Computers & Education 94 (2016) 102–119

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

A meta-analysis of the effects of audience response systems (clicker-based technologies) on cognition and affect

Nathaniel J. Hunsu*, Olusola Adesope, Dan James Bayly

Educational Leadership, Sport Studies, Educational and Counseling Psychology, Washington State University, Pullman, WA 99164-4530, USA

ARTICLE INFO

Article history:
Received 27 July 2015
Received in revised form 24 November 2015
Accepted 25 November 2015
Available online 28 November 2015

Keywords:
Clickers
Audience response system
Student response system
Student engagement
Meta-analysis

ABSTRACT

Audience Response Systems (ARS) are thought to be a good way of using technology to increase engagement in the classroom and have been widely adopted by many instructors seeking to improve academic performance through student engagement. While researchers have examined the degree to which they promote cognitive and non-cognitive learning outcomes in the classroom, most of their findings are largely mixed and inconclusive. This meta-analysis seeks to resolve the conflicting findings. Specifically, the meta-analysis compared classrooms that did, and did not use ARS-based technologies on different cognitive and non-cognitive learning outcomes to examine the potential effects of using ARS. Overall, we found small but significant effects of using ARS-based technologies on a number of desirable cognitive and non-cognitive learning outcomes. Further analysis revealed that knowledge domain, class size, and the use of clicker questions, are among factors that significantly moderated the summary effect sizes observed among the studies in the meta-analysis. These findings hold significant implication for the implementation of clicker-based technologies in the classroom.

1. Introduction

Audience Response Systems (ARS) have received increasing acceptance among educators who are using technologies to enhance student involvement and active engagement in the classroom (Duncan, 2005; Fies & Marshall, 2006). They grew in popularity across many college and secondary school classrooms as they became more affordable, and as a result of benefits perceived to accrue from using ARS in the classroom[1] (Abrahamson, 2006; Judson & Sawada, 2006). Since the introduction of clickers in the 1960s, ARS-based technologies have evolved in terms of their forms, capabilities and availabilities. They have significantly evolved from what they used to be – a hardware-software polling system that uses dedicated handheld devices known as *clickers*. More recently, clicker applications that support mobile devices (e.g. i>clicker GO and Socrative) and a host of internet-based platforms (e.g. GoSoapBox, QuestionPress, etc.) have resulted in increasing web-based ARS options (Richardson, Dunn, McDonald, & Oprescu, 2015). Unlike the classical clicker system however, some newer web-based ARS systems (e.g. GoSoapBox) also offer classroom response functions that reach beyond student polling. The proliferation of web-

* Corresponding author.
E-mail addresses: nat.hunsu@wsu.edu (N.J. Hunsu), olusola.Adesope@wsu.edu (O. Adesope), dan.bayly@wsu.edu (D.J. Bayly).

[1] Uses of Audience Response Systems are discussed in subsequent sections.

http://dx.doi.org/10.1016/j.compedu.2015.11.013
0360-1315/

based ARS solutions has further driven down the costs associated with implementing ARS-based technologies in the classroom.

ARS-based technologies appear in research literature under many names referring to the same or similar systems among which are: student response systems (Anthis, 2011), audience response system (Cain, Black, & Rohr, 2009), personal response system (Chan & Knight, 2010), classroom response system (Graeff et al., 2011), electronic feedback system (Brady, Seli, & Rosenthal, 2013), immediate response systems (Yourstone, Kraye, & Albaum, 2008), classroom communication systems (Paschal, 2002), classroom performance system (Petersohn, 2008), and mostly just as *clickers*. For the sake of using a consistent term in reporting this study however, we use *clickers* or *clicker-based technology* when referring to all categories of ARS-based technologies (technologies that work on the same *clicker principle*) used in the classroom.

The classical clicker technology is a transmitter-receiver system comprising of a handheld device, *clicker*, and a computer software program that receives signals from the handheld device (Fies & Marshall, 2006). Clickers look much like a typical remote control and work by the same principle – student press buttons on their handheld device which transmits signals that are collected by a receiving system that interprets and aggregates the resulting signals (Caldwell, 2007). Clicker-facilitated learning mimics the stimuli–response relationship proposed by behaviorists' theories of learning – students have to periodically respond to 'stimuli' – which in this case are the *clicker questions* posed by the instructor (Naismith, Lonsdale, Vavoula, & Sharples, 2004). The instructor projects multiple-choice questions at various points during class time and students are required to answer by pressing a corresponding button on their clicker keypads, mobile phones or a similar web-based interface. Responses are tallied by back-end software and aggregates of the polls can be displayed as charts. Students may then work in groups to discuss the rationale for the answers they had given while the instructor provides feedback (Filer, 2010). This response profiling mechanism makes it possible for the instructor to monitor students' understanding and to spot misconceptions about the material being taught (Caldwell, 2007). Clicker-facilitated lectures are intended to foster cognitive interaction between students and their instructor (Kay & LeSage, 2009).

The practice of punctuating lecture periods with questions is not solely associated with clicker-facilitated instruction, however. Instructors have always required students to indicate their answer choices to questions posed during lecture periods by simply raising their hands (Bartsch & Murphy, 2011; FitzPatrick, Finn, & Campisi, 2011; Mayer et al., 2009); raising response cards (e.g. Fallon & Forrest, 2011; Freeman et al., 2007; Stowell, Oldham, & Bennett, 2010) or paddles (e.g. Brady et al., 2013). However, clicker-based technologies seem more advantageous than these other low-tech methods because students' responses can be anonymous and instructors are also able to instantaneously view a graphical summary of such responses. Some studies have reported that students participate more when clickers are used in the classroom, and view using clicker-based technologies positively because of the anonymity they afford (Caldwell, 2007). Besides, some studies have reported that reluctant students may be more inclined to participate in a clicker-facilitated classroom. For instance, Graham, Tripp, Seawright, and Joeckel (2007) reported that in a study with 688 participants in undergraduate science courses, 125 participants identified as low-participators also reported that using clickers helped them understand their performance in relation to their peers, motivated them to engage, to stay interested in class and made class times more enjoyable. Caldwell (2007) posited that many students in large classrooms often are hesitant to volunteer answers because they dread making mistakes in public and the fear of public disapproval. The lack of privacy in volunteering answers in low-tech classes impairs honest votes. With the use of clicker-based technologies however, students are able to gauge their response against those of other classmates, which may improve their self-confidence and perhaps spur them to diligence (Knight & Wood, 2005).

1.1. Reasons why instructors use clickers

Instructors have embraced using clickers-based technologies in their classrooms for reasons that transcend the anonymity they afford. Some use them within lectures to record class attendance – clicker-use has been credited with improved class attendance – particularly when attendance is linked to grades (Zhu, 2008). In addition, clicker use is noted to improve interaction and attention to learning. Studies have indicated that student attention wanes and recall diminishes after 20 min of lecture time (Burns, 1985). Instructors may break lecture periods into manageable time blocks by periodically interjecting *clicker questions* which trigger discussions and allow students to refocus their attention on the lecture. This, some argue, fosters increased participation and sustained learning engagement and peer discussions, and increases the avenue for instructors to provide immediate feedback on group discussions (Zhu, 2008). Surveys of students' opinion reported in the literature indicate that students think that using clicker-based technologies increases learning engagement (Bergtrom, 2006; Simpson & Oliver, 2007). Some instructors have argued that students who use clickers are more likely to ask and answer questions in the classroom, and are more psychologically invested in their answers, even if it were a guess, and may be more attentive to discussions that follow (Beatty, 2004; Beatty, Gerace, Leonard, & Dufresne, 2006; Caldwell, 2007; Elliot, 2003; Wit, 2003).

The reasons for using clickers noted in the foregoing seem to have a notable appeal in large lecture classes. Encouraging student participation in large lecture halls with hundreds of students is often challenging. Oftentimes, the professor only engages with the few students who sit in the front rows of the class, while other students indulge in non-class related activities during lecture periods. Such learning situations often leave many students less invested in what goes on in the classroom and estranged from the material being presented (Mayer et al., 2009). Concerned about active participation in their classrooms, instructors may find clicker-based technologies as helpful aids in large lecture halls because students who might