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MISTAKE DETECTION VIDEOS TO IMPROVE STUDENTS' MOTIVATION IN MATH

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This article describes the design case of an instructional experience incorporating videos of mistakes for students to practice mistake detection and recovery skills. Learning from mistakes is often encouraged, but students may need practical support to address them effectively. The intention of this design is to facilitate adaptive cognitive and emotional responses to handling mistakes. This article documents two distinct but related formats of a mistake recovery design: a personal video recording and pre-recorded videos featuring fourth grade mathematics. These two formats evolved from personal experiences to become a classroom intervention. We trace this design process including the context, theory, and implementation experiences that shaped the design and discuss unforeseen obstacles and design alterations that arose during this process.

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VIDEOS AND MATH MISTAKES

We designed an intervention in which learners interacted with videos that showed a younger student make common mathematical mistakes. These videos integrated with in-class mathematical curricula to create an experiential learning opportunity to improve mistake detection, explanation, and correction—empowering students to become mistake detectives. Involving learners in active mistake detection has the potential to encourage persistence and incremental improvement upon mathematical problem solving (e.g., Tulis, Steuer, & Dresel, 2016). As detailed in this design case, our decisions reflect the specific context and experiences of the first author, and were shaped by our interest in designing a mistake detection intervention that incorporated recommendations from the research literature on implicit theories of intelligence (e.g., Blackwell, Trzesniewski & Dweck, 2007) into its delivery and content. The aim of this paper is to describe the evolution of what we believe is an innovative design, and to share our experience learning from and altering our design across multiple iterations of mistake detection videos.

This mistake detection video design evolved from experiences of Luna-Lucero creating videos to identify and improve upon her math mistakes. The mistake recovery personal recording section is written from Luna-Lucero's perspective and will trace the initial context and inspiration for the mistake detection videos. Elmore was involved in decision-making to develop a video design that would be appropriate for implementation as a classroom intervention in several high schools in a major U.S. city.

MISTAKE RECOVERY: PERSONAL VIDEO RECORDINGS

The mistake detection video classroom design originated from my experiences as a learner who had trouble with math mistakes. My greatest challenge in learning math was knowing what to do when I got stuck on a problem. As a doctoral student learning statistics, I knew that I was making mistakes, but felt powerless to identify them. In response to

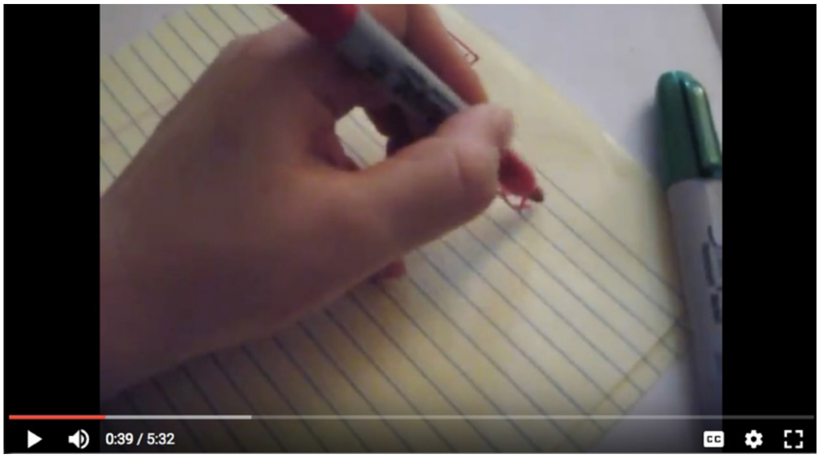

FIGURE 1. A screenshot of the first recording I used to improve my math performance in a statistics course.

my frustration, I sought to adopt a new approach by mounting a digital camera on a tripod over my work and recording my problem-solving processes (see Figure 1). I watched the videos and reflected on the paths I took to solve the math problem. I then attempted the problem again; applying any new insights to incrementally improve my performance (e.g., try a different strategy or retrace steps).

In retrospect, the idea to record myself emerged from my teaching experiences. I have taught public speaking for over ten years and my instruction frequently involved video recording students delivering speeches. In a typical assignment, students reviewed these videos and wrote reflection papers describing ways to improve their public speaking. By applying this video recording method to mathematics, I could see where I was making mistakes in my work, enabling me to better articulate to a tutor or teacher when I sought help. Thus, reflection and help-seeking were a key part of the process (see Figure 2 for a description of the personal recording process). My math performance did not improve overnight, but through the video recordings I was able to decrease the number of mistakes I made on subsequent attempts. I became comfortable openly discussing mistakes with others; signifying a positive change in my beliefs and behaviors related to mistakes. Following these discussions and adjustments, I experienced an improvement in my performance and mathematical understanding.

The video recording design emerged from a personal need and was not originally intended to become a research project or instructional design. Rather, it was an attempt to identify my mistakes, build confidence, and improve my performance. However, as a graduate student working towards a degree in education, my own success with these mistake recovery recordings inspired me to adapt these videos into a design that would suit the context of math learners in traditional K-12 classroom settings. As could be expected with creating a design while doing academic work, a number of research studies influenced our design decisions.

INFLUENCES ON THE DESIGN

When brainstorming how to create a mistake detection video experience that would suit a classroom setting, we were influenced by prior research on motivational beliefs that support effort in the face of failure. Belief that intelligence is fixed leads students to attribute failure to their ability rather than their effort; attributions that undermine motivation (e.g., Blackwell, Trzesniewski & Dweck, 2007; Dweck, Chiu, & Hong, 1995; Dweck & Leggett, 1988). Interventions that encourage the belief that intelligence can be changed with effort improve students' achievement over time (e.g., Paunesku, Walton, Romero, Smith, Yeager, & Dweck, 2015). These beliefs about effort and intelligence likely shape whether or not students are able to recover from their mistakes. For example, excessively negative emotional responses to failure may lead to task avoidance (e.g., Tulis & Fulmer, 2013), whereas positive responses to failure can inspire persistence and effort to master the content (e.g., Schunk, Pintrich, & Meece, 2008). Specifically, students who remain positive despite failure tend to also view error feedback positively (Tulis & Ainley, 2011). Drawing from this literature, our design aimed to interrupt a demotivating cycle of beliefs that mistakes are a sign of low intelligence (see Figure 3) and support beneficial beliefs that mistakes are learning opportunities (see Figure 4). This cycle of adaptive and motivating beliefs may galvanize students to persist when confronting mistakes because they value mistake detection as a normal, iterative process towards understanding (e.g., Eggleton & Moldavan, 2001). Beliefs about mistakes may matter particularly for students in mathematics, a subject in which incremental progress and recovery from mistakes are a fundamental part of learning (Boaler, 2013, 2016).

To address the importance of the cycle of motivational beliefs in mistake detection, we drew upon them as an influence on the video design. Accordingly, our goal was not to create mistake detection videos that taught students how to avoid making mistakes. Nor was the design intended to replace typical class instruction. Instead, we wanted to show that mistakes are a normal part of learning. Thus, mistake detection videos combine practice in mistake detection and recovery with motivational messages. Although our videos featured math mistakes, we were wary of encouraging learners to focus only on whether the answers were right or wrong, which might evoke an unhelpful performance-oriented perspective (Ames & Archer, 1988; Ames, 1992; Anderman, Patrick, Hruda, & Linnenbrink, 2002; Dweck, 1986). Instead, we decided to focus students on what

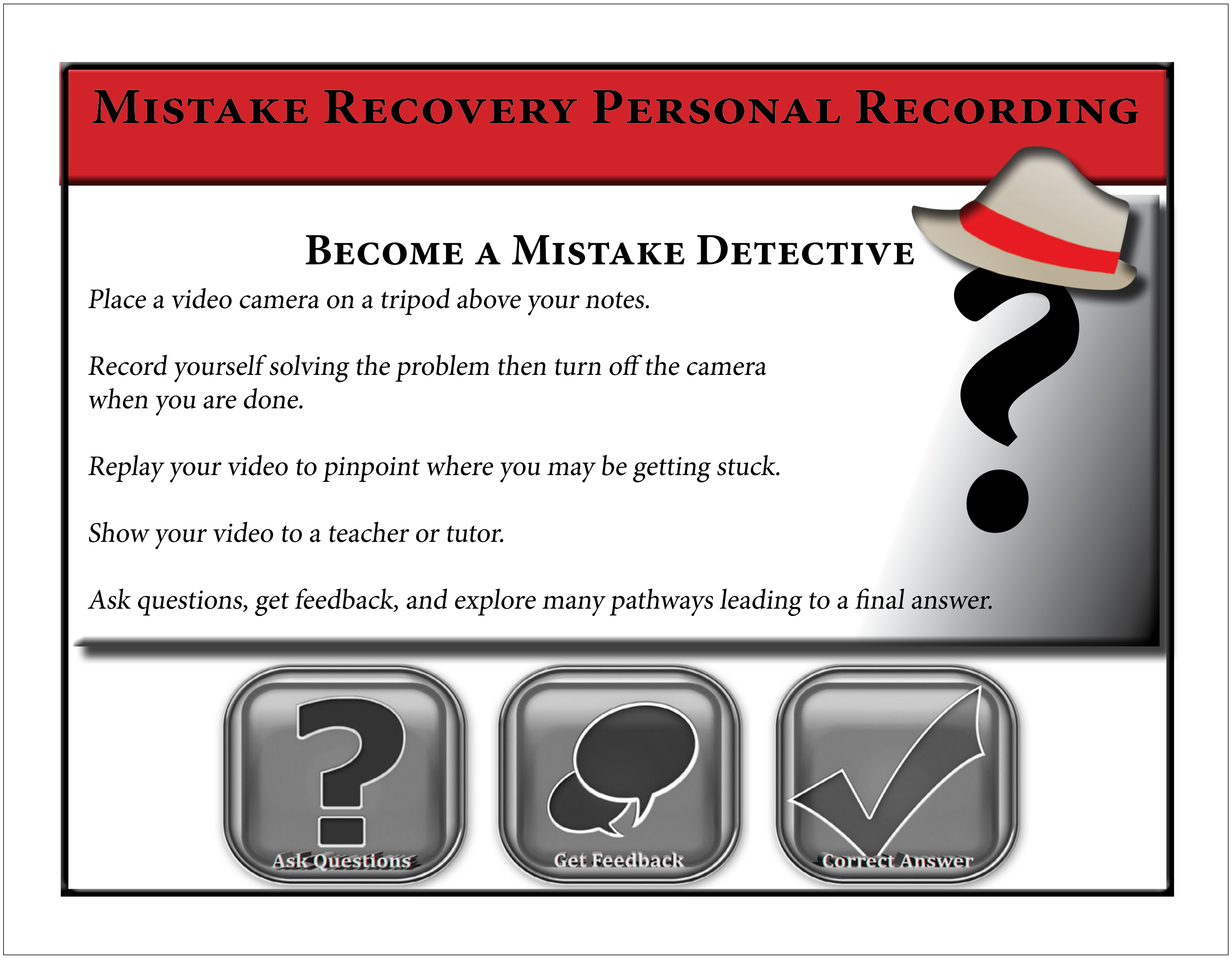

FIGURE 2. Description of the "mistake recovery personal recording" process.

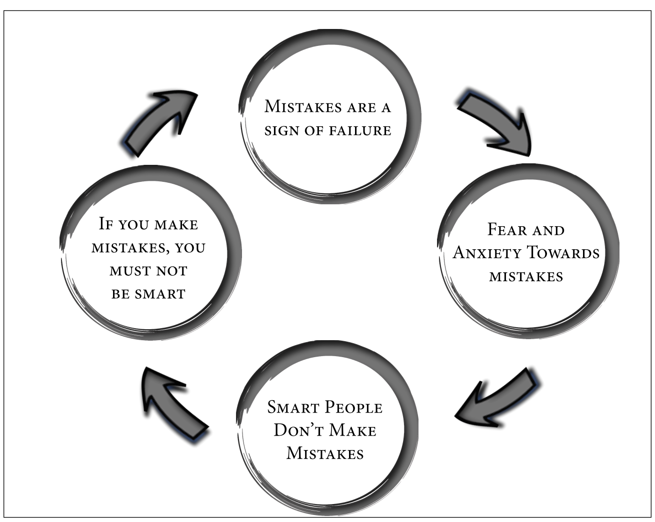

FIGURE 3. Demotivating cycle of beliefs about mistakes.

FIGURE 4. Motivating cycle of beliefs about mistakes.

pathways led to the final answer and what can be learned from this experience, a mastery-oriented perspective. Throughout the design process, we avoided design choices that might overemphasize performance and push students into a demotivating cycle of beliefs about mistakes.

RECONCILING RELEVANT LITERATURE WITH PRACTICAL IMPLEMENTATION

With motivational beliefs in mind, we faced the challenging task of designing mistake detection videos suitable for the affordances and limitations of a classroom setting. As teachers and researchers who are familiar with a high school classroom structure, we first considered using cell phone cameras as a way for students to record their own mathematics classwork or homework. This option proved impractical because not every student had access to a cell phone with a camera or sufficient storage capacity for video recordings. We then deployed a small pilot study in which individual students solved math problems on a digital graphics tablet (Wacom Intuos Pen Tablet). We used the "screen recording" feature in QuickTime to capture their work on a computer. We saved these videos as Audio Video Interleaved (AVI) files for later playback. In addition to being labor-intensive and time-consuming for each student, the process of recording with a Wacom tablet appeared too different from how students typically solve math problems in the classroom. Other mobile-friendly applications (e.g., Penultimate) posed similar issues. Additionally, not every student had reliable Internet access either at home or school, making the video recording process challenging.

As a result of these practical constraints, we shifted our design from personal recordings to instead have students detect mistakes in other students' math solutions. This was a difficult decision because we suspected that having students detect and recover from their own mistakes would be a more ideal way to challenge unhelpful cycles of beliefs about mistakes, rather than having them watch the mistakes of others. However, creating pre-recorded mistake detection videos allowed us to balance our goal of providing practice in mistake detection with the technological constraints of typical classrooms.

While considering the use of pre-recorded videos, we discussed other possibilities like working out math problems in person on a dry erase board, or showing pre-recorded mistake videos to the entire class on an overhead projector. However, we were concerned that issues surrounding group communication and classroom seating would impact individual student engagement in a group setting. We rejected both ideas because we believed that each student needed to be able to work autonomously and at their own pace to actively practice mistake detection and recovery.

We settled on a design in which students viewed and interacted with pre-recorded videos individually at their own computers. Creating pre-recorded videos allowed us to take advantage of affordances that do exist in typical classrooms, such as classroom computers with access to digital video playback (e.g., AVI software) that learners can manipulate (play, pause, stop, rewind, etc.).

THE DESIGN AND EVOLUTION OF THE MISTAKE DETECTION VIDEO EXPERIENCE FROM ADULT STUDENTS TO HIGH SCHOOL STUDENTS

Next, we outline two iterations of the design. We tested the first iteration with adult students in a research lab. We then made changes and tested the second iteration with our target population of high school students in classroom settings. Our goal was to design a mistake detection video experience that guided learners to (a) try to understand the steps in the math problem they viewed, (b) focus on mistake detection and recovery strategies and not only the final outcome, and (c) offer advice or suggestions for solving the problem while replaying the video as necessary.

Iteration 1: Adult Students

Mistake detection video preparation

For the first design iteration, we created pre-recorded mistake detection videos that featured four math problems written out on a Wacom tablet. The video recordings were captured using the "screen recording" feature in QuickTime. The four videos were recorded individually without audio and saved as AVI files. The video files were Windows and Macintosh compatible and could be played locally on a hard drive or posted on YouTube or Vimeo. The math and mistake content in the videos was adapted from online sources such as Khan Academy (www.khanacademy.org) and websites describing common mistakes in mathematics (e.g., math-mistakes.org). The four math problems varied in difficulty, but each included content that most adult students would recognize. Across the four videos, we included both computational and conceptual mistakes.

Mistake detection video experience

A demographically-diverse group of adult students (aged 26-35 years old) from a major city university participated in testing the first iteration of the design. We presented four two-minute YouTube videos, one at a time, in increasing difficulty on an individual computer in a research lab on campus (see Figure 5). Participants were told to watch the videos individually and answer the following questions for each video: "Do you see a mistake: Yes or no?"; if "no," continue to the next video, if "yes," then, "please provide the time in the video where you found the mistake (Ex: 1 minute,

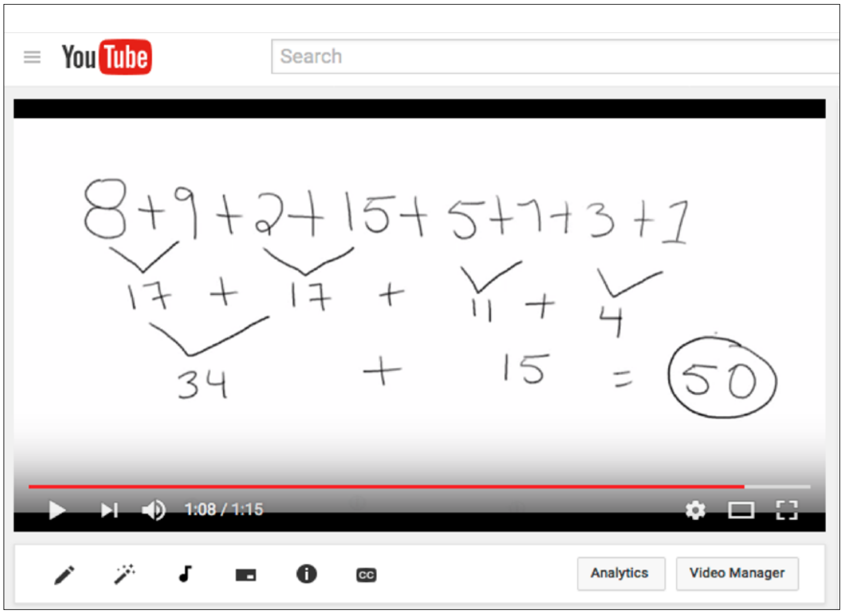

FIGURE 5. A screenshot showing one mistake video used in the first pilot test with adult students. This image shows two mistakes "5+7=11" and "34+15=50."

17 seconds)." After participants indicated the point at which they detected a mistake, they were then asked, "What was the mistake?" and "How would you fix it?"

Design issues and adjustments

This first iteration with adult students exposed three primary issues in the initial mistake detection video experience that needed to be addressed: (a) the number and type of mistakes in each video, (b) the video introduction wording and framing, and (c) the prompts dichotomizing problems as either correct or incorrect (e.g., "Do you see a mistake: Yes or no?"). For each design issue, we took steps to improve upon this design for the high school classroom iteration.

First, we observed that adults in the first iteration struggled to identify multiple mistakes in a single video. For the high school student iteration, we adjusted the mistake detection videos to only include one mistake to detect. We also simplified the task by avoiding mistakes that were uncommon or overly confusing. To help in this effort, we consulted with a team of math teachers to ensure the math presented in the videos was appropriate for the age-level of the students in their classes. This practical design consideration was consistent with work showing that learners need to have sufficient prior content knowledge in order to benefit from exposure to incorrect worked examples (e.g., Große & Renkle, 2004, 2007).

Second, the videos were introduced to adult students using one sentence, "Please watch the following videos." Students' responses did not typically reference any person in the video and their responses often appeared terse and prescriptive (e.g., "addition error"). The task orientation of these responses did not address the socio-emotional factors that seemed relevant to how students confront mistakes. To foster a connection between participants and the mistake videos we introduced a vignette that contextualized the videos as real work from a student. This introduction depicted a student named Sarah making a mistake while answering a problem. This design decision situated learners as student advisors, an approach that has been effective in previous motivational interventions because it helps students internalize motivational messages (Aronson, Fried, & Good, 2002; Walton & Cohen, 2007). We framed the video responses as correspondence with a younger mistake-maker to make the activity seem more meaningful and to facilitate internalization of the motivational messages.

Third, asking students, "Do you see a mistake," may have created unnecessary frustration or stress if a student did not initially detect a mistake. For example, we observed adult students identifying superficial outcomes such as penmanship as a mistake rather than the mathematics. Reframing the prompt for mistake detection was important because students should feel they are exploring the math in the problem and not just orienting themselves to look for errors. While mistake detection and correction was the primary goal, it was also important to us to use prompts that encouraged students to productively engage with the math in the videos, whether they successfully detected the mistakes or not. For the high school student iteration, we reworded the question and instead asked, "Did Sarah solve this problem correctly? Yes, no, or I don't know" and "Did Sarah solve this problem as you would have solved it? Explain," rather than "Do you see a mistake? Yes or no." This shift in language was intended to decrease any frustration arising from being asked, "Do you see a mistake" that the student may not see. Moreover, including direct language about the mathematics problem in the video clarified the intention of the question prompt. In addition, the inclusion of the "I don't know" option could help identify students who struggled with the task.

Iteration 2: High School Students

We conducted the second iteration of the mistake detection video experience with our population of interest, high school math learners. Along with the alterations based on the first iteration, a few additional design decisions were necessary to deal with the specific constraints of the high schools in which we were working. This design was implemented as part of a research project to determine its efficacy as an intervention to improve math performance. This introduced constraints on time (to allow time for students to complete related paper surveys) and required students to work independently (to allow for some students to simultaneously complete a different activity and provide a control comparison group).

Mistake detection video design consultations and adjustments

We presented our revised design plan to a group of experienced high school math teachers, who provided feedback on design features and content. Our initial plan was to present at-grade-level math to high school students. However, teachers rejected this idea, predicting that their students would struggle with mistake detection if the math were too difficult. In response, we chose to feature videos of fourth grade mathematics, including addition and fractions, because this knowledge is essential for learning more advanced mathematics (National Mathematics Advisory Panel, 2008) and reflects the mathematical skills of the average student population.

Our teacher consultants also provided feedback about the types of mistakes to feature. Echoing our conclusions after the iteration with adult students, teachers agreed that the mistakes should be common for the sample population, devoid of superfluous content (e.g., poor handwriting), relevant to students' prior content knowledge, and relatively easy for students to detect without being too obvious. After much discussion, teachers also reached a consensus that mistakes should include both computational and conceptual errors.

We again consulted with our team of high school math teachers for feedback on the fourth-grade math problems for use in the videos. They reviewed the math problems and agreed they were understandable for their student population. However, they suggested an alternative order. Our initial intuition had been to present the videos in order of increasing difficulty. In contrast, teachers felt that ending the video sequence with a relatively easy to solve math problem would allow students to leave the video experience with a greater feeling of competence. Based on their advice, we decided to present high school students four videos of math problems in the following sequence: Video 1—easy to solve; Video 2—somewhat difficult to solve; Video 3—difficult to solve, and Video 4—somewhat easy to solve.

Teachers also informed us that, unlike in the adult student design, we would be unable to use YouTube to deliver the videos. Although YouTube is an accessible and inexpensive mode for presenting videos because anyone with an Internet connection can share content, it was infeasible for use in schools for two reasons. First, schools that have unreliable Internet connections make reliance on a

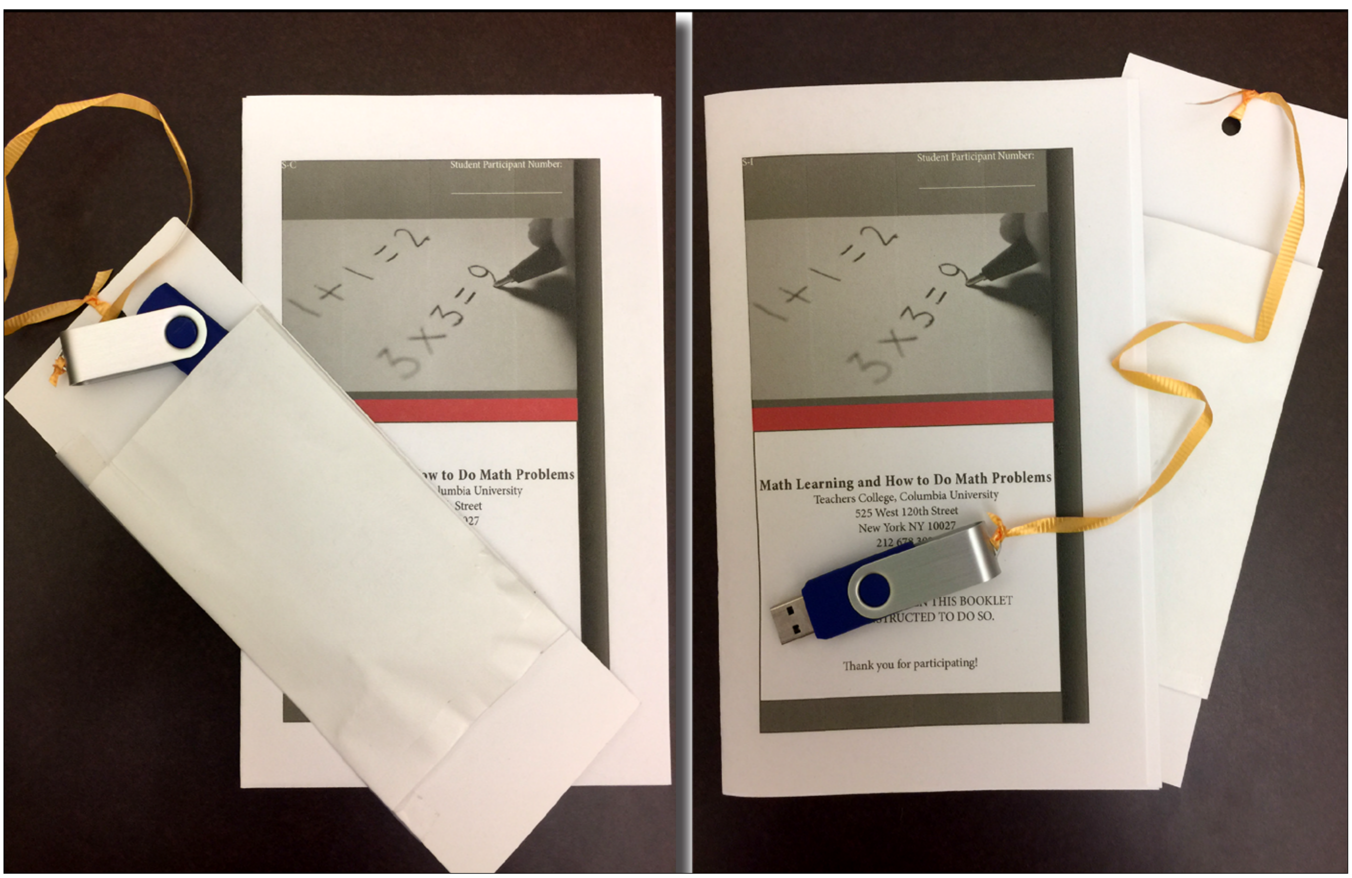

FIGURE 6. Photographs of the mistake detection survey and USB drive containing the mistake videos.

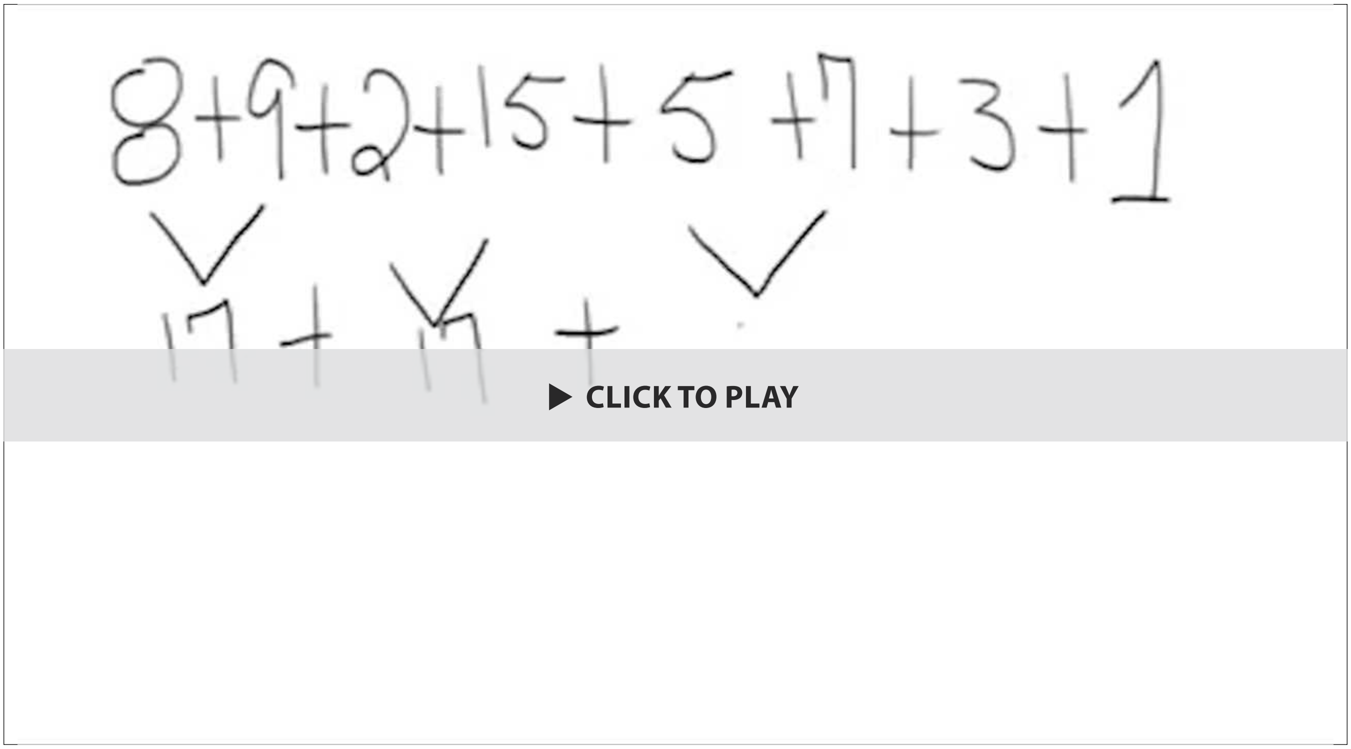

FIGURE 7. Video One from the high school iteration. This video shows one mistake "5+7=11."

web-based platform challenging. Second, YouTube displays advertisements, recommended videos, and comments alongside content. For this reason (and supervision challenges), YouTube is banned in many schools. Additionally, so many competing images could contribute to information overload—which may have undermined the impact of our videos. We decided to develop an alternative way to present the videos, as described next.

Mistake detection video preparation

All videos were pre-recorded using the same materials as the adult student videos (i.e., Wacom tablet, QuickTime software, etc.), had no audio, and were approximately two minutes in length. As opposed to using YouTube, we saved the videos on individual Universal Serial Bus (USB) drives to address the lack of Internet access in classrooms. These USB drives contained clearly marked folders to ensure that students watched the videos in the assigned sequence. We did not label the videos as containing mistakes; rather we labeled them as "Video 1," "Video 2," and so on. Each student received one USB drive attached with a colorful ribbon to a large bookmark-sized piece of paper (see Figure 6). The bookmark had a hand-made envelope taped to it that held the drive inside. For accountability and management of materials, the envelope was tucked into a paper survey that related to the larger research study.

The math problems and mistakes featured in the pre-recoded videos were examples adapted from the Program for International Student Assessment (PISA, 2016) and Trends in International Mathematics and Science Study (TIMSS, 2011) fourth grade mathematics assessment items. Each of the four videos allowed students to start, stop, and rewind them independently (see Figure 7 to watch Video One).

We created a set of paper-based instructions and questions to accompany the four mistake videos. The instructions described the videos as depicting a younger student (named "Sarah") answering a set of problems. The conceptualization of Sarah as a design feature emerged from personal interactions with a friend's fourth grade daughter and her experiences in a math class. The vignette was based on the lived experiences of an actual fourth grade student and included some of her thoughts about math.

In addition to the description of Sarah, we also integrated a motivational message into the video introduction. The video introduction described the benefits of getting feedback when struggling in math. This message offered a rationale for why students were being asked to watch the videos and reminded them to focus on incremental progress in learning. This message was intended to challenge students' potential beliefs that mistakes are a sign of failure and low intelligence.

In the questions about the videos, we intentionally omitted any prompts asking students to solve the math problems they observed in the videos. We focused our questions on students' thoughts and feedback, and encouraged them to write out advice for Sarah based on what they saw in the videos.

Mistake detection video experience

A demographically-diverse group of high school students between the ages of 15-19 years old attending several high schools in New York City experienced our video design. The mistake detection experience occurred in a single 45-minute class period. However, it should be noted that students completed related surveys in a previous class day because this design was nested in a research study. Students were assigned an individual laptop or desktop computer and asked to work independently.

To allow us to compare the differences between our mistake detection design and a control group, we distributed laptops and seating arrangements based on those groups. Distributing the materials to students and setting up the laptops for students to view the videos in the classroom took approximately ten minutes.

Additionally, we distributed scrap paper to all students in case they wanted to take notes during the activity. For an overview of the mistake detection video design, see Figure 8.

To begin, students first read information that oriented them to the video task and introduced Sarah:

> *"We think high school students often do a great job explaining math ideas to younger school students because they tend to offer help that teachers may miss. We are going to ask that you watch some videos of a fourth grade student named Sarah.*
>
> *In math, it is often helpful to watch how others solve problems. It is helpful to see and understand how people get their final answer. When a student gets stuck, they should not keep doing the same thing over and over again if it is not working. Instead, they should get advice from other people who know how to do the work or can help. In just a minute, you'll be watching a younger student solve problems and trying to understand their work. You will be asked to give this student your opinion on what you see" (see Appendix A for the full set of instructions).*

Next, students were asked to plug the USB drive into their laptop or desktop computer and click through the video sequence individually and at their own pace.

After viewing each video, students read another set of questions on their accompanying paper survey that asked them to (a) determine whether Sarah solved the problem correctly (e.g., "yes," "no," or "I don't know"), (b) determine whether they would solve the math problem similarly, and (c) generate advice for Sarah for the math problem in the video. Students answered these survey questions in writing on paper surveys (see Appendix B for the exact wording). Some students used the scrap paper to mark significant moments within the

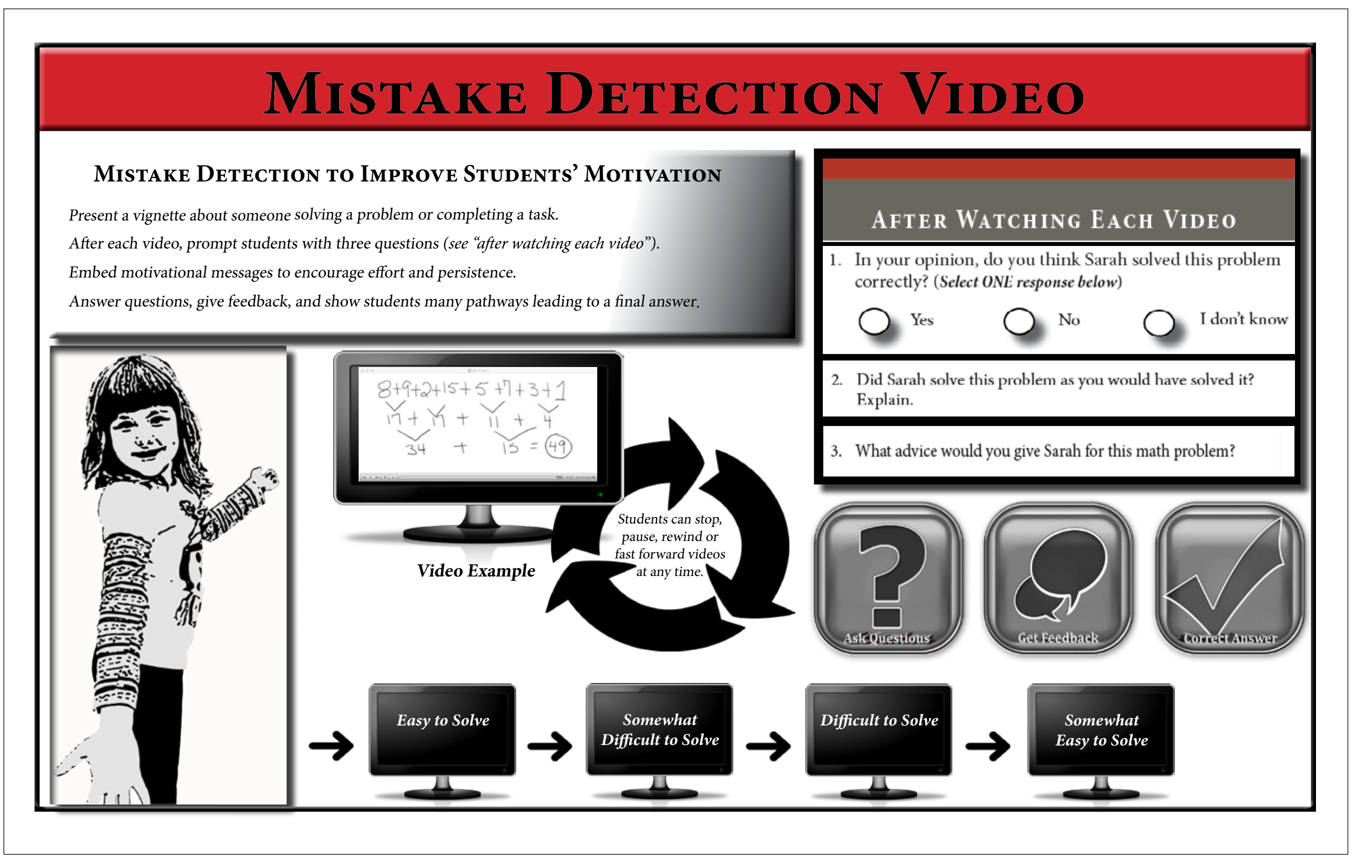

FIGURE 8. Overview of the mistake detection video design.

videos, such as when they observed a mistake or points they wanted to review again in the video.

At the end of the videos and survey sequence, students read a message from Sarah describing mistakes as an opportunity to learn. A photo of Sarah (portrayed by an actual fourth grader) also was included with the following message: *"Thanks for watching my videos! I like math a lot. I know I get stuck, but I also know to keep trying. I think solving math problems is good because I learn from it."* This motivational message reminded students that mistakes could provide a learning opportunity rather than signaling failure.

UNFORESEEN OBSTACLES AND UNEXPECTED DISCOVERIES OF THE DESIGN

We implemented the mistake detection video experience in several high school classes and experienced two unforeseen design obstacles—language barriers and limited opportunities for group discussion—and made two unexpected discoveries—increased student engagement (based on teacher feedback) and social empathy towards our Sarah character. We reflect on these lessons learned based on our observations of user experiences.

Unforeseen Obstacles

The materials in our initial design were only in English. We were sensitive to student comprehension and offered examples for some vocabulary words (e.g., Anxiety means to worry about something) to ensure understanding. When we began testing in classrooms we found that a small group of students in one class were English Language Learners (ELLs). These students struggled with reading materials (during an earlier research phase) in English. In response to students needs, we translated the subsequent paper materials and coordinated with a classroom tutor to help disseminate the mistake detection video instructions in their native language. These new materials were created partway through the implementation of the design, and were possible only because one of the designers spoke Spanish. While we recognized the translation of our materials was hurried, this group of students navigated through the materials at the same pace as their English language counterparts. In retrospect, more attention to ELLs across classrooms would have avoided this rushed translation effort. However, there is little need for language when watching the mistake detection videos themselves because the translations were for the accompanying paper surveys, which highlights the flexibility of this design.

We also experienced challenges with the design that occurred because it was nested within a larger research study. For example, we asked students to work independently and not openly discuss the videos with others. While students engaged with the videos, it became apparent that they wanted to talk to their peers and their teachers about what they saw. We observed students responding verbally during the video viewing by using statements like, "Wow," or "Come on Sarah," or, "Good job Sarah, you can do it." Students responded nonverbally by pointing at their computer screens, clapping their hands, raising their eyebrows, and nodding or shaking their heads. When we returned to debrief participants at the end of the larger research study, students verbally recounted their experiences with the videos. Some students even worked out the math problems on the dry erase board and commented about their experiences with math generally.

We did not anticipate how much students wanted to talk about math and math mistakes after watching the videos. Regrettably, we missed an opportunity to include these discussions in the design itself. In future iterations of this design, we would likely encourage small group discussions to capitalize on this interaction. Allowing students a forum to discuss mistakes, but focusing on Sarah rather than themselves, may have avoided embarrassment or anxiety for individual students. A future design could target a classroom culture of motivating beliefs about mistakes by using the mistake detection videos as a springboard for discussion or group work (see Borasi, 1994, for a similar approach).

Unexpected Discoveries

The mistake detection introduction text included age-appropriate language and highlighted the importance of student involvement. For example, we included sentences like, "We think high school students often do a great job explaining math…because they tend to offer help that teachers may miss." We intentionally omitted instructions asking students to solve each problem in the video in order to alleviate potential anxiety-inducing triggers associated with solving mathematics problems. Despite the lack of a direct problem-solving prompt, most students worked through the problems anyway. Observing the high level of student engagement with math, several teachers voiced surprise stating they did not expect students to immediately engage with the videos and use the provided scrap paper without being directly prompted to do so. Teachers also stated they observed typically quiet students ask questions and request feedback on how to solve the math problems. Although we did not directly measure student engagement, we speculate that students appeared engaged because the videos were a novel classroom experience. Future iterations of the design could empower teachers to create their own videos based on mistakes that they are encountering with their students' work.

Additionally, we discovered that student participants were far more interested in the welfare of Sarah than we expected. Although the mistakes by Sarah were based on those actually made by real fourth grade students, the persona of Sarah was a design feature that we constructed—one that was unexpectedly intriguing to students. Presenting the math videos as coming from a person in need of assistance noticeably changed the way participants reacted to mistakes, gave advice, and offered encouragement for overcoming mistakes and improving math performance. Students may perceive mistakes as private interactions. Therefore, offering advice to another person, real or imagined, opened up possibilities for dialogue surrounding mistakes without explicitly provoking performance anxiety and self-consciousness. Specifically, students expressed concern for Sarah's educational well-being without being vulnerable themselves. Students expressed concern in their written responses to Sarah after watching the mistake videos: "If you don't get something right the first time, try again;" "Try your best, ask for help if you need to, don't be scared and ask;" and "Practice makes perfect."

In future iterations of the design, we could focus more directly on the social and emotional aspects of providing advice (or error feedback) to another student. For example, we learned of a teacher who adapted our mistake detection videos to help a fourth-grade student confront her anxiety in math. The teacher did not discuss math with the student, but asked the student how she thought Sarah from the video felt about making a mistake and what she should do about it. The student discussed feelings of shame and stress. The teacher talked through ways to confront these emotions and reported that after the student explored these strategies to help Sarah's emotions, she was able to reattempt the math in her own work.

CONCLUSION

In this paper, we discussed how a student-centered mistake detection video that includes motivational messages could be used to confront students' maladaptive beliefs about mistakes and enhance students' mistake detection. We described our final mistake detection video experience, outlining the factors that influenced the evolution of our design and lessons learned along the way. We designed our instructional experience to make mastery goals and incremental progress salient in hopes that students would adopt an adaptive motivational mindset in their own math work and with their own mistakes.

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APPENDIX A

High school students received a description and introduction statement prior to viewing the videos.

Description

We think high school students often do a great job explaining math ideas to younger school students because they tend to offer help that teachers may miss.

We are going to ask that you watch some videos of ***a fourth grade student, named Sarah.***

- You will be asked to watch, on your own, at your own pace, a total of FOUR videos that last about two minutes each.
- You can replay, stop, rewind, or pause any video.
- You can also use scrap paper if you need to take notes.
- Please pay attention to your own videos as some students may be watching a different part than you. Remember, you should only respond to the videos you are watching.

When you are completely done with this portion and reach "The End" please raise your hand.

Thank you!

Introduction

In math, it is often helpful to watch how others solve problems. It is helpful to see and understand how people get their final answer.

When a student gets stuck, they should not keep doing the same thing over and over again if it is not working.

Instead, they should get advice from other people who know how to do the work or can help.

In just a minute, you'll be watching a younger student solve problems and trying to understand their work. You will be asked to give this student your opinion on what you see.

APPENDIX B

High school students were asked to answer survey questions after viewing each video.

After Watching Video One

1. In your opinion, do you think Sarah solved this problem correctly? (***Select ONE response below***)

   ○ Yes ○ No ○ I don't know

2. Did Sarah solve this problem as you would have solved it? Explain.

   ____

   ____

   ____

   ____

   ____

3. What advice would you give Sarah for this math problem?

   ____

   ____

   ____

   ____

   ____

Please go to the next video and continue...