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The role of math self-efficacy in the structural model of extracurricular technology-related activities and junior elementary school students' mathematics ability

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ABSTRACT

With increasingly sophisticated information and communications technologies in the modern era, technology is considered to be an important agent for children's perceptual and cognitive skill development. Yet, research on the effect of technology on students' academic learning is inconclusive because there is a longstanding debate about the impact of internet use and video gameplay on student learning achievement. This study examined the relationships between math self-efficacy, extracurricular technology-related activities (TRAs) and Canadian sixth graders' math achievement. Using large-scale student survey and test performance data (N = 26,767), we examined the latent structural relationship between the TRAs (e.g., video gameplay, internet use and TV viewing) and math achievement by taking into account students' self-efficacy as a mediator. Results from structural equation modeling confirmed our hypotheses indicating the negative direct effects of TRAs on math achievement and a positive mediating effect of math self-efficacy on the relationship between video gameplay and math achievement. We also observed negative indirect effects of TV reviewing and internet use on math achievement via math self-efficacy. This study emphasizes the critical interaction between students' psychological orientations and external digital surroundings on their academic achievement.

1. Introduction

With the emergence of increasingly sophisticated technology for information and communications in the modern era, today's kids are living in an environment where digital technology is pervasive. Technology is considered an important agent for perceptual and cognitive skill development (Adachi & Willoughby, 2013; Novak & Tassell, 2015; Willoughby, 2008). Yet, research on the effect of technology on students' learning and development is inconclusive because there is a longstanding debate about the potential positive impact of internet use and video gameplay on student learning achievement and well-being (Chen, Hsial, Chern, & Chen, 2014; Gee, 2003; Gentile & Anderson, 2003; Gil-Flores, Torres-Gordillo, & Perera-Rodríguez, 2012; Odaci & Kalkan, 2010). Moreover, the majority of research to date, to our knowledge, has mainly focused on the direct link between technology related activities (e.g., video gameplay, internet use and TV viewing) and academic outcomes without considering learners' psychological characteristics, such as self-efficacy.

The present study is intended to address this knowledge gap by examining the relationships between students' academic self-efficacy, technology related activities (TRAs[1]) and academic achievement. Specifically, we were interested in determining whether and the extent to which the effects of extracurricular TRAs on mathematics achievement are mediated by math self-efficacy. We were also interested in examining the differential effects of various extracurricular TRAs on mathematics achievement.

1.1. Computer use and academic achievement

Over the years, students have steadily increased their internet

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[1] TRAs stands for technology related activitives, which include video gameplay, internet use and TV viewing.

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use for schoolwork and for recreational purposes because of high computer ownership and internet connectivity rates. For instance, in 2012 annual survey on Student Drug Use and Health, Pearce (2012) reports that 327,000 Ontario students from grades 7 to 12 spent at least seven hours a day in front of a TV or computer. Furthermore, data from the Ontario Ministry of Children and Youth Services, 2011 report suggested that 64% of female and 53% of male students in grades 9–10 spent at least two hours every day chatting online. Whether computer use is for pleasure or learning, the boundary seems to become less clear. Consequently, this phenomenon has prompted researchers to use a variety of theories to frame their understanding of the effects of computer use on students' academic achievement. Some studies (e.g., Berland & Lee, 2011; Gee, 2003; McGonigal, 2011; Papert, 1980; Subrahmanyam, Greenfield, Kraut, & Gross, 2001) posited that computer use can be treated as an important positive agent for cognitive and social development (Dye, Green, & Bavelier, 2009; Espinosa, Laffey, Whittaker, & Sheng, 2006; Ferguson, 2011; Spence & Feng, 2010; Willoughby, 2008) and for enhanced working memory capacity and visual intelligence skills (Espinosa et al., 2006; Green & Bavelier, 2003; Subrahmanyam et al., 2001; Sutherland, Facer, Furlong, & Furlong, 2000; Uttal et al., 2013). Conversely, other research (e.g., Odaci & Kalkan, 2010; Odaci & Çelik, 2013) indicated that computer use, such as video gameplay and internet use, are negatively associated with academic performance and academic self-efficacy. They argued, for instance, that children who play videogames frequently have lower grade point averages and more problematic behavior in school in comparison to those who play videogames less often.

Furthermore, research on the effects of computer use on student's academic performance has considered both proximal (e.g., age, gender, SES) and distal (e.g., home, community) learner variables. Converging evidence in this research domain has shown that proximal variables such as gender and students' socio-economic status (SES) have a direct impact on students' academic achievement, and the findings seem consistent across different research designs. For instance, longitudinal research has shown that internet use has a positive effect on low-income youth academic performance, and that boys tend to spend more time gaming in comparison to girls (Jackson, von Eye, Witt, Zhao, & Fitzgerald, 2011). However, according to Willoughby's (2008) longitudinal study, both boys and girls in their early and late high school years tended to spend an equal length of time on the internet. It further showed that moderate use of the internet was associated with a stronger academic orientation than no use or a high level of use; greater videogame playing was associated with a weaker academic orientation.

In addition, some literature suggested that computer use is associated with students' academic performance in their early school years. Jackson et al. (2011) found a reciprocal relationship among internet use, academic performance, and cognitive skills. In their study, they found that internet use had a positive effect on academic performance for youth with low initial levels of reading skills. They also indicated that internet use has no effect on subsequent reading skills for youth with average or high initial levels of reading skills. But, their study suggested that playing videogames is a harmful distraction to academic performance for youth with low initial levels of visual-spatial skills.

Some researchers have also examined the impact of distal variables on students' academic performance. For instance, Wittwer and Senkbeil's (2008) study provided empirical evidence to explain the underlying process of how a distal variable such as home computer use could affect students' learning. According to their findings, the types of activities children engage in when using a computer at home are related to whether or not they read, but the frequency of home computer use is not associated with reading. Their study also suggested that proximal variables such as ethnicity, age, and socioeconomic status (SES) influence computer access and use.

1.2. TV viewing and academic achievement

Watching television is a popular pastime for children. In Canada, children spend approximately 40 h per week on screen (Picard, 2012). The average time children spend on viewing TV increases steadily during the elementary school years, and it reaches a peak of three to five hours daily at age 12 (Zuckerman, Singer, & Singer, 1980). Apparently, if children spend a minimum of seven hours at school and six hours watching television each day, they have little time for doing homework at home. Research converges that heavy TV viewing displaces intellectually demanding activities (e.g., reading and homework), imaginary activities, physical activities, and social interaction (e.g., Beentjes & Van der Voort, 1988; Kohn, 1998; Singer & Singer, 2005; Zuckerman et al., 1980) and risks children's attention and behavioral problems (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Ferguson, 2011; Singer, Singer, & Rapaczynski, 1984; Swing, Gentile, Anderson, & Walsh, 2010; Zimmerman & Christakis, 2005; Zuckerman et al., 1980). For instance, two longitudinal studies (e.g., Christakis et al., 2004; Singer et al., 1984) found that heavy TV viewing causes children's attention disorder symptoms and is associated with children's later aggressive behaviors.

On the other hand, some research reported mixed effects of TV viewing on students' learning (e.g., Keith, Reimers, Fehrmann, Pottehaum, & Aubey, 1986; Zuckerman et al., 1980) depending on two factors: TV content and the amount of exposure to TV. Findings from research conducted in the 1980s and 1990s have indicated that the amount of exposure to TV determines the nature of the relationship between TV viewing and school achievement. Heavy TV viewing tends to have strong negative effects on achievement, especially for girls and higher ability children, but TV viewing for less than 10 h per week is beneficial for children (Keith et al., 1986). These findings seem to be relatively consistent from preschool to the teen years when considering children's individual differences in the amount of TV exposure (Anderson, Huston, Schmitt, Linebarge, & Wright, 2001).

The negative cognitive effects of screen time are often attributed to the pacing of the media (Zuckerman et al., 1980). According to Bandura (1994), attention and retention are core learning processes from TV viewing (as cited in Anderson et al., 2001). Stimulating, rapidly shifting TV programs do not allow children to assimilate the information and, as the amount of exposure to such TV programs increases, children become less tolerant of a relatively calm, fairly slow-paced learning environment such as a classroom (Ferguson, 2011; Zuckerman et al., 1980).

1.3. Math self-efficacy and math achievement

Self-efficacy (Bandura, 1986, 1997) refers to a cognitive representation of one's judgement of his or her capability to organize and execute a task. The social cognitive theory of self-efficacy conceptualizes the individual as being agentic, purposeful, proactive, self-evaluative and self-regulatory (Bandura, 1989; see Komarraju & Nadler, 2013). It is effective to explain individuals' cognitive and motivational processes in achievement contexts (Phan, 2012). Self-efficacy can predict one's effort, persistence and success in a challenging setting (Bandura, 1986, 1993). As Bandura indicated, how people behave can be better predicted by their beliefs than by what they are actually capable of accomplishing (Fast et al., 2010; Pajares & Miller, 1994). For instance, students often achieve higher