Project DREAM Year 2: Validation and Pilot of Video Models to Enhance Rural East Texas Algebra Teachers’ Knowledge and Use of Evidence-based Strategies

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Abstract

Teachers need access to evidence-based strategies to support students in learning algebra content. This study explored the use of video models to support teacher knowledge of evidence-based algebra strategies. Results from a mixed methods study including 66 rural East Texas teachers suggest that the use of video models supports teacher knowledge, use, and comfort with evidence-based instructional practices while bolstering teacher confidence and capacity to provide quality instruction. Study limitations, implications for practice, and future research directions are reported.
Introduction

Approximately 65% of all jobs in the United States require postsecondary education or training beyond high school (Georgetown Center for Education and the Workforce, 2018). Although Texas postsecondary graduation rates continue to increase, they are not sufficient to meet industry demands and remain competitive in a global economy. To systematically address these shortages, the 60x30TX Education Plan aims to ensure that 60% of Texans aged 25-34 will have earned a certificate or college degree (Texas Higher Education Coordinating Board, 2017). To meet this goal, it is critical that Texas students have access to a quality algebra course.

One of the predictors of college admission and degree completion is access to an authentic algebra course by grade eight (National Mathematics Advisory Panel, 2008). While most empirical studies focus on the effects of high school math and science courses on college success in science, technology, engineering, and mathematics (STEM), few focus on the quality of those courses and implications for rural educators (Carnegie Science Center, 2014). In Texas, only 50% of students score in the mastery range on the end of course algebra assessment, suggesting intervention and supports are needed to assist students in mastering critical algebra concepts (Texas Education Agency, 2019). These scores have remained relatively stable over the last five years with minimal increases in student performance. It is plausible that improvements in algebra instruction have the potential to improve access, persistence, and completion of postsecondary education, especially for under resourced and underserved rural districts.

Quality Algebra Instruction

Although algebra, especially algebra instruction beyond grade eight, is an under researched area, the field has identified several promising practices. These practices include: (1) using solved problems to engage students in analyzing algebraic reasoning and strategies, (2)
teaching students to utilize the structure of algebraic representations, and (3) demonstrating to students how to intentionally choose from alternative algebraic strategies when solving problems (Star et al., 2015).

**Incorporate Solved Problems.** Students are required to think abstractly to master algebra content. The use of solved problems to support algebraic reasoning and strategy use has shown to increase abstract thinking (see Boyer, 2006; National Council for Teachers of Mathematics, 2019; National Mathematics Advisory Panel, 2008). When incorporating solved problems to support mathematics development, teachers share sample problems and solutions during instruction and activities to support student abstract thinking (Strickland & Maccini, 2010). The process often involves the teacher directing or facilitating a discussion of the steps involved and strategies used to successfully solve problems, and can be completed during whole class, small group, and individual lessons.

**Use the Structure of Algebraic Thinking.** Students are required to solve a variety of expressions and problems that are presented in several forms (e.g., symbolic, numeric, verbal, graphic). Explicitly teaching the structure of problems allows students to focus on the similarities and relationships across problem types (Powell, Fuchs, & Fuchs, 2013; Star, 2015). Examples of teaching students to effectively evaluate problem structures include: (1) using and modeling mathematics language (i.e., use “z represents zebras” rather than “z is zebras”); (2) encouraging students to use “think alouds” (i.e., Is this problem like others I have solved?, How?) and, (3) using diagrams when solving equations (Scheiter, Gerjets, & Schuh, 2010; Star & Rittle-Johnson, 2008; Xin, Jitendra, & Deatline-Buchman; 2005). As with most strategies, students should be explicitly taught how to use problem structures, and this can be accomplished in whole, small, or individual settings.
**Intentionally Choose Alternative Algebraic Strategies.** A strategy is an approach or a series of steps used to solve a problem (Rittle-Johnson, Star, & Durkin, 2012). Although it is impossible to teach every possible strategy for solving a problem type, teaching students several strategies from which they can choose promotes problem-solving flexibility and develops abstract thinking skills. Allowing students to compare strategies helps them understand the advantages and disadvantages of using one approach instead of another; students can make these comparisons individually, with a partner, or in a group (Jitendra et al., 2018; Star & Seifert, 2006).

**Rural Texas Algebra Instruction**

The majority of Texas districts are classified as rural. The Texas Education Agency (TEA) defines a rural district as either having a total student population of less than 300 or an enrollment of between 300 and the median district enrollment for the state with an enrollment growth rate over the past five years of less than 20 percent. Approximately 2,000 campuses located in 445 districts are considered rural campuses (TEA, 2015).

Although important advances in what we know constitute quality mathematics instruction have occurred, research-based practices are not always successfully incorporated into classroom instruction (Klingner, Boardman, & McMaster, 2013; Vaughn et al., 2000). Rural districts often lack access to specialists, have few discretionary resources, and are geographically isolated (Feinberg, Nujens, & Canter, 2005). Students’ lack of access to evidence-based instructional practices has the potential to decrease their likelihood to have the background necessary to pursue advanced mathematics courses, obtain admission to competitive universities, and/or meet eligibility requirements for post-secondary career and technical education programs (Boyer, 2006). There is a critical need to understand and remove the barriers that impede mathematics
Hott and colleagues (2019) explored the knowledge and perceptions of rural Texas teacher’s algebra strategy and intervention use. Findings suggest that rural Texas teachers do not use, or are unaware of, evidence-based strategies to support diverse learners. Teachers reported relying heavily on lecture-based lessons (teacher talking and students passively listening) and practices that have a questionable evidence base, including learning styles (teaching using students preferred learning modalities) and embodied cognitive processing (student learning is associated with student movement). Less than half of teachers reported use of empirically validated strategies including: (1) use of solved problems (sharing problems and solutions during instruction and activities), (2) problem based learning (students learn concepts by solving open ended questions), (3) reflective questioning (opportunities for students to explain how they solved a problem aloud), and (4) teaching different algebraic representations can convey different meanings (understanding and moving between words, graphs, and numbers). Further, over 70% of teachers reported having less than two hours of professional development related to algebra content or instruction within the last three years.

**Video Models to Support Teacher Knowledge of Evidence-Based Practices**

Given the algebra performance of Texas students, teacher knowledge and perceptions of evidence-based practices, and the lack of reported educator access to quality professional development, it is critical that school districts, higher education, and policy makers work to enhance access to quality instructional practices in our rural districts. Video models are demonstrations of specific behaviors through video clips (Shukla-Mehta, Miller, & Callahan, 2010). Video modeling has been effectively used to support student acquisition of both academic and behavioral skills (Morin et al., 2018; Satsangi, Hammer, & Bouck, 2019) and in teacher
coaching (Baecher, Kung, Ward, & Kern, 2018). However, less is known about the use of video models to introduce practices and support rural teachers in academic content areas. To begin addressing the unique needs of rural East Texas algebra teachers serving diverse students, video models of evidence-based algebra strategies, interventions, and resources were developed. The data reported for the development, validation, and teacher knowledge and perceptions is part of the larger project.

**Method**

After internal review board (IRB) and district approvals, this study took place in three phases: (1) video development and validation, (2) educator perceptions of evidence-based teaching strategies, and (3) follow-up interviews including a sample of educators to expand on findings from teacher reports and to contextualize responses. First, expert panels convened to develop and validate video models. Next, educators viewed videos and reported strategy knowledge. Finally, follow-up interviews with a representative sample of educators were completed.

**Video Development and Validation**

An expert panel including retired practitioners with significant experience living and teaching in East Texas; district administrators from East Texas schools knowledgeable of student algebra performance and teacher needs; higher education personnel with experience in rural education, curriculum and instruction, mathematics, mathematics education, special education, and bilingual education; and community members with expertise in workforce development and industry met for two hours in April 2018 to discuss findings from Hott and colleagues’ (2019) study of teacher knowledge and perceptions of evidence-based algebra strategies. The panel recommended videos to introduce the purpose of evidence-based strategies and follow-up videos
to address the use of solved problems, reflective questioning, and teaching multiple mathematical representations that convey different meanings. Two teams consisting of mathematics, special, and bilingual educators developed three 5-7-minute videos outlining the steps in the aforementioned strategies, demonstrating how to implement the strategy, and offering two implementation exemplars. The teams also produced an 11-minute video addressing the need for evidence-based practices, neuromyths and pseudoscience in education, and recommendations for replacing inefficient strategies with efficient strategies. Next, 21 in-service teachers enrolled in a graduate-level teaching methods course reviewed the outlines, and adjustments were made to exemplars for clarity. Two practicing teachers, who also served as project graduate research assistants, created the videos. Finally, the expert panel reconvened in May 2018 and reviewed the videos to ensure both content accuracy and clarity.

**Video Dissemination and Review**

Phase 2 of the project involved developing a website including (1) a description of the project, (2) evidence-based practice video and transcription, (3) strategy videos and transcriptions, and (4) a mechanism for the project team and participants to collaboratively ask and answer questions was created (see https://projectdreamtx.net/). Next, in-service East Texas algebra teachers were recruited by email and through social media. Sixty-six teachers from 42 East Texas districts participated in the study. The majority of teachers identified as Caucasian ($n = 59$) and the mean teaching experience was 11.5 years. The majority of teachers reported teaching at least three different courses (e.g., Algebra I, Geometry, and Biology). Teachers completed a brief, online pre-project survey including Likert scale ratings of their knowledge of evidence and non-evidence based algebra strategies developed by Hott and colleagues (Hott et al., 2019). The following evidence-based and commonly used but not empirically validated
strategies were included in randomized order (1) embodied cognitive processing (student learning is associated with student movement), (2) use of solved problems (sharing problems and solutions during instruction and activities), (3) lecture (teacher talking and students passively listening), (4) learning styles (teaching using students preferred learning modalities), (5) mindsets (fostering perceptions that students can learn material), (6) problem based learning (students learn concepts by solving open ended questions), (7) reflective questioning (opportunities for students to explain how they solved a problem aloud), and (8) teaching different algebraic representations can convey different meanings (understanding and moving between words, graphs, and numbers). The end of the survey included two open-ended questions asking teachers to share strategies that they incorporate to support diverse learners. Next, teachers viewed the initial evidence-based practices video and completed a post survey of their knowledge and perceptions of evidence-based practices.

Four weeks following the project introduction and assessment, teachers completed a brief survey. The survey included ratings of their knowledge and perceptions of the use of solved problems, reflective questioning, and teaching pictorial representations can convey different meanings (understanding and moving between words, graphs, and numbers). Teachers then viewed videos and completed a post-survey including the same questions as the pre-survey in randomized order. Two open-ended questions inquired about video usefulness and if teachers will incorporate strategies into their instruction. Six months after completion of the initial post-survey, teachers completed a second post-intervention survey.

**Teacher Interviews**

Phase 3 of the project involved conducting individual, semi-structured interviews to glean additional insight into teacher knowledge and use of evidence-based practices and the
effectiveness of video models. Interviewees were asked to answer the following questions within the context of providing algebra instruction: (1) Were the videos helpful? Why or why not?, (2) Did you implement any of the strategies shared in the videos?, (3) If you implemented any of the strategies shared in the videos, how effective were the strategies with your students?, and (4) Please share any additional information about the project or videos.

After completing the survey, participants had the opportunity to volunteer to complete a brief follow-up interview. Forty-seven respondents volunteered for follow-up interviews. The researcher selected a purposeful sample of 12 volunteers that represented the survey population in regard to teaching experience and knowledge and perceptions of strategy use. Semi-structured phone interviews were completed by trained graduate research assistants. The interview protocol included four questions and interviews ranged from 42 to 57 minutes. After each interview was completed, a graduate research assistant transcribed the interview. First-level member checks were used to assist with credibility (Bratlinger et al., 2005). After transcriptions were completed, interviewees were emailed a copy of their responses to check for agreement with the transcription.

Data Analysis

To examine the effectiveness of the introductory evidence-based practices video, a paired samples t-test was completed (Fisher, 1949). Analysis of Variance (ANOVA) procedures were used to evaluate teacher reports of knowledge of evidence-based algebra strategies immediately and six months after viewing video models (Cliff, 1987). After verification of interview transcriptions in their entirety, a graduate research assistant and the first author independently completed open coding of a series of interviews. Next, five primary categories and 12 subcategories were identified, agreed upon, and defined. To assist with maintaining consistency
and trustworthiness of the analysis, a third coder served as a peer de-briefer (Bratlinger et al., 2005).

Results

Results suggest that rural East Texas teachers increased their knowledge and use of evidence algebra strategies after viewing video models. Further, teachers report maintaining the knowledge and use of evidence-based practices over time. Video models appeared to have both social validity and impact on mathematics instruction.

Teacher Knowledge of Evidence-Based Algebra Practices

Teachers were asked to rate their knowledge of algebra strategies using a Likert scale, with ratings of 4 indicating high levels of understanding, and ratings of 1 indicating low levels of understanding. A paired samples t test was conducted to evaluate the change in teacher perceptions of their knowledge of algebra strategies before and after viewing the videos. The results indicate that mean ratings of knowledge of evidence-based practices was significantly greater after viewing the introduction to evidence-based practices video ($M = 3.69$, $SD = 1.2$) compared to mean ratings before viewing the video ($M = 2.22$, $SD = 1.0$), $t(130) = 7.65$, $p < .01$. The standardized effect size index, $d$, was .52, with considerable overlap in the distributions for the Likert ratings of evidence-based practice knowledge. In other words, teachers reported significant increases their knowledge of evidence-based algebra practices after viewing the video.

Teacher Knowledge and Use of Algebra Strategies

A one-way ANOVA was completed to evaluate the relationship between video models and the change in teacher perceptions of algebra strategy use. The ANOVA was significant, indicating difference in teacher knowledge and use of the three evidence-based strategies, $F(2,$
195) = 48.44, \( p < .01 \). The strength of the relationship between use of video models and teacher perceptions of strategy knowledge and use, as assessed by \( \eta^2 \), was strong, with the video model factor accounting for 38\% of the variance.

Follow-up tests were conducted to evaluate pairwise differences among the means. Because of the variances among teacher reports of strategy knowledge and intervention ranged from 2.17 to 4.0, we chose not to assume that the variances were homogeneous and conducted post hoc comparisons with the use of the Dunnet’s C test, a test that does not assume equal variance. There was a significant difference in the means between the pre and post video modeling reports of algebra strategy knowledge and use, but no significant differences between the post survey and six months follow up survey results. As illustrated in the figure below, viewing video models increased teachers’ reports of their knowledge and comfort with implementing evidence-based algebra strategies in their classrooms.
Teacher Perceptions of Video Models

The interview participants painted a similar picture of survey results. Each of the 12 interviewees reported that the video models were beneficial and noted at some point during their interview that they want to take advantage of future opportunities to view video models that support instruction and collaboration. All of the interviewees reported that the introductory video which included information about pseudoscientific practices and neuromyths was sufficient to remove both learning styles and embodied cognitive processing from their practice. Additional information about how to cost effectively replace the practices with more robust, empirically validated options was a theme across each of the interviews.

Although all of the participants viewed the videos favorably, only one participant reported that information contained in the strategy videos was sufficient to successfully implement practices daily. Over half of the participants emphasized it helped to have information disseminated by professionals who understand local context. All of the teachers expressed significant interest in additional professional development opportunities including online courses, coaching, and professional development days devoted to algebra instruction. Ten out of the 12 teachers shared that having someone observe their class and offer feedback in a non-evaluative fashion would be helpful. Participants also reported similar perceived obstacles to accessing professional development in their districts or schools. These barriers included difficulty knowing where to look for professional development or to learn more about practices and access to specialists to discuss progress.

Discussion

Traditionally, researchers disseminate findings through professional journals that may not be accessible to practitioners (Cook & Odem, 2013; Hott et al, 2019). Study findings suggest that
the use of video models is a viable, cost effective means of exposing rural algebra teachers to evidence-based algebra strategies. Further, video models may be sufficient to stop the use of ineffective strategies. There is a rich body of evidence that indicates “one-shot” professional developments are ineffective (see Flint, Zisook, & Fisher, 2011). Although the use of brief video models used in isolation do not replace face-to-face and quality online professional development, they may serve as a means to spark interest, encourage reflective practice, and empower practitioners to access additional resources.

Presenting information for trustworthy sources appeared paramount. Several participants emphasized that they enjoyed watching videos and felt that it helped to have information disseminated by professionals who understand local context. Disseminating results of what is working in rural schools and methods for replication are critical. This can be accomplished through pre-service teacher education programs and reinforced through district and regional professional development. To begin truly addressing teacher needs, coordination is needed across fields (e.g., special education, curriculum and instruction, mathematics education) and between universities, regional service centers, and districts (see Evans, Williams, King, & Metcalf, 2010; Maheady, L., Magiera, K., & Simmons, 2016). Collaboratively and consistently using a common set of vocabulary or clearly delineating differing terms and their meanings, having an open dialog about philosophical differences in pedagogy, and clear goals based on data are paramount to provide an equitable education for rural students.

Further, training to support implementation of effective strategies and interventions is warranted. Leveraging the responsible use of low or no cost technology has the potential to not only improve access to evidence-based practices but also to provide the support necessary for effective implementation (Sundeen & Sundeen, 2013). Given the significant increases in teacher
knowledge from video models, professional development providers, organizations, and researchers may consider disseminating evidence-based practices, addressing implementation questions, and providing feedback through online outlets (Trust, 2012).

Video conferencing between university faculty or professional development providers and teachers is also a plausible means of supporting both teacher identification of relevant evidence-based practices and implementation of those practices in rural schools (Canter, Voytecki, & Rodríguez, 2007; Pemberton, Cereijo, Tyler-Wood, & Rademacher, 2004). Many technological advances have occurred over the years with infrastructure and resources now being an option to facilitate online professional learning communities using video conferencing methods (McConnell et al., 2013). Teachers, both general and special education, can complete book studies, discuss a strategy or intervention, or share materials using video conferencing methods, thus removing the isolation of being the “only algebra teacher” in a school or district. Bug-in-ear technology is another promising practice. Although there are several models of bug-in-ear technology, the majority rely on a webcam, Bluetooth USB adapters, headsets, and a video conferencing tool such as Skype or Zoom that allows coaches and instructional specialists to provide real time instructional feedback from another location (Rock et al., 2014). This technology further reduces some of the barriers that rural special educators face such as access to specialists and isolation (Abell, Collins, Kleinert, & Pennington, 2014; Berry, 2012; Ludlow, 2015). Developing materials at the regional level and disseminating through professional developments appears one plausible way to address this need.

As researchers continue to focus on developing effective interventions to support practitioners, it is also important to both assess the social validity of interventions and ensure that dissemination efforts are effective. There are many areas of future work that have the potential to
improve outcomes for rural students. Implementation and evaluation of professional development to support secondary mathematics instruction, particularly in algebra, is desperately needed. These offerings need to take into account the unique needs of rural educators. Assessments should include both teacher and student data to track effectiveness. Additional studies may examine follow-up professional activities using technology such as Twitter chats, blogs, and social media. Finally, and perhaps most importantly, strategies to ensure that teachers remain in the field and have the supports necessary to meet the demands of students are desperately needed.
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