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The Use of an Audience Response System in an Elementary School–Based Health Education Program

Alexandra L. DeSorbo, MPH¹, James M. Noble, MD, MS¹, Michele Shaffer, PhD², William Gerin, PhD², and Olajide A. Williams, MD, MS¹

¹Columbia University Medical Center, New York, NY, USA

²Pennsylvania State University, State College, PA, USA

Abstract

Background—The audience response system (ARS) allows students to respond and interact anonymously with teachers via small handheld wireless keypads. Despite increasing popularity in classroom settings, the application of these devices to health education programming has not been studied. We assessed feasibility, engagement, and learning among children using an ARS compared with traditional pencil–paper formats, (ARS) for a stroke health education program.

Method—We compared outcome data generated via an ARS-based intervention to pencil–paper controls, including test scores and missing data rates among 265 schoolchildren 9 to 11 years old participating in stroke education. Among 119 children, we evaluated the feasibility of ARS use and explored student motivation with a 10-item questionnaire. We assessed facilitator experience with both methods.

Results—ARS use is feasible. Students reported having more fun ($p < .001$), increased attention ($p < .001$), participation ($p < .001$), and perceived learning outcomes ($p < .001$) compared with pencil–paper controls. Test scores showed highly positive improvement for both ARS and paper without additional benefits of ARS on learning. There was no difference in missing data rates ($p < .001$). Educators preferred the ARS.

Conclusion—The use of an ARS among children is feasible and improves student and facilitator engagement without additional benefits on stroke learning.

Keywords

adolescents; evaluation; health promotion; literacy; school-based health

An audience response system (ARS) is an interactive electronic tool used to survey an audience for their responses to specific questions. The use of this system has been tested in several domains and found to be useful in increasing student participation and motivation in

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Corresponding Author: Alexandra DeSorbo, Department of Neurology, Stroke Division, Columbia University Medical Center, 710 West 168th Street, New York, NY 10032, USA. ald2146@columbia.edu.

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classroom lecture formats (Boyle, 1999), but, to date, it has never been tested for its utility in health education. We examined the potential advantages in terms of student motivation and learning in a classroom setting in which children aged 9 to 11 years were being taught to recognize symptoms of stroke, and strategies for teaching their parents this important material.

The use of ARS in education has gained acceptance and become more widespread in recent years, especially among college and graduate students (Graham, Tripp, Seawright, & Joeckel, 2007). Multiple studies have found that the system increases participation rates and helps build students' self-confidence, knowledge, and mastery of the material (Cain, Black, & Rohr, 2009; Graham et al., 2007). In academic settings, the ARS has been rated as more engaging and enjoyable than traditional lecture formats (Boyle, 1999; Burnstein, 2001) by audience participants. Students report that the ARS provides them with incentive to pay closer attention to lecture material and respond to in-class questions over and above that of traditional lecture formats (Mestre, Gerace, Dufresne, & Leonard, 1997). Although shown to be superior to traditional lecture methods in terms of material learned and retained, the Socratic method, which involves having students reply to questions posed by the instructor as a means of learning, has typically been resisted by students because of anxiety due to possible embarrassment for incorrect responses (Adib-Hajbaghery & Aghajani, 2011). Using ARS, which uses the principles of the Socratic method, students have reported feeling empowered by an increased sense of control, because they can respond anonymously to a question and receive an immediate answer without fearing the threat of embarrassment or humiliation (Graham et al., 2007; Stowell, Oldham, & Bennett, 2010). Moreover, similar principles have been the basis of Self-Paced Programmed Instruction, a technique pioneered by early behaviorist theorists that, like the Socratic method, have been shown to produce results superior to those of traditional lecture approaches in terms of student satisfaction, self-efficacy, and learning and retention (Gropper & Kress, 1964). The benefits of anonymity, immediate feedback, and increased self-confidence and self-efficacy provide students with reinforcement of perceived educational content comprehension (Naismith, Lonsdale, Vavoula, & Sharples, 2004).

Drawing on the use and success of ARS in academic settings, we explored the potential benefit of including the ARS in health education programming for children. Specifically, we evaluated feasibility, motivation, and learning regarding the use of an ARS among young schoolchildren aged 9 to 11 years in low-income urban public schools to examine the effects of an ARS over and above that of the classroom presentation to increase motivation and improve learning compared with traditional pencil–paper formats. The topic material comprised a multimedia presentation that involves cartoons, video games, role-playing, and music (called “hiphop stroke”; HHS) that we have developed and found to be effective in enhancing stroke education in students and their parents (Williams, DeSorbo, Noble, & Gerin, 2011).

Method

Using a case–control design, we recruited 265 fourth- to sixth-grade children aged 9 to 11 years into HHS. Two HHS programs were delivered in two elementary schools located in

Central Harlem, New York, where more than 75% of children come from families with incomes at or below 130% of the poverty level and more than 95% were Black or Hispanic. Assigned quasi experimentally by school, students were enrolled into an ARS-based HHS intervention ($n=105$) and compared with pencil-paper-based HHS program, which was used as a historical control group ($n=160$). After obtaining passive parental consent and the students assent, two HHS facilitators delivered the HHS multimedia curriculum embedded in Microsoft® PowerPoint® (the same two facilitators were used for both schools), in the school auditorium, in 1-hour per day sessions over 3 days. In the ARS-based intervention school, a handheld wireless keypad (see Figure 1) was given to each student to collect pretest and posttest data and enable evaluation of real-time responses to questions posed during the program as a means of developing the students' understanding of the principles being taught. Prior to program delivery, HHS facilitators participated in ARS training, which was conducted by an ARS vendor in the form of a webinar delivered over a 1-hour period. For this study we used the Option Technologies™ system (<http://www.optiontechnologies.com/>). Each student was given the ARS keypad as they entered auditorium in single file for the program. At program onset, facilitators described the purpose of the keypad. ARS questions were delivered in a pretest–posttest format within the PowerPoint-based HHS curriculum. To familiarize students with the ARS keypad, they were asked to answer two practice questions within a predetermined amount of time (usually 10–15 seconds, depending on question length), indicated by the countdown timer feature of the ARS in the corner of each screen, and were provided an opportunity to ask the educators questions about the process. Students were prompted to respond by pressing the corresponding button on their keypads, each signifying a unique response (e.g., “yes” or “no” or multiple choice—“A, B, C, D, E”). This was followed by a formal five-question pretest to assess baseline stroke knowledge pertinent to the intervention. Additional ARS-based questions were interspersed throughout the 3-day program to assess real-time learning of content. The keypads communicated with a receiver using an infrared signal, which was synchronized to the presentation, and the data were automatically stored into a database for later analysis. Within these systems, at the conclusion of each session or question slide, the facilitator has the option to immediately present the aggregated response data to students in chart form. Answers to questions from the entire group were displayed as a histogram on the screen (adjacent to the question) providing anonymous instant feedback-reinforcement for students and as a guide for facilitators by providing them with immediate feedback on the clarity of their instruction for the purpose of real-time course correction (see Figure 2). At completion of the 3-day intervention, students took a five-question posttest that was similar to the pretest. In the pencil–paper control school (Williams & Noble, 2008), an identical HHS program curriculum was delivered to students, with the exception of testing methods. Paper tests and pencils were distributed to the students, and they were instructed to take 5 minutes (based on preprogram focus group average test completion times) to quietly and independently complete the test. On completion, the facilitators and school staff collected the completed tests and compiled them for data entry. This study was approved by the Columbia University Institutional Review Board.

Feasibility

We assessed whether the children were able to use the devices easily and properly by evaluating their responses to practice questions, pretest and posttests, and educator observations captured by a semistructured survey delivered by the research team: Specifically, we (a) compared class setup times, including the time required for facilitator setup, distribution of ARS keypads, and completion of practice questions; (b) compared missing data rates across intervention (ARS) and control (pencil–paper test) schools; and (c) compared pretest and posttest scores of intervention versus control schools in response to the HHS program.

Engagement and Motivation

We administered a 10-item questionnaire to 119 additional 9- to 11-year-old schoolchildren to assess perceived experience (vs. paper tests), engagement, preference, and acceptability of the ARS. This 10-item instrument, adapted from a prior study involving hundreds of students, was originally designed to assess undergraduate college student engagement with the ARS (Graham et al., 2007). An example of a question used to assess perceived learning, evaluated using a three-item Likert-type scale (*agree, I am not sure, disagree*), is the following: “The use of the keypad helped me have a better understanding of the stroke information.” Learning experience of children as perceived by facilitators was explored using a semistructured survey administered to five certified HHS facilitators, three of whom did not deliver the HHS program to the intervention or control groups of this study. This survey also assessed each facilitator's personal experience with both testing methods. Facilitators varied in their level of education (two with master's degrees, one with a college degree, and two with high school degrees; 29–49 years old). Four facilitators self-identified as African American, and one facilitator self-identified as South Asian. The facilitator survey was derived from Nicholson and Bassignani (2009), who surveyed radiology professors on their experience implementing the ARS with medical residents.

Statistical Analysis

Data were analyzed using PASW Statistics, Version 19.0.0, and SAS Version 9.2. As the pretest and posttest data were not linked, chi-square tests were used to test for improvement from pre to post within the ARS-based and paper-based groups. Logistic regression was used to compare improvement from pretest to posttest between the ARS-based and paper-based groups. Values of p less than .05 were considered statistically significant.

Results

Feasibility

Class setup time was slightly greater (by approximately 15 minutes) in the ARS intervention group compared with the pencil–paper control group. Student rating by the facilitators regarding the ease of use of ARS keypads was favorable, with facilitators reporting that students responded accurately and completely to the five pretest and posttest stroke knowledge questions within 10 seconds. Missing data rates for the ARS intervention group were 8.5% and 9% for paper test controls.

Learning

Table 1 shows that both ARS and pencil–paper controls performed significantly well on all five stroke symptom questions in response to the intervention. Analysis of the magnitude of change (pretest to posttest) between groups found that there was no significant difference in retention of the material between testing methods for questions for three out of the five questions. The differences observed in responses to the remaining two stroke symptom questions may be because of significantly lower baseline scores among paper test controls (Table 1). However, because we did not track individual students from pretest to posttest, we were unable to conduct analyses that would adjust for pretest as a covariate. Thus, the data suggest that the ARS system did not confer an independent benefit in terms of the children's learning of the materials.

Engagement and Motivation

Table 2 shows percentages of children's responses to probe questions regarding their overall experience with both testing methods. The children overwhelmingly preferred ARS-based tests over pencil–paper tests ($p < .001$). They reported that the use of the ARS made the program more fun ($p < .001$) and that the ARS helped them stay interested during all 3 days of health education programming ($p < .001$). Sixty-five percent of children believed that the ARS helped them better learn the health information ($p < .001$; although this perceived learning outcome was not supported by comparative outcome data (Table 1), 59% reported that it improved their attention span ($p < .001$) and 67% reported that the ARS system made them more likely to participate ($p < .001$) in the intervention, compared with traditional formats. Facilitators, although obviously not blinded to condition, unanimously corroborated student responses, reporting that students in the ARS intervention group seemed “much more engaged” than children in the pencil–paper controls. Facilitators reported that they too preferred the ARS-based format to pencil–paper formats and that they often adjusted both the curriculum content and pace of instruction in real time, based on immediate feedback questions interspersed within the ARS-based program.

Discussion

Our data suggest that the use of an ARS among low-income schoolchildren for health education programming is feasible and may be more engaging for children than traditional pencil–paper test formats. However, we did not find translation of these benefits, including perceived learning outcomes, to actual learning of the material. Thus, we conclude that in this sample, using the HHS presentation, the ARS did not add to the probability of stroke symptom knowledge retention. However, there are at least two other factors that may account for this. First, as noted earlier, the baseline differences in knowledge were not the same across the two schools: Students in the ARS condition started out with a higher baseline level of knowledge, and thus this dimension was vulnerable to a ceiling effect concerning improvement, compared with the students in the control school. Second, we speculate that there are at least three sources of potential contributors to knowledge retention: the ARS system, the quality of the presentation and materials, and the educational context of the presentation or lecture, independent of whether ARS or pencil-and-paper was

used. Our previous studies showed that children find the HHS program highly engaging, perhaps so much so that other aspects, such as ARS, cannot be expected to add to the effect.

However, although we found no robust differences in learning, we did observe differences in the children's motivation and enjoyment of the material. The value of motivation or increased engagement alone, independent of learning, may not be sufficient to justify an investment in an ARS. However, it is worth considering that although no learning effect was observed in the short-term follow-up used in this study, retention differences might emerge in the longer term, which is a focus of our next study.

We also note that our use of the ARS is partly driven by the increased efficiency gained by our facilitators and program managers. We collect a high volume of data in large school-based public health programs, which collectively enroll more than 10,000 local students annually. Real-time data collection would require labor-intensive efforts for manual data abstraction, data entry, grading, and statistical analyses. Moreover, the feasibility of collecting data "online," that is, while the presentation is actually occurring, would be limited.

Despite the potential advantages of using ARS in health education programming, our study reveals several limitations and disadvantages to using an ARS. Educators require preparatory ARS training by ARS vendors, usually in the form of a webinar delivered over a 1-hour period, which is more time than required for traditional pencil–paper formats. Class setup time is longer for ARS-based interventions and may vary depending on the size of the class. Technical difficulties related to ARS keypads or software may arise. The ARS restricts test questions to a multiple-choice format, because of the nature of polling devices and their incapacity to enable open-ended responses. Therefore, the need to design effective questions formatted for ARS use may further limit widespread application (Roediger & Marsh, 2005). Longitudinal tracking of survey participants using an ARS requires the use of personal identifiers. We have found that assigning a single keypad to a child for sequential surveying over extended periods of time is not feasible. Instead, we have successfully assigned personal identifying numbers for entry into random keypads given to children during each encounter. The success of this method among young children depends on each participant remembering his or her pin number and on a backup system for researchers. For this study, we analyzed pretest and posttest data in both conditions at a group level since we did not identify and track individual students across the testing sequence. We have not formally done a test of reliability for the instrument used to assess engagement and perceived learning experience, which was derived from a large study evaluating ARS experience among students (Graham et al., 2007). Concerning validity, the one measure we have is the agreement between educator ratings and children's ratings of the children's engagement in the ARS condition. Finally, we also used a small convenience sample of local Central Harlem students, which may limit generalizability beyond our community.

In conclusion, our study suggests that the ARS may increase student motivation and engagement when compared with traditional pencil–paper formats without additional benefits on short-term learning. Further studies are required to confirm our findings and

evaluate the effects of increased motivation from ARS use on long-term learning and retention.

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Figure 1.
Option Power™ audience response system handheld unit.

Figure 2.
Audience response system slide sample with histogram.

Table 1

Comparison of Student Performance on Stroke Symptom Pre- and Posttests: ARS Versus Paper Testing Methods.

Stroke Symptom Questions	ARS-Based Testing Method			Paper-Based Testing Method			ARS Versus Paper, <i>p</i>
	Pretest (<i>n</i> = 105), <i>n</i> correct (%)	Posttest (<i>n</i> = 105), <i>n</i> correct (%)	ARS Pretest Versus Posttest, <i>p</i>	Pretest (<i>n</i> = 160), <i>n</i> correct (%)	Posttest (<i>n</i> = 158), <i>n</i> correct (%)	Paper Pretest Versus Posttest, <i>p</i>	
Q1: Vision (Sx)	59 (0.56)	93 (0.89)	<.001	56 [*] (0.35)	128 (0.81)	<.001	.2084
Q2: Chest pain (Distracter)	22 (0.21)	94 (0.9)	<.001	20 (0.13)	100 (0.67)	<.001	.0927
Q3: Facial droop (Sx)	75 (0.71)	98 (0.93)	<.001	41 [*] (0.26)	141 (0.94)	<.001	.0004
Q4: Slurred speech (Sx)	76 (0.72)	93 (0.89)	.004	69 [*] (0.43)	134 (0.89)	<.001	.0068
Q5: Headache (Sx)	39 (0.37)	77 (0.73)	<.001	84 ^{**} (0.53)	120 (0.8)	<.001	.5286

Note. ARS = audience response system; Sx = symptom. Baseline (ARS vs. paper methods) chi-square testing for significance.

^{*}
p < .001.

^{**}
p < .05.

Table 2

Percentages of Children's Responses to Probe Questions Concerning Learning Experience.

	Agree	Not Sure	Disagree	p
Prefer ARS-based tests	85.1	7.4	7.4	<.001
ARS made the program more fun	65.0	12.0	23.0	<.001
ARS helped them stay interested	58.4	21.3	20.2	<.001
ARS improved learning experience	65.3	18.4	16.3	<.001
Improved their attention span	59.0	22.0	19.0	<.001
Increased likelihood of their participation	67.3	12.2	20.2	<.001

Note. ARS = audience response system. *N* = 119. Responses reflect comparisons with traditional format/paper tests.