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Understanding the effects of professors' pedagogical development with Clicker Assessment and Feedback technologies and the impact on students' engagement and learning in higher education

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ABSTRACT

Clicker Assessment and Feedback (CAF) is an instructional assessment and feedback strategy that is incorporated with interactive technologies, often referred to as clickers. Several thousand colleges and universities across Europe and North America have adopted CAF as a strategy in their classrooms. This study has three major objectives. The first objective is to discuss the development of an instrument used to assess and investigate students' perceptions of CAF tools. The second is to examine the effects of university professors' CAF development on student perceptions of CAF. The third is to investigate the impact of professors' CAF methods on student learning and engagement. In this study the CAF project was initiated to enhance students' engagement in undergraduate courses by supporting CAF development to university professors at a large, publically-funded University. Professors ($n = 74$) and students ($n = 5459$) volunteered to participate over this four-semester long project. Principal Component Analysis (PCA) was performed to explore students' perceptions of CAF efficacy. Multivariate Analysis of Variance (MANOVA) was used to explore the relationship between professors' CAF development, their use of CAF in formative or summative assessment and students' perceptions of CAF. The results demonstrate that 1) students perceive the use of CAF tools as having an impact on their engagement and learning, 2) increased CAF development by professors impact on students' perceptions of CAF, and 3) professors' use of CAF for formative assessment is more influential than summative assessment on students' perceptions of engagement and learning. This study suggests that CAF is most effective for student engagement and learning if it is supported by appropriate CAF development of professors and their subsequent formative use of CAF during teaching.

1. Introduction

Clicker Assessment and Feedback (CAF) is an easily adopted teaching approach for higher education (Bruff, 2009). CAF is also referred to as a Classroom Communication System (CCS), Student Response System (SRS), Audience Response Technology (ART), or clickers. CAF refers to inquiry-based teaching strategies coupled with a clicker technology system, a wireless system that enables professors to ask questions and have students respond using hand-held devices (clickers). The questions and the results summarizing student responses can be presented simultaneously on the classroom's projector (see Fig. 1).

Many studies have investigated the effects of CAF on various aspects of students' classroom experiences. The educational benefits of CAF can be summarized in terms of the aspects of teaching and learning affected: CAF enables professors' contingent teaching (McKeachie, 1990) by providing real-time feedback and assessment, as students anonymously participate in classroom activities (e.g., peer teaching). Professors can assess student understanding, and students can assess their own understanding of a concept (Kay & LeSage, 2009). Nobel Laureate Weiman (2010) summarized the use of CAF as having "… *a profound impact* on the educational experience of students" (p.186).

The *profound impact* on student learning is well documented in many CAF studies (e.g., Kay & LeSage, 2009). CAF can have a positive influence on students' emotional, motivational, and cognitive experiences in the classroom (e.g., Simpson & Oliver, 2007). Based in part on

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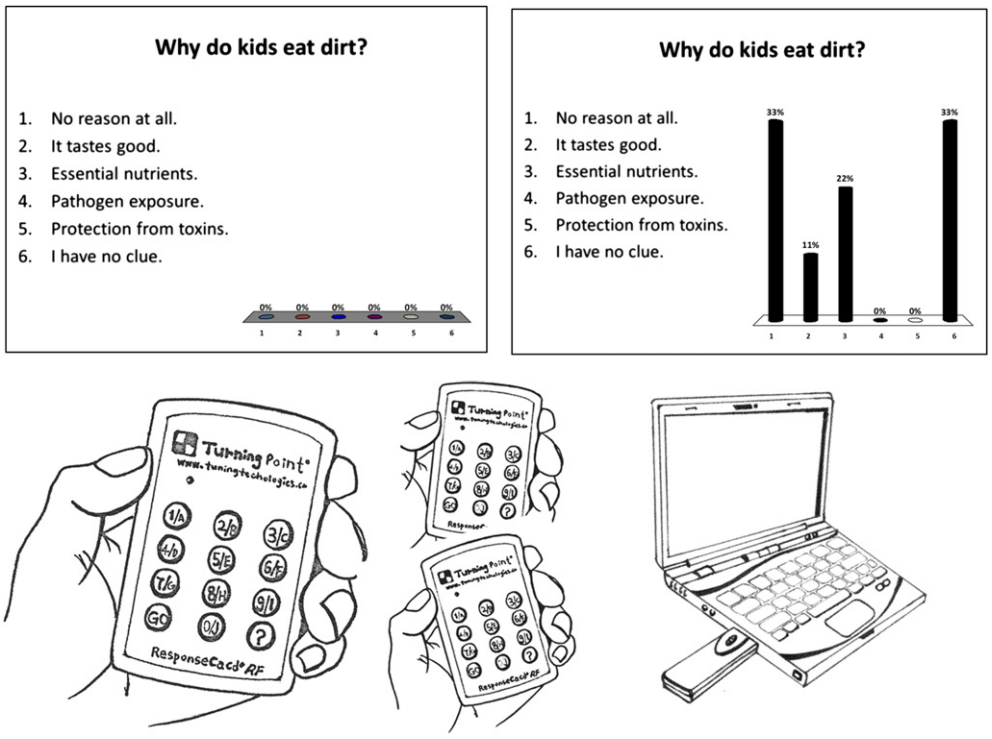

Fig. 1. Clicker Assessment and Feedback (CAF) mechanism. Professors can project questions on a wall or screen in their classrooms. Students can then respond to the questions on their hand held devices (clickers). A receiver is connected to a laptop – Receivers can gather students' responses and transform their responses into digital data. Professors can then display the results of the students answered if they choose.

the support of these findings, CAF has been used on over a half-million students in several thousand colleges and universities in Europe and North America (Steinberg, 2010, p. A14). However, two issues with CAF have been recognized. One is the validity and reliability of the instruments used to gather data on CAF use have been criticized, and thus, questions regarding the credibility of these studies have surfaced (e.g., Kay & LeSage, 2009). Most CAF studies (e.g., Bunce, VandernPlas, & Havanki, 2006; Hoekstra, 2008) measured students' perceptions of CAF as engagement and learning with only one or two items. This has led to concerns of reliability and validity (DeVellis, 2012). Another concern is that the relationships between professors' teaching and students' learning have not been adequately explored in CAF studies in higher education (Offerdahl & Tomanek, 2011). However, the literature on university teaching consistently demonstrates the educational effects of CAF on various aspects of student learning (e.g., Bruff, 2009; Simpson & Oliver, 2007). CAF studies have tended to focus on the effects of adopting CAF on students by comparing CAF and traditional lectures rather than exploring a holistic interaction among professor's teaching approaches, CAF, and student learning (Fies & Marshall, 2006; Kay & LeSage, 2009). The results of these studies do not provide the evidence of which components of CAF approaches are associated with which educational benefits and challenges (Fies & Marshall, 2006; Penuel, Boscardin, Masyn, & Crawford, 2007).

This study aims to respond to some of the criticism of CAF studies by exploring students' perceptions of CAF using Principal Component Analysis (PCA). PCA is a method of analysis that is a psychometrically sound technique with established credibility that avoids factor indeterminacy (Stevens, 2002). This study also intends to investigate the relationship among professors' pedagogical development using the technology, their use of technology, and students' perceptions of the impact of CAF on their learning, which is considered a *missing link* in the technology evaluation literature in higher education (Offerdahl & Tomanek, 2011; Simpson & Oliver, 2007).

2. Literature review

The initial clicker device prototype was designed and produced by Carpenter (1950a, p. 33, 1950b, p. 20) at Pennsylvania State University. Approximately 47 years later, Mazur (1997) wrote his seminal work, *Peer Instruction*, which resulted in the rapid adoption and implementation of CAF at several thousand universities and colleges in Europe and North America (Steinberg, 2010, p. A14). This may have been a result of the research of Mazur's Harvard Physics group (Crouch & Mazur, 2001; Fagen, Crouch, & Mazur, 2002; Larsy, Mazur, & Watkins 2008), which consistently highlighted the benefits of CAF on various aspects of students' experience. CAF was found to enhance student engagement with content and with peers in the classroom and impact learning by helping to address important misconceptions (Crouch & Mazur, 2001). Teachers of physics and virtually all other disciplines (Science, Technology, Engineering, Mathematics – STEM, Medicine, Social Sciences, and Arts and Humanities) began developing and implementing their own customized instructional strategies using CAF, such as class-wide discussion (Nicol & Boyle, 2003), technology-enhanced formative assessment (Beatty & Gerace, 2009), and the question-sequence method (Reay, Li, & Bao, 2008).

The growing body of CAF studies reveals various effects of CAF on student experiences in the classroom across virtually all disciplines in higher education: increasing attention (Latessa & Mouw, 2005), attendance (Moredich & Moore, 2007), interaction (Johnson & Meckelborg, 2008), teamwork (Stevenson, 2007) motivation (Van Dijk, Van Den Berg, & Van Keulen, 2001), positive emotion and participation (Stowell & Nelson, 2007), engagement and metacognition (Campbell & Mayer, 2009) and learning (Mayer et al., 2009). However, literature reviews