The Role of Learning Styles in Game-Based Learning

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ABSTRACT
Adapting learning to the level and preferences of learners and game-based learning have increasingly received much attention. The current study examined whether learning styles based on the Felder-Silverman classification (perception, input, processing and organization of information) influence learning in GBL. Only the input and processing scales were found to be reliable. 109 students from prevocational secondary education played a math game (proportional reasoning) after which learning gain and motivation were measured. Gameplay yielded no learning, but a median-split breakdown (prior knowledge) indicated that students with little prior knowledge did learn from the game, while those with much prior knowledge deteriorated. Subsequent multiple regression analyses revealed no predictive effect for motivation. The processing preference was predictive for learning: Students with an active processing preference performed better than students with a reflective processing preference. The discussion discusses consequences and a number of directions for follow-up research.

KEYWORDS
Adaptive Learning, Game-Based Learning, Learning Preferences, Learning Styles, Mathematics, Personalized Learning, Serious Games

INTRODUCTION
In current technology-oriented education two trends, among others, can be discerned: an increasing attention for game-based learning (GBL, see Wouters, van Nimwegen, van Oostendorp & van der Spek, 2013) and personalised learning (Beetham & Sharpe, 2013; Tseng, Chu, Hwang & Tsai, 2008). With respect to GBL reviews indicate that GBL is not always as effective and motivating as is always assumed (Wouters et al., 2013) or that these outcomes can only be realised when certain instructional conditions are met such as the inclusion of opportunities for players to explicate the acquired knowledge (Wouters et al., 2013; see also Clarke, Tanner-Smith, & Killingsworth, 2016). In addition, Erhel and Jamet (2013) have suggested that the contradictory findings regarding GBL can be explained by the different methodologies used in the studies, the variety of topics and learning situations and individual learner characteristics. The latter factor connects with personalized learning which can be defined as instruction in which the pace and the instructional approach adapt to the educational needs of the learner (Thomas, 2016).

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In this study GBL refers to the use of computer games for the purpose of learning, training and education. The assumption is that two processes are involved: a direct cognitive process (i.e. the selection and organisation of new information and integrate these with prior knowledge) and an indirect process whereby the motivational appeal of the game is used to expose the player longer and more engaged to the learning content in the game (see Wouters & van Oostendorp, 2017). Computer games and therefore also GBL environments have a number of features that make them suitable for applying personalized learning. To start with they are highly interactive: players act in the game world and receive feedback as the consequences of their actions are reflected in the game world. Second, the digital nature makes it possible to record, unobtrusively and unlimited, performance data that can be used to adjust the game world accordingly. For example, in a GBL environment the complexity of a learning task could be decreased real-time when the performance data indicate that the previous tasks were too difficult. In this context the results of stealth assessment are promising (Shute, Ke, & Wang, 2017).

However, for personalized learning not only real-time adaptivity based on performance data is important but also a better understanding with regard to student characteristics such as prior knowledge, preference for an instruction method, interests, learning style etc. Some of these characteristics can be adapted by learners themselves, for example, selecting a context in which the learning material is presented, the composition of an avatar or even the preference for an instruction method. In a study using a game-based environment with arithmetical problems, children who received a personalized version (e.g., they could choose a context for the arithmetical problems and the names of characters) outperformed children in the non-personalized version in motivation as well as learning (Cordova & Lepper, 1996, see also Wouters & van Oostendorp, 2017). Other learner characteristics such as prior knowledge and learning style are more complex and must be determined in an objective and valid manner.

However, despite these observations, still little is known about how learner characteristics may influence learning and motivation. An exception is the role of learning styles in GBL and their effect on learning. As we will discuss in the next section, a number of studies have been conducted to investigate the relation between GBL and learning styles/preferences. The assumption for using learning styles/preferences is that they can be used to design personalized learning environments (Felder & Spurling, 2005) which in turn will improve learning as well as motivation (Chen, 2014; Jones, Reichard & Mokhtari, 2003) In this study we investigate if specific learning style/preference characteristics, and if so which one and to what extent, can affect learning and motivation in GBL and in this way contribute to the optimization of personalized learning.

**Learning Styles**

A learning style can be defined as psychological, emotional and affective characteristics of individuals that can be regarded as relative stable indicators for perceiving, interpreting, interacting with and responding on learning content (Felder & Spurling, 2005; Keefe, 1987). The last decades different learning style theories have been proposed (see for an overview Cassidy, 2004). Felder and Silverman (1988) have developed a learning style model that contains elements from several learning style theories and consists of four dimensions (see Table 1). Felder and Spurling (2005) have argued that the Felder-Silverman learning style model (henceforth FSLSM) meets the psychometric criteria of reliability and validity when used and interpreted in an appropriate way. This implies that one should take notice of some characteristics of FSLSM. To start with, contrary to most learning style theories that try to categorise learners in a few groups, FSLSM describes the learning style in more detail by classifying the learner’s preferences on four dimensions. In other words: each learner can be characterized by a preference on each of the four dimensions. Furthermore, they state that the dimensions are a continuum: a person’s score on a dimension can be low, moderate or high. In addition, Graf, Viola, Leo and Kinshuk (2007) have pointed out that FSLSM is based on tendencies,
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