetaert, & Schellens, 2010; De Grove et al., 2012), there are potential problems with integrating games into curricula, issues with long learning curves (for both teachers and students), in situ technical problems, issues with implementing sustainable support for teachers, and cost limitations (e.g., Bourgonjon et al., 2010; De Grove et al., 2012; Egenfeldt-Nielsen, 2005; Ketelhut & Schifter, 2011; Klopfer, 2008; Wastiau et al., 2009; Williamson, 2009). For instance, it may be complicated for learners who do not play games regularly to learn how to control a complex game (Bourgonjon et al., 2010; Egenfeldt-Nielsen, 2005). Typically, games also have to be played in a computer laboratory. In many schools, it may not be possible for teachers to take their class to the lab whenever they want because the lab is a shared resource (Kebritchi, 2010, p. 261; Watson et al., 2011; p. 473; see also Klopfer, 2008; Ch. 6). Coping with fixed lesson lengths (usually 45–60 min) is also a problem for many teachers; as is accommodating long game-play sessions within an overloaded curriculum (e.g., De Grove et al., 2012; Sandford, Uliscak, Facer, & Rudd, 2006).

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However, many of these issues can be addressed. For example, there are attempts to overcome problems with access to a computer laboratory by using mobile devices specifically dedicated to learning through game playing (Klopfer, 2008) or by using an interpersonal computer (Szewkis et al., 2011).

One approach to overcoming both the technological and curricular-congruency problems is the use of *micro-games* (e.g., Brom, Preuss, & Klement, 2011). Use of single-player micro-games in the context of secondary education is in the scope of this paper.

Micro-games are "relatively simple computer games that do not require special skills to play and that challenge players with clearly-defined goals reachable within minutes or tens of minutes of game-play" (Brom et al., 2011, p. 1979). Unlike commercial-off-the-shelf games, they do not require up-to-date hardware, they fit well within short school lessons, and they are often directly created to cover a curricular topic. Because of their simplicity, developers can construct user interfaces that can be mastered within a matter of minutes. The drawback is that these games may be cognitively more superficial compared to games played over prolonged periods and/or repeatedly. Therefore, they may be less educationally effective (cf. Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013, p. 259). Nevertheless, micro-games can be, similarly to educational simulations, particularly useful as supplements to traditional lessons.

A single-player micro-game still, however, has to be played in a computer laboratory, or every student has to have a mobile device equipped with the game. Both approaches require expensive resources shared by many teachers. "Minor" technical issues, such as forgotten passwords or empty batteries, can also arise, which is troubling because solving these technical issues can take substantial time away from the class period (cf. Klopfer, 2008).

Alternatively, the teacher can play the micro-game on a computer directly in the classroom, via a projector, and prompt students in the class with questions on how to proceed in the game. Collectively, they can decide on the next steps (i.e., the students do not play the game individually: each with one device; instead, there is just one device controlled by the teacher). Such an approach is technically easier and cheaper to implement in real schools compared to lab visits or mobile devices, because it requires just one working computer and projector. Based on our eight years of experience with game-based learning, this is the approach many teachers tend to adopt in the case of micro-games. However, intuition suggests that under such "collective" play, learners tend to be cognitively more passive compared to "individual" play, and cognitive passivity does not promote meaningful learning (e.g., Mayer, 2004).[1]

It is thus useful to known if such "collective" play is comparable to "individual" play in terms of cognitive and affective outcomes; or to what extent is it worse. The answer can have practical consequences for usage of micro-games in schools. Many media comparison studies, in which one group received game-based instruction and the second group a comparable "traditional" lesson, have been conducted in the past (meta-analysed in Sitzmann, 2011; Vogel et al., 2006; Wouters et al., 2013[2]). The treatments used for comparison were diverse (All, Nunez Castellar, & Van Looy, 2014; Wouters et al., 2013) but we are unaware of any study that would use, in the control group, the same single-player game where played collectively by the whole class.

In this paper, we present an exploratory study that investigates whether learning gains and subjective evaluation of the micro-game played differs if each student plays the micro-game individually in a lab, as opposed to collectively with a teacher as part of a small class (i.e., up to 15 students). The game is used as a supplement after a traditional expository lecture. To attempt at partial generalization, the study uses two different micro-games (the topics: genetics, animal learning). The study was conducted in schools as part of regular education programmes. We recruited 9 high school classes (10th or 11th grade) in two different, above-average, urban high schools in the Czech Republic and used stratified randomization (with the stratum being a class). Immediate and one-month delayed knowledge tests were administered and enjoyment and self-estimated learning assessed. Quantitative instruments were supplemented with informal in-class observations.

2. Study background

Educational computer games are multimedia learning materials. In this study, we adopt a view of multimedia learning as *active knowledge construction* (Mayer, 2009; pp. 17–19), as concerns declarative knowledge acquisition. In this view, learners construct a coherent mental model of a subject based on the learning material presented and their prior knowledge. Model construction is a personal process and learners must engage in it *actively* to create their own *individual* knowledge. Teachers serve as "cognitive guides" assisting the learners during the knowledge construction.

In this view, cognitive activity rather than behavioural/physical activity is important for effective (declarative) knowledge acquisition (Mayer, 2004, 2009; p. 23). Behavioural activity may nevertheless serve as a trigger for instigating cognitive activity. This is important for educational games, which are highly interactive and interactivity is one of the key features for promoting behavioural activity; but not necessarily cognitive activity.

This view is adopted by the prominent theory of multimedia learning, Cognitive Theory of Multimedia Learning (CTML; Mayer, 2009). Capitalizing on Baddeley's classical memory model (Baddeley, Eysenck, & Anderson, 2009) and Dual Coding Theory (Clark & Paivio, 1991), CTML posits that multimedia information is processed by learners through two separate cognitive channels (verbal and visual), organized in their working memory into coherent models and integrated with prior knowledge "stored" in their long-term memory. This process' efficiency depends on the level of a learner's active cognitive participation (Mayer, 2009; Moreno, 2010; Moreno & Mayer, 2007), on available cognitive capacity (Sweller, 1999) and various other learner- and environment-related contextual factors (Moreno, 2005; Moreno & Mayer, 2007).

The active-learning view is also reflected in the Integrated Model of Multimedia Interactivity (INTERACT) (Domagk, Schwartz, & Plass, 2010), proposed by its authors as an explanatory framework for *interactive* multimedia learning studies. Two primary components of this six-component, process-oriented model are Behavioural Activities and Cognitive/Metacognitive Activities. Other components include Learning Environment, Learner Variables (trait-like), Emotion and Motivation (state-like), and Mental Model. Interactivity is represented by feedback loops among the majority of these components. This model explicitly informs us that behavioural activity alone is insufficient for deep-level cognitive processing, which is vital for mental model construction.

In this study, we are interested in using an interactive micro-game in two different ways after an expository lecture. The lecture is the same for both conditions and the game is used for the same purpose in both conditions: *reinforcing* and *integrating* (in the terms of Thomas & Hooper, 1991) part of the knowledge learnt in the lecture. However, there are between-condition differences as concerns the game's usage method.

[1] Note that collective playing *per se* is not collaborative.

[2] The meta-analyses demonstrated the modest superiority of educational games but with some caveats, such as evidence of publication bias (Sitzmann, 2011) or diminishing positive impact of games in studies with randomization (Wouters et al., 2013).