

Chapter 10

Game Design as a Complex Problem Solving Process

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ABSTRACT

Problem solving is one of the most essential skills for individuals to be successful at their daily lives and careers. When problems become complex, solving them involves identifying relationships among a multitude of interrelated variables, to achieve multiple different possible solutions. Teaching Complex Problem Solving (CPS) skills in formal education contexts is challenging. In this research, we examined if through an innovative game-design course middle school students improved in their CPS skills. Our results showed that students showed significant improvements in their CPS skills, especially in terms of system exploration, $t(10) = 2.787$, $p = .019$; system knowledge, $t(10) = 2.437$, $p = .35$; system application, $t(10) = 2.472$, $p = .033$. In addition, there was a statistically significant change in students' interest for CPS after attending the GDL program, $t(6) = 3.890$, $p = .008$. We discuss implications regarding use of game-design tasks as contexts to teach CPS skills in formal and informal educational contexts.

INTRODUCTION

Problem solving is an important part of human life (Van Merriënboer, 2013). The increasing complexity of problems our society is facing makes it essential for the new generation of learners to grow up possessing abilities to solve complex and dynamic problems (Sonnleitner, Brunner, Keller, & Martin, 2014; Sonnleitner, Keller, Martin, & Brunner, 2013; Wirth & Klieme, 2003). Therefore, curricula supporting the development of such skills are critical (Greiff, et al., 2014; Sonnleitner et al., 2014).

Complex problems, similar to ill-structured problems, can be defined as situations that involve orchestrating a number of interrelated and dynamically varying operations (Funke, 2010). Complex problems are opaque (i.e., the relationship among the variables cannot be seen) and polytelic (i.e., a number different targets are possible). Complex problem solving (CPS) is considered as a valid and reliable

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representation of higher-order thinking skills, including problem solving and intelligence (Sonnleitner et al., 2013; Sternberg, 1982).

Teaching problem solving is an important goal for education (Van Merriënboer, 2013), but integrating complex problem solving into current formal education curricula is not an easy endeavor. Mostly, the issue stems from the fact that schooling tends to focus on well-defined problems, symbolic thinking over direct engagement with objects, and general skills and knowledge, instead of the situation-specific competencies needed in real-life contexts (Resnick, 1987). In addition, time to teach these skills during regular school hours is a hardship reported by most teachers (Tabary, 2015).

Given the importance of learning problem solving skills and the lack of emphasis in formal education, it is important that children get opportunities to engage in problem solving in other contexts. One promising arena for such skill development has been after-school clubs where children design and create digital artifacts (e.g., Harel, 1991; Kafai, Peppler, & Chapman, 2009; Resnick & Rusk, 1996). These after-school opportunities are casual and stress-free, getting learners to engage in creative problem solving and active knowledge construction in ways that appeal to young learners' interests (Resnick & Rusk, 1996). Following the theory and practice from early clubhouse work and recent work with game-design and problem solving (e.g., Akcaoglu, 2014), in this study, our purpose was to investigate the cognitive (i.e., complex problem solving) and motivational outcomes (i.e., interest, value, and self-efficacy) from an after-school game-design course: Game-Design and Learning program.

BACKGROUND

Complex Problem Solving

In any given domain, solving a problem can be seen as the process of successfully overcoming barriers to reach certain goals (Reed, 2013). Problems, however, strongly vary concerning the characteristics of these barriers and goals, and hence, their complexity. Beginning in the late 70s, research increasingly focused on computer-simulated, real-world problems (e.g. governing a city, managing a small factory), that were characterized as complex (Funke & Frensch, 2007). To solve these kinds of problems, the problem solver has to (a) achieve several, partly contradicting goals, by (b) efficiently interacting with a large number of variables that are (c) connected through (d) an unapparent net of relations, and (e) that are dynamically changing over time. Current research on complex problems still focuses on these core characteristics but stresses their domain-general aspect by using smaller scenarios that draw less on content knowledge (Funke, 2010, Greiff, Wüstenberg, & Funke, 2012; Sonnleitner et al. 2012).

Evidently, dealing with such complex scenarios requires a broad set of skills and abilities. It has been shown that reasoning plays a central part in complex problem solving, but that there are additional, specific problem solving skills at work (Sonnleitner, et al., 2013). First, the problem solver has to develop an appropriate strategy to find out about the underlying connections between the variables involved. Typically, the most efficient exploration strategy involves a systematic and sequential manipulation of single variables. Only if all other variables are held constant, change in the scenario can unequivocally be traced back to the manipulated variable. This procedure equates to unconfounded experiments and is usually called Control of Variables Strategy (CVS; Chen & Klahr, 1999). Second, the created information of these experiments has to be translated into knowledge about the problem. Only if the problem solver was successful in building a mental representation or model of the problem, effective strategies

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