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Research Review: Visual Media Tools & Learning Outcomes

INTRODUCTION

The introduction to multimedia has been restructuring the way we think, learn, and live for the past two centuries. Multimedia tools converge text, picture, video, and sound into a single format or at least utilize a combination of the different forms. As we advance further into the 21st century, and multimedia forms and uses evolve, educators and researchers alike have recognized the power of media and have sought ways to harness it as an educational tool to improve learning outcomes and address modern educational problems. The purpose of my research is to derive evidence-based principles for more effective use of visual media in the classroom, specifically in areas concerning knowledge regarding multimedia instruction, multimedia learning, and multimedia tool selection as well as a close examination of how those factors interact with one another.

METHODS

The common question amongst the research reviewed is: do media influence learning? However, due to technological and theoretical advancements the questions and resulting discussion amongst the reviewed studies varies greatly. Also, the implications and findings from early studies led *advances* in later studies. The studies can, at large, be organized in terms of each other starting with the earliest research studies regarding visual media and learning: (1) cognitive-behaviorist theory based research- *media effects* studies, (2) cognitive-constructivist theory based research- *media comparison studies* (3) cognitive theory of multimedia learning- *new age studies.*

The cognitive-behaviorist theory base was common amongst early visual media research studies, which is evident in the media-based methodology (Fadel & Lemke, 2008; Koehler, Yadav, Phillips, & Cavazos-Kottke, 2005; Mayer & Moreno, 2003; Sankey, Birch, & Gardiner, 2011). These studies rely on a media effects approach, typically using an instructional-delivery model to identify how effective multimedia forms of presentation are in helping learners learn. That is, the shared question for these initiatives asks: How effective is visual media technology in helping learners acquire desired behaviors? By comparing different visual and auditory modes, like text and picture compared to audio and picture (video), early studies sought to identify which combinations best improved learning (Fadel & Lemke, 2008; Koehler et. al, 2005; Mayer & Moreno, 2003; Sankey et. al, 2011). Specifically, one study compared learning outcomes between students who watched video stories and students who read video stories in text format. The outcomes were measured using questionnaires as well as pre- and post-test data (Koehler et. al, 2005). Another similar study focused on modes of representation as well as learning style preferences. A similar study explored differences across predominant learning styles/modal preferences (Sankey et. al, 2011). The researcher used an experimental design that allowed for the manipulation of instructional delivery, as well as a post-experiment investigation (qualitative) to identify which learning elements were considered to be most helpful in assisting learning. The qualitative data was combined with quantitative data collected through pre- and post-test scores (Sankey et. al, 2011).

Several studies used inquiry based qualitative research methods of data collection-- such as in-depth interviews, questionnaires, ethnographic observation, case studies, and review of documents—to better understand teaching and learning processes given a specific setting, context and group of participants (Koehler et. al, 2005; ITL Research, 2011; Sankey et. al, 2011; Sherer & Shea, 2011). Other studies used only quantitative methods to measure achievement (Fadel & Lemke, 2008); specifically, pre and post test data. While the qualitative data provides insights into attitude and perception changes, the quantitative findings gathered by comparing pre- and post-test data allows researchers to identify statistically significant changes in learners' achievement. However, most studies used a mixed-method approach, combining qualitative and quantitative measures, to identify trends and associations that promote the transformation of teaching practices and the impact those changes have on students' learning outcomes across a broad range of country contexts (CGTV, 1992; Gravoso, Pasa, Labra, & Mori, 2008; Koehler et. al, 2005; Mayer & Moreno, 2003; Sankey et. al, 2011; Shyu, 2000). This approach was used in several studies grounded in *cognitive-constructivist* theories to account for very different classroom features (demographics, practices, etc.) and to recognize learners as active constructers of knowledge.

Moreover, advances in the fields of cognitive science and neuroscience led to many identifiable implications with the traditional cognitive-behaviorist studies. Countering claims argued that *media effects* studies fail to recognize learners as active constructers of knowledge (Bransford et. al, 2000; CTGV, 1992). Grounded in constructivist principles and cognitive theory, the cognitive-constructive theory generated a new wave of research studies that extended beyond transmitting learned behaviors from on source to another, and aimed to create environments in which students generated their own knowledge with appropriate assistance from teachers. Educators, psychologists, and researchers who espoused this perspective recognized that learning occurs during reciprocal interactions between learners' cognitive resources and aspects of the environment, which turned the focus from the impact of the technology being used to the impact of "anchored instruction" with supporting technology (Bransford et. al, 2000; Shyu, 2000). As a result several studies examined the impact videodisc instruction in anchored learning environments had on student learning outcomes (Bransford et. al, 2000; CTGV, 1992; Gravoso et. al, 2008; Shyu, 2000). These studies relied heavily on a *media comparison* approach, and led to developments suggesting when and how multimedia actually enhances learning.).

To examine behaviors and skills, there were many experimental and quasi-experimental media effects and media comparison studies (CGTV, 1992; Gravoso et. al, 2008; Koehler et. al, 2005; Sankey, Birch, & Gardiner, 2011; Shyu, 2000). These studies typically compared multi-modal methods with uni-modal methods to determine which method improved learning outcomes and perceptions. That is, several studies examined the difference in learning outcomes when one group was given one mode, like text, as opposed to another group who was given multiple modes, like video. Meta-analysis studies were also predominantly used to identify trends in findings across studies (Fadel & Lemke, 2008). However, media effects and comparison analyses **research often had uncontrolled effects due to methods and content**. For example, two methods being compared had different teachers or were learning different content. Thus, arguably, the teacher or other variables could have caused the effects attributed to the technology (Bransford et. al, 2000; CGTV, 1992; Gravoso et. al, 2008). This analysis led to inconclusive empirical results. Further, on methodological grounds, such studies suffered from confounding variables, especially those examining cognitive and social interactions. That is, often times there were too many variables involved that could've contributed to the results (Bransford et. al, 2000; Koehler et. al, 2005; Sankey et. al, 2011; Shyu, 2000). For example, learning from two types of media (uni-modal/multimodal) in two different environments (student-centered/teacher-centered) (Gravoso et. al, 2008).

In essence, media comparison research thus far has failed to support the assumption that media improves learning. If anything, these studies, suggest that learning is influenced more by content and instruction than the media itself and have at most provided positive affective results. While the qualitative and quantitative analyses were correct approaches, gathered through questionnaires and pre and post test data, the researchers failed to consider all factors, which questions the validity of the findings and suggests changes need to be made to the methodology. The inconclusive findings and implications put an end to media comparison studies. General design flaws include: small sample sizes that reduce statistical significance; measures of impact unrelated to objectives of the materials; measures of impact that are not objective and/or validated; descriptive, non-quantitative methods only with no control or comparison groups (Berk, 2009; Sherer & Shea, 2011); and experimental studies with no control group (Koehler et. al, 2005; Sankey et. al, 2011; Shyu, 2000). Theoretical implications in relation to passive and active learners also caused implications based on how learning outcomes were measured (Mayer & Moreno, 2003; ITL Research, 2011). For example, study examining video-disc instruction in an anchored environment drew their analysis by comparing standardized test scores from the experimental and control groups before and after the experiment (CGTV, 1992), but quickly found that standardized tests didn't measure the participants abilities to find and solve complex problems, which was the point of the study, so other qualitative measures were added, such as, collecting data through observation and samples of student work (Bransford et. al, 2000; CGTV, 1992).

The intent of two different meta-analytic studies was to summarize across quantitative studies related to the effectiveness of multimodal learning in comparison to traditional learning (Fadel & Lemke, 2008). The articles for this meta-analytic study were selected to light research findings regarding instructional theory and communications media, the differential learning outcomes between single-mode (uni-modal) and multiple modes (multimodal) of learning (Fadel & Lemke, 2008; Mayer & Moreno, 2003). Particularly, the articles were selected to summarize key elements of emergent research in how the brain functions, how people learn, and prior research in multimodal learning. Then, those articles were used to report meta-analytic findings on the multimedia principle –one of numerous considerations in multimodal learning (Fadel & Lemke, 2008; Mayer & Moreno, 2003). One of the meta-analytics studies concludes with implications to avoid cognitive overload (Mayer & Moreno, 2003) and the other concludes with implications for instructors in their design of multimedia lessons (Fadel & Lemke, 2008). The meta-analysis approach also allowed comparisons to be made about the relative effectiveness of various strategies to increase student achievement.

Other studies used control groups and experimental methods to analyze multimodal lessons compared to uni-modal lessons. Specifically, these studies compared student achievement between two groups where one group received videodisc instruction (amongst other variables) and another group received an alternate single mode of instruction, like text (CGTV, 1992; Gravoso et. al, 2008; ITL Research, 2011; Mayer & Moreno, 2003). However, too many factors led to uncontrolled variables and confounding findings. The report provided insightful information; however, a careful read of the report shows that pre and post test scores improved in both the experimental group and the control group; thus, the results are positive but not statistically significant (Bransford et. al, 2000; CGTV, 1992; Gravoso et. al, 2008; ITL Research, 2011; Mayer & Moreno, 2003).

In more recent studies, developments have been made to link multimedia and learning by establishing specific conditions for multimedia learning and instructing that address both the theoretical and methodological implications from previous studies (Berk, 2009; Bransford et. al, 2000; ITL Research, 2011; Sherer & Shea, 2011). Mayer & Moreno (2003) proposed research move away from an instrumental focus and develop a framework that considers how pedagogy (instructional methodology) and technology (visual media tool) interact, resulting in the *Cognitive Theory of Multimedia Learning.* Cognitive load theory and dual coding theory formed a substantial foundation for this theory providing evidence-based principles that allow for improved learning outcomes with visual media tools. However, continued research experiments found limited transfer and processing between contexts, which was later identified by the lack of context specific knowledge (Bransford et. al, 2000). Reports concluded that learning outcomes improve only when the overlay of cognition, pedagogy, technology, and content are considered (Berk, 2009; Bransford et. al, 2000; CGTV, 1992; Gravoso et. al, 2008; ITL Research, 2011; Mayer & Moreno, 2003; Sankey et. al, 2011; Sherer & Shea, 2011). That is, there is no single best theory or framework for learning, but rather successful learning depends on the complexity of the learning context and requires a closer look at the combination of method, learner, and environment.

This development led to *new age* studies. *New age* studies analyze technology from a more progressive viewpoint: the emerging theory base demands that studies look at technologies not as delivery systems, but as components of solutions to educational problems. N*ew age* research merges the problem driven and goal-based analyses aligned with cognitive-behaviorist studies to measure whether objectives have been achieved with the knowledge-construction analyses aligned with constructivism to investigate the details that could account for the outcomes. Meta-analysis summarizing across quantitative and qualitative studies is effective here because the trends identified promise transfer. The report makes sense of what works, when it work, and why (Bransford et. al, 2000). Thus, data from *new age* studies can be used to craft and study visual media tools that work in actual instructional settings and allow for unique affordances. Several studies examined unique visual media tools from a problem specific context, elaborating on learning outcomes and grounded in theory, yet they failed to provide quantitative data to support their claims (Berk, 2009; Sherer & Shea, 2011). Good evidence based findings require not only trying to capture valid and reliable proof of improvement, but also attempt to explain the complex set of conditions that led to improvement.

Other studies used meta-analysis to monitor and report technology uses amongst students and teachers from all over the world. The meta-analysis was effective in this sense because it identified trends that helped shape characteristics of visual media tools. Moreover, trends were identified across a broad context, identifying which multimodal tools serve as a solution to educational problems (ITL Research, 2011). Specifically, to collected data, this meta-analysis used a common framework and inquiry based qualitative research methods of data collection-- such as in-depth interviews, ethnographic observation, case studies, and review of documents—to help the research team understand teaching and learning processes and provided detailed information about each specific setting/context and it's participants. Using common rubrics, the research team was able to take that data and convert it to provide measurable evidence that helped establish associations and relations. Taken together, the findings provided insights into a breadth of learning experiences and allowed the research team to provide insightful findings that inform instruction and policy on what and how effective education looks like using technology (ITL Research, 2011). Further, the ITL Research (2011) report examined innovative technology tools and uses amongst teachers and students and found that variation was larger across different sites implementing the same program than it was across different programs. While the meta-analysis allowed for this trend to be identified, it also emphasized the importance of individual difference. While studies can identify trends in effective visual media uses, more often than not the findings were specific to local contexts that required differences in programs, personnel, teaching methods, budgets, leadership, and kinds of community support. In addition to these methodology errors, several studies did not have a random sample nor did they provide legitimate reasoning for the selected participants. Other studies suffered from small sample sizes as well as short research study periods due to time constraints.

FINDINGS

With the constant push for technology use in education, there seems to exist a prevailing assumption that video and other forms of multimedia improve the quality of instruction and help students connect with the content. However, the literature reveals that research consistently fails to support this claim. Another commonly held assumption is that the research findings regarding visual media and learning outcomes provide convincing evidence about the unique ways multimedia enhance achievement and motivation and that these findings shape practice in the field. However, a careful review of the literature, yet again, reveals that studies fail to provide significant, unique findings and even so, the findings that do exist fail to shape instructional methods and learning. Historically, studies investigating the role of visual media in learning have been problematic. Several studies examined learning outcomes by comparing media and multimedia (or methods); however, these studies generally reported mixed findings and often suffered from confounding variables because information content, instructional strategies, and other aspects of learning were not held constant (Koehler et. al, 2005; Mayer & Moreno, 2003; Sankey, Birch, & Gardiner, 2011). Regardless, of the implications, a general consensus across the literature denotes that students tend to learn more when teachers present material through multiple modes and media rather than in just a single mode (Fadel & Lemke, 2008; Mayer and Moreno, 2003); however, the unintended implications reveal much more than the attributes of multimodal learning. Several relations and conditions identified by early studies that were plagued with confounding variables provided the groundwork for future studies and research areas (CTGV, 1992; Shyu, 2000). It is through those findings that researchers attempted to determine the best practices and conditions for multimodal teaching and learning (Bransford et. al, 2000; Gravoso et. al, 2008). However, recent critical analyses of innovation technology use and multimodal learning across several countries reveals that the research was done in vain (Berk, 2009; ITL Research, 2011; Sherer & Shea, 2011). Educators and students alike fail to use tools and resources to promote deeper thinking and problem solving, and several studies suggest that students and teachers may not know how to utilize tools that stimulate 21st century thinking and learning.

A review of literature regarding multimedia and education exemplifies that successful uses of instructional multimedia are grounded in research-based theory. Theoretical foundations of multimedia use, particularly developments in neurosciences (how the brain functions) and cognitive sciences (how people learn), provide the groundwork for research involving visual media modes and learning outcomes, which, through extensive research studies and meta-analyses, have led to greater gains in cognitive psychology and have provided important information with regards to teaching and learning with various visual media tools and modal combinations.

Early research grounded in cognitive-behaviorist theories examined how and when to use technology to improve learning behaviors. In these studies, the tools were used to transmit knowledge from the instructor to the learner by way of the visual media. Thus, the learning in these studies was passive, which remains constant with the rarely disputed behaviorist methods of the time. Dual coding theory and cognitive overload theory were the two main research-based theories supporting the research. These theories suggest that using a combination of verbal and non-verbal approaches, that stimulate both visuals and audio modalities, can increase working memory (known as “Dual Coding Theory”) help students retain information and can help reduce cognitive overload (known as “Cognitive Overload Theory”) (Mayer & Moreno, 2003; Bransford et. al, 2000; CTGV, 1992; Fadel & Lemke, 2008). This research-based theoretical cocktail was confirmed in the findings from a meta-analytic review based on twenty-three studies and meta-studies that together surveyed almost 6,000 students. This report concluded that students of all ages retain more verbal information -- textual or oral -- when educators supplement it with visual examples (Fadel & Lemke, 2008). This analysis provided a clear rationale for using visual media to improve learning, but due to the constantly evolving field, the findings from media effects and media comparison studies revealed that efficacy, motivation, and volition of learners, as well as the type of learning task and the level of instructional scaffolding, can weigh heavily on the learning outcomes from the use of visual media.

In a study that examined whether video representations of different story types (e.g., human-interest story vs. informative story vs. artistic work vs. scholarly lecture) had greater impact on participants’ engagement and recall compared to text-only versions of the same stories, the researchers found that video influenced participants in areas of engagement, affective change, and impressions of quality; however, in traditional measures of cognitive achievement such as information recall and summarization of main ideas, there was very little variance between the text (uni-modal) and video (multi-modal) formats (Koehler et. al, 2005). These findings, contrary to findings reported by Mayer & Moreno (2003) and Fadel & Lemke (2008), suggest that the video influenced how students perceived and felt about the learning but did not actually improve learning outcomes (Koehler et. al, 2005). Arguably, the implications related to uncontrolled variables in the study suggest that students’ engagement is correlated with perception of ease; thus, the engagement findings cannot be contributed to video use alone. Based on these findings, Koehler et. al (2005) argues that when a benefit of video does arise, such as engagement, it is the result of a complex interaction between the content, method, and learning task. Therefore, the findings suggest educators must have a greater understanding of how to present certain learning experiences (which conditions need to be met regarding the learning goals and context) in relation to the multimodal method of presentation that best enhances learning and achievement.

Comparably, a study investigating the impact of multiple representations of content on learning outcomes (achievement and engagement) across learning styles and modal preferences reported similar findings (Sankey, Birch, & Gardiner, 2011). Contrary to the findings reported by Mayer and Moreno (2003), the experimental data identified that although there was an improvement on posttest scores, it was not statistically significant, which indicates participants didn't necessarily perform better because of the modes of representation. On the other hand, the qualitative data collected was much more in tune with the inferences of Mayer & Moreno (2003) indicating that most students felt all of the learning resources were helpful, with the more enhanced multimodal learning resources—combined dynamic visual with audio-- considered the most helpful; and, they felt multiple representations assisted their comprehension, understanding and retention of content, and made the instruction interesting, enjoyable, and easier (Sankey et. al, 2011). However, much like Koehler et. al (2005) concluded, the findings in this report also yield that such relations/effects, such as engagement, are not inherent to any specific coupling of modes or learning preferences, and whatever message learners derive from a particular presentation of information depends far more on an interaction between the content and style of the presentation than on the learners individual modal preferences alone. This finding was certainly confirmed and reinforced in this study as low engagement levels were correlated with learners' distaste or disinterest in the content presented and positive opinions and perceptions appeared to be correlated with ease of the learning task- not the multiple modes of representation or individual learning preferences (Sankey et. al, 2011). On a similar note, Mayer & Moreno (2003) caution that too many layers of multimedia enhancements may serve to confuse, rather than enhance. Fadel & Lemke (2008) warn of similar dangers explaining that while multimodal approaches help students retain complex information, lessons should not be unnecessarily complicated. These findings support the qualitative data collected by Sankey, Birch, & Gardiner (2011) that, albeit the generally positive feedback, revealed comments concerning the perceived potential for cognitive overload where students felt they had too much choice. The research-based theoretical evidence shows that brain overload occurs based on the limitations of memory and attention and that students are at risk when too many stimulants compete for their focus (Fadel & Lemke, 2008; Mayer & Moreno, 2003), which could potentially be the case in this study (Sankey et. al, 2011). A meta analytic report conducted by Mayer & Moreno (2003) confirm these claims as the consensus across several studies consistently revealed all students perform better on problem-solving transfer tests after receiving a concise narrated animation opposed to an embellished narrated animation (Mayer & Moreno, 2003).

With that said, Sankey, Birch, & Gardiner (2011) argue that multiple representations of content do not lead to cognitive overload but rather to improved learning by accounting for all individual learning styles and modal preferences. Several studies claim that individual learner preferences are integral to the design of multimodal learning environments. In other words, different modes of instruction may be optimal for different learners because different modes of presentation exploit the specific perceptual and cognitive strengths of different individuals (Berk, 2009). For example, Sankey, Birch, & Gardiner (2011) report that multimodal learning may be of greater benefit to lower achieving students, while higher achieving students perform well regardless of how the content is presented. And, while theoretical and methodological implications may compromise the viability of their report, the findings are still relevant because they illustrate that even though representations/multimodal learning do not improve student achievement, relations do exist under certain conditions (Sankey et. al, 2011).

Although, as examined by Sankey, Birch, & Gardiner (2011) it is undoubtedly the case that one student may benefit from a particular kind of course content presented a certain way over another; yet, when students become over stimulated they are at risk for cognitive load. Consequently, there is a fine line between effective and ineffective instruction. In attempts to find an instructional method that accounted for both individual learning preferences and cognitive overload, Berk (2009) examined how video clips can be used to engage students' brains and cognitive thought processes by tapping into multiple intelligences. He reported that video clips embedded in instruction were used to attain 20 specified learning outcomes and effectively increased memory, comprehension, understanding, and deeper learning amongst students. This being the case, when learning environments are designed to cater to multiple sensory channels, information processing can become more effective. Yet, a review across the literature indicates that a general consensus would be hard to make without considering several other conditions. So, even when a specific mode, such as video clips, revealed improved learning outcomes, other factors appear to contribute to the gains.

Developments in cognitive sciences grounded in social-constructivist theories led to attacks on early studies due to their instrumental approach and traditional instructional methods. That is, as technology advanced at an exponential rate and developments in cognitive sciences led to new learning theories, it became evident that studies grounded in behaviorist learning theories failed to recognize learners as active constructors of knowledge. This is evident in the conflicting results from previously discussed studies (Mayer and Moreno, 2003; Sankey et. al, 2011) where one report (Sankey et. al, 2011) concluded that no single mode, specific combination of modes, or amount of modes provided led to improved learning outcomes and the other (Mayer & Moreno, 2003) found that students tend to learn more when teachers present material through multiple modes and media rather than in just a single mode. The differences between the studies appears to be due to the fact that Mayer & Moreno (2003) indicate that meaningful learning –engagement and achievement- is reflected in the ability to apply what was taught to new situations, and consequently can only be measured through problem solving transfer tasks where learners actively construct new knowledge and engage with the problem where (Sankey et. al, 2011) measure achievement by examining how a student responds to information that is conveyed to them through multiple modes of representation in relation to their individual learning preferences. Thus, this may be a difference between research grounded in cognitive behaviorist theories, where the learner remains a passive receiver of information and research grounded in cognitive constructivist theories, where learners are active constructers of knowledge.

However, according to Mayer & Moreno (2003) meaningful learning is reflected in the ability to apply what was taught to new situations; yet, research discussed thus far has examined visual media as an instructional delivery tool, the learners have remained passive and have thus been knowledge receivers, not knowledge constructors, which begs the question: How can you measure learning outcomes if learners aren't actively constructing new learning? Therefore, if we can conclude anything at all from the cognitive-behaviorist studies it is that *how* visual media is used is of much more importance than *if* it is used. A review across the literature thus far reveals that even though the studies did not show improved learning through multiple modes of representation (perhaps because it is impossible to measure learning outcomes due to theoretical implications on how students learn) different modes of media do have different instructional capabilities and potential for different situations, environments, learning tasks, students, and forms of content knowledge (Fadel & Lemke, 2008; Koehler et. al, 2005; Mayer & Moreno, 2003; Sankey et. al, 2011).

These early studies and the advances in cognitive psychology provided the starting point for revamping multimedia designs to account for such potential. One of the most important avenues of cognitive psychology is to understanding how technology--such as multimedia--can be used to foster student learning. When taken into consideration, early research studies grounded in cognitive-behaviorist theories were not done in vain. The findings provide further insights into how students process multimedia information, and consequently, these reports provide the groundwork for successive, more focused research as the findings yield some preliminary principles of multimedia design. So even though all of the studies suffered from methodological and theoretical error and were subject to further testing, the discoveries demonstrate how it is possible, and necessary, to take a learner-centered approach to instructional technology. For example, findings from one study suggest that the innovative use of technology provides valuable opportunities for educators to design an enhanced, interactive, more inclusive and engaging curriculum (Sankey et. al, 2011). Specifically, the widespread access to multimedia has allowed educators to consider multiple representations for specific content using a combination of text, video, aural and interaction to cater more effectively for different learning styles and modal preferences.

In my investigation and summarization of visual media learning research, the general consensus concludes that arrangements of verbal and visual information that highlight important relationships, remove irrelevant information, and manage the information so that learners' working memory resources are not overloaded, tend to improve learning. However, not all visualizations are equal. Mayer & Moreno (2003) proposed that learners must be able to organize relevant audio and visual modes into a coherent multimode in order to make connections. Specifically, research regarding the most effective combinations of visual media—auditory and visual—reports that students who learn with integrated auditory verbal materials and animations are able to recall more, solve problems better, and are better able to match the visual and verbal elements to make connections than those who learned with other audio-visual combinations (Mayer & Moreno, 2003; Fadel & Lemke, 2008). Thus, the simultaneous combination of verbal and visual media, as well as concise, sensory conscious presentations are important for reducing the cognitive load on memory and for establishing meaningful learning scenarios (Mayer & Moreno, 2003; Sankey et. al; Fadel & Lemke, 2008). These findings make the case for video-based instruction over other visual media combinations for transfer and retention.

Video, as dynamic visual information combined with verbal audio, forms a powerful means of communicating meaningful-scenarios rapidly and efficiently. The advantage of video instruction goes beyond the underlying simplicity and speed: it allows for material to be presented in realistic contexts and for known content specific landscapes to be brought to life in unprecedented ways, thus addressing the problems of inert knowledge while promoting constructive and generative learning (Berk, 2009; Bransford et. al, 2000; CTGV, 1992; Sherer & Shea, 2011). In some learning situations, videos are not only a desirable, but are an important prerequisite for successful learning to take place. For example, from a cognitive perspective, videos can support abstraction by visualizing dynamic processes, which may not be realistically observed or are hard to describe verbally. Videos can also support processing by combining diverse symbol systems, such as pictures, texts and narration, into coherent, sensory sensitive media message (Berk, 2009; Mayer & Moreno, 2003; Bransford et. al 2000; CTGV, 1992). Consequently, video has been used in high-quality instructional modules. However, the research suggests that in order to amplify cognition and transfer knowledge, video instruction must be embedded in situation problem solving contexts. That is, when learners remain passive viewers of video-based instruction, learning will not improve; however, videodisc instruction anchored in a problem-solving context is the optimal design for processing and transfer.

Similar findings across the literature reveal that studies successive research needs to be done that goes beyond the scope of the tool and focuses on the way the tool is used and implemented and for what purpose or goal. In line with the findings from Mayer & Moreno (2003), Fadel & Lemke (2008) report that multimodal learning is best utilized in problem solving contexts. In the meta-analysis, comparable findings that show when learning basic skills, the average students scores increase with multimodal learning but the increase is greater when the lesson isn't interactive. Likewise, when learning higher-order, advanced skills the average students scores increase with multimodal learning; however, the increase is greater when lessons are interactive (Fadel & Lemke, 2008). Thus, the quality of processing is affected to the degree to which characteristics and strategies such as discovery learning, problem-based instruction/learning, scaffolding, cooperative learning, and so forth, are applied in the instructional design. For example, for basic skill building uni-modal learning may be the optimal design. Yet, for a different learning objective involving that same student in collaborative problem solving might be the most effective learning approach (Fadel & Lemke, 2008).

Nonetheless, educators must be vigilant to ensure that multimodal presentations and learning activities are appropriate for each particular context, for each instructional purpose, and ultimately, for each student in their learning endeavors. In knowledge management, the transfer of knowledge is a core process, which can be improved by using our innate abilities to process visual representations. Thus, the potential of videodisc instruction methods in situation learning environments are manifold (Bransford et. al, 2000). Videodisc anchored instruction refers to the true integration of video in situated learning environments, where it is not regarded as a mere illustration, but can also be structured through problem solving tasks, collaborative periods, and individual reflections. Anchored instruction augments video capabilities by providing flexible interactive mechanisms that integrate different types of media in ways that can be adapted to a great variety of learning styles and contexts (Bransford et. al, 2000; CTGV, 1992). Using findings from earlier studies, videodisc anchored instruction was developed to best support learning processes. Different learning styles are also supported, through the integration of various media, perceptual modalities, and interactive social choices.

Moving forward, researchers adopting the constructivist perspective claimed that the aim of education is not to transmit learned behaviors--knowledge and skills-- from an expert source (teacher or multimodal media) to students. Instead, the purpose of education is to create environments in which students generate their own knowledge with appropriate assistance or “scaffolding” from teachers (Bransford et. al, 2000; CTGV, 1992; Mayer & Moreno, 2003; ITL Research, 2011). That is, learning is an active, constructive, cognitive, and social process in which the learner strategically manages available cognitive, physical, and social resources to create new knowledge by interacting with information in the environment and integrating it with information already stored in memory (Bransford et. al, 2000; CTGV, 1992; Mayer & Moreno, 2003). Theorists and researchers in favor of this perspective, which is primarily based on the work of Vygotsky in cognitive scaffolding and Bransford et. al (2003) in situated cognition and anchored instruction, turned the focus from the impact of the technology being used to the impact of “anchored instruction” which visual media technology could support. As a result several studies examined the impact of videodisc instruction in anchored learning environments.

Bransford’s study team (2000) coined the term “anchored instruction” to refer to a problem a problem context that situates students’ perceptions and comprehension. The initial goal of anchored instruction was to alleviate the problem of inert knowledge, where students lacked the ability to access knowledge spontaneously during problem solving. Using data and theoretical findings from previous studies, the study team developed and explained four principles of anchored instruction. The team then used these principles to analyze earlier research regarding videodisc-based mathematics curriculum in middle school classrooms called The Jasper Series (Bransford et. al, 2000; CTGV, 1992). The Jasper Series study reported that using video in a mathematics classroom allows students to learn in a “contextualized” way and teaches them to use their existing knowledge as a tool to accomplish tasks in new, real life problem situations (CTGV, 1992). The Jasper Woodbury Problem Solving Series is an example of video-based instructional problems that force the learner to establish what matters in a problem scenario and involves them in the problem solving process, which the authors argue is something the Jasper series can do that traditional mathematics and problem solving materials cannot (CTGV, 1992). The findings indicate: in terms basic math concepts, both groups improved at the same rate, and in terms of student perceptions, there were no major differences between the groups. However, in comparison to the control group, the study revealed that the problem solving performances of the Jasper students were superior (CGTV, 1992). While data signifies improved learning outcomes with the Jasper Series, the instructional model and method was of extreme importance in those improvements. This begs the question: was it the tool that improved learning, the instruction, or a combination of both? Moreover, while the Jasper Series units showed promise in promoting mathematical problem solving, the developments from this study showed that students were not able to transfer the knowledge to new situations beyond the scope of the videos (Brandsford et. al, 2000). After careful analysis, the curriculum designers identified their lack of understandings about deep mathematical principles, and the resulting lack of emphasis on those principles in The Jasper Series units as the inherent problem leading to lack of transfer. To address this, the curriculum designers teamed with mathematicians to ensure mathematical principles were embedded in the design of subsequent Jasper Series units. This modification resulted in increased transferability of learned skills among the targeted learners (Bransford et. al 2000). These findings are significant because they extend beyond the four principles of anchored instruction and problem solving. The report concludes that educators must have a deep understanding of mathematical concepts and principles to ensure learners are able to make connections and apply their learning to new situations (Bransford et. al, 2000; Mayer & Moreno, 2003). These findings show that visualization tools can be used in accordance with content knowledge and specific pedagogical methods/strategies (4 principles) to advance learning, but one (or two of them) alone will not achieve the intended results.

Additional findings and implications are also revealed amongst the four principles of anchored instruction (CTGV, 1992). The first principle, which aligns with suggestions from earlier studies (Fadel & Lemke, 2008; Mayer & Moreno, 2003), advised that all learning and teaching activities be centered on anchors, which should be a case study or problem situation (Bransford et. al, 2000). This principle is most clearly elaborated on in a study that investigated the effects of computer-assisted videodisc-based anchored instruction on attitudes toward mathematics and instruction as well as problem-solving skills among Taiwanese elementary students (Shyu, 2000). Shyu (2000) found that students had a positive change of attitudes toward mathematics and situated learning. The findings also show that the students improved their thinking and problem solving skills and were able to solve complex mathematics problems; although, all of the students in the study, regardless of their mathematics abilities, benefited from the effects of anchored instruction in relation to their problem-solving performance (Shyu, 2000). These findings are significant as they provide empirical evidence of situated learning effects on affective and cognitive responses amongst mathematics learners and their problem solving abilities. However, the findings are somewhat compromised due to too many uncontrolled variables in addition to no control group. The results suggest that anchored instruction may have been more important than the visual media attributes in the teaching of problem solving. Despite the implications, the report concludes that video-based situational learning can inform and inspire learning in ways that traditional lectures cannot by providing more visceral examples and memorable associations (Shyu, 2000). This begs the question: Could the same learning outcomes be achieved through anchored instruction alone or was it the coupling of the video-based presentation and anchored instruction method that resulted in the improved outcomes? Likewise, could the learning outcomes be achieved through the videodisc instruction alone? These questions align with the findings of Mayer & Moreno (2003) that suggest visual media enhances learning when it is concise and necessary; otherwise it slows down processing (Fadel & Lemke, 2008).

The second principle of anchored instruction says that curriculum materials allow exploration by the learners (Bransford et. al, 2000). Previous findings suggest that experiences that stimulate deep thinking cue longer-term memory than experiences that allow us to simply absorb information via our senses (Mayer & Moreno, 2003). Thus, the findings (Fadel & Lemke, 2008) conclude that teachers craft multimodal and -- for higher-order skills -- interactive or collaborative lessons that stimulate deep thinking. This is evident in the research studies examining anchored instruction and videodisc instruction (Bransford et. al, 2000; CTGV, 1992; Gravoso et. al, 2008; Shyu, 2000) and is supported by the second principle of anchored instruction (CTGV, 1992). However findings from a critical analysis mixed-methods study that examined what Information Communication Technology (ICT) tools teachers are using and how they are using them across 7 countries reported that teachers used ICT most commonly to present information, while students most commonly used ICT to find information, practice routine skills, and take tests (ITL Research, 2011). However, as reported by (2008), such practices do not best support higher-order thinking skills and contradict the purpose for implementing visual media tools in general (ITL Research, 2011). So, even though findings from the ITL Research (2011) study did show a small percentage of teachers use innovative teaching methods, the findings also reported opportunities for students to develop problem-solving and collaboration skills remained low across the seven countries studied. Thus, when instructors use visual media tools and methods, they appear to be "wasting" them to build students' basic skills, rather than devoting the resources to complex, interactive problem solving scenarios that promote higher-order thinking and build advanced skills (Fadel & Lemke, 2008; ITL Research, 2008). A critical analysis study conducted by Sherer & Shea (2011) addressed this phenomena reporting that many teachers do not know how to effectively use innovative visual media tools (specifically online video) to enhance the overall classroom experience, and more often than not, their students are more tech savvy and comfortable using the tools.

The third principle of anchored learning says that all data needed to solve the problem should be embedded in the situation alongside irrelevant data (Bransford et. al, 2000). This principle contradicts findings reported by previous studies that suggest too much information may lead to cognitive overload, slow down processing, and take away from the visual media presentation all together (CGTV, 1992; Fadel & Lemke, 2008; Mayer & Moreno, 2003). Although, from my personal experiences, being able to decide what matters in a problem solving scenario is an important yet underrated skill that needs to be developed.

Lastly, the fourth principle of anchored instruction proposes students work in dialogic small groups to investigate aspects of a situation and gather relevant information to solve the problem and allow for revisions as they progress (Bransford et. al, 2000). The fourth principle is most easily examined, in conjunction with the three previous principles, in an experiment done to see if technology implementation would improve learning outcomes in a learner-centered environment (Gravoso et. al, 2008). The learning outcomes were compared to a group of students who learned the same concepts in a teacher-centered classroom. The video documentaries were made by a team of seasoned educators, and through careful collaboration, created according to a specific context and learning goals to actively engage learners in knowledge construction. That is, the learners are not passive information receivers; they are not just watching a video. The documentaries also required changes to be made to the structure of learning activities. The teacher became the facilitator and the documentaries were embedded in problem exploration activities. The findings demonstrate that both groups showed improvements in their learning, which suggests that students are able to learn information regardless of the way they encounter the lesson; however, the comparison between the teacher-centered and learner-centered groups showed that the former group's improvement was much less than the latter. These findings suggest that the manner by which the information was learned was responsible for the difference in achievement levels. Thus, it is not the capabilities of the media that facilitate learning but the creative development of instructional methods that actively engage the learners (Bransford et. al, 2000; Gravoso et. al, 2008; Koehler et. al, 2005). This is shown in an analysis of the learning environments. Learning in the learner-centered classroom was generative. Learners generated their own problems & sub-questions, collaborated, reflected, formulated their own answers, and constructed new knowledge on already existing frameworks; the environment engaged them in knowledge construction. Conversely, the teacher-centered environment tended to induce information absorption and memorization, similar to studies grounded in cognitive-behaviorist theories (Gravoso et. al, 2008; Mayer & Moreno, 2003). The analysis of the learning environment shows that direct instruction methods that simply transmit information to students will not result in quality learning, which again, confirms earlier reports (Mayer & Moreno, 2003). Particularly, the teacher-centered group described their learning in terms of surface approaches while the learner-center described theirs in terms of deep approaches, providing analysis. These findings are significant because they suggest that technology can change and improve the quality of learning outcomes if designed to support knowledge construction in a learner-centered environment (Gravoso et. al, 2008). However, similar to Shyu (2000) it could be argued that it was the instructional model and student-centered environment that caused the improved learning outcomes, not the technology. Further research needs to be done to identify if similar results could be achieved by comparing learner-centered and teacher-centered groups without the video documentaries. Which brings us to the next point: could similar learning experiences be replicated without the use of technology, or in this case, video documentary?

While each study reviewed identified unique attributes and implications while learning with visual media, a general consensus can be made: there is not one correct method for learning with visual media. Meaningful learning with visual media is contingent on various factors. These findings align with those of ITL Research (2011) and Cognition and Technology Group at Vanderbilt (1992) suggesting that there will never be one correct method or approach to visual media learning. Instead, to create optimal visual media designs, educators must be in tune with their learners, the content, instructional strategies, and the visual media medium. Specifically, educators should recognize that lesson design must adapt to the expertise and prior knowledge of the learner, the complexity of the content, and interests of the learner. That is, optimizing learning for each student requires more finely tuned differentiation of instruction that considers – and leverages – each of the three areas mentioned in this review: how the brain functions, how people learn, and multimedia design (Koehler et. al, 2005; Mayer & Moreno, 2003; Fadel & Lemke, 2008; Berk, 2009). This is apparent within the literature and can be further examined in trends across several countries that reveal variance is greater across schools than within them (Bransford et. al, 2000; ITL Research, 2011). This finding makes sense, as each local context is different, requiring differences in programs, personnel, methods, funding, leadership, and kinds of educator and community support. Thus, the sheer complexity of the learning context calls for a closer look at the combination of method, learner, and environmental variables that contributes to successful learning. Sherer & Shea's (2011) research aims to do so by bringing awareness to educators regarding dynamic Web2.0 visual media tools and resources available to them, as well as to inform them on how to effectively employ those tools in their classroom. Although, experienced researchers recognize that the use of technology and multimedia, resources, and lessons can vary in the level of interactivity, modality, sequencing, pacing, guidance, prompts, and alignment to student interest, all of which impact the effectiveness in learning. Therefore, further research is needed to capture valid and reliable evidence of improvement but also to explain the complex set of conditions that led to improvement.

In sum, it is evident that using visual media technology does not ensure that its use will be appropriate and that learning will occur. Based upon current research, in order to address some of the concerns brought on in previous studies, as well as increase effective innovative teaching practices in schools, there needs to be increased collaboration amongst district staff and a school culture that offers a common vision of innovation and support for new types of teaching, and professional development that provides teachers opportunities to experiment and apply innovative teaching methods, such as critical thinking, complex problem solving, collaboration, creativity, or technological fluency (ITL Research, 2011). In doing so, educators and researchers can analyze the capabilities of visual media to influence particular students, tasks, and situations according to a specific educational problem. When reported, such findings will contribute to the improvement of teaching and learning.

RESEARCH PROPOSAL

A review and analysis of the history of recent research on visual media technologies in education reveals key issues and problems that must be addressed as we contemplate a research agenda for the next era in technology use in education. Namely, to avoid similar methodological and theoretical errors that plagued earlier studies, new research questions must be stated in a way that the contributions from the visual media tool can be examined and tested, both quantitatively and qualitatively. That is, educators must specify a specific educational problem they are addressing and then make the case as to why the visual media tool is the best solution to that problem. In addition, the rationale-building research should concentrate on why their solution is necessary and what it has to offer over other methods and/or materials by studying the benefits of visual media applications as integral components of solutions to instructional problems. Therefore, my proposal ponders the unique affordances of a technology-based visual media method, rather than the visual media medium itself. Specifically, the new research focuses on assessing problem solving skills in secondary mathematics classrooms and hypothesizes that video assessment, using a networked device such as an iPod, will allow for creative assessment methods that best capture and measure 21st century problem solving skills in mathematics. The research is grounded in theories and relations identified in earlier studies regarding visual media tools and student learning outcomes.

At large, secondary math students lack the ability to solve complex math tasks that require reasoning and application beyond simple computations due to their limited learning experiences. To address this, schools are implementing networked devices (mLearning) and inquiry-based instructional models that scaffold abstraction. However the pedagogy design is problematic due to outdated assessment models that fail to capture and measure the new skills being assessed. I chose to address this problem because it is a realistic, relevant problem and the research will inform my work as a secondary math teacher. My research plan builds on an already established teaching model that allows students to be involved in the process of mathematical abstraction: stimulating collaboration and higher order thinking as students work through complex mathematical reasoning tasks and tackle problems as they unfold naturally, something a print textbook cannot do due to its fixed nature, and focuses on creating and implementing assessment methods that align with the new curriculum model. The technology needed to support such a change in the mathematics assessment model would be the same as the student uses during class- a mobile electronic device with Wi-Fi for each student; specific to this study, students will be using an iPad.

With the success of this teaching model, it is apparent that assessment practices have not kept pace with innovation, resulting in challenges for schools and teachers to integrate the two contrary visions: innovative instruction & traditional assessments. The goal of this plan is to improve secondary mathematics student learning outcomes and mastery by engaging them in rich problem solving tasks that transform what and how they are learning. Specifically, **I hypothesize that video assessments will best support the mLearning pedagogy model and allow students to demonstrate their ability to formulate and solve mathematical reasoning problems and I believe that a networked device in correspondence with the video assessments will best support students as they learn to problem solve, make connections, apply understanding, and reflect in terms of the big picture**.

RESEARCH PROPOSAL RATIONALE

As technology continues to advance at a rapid pace, permeating all facets of our daily lives, society is becoming increasingly digitized. This digital transformation has implications for education, and has the potential to change the way educators teach, how students learn, and the manner in which both parties interact with course material. To support the most pressing needs of 21st century learners, education stakeholders in both the public and private sectors have identified mobile learning (mLearning) as a strategy to drive change, redesigning the outdated educational model to better align with the diverse needs of the rapidly growing and changing 21st century global, digital economy. While the definition of mobile learning varies based on context and purpose, mLearning as it best addresses the salient issues of 21st century learning is defined as networked, handheld technologies that facilitate, support, enhance and extend the reach of teaching and learning- while fully supporting cognitive learning theories regarding how students learning and process information using multimedia. Moreover, with a networked curriculum and mLearning initiative, the look and feel of teaching and learning changes immensely. Students are able to use the network to support their learning: Once they identify what they need to complete a problem-solving task (a goal of the districts new curriculum redesign), they can use the network to access that information, receive feedback, collaborate and reflect. The device, its apps, and the network work simultaneously to individualize the problem solving process, differentiate the instruction and provide choice for students as they select tools to support their learning. Thus, just as the problem solving/learning process unfolds naturally, so shall the assessments.

However, for one reason or another, districts often preserve and carry over an industrial assessment model.

It isn't that districts fail to acknowledge the necessary assessment reform as part of the curriculum redesign; in fact, more often than not it has an important place on the mLearning roadmap with its own series of goals and expected outcomes. But, it is often believed that the assessment will happen naturally through the device or learning model. That is, the focus remains on the instruction and tool and fails to acknowledge an assessment model that aligns with the new learning design.

The research study I am proposing moves beyond teaching and learning 21^{st} century skills and focuses on redesigning the assessment framework, allowing teachers (and learners) to accurately measure growth and understanding- and in turn, can be used to inform and drive instruction. Restructuring teaching and learning alone will not suffice. With the mLearning initiative, the issue is how to meet the challenges of delivering content and skills in a rich way that genuinely improves outcomes for students, which leads to an even greater issue: how to redesign the assessment framework to accurately measure richer learning and more complex tasks. It is no secret that assessments and grades motivate students. Memorizing facts, re-reading textbook chapters, and reviewing study guides have long since been the way of preparing for assessments. While this process is efficient and serves its purpose in the short term, it renders useless in the long run- categorized in the brain as impractical information and forgotten in the long term. If you fail to update the assessment model, students will regress: they will begin to ask for traditional learning experiences and lectures that match the assessments they will be given. Thus, there is no point in investing in a curriculum redesign without also investing in an assessment framework that allows teachers and learners to evaluate what is or is not being learned and/or understood.

To better prepare learners for the diverse demands of a global economy, schools have shifted their focus from what they are teaching to how they are teaching. Districts seek to be deliberate about teaching critical thinking, collaboration, and problem solving to all students, and through mLearning initiatives, they have the support and tools to do so. However, without intentional planning and instruction, no 21^{st} century learning initiative will be successful. Just as with assessing 21^{st} century skills, no device will save the assessment policy alone, it takes deliberate, intentional planning and a strong framework grounded in the cognitive goals set by the district in the mLearning action plan/roadmap. The remedy, though, for assessing 21^{st} century problem solving skills with a mLearning program in place, may appear obvious: Mobile learning devices offer consolidated access to high- quality learning materials, including a myriad of tools within the supporting infrastructure built into the device (seamlessly integrated applications, calendar, internet capabilities, social media, multimedia, calculator, e-mail, notes, reminders, & management of technology), allowing users to do more with less. But don't be fooled; effective assessments are carefully thought before the device is even considered.

Digital tools allow the assessment to occur in a completely different way, a way that allows the learner to reflect on their growth and construct new understanding based on prior knowledge as they work through the problem using various tools and supports. The assessments embedded in the design force students to consider what they already know and how they may use that information. Although higher-level skills like critical thinking and analysis can be assessed with well-designed multiple-choice tests, a truly rich assessment system goes beyond multiple-choice testing and includes measures that encourage creativity, show how students arrive at answers, and allows for collaboration. The new assessment framework should not be universal; it should be personal and match the unique needs of each learner. A key tenet of personalized learning is the ability of individuals to choose the right tools for the right tasks, which means the educator must be able to accurately measure student understanding regardless of the tool(s) they choose to support their thinking and learning. The assessment framework should be both prescriptive enough to be *useful* and flexible enough to be *usable.*

Perhaps the first step towards understanding how to create effective assessments is accepting that we are no longer assessing the same types of skills. The new assessment framework should focus on the process, the tools used for supports, the approach, and the analyses, not the end result or answer. We are interested in the learner's ability to identify which components matter and how they use those ideas to work through a task. For example, if your task is to drive to college for the first time, of course I am concerned with whether you make it to your destination, but it's actually the least of my concerns. I care more about things like: how long it took you to get there; if you used GPS, Google maps, a map from your glove box, or nothing; if you phoned a friend when you got lost; how many wrong turns you took, but more importantly how you recovered from each wrong turn; how your routed your trip – fastest, direct, highways, etc. You see, I learn much more about the driver by considering their entire trip than I do if I only pay attention to their arrival at the destination. This assessment model focuses more on whether a learner learns from their mistakes: They may not have reached the correct solution or used the most efficient method, but did they recover from their mistakes? One learner may have a really keen sense of direction, but horrible problem solving skills, leaving them close enough to the destination, but road blocked by dead ends and one-way streets. Just as learners bring unique abilities into the classroom, this assessment model should help the instructor understand student strengths and use them to build up their weaknesses. By involving learners in the formulation of the problem solving process, the learners are able to see that problem solving is an ongoing process and is not about finding the answer or being right.

Students will seek tools to support their understanding, just as they did to support their achievement in the industrial assessment model (i.e. study guides, chapter review, lectures). With the new assessment framework, the assessments and tools occur much more naturally and are embedded throughout. The learning tasks should mimic how we work through problems in real life and the assessments should unfold naturally; they can be as subtle as knowing to use GPS on a cell phone or Google to lookup a formula or conversion. When students learn to embrace tools that are available, they can move along in the problem solving process at their own speed, on their own terms. The assessment opportunities are endless. Learning through simulated environments, blogs, Twitter, apps, polls, networked sites, etc. are only a few amongst the many resources available that allow educators to assess student learning and provide timely feedback. For example, data collected from polls and Google forms, allows the teacher to identify trends and misconceptions and then use those findings to inform instruction.

Other technologies enable us to assess how well students communicate for a variety of purposes and in a variety of ways, including in virtual-networked environments, which can be as general as a classroom Twitter hashtag. Educators and learners alike must learn to embrace applications that allow interaction with large networks of people. These applications enrich education and allow for unique assessment opportunities. Networked apps like Instagram, Facebook, FaceTime, SnapChat, Gmail, Safari, Twitter, Pandora, Blogger, and Pinterest remove learning barriers and stimulate collaboration, providing a framework for students to interact with others and question new ideas. The process involves self-assessment and peer-assessment as well as reflection, which help students think more deeply about the learning process and move from the known to unknown by building on ideas they are already familiar with. Discovering the connections and regularities within knowledge they already have is empowering. Reflective periods allow students to learn from their mistakes and experiences by accommodating what they thought to be true with what they have found to be true, all while documenting their progress. Naturally, this learning process serves as an effective assessment framework.

These assessment methods demand that teachers be knowledgeable about a broad range of topics and tools and are prepared to make decisions *on the fly* as the lesson plan progresses. Simultaneously engaging with content, classroom management, technology, students, and the ongoing monitoring of student progress is demanding work. It's a constant juggling act that involves keeping many balls in the air. For this modern assessment approach that utilizes the multimodal capacities of technology, educators must be equipped with the pedagogical and technological tools they need to create, implement, and analyze a 21st century assessment framework. However, cross curricular differences change what and how educators assess, so prior to giving assessments, educators must discern and categorize assessment methods and tools as they relate to content specific goals and strategies. Yet, despite curricular differences, all great assessments are driven by great learning goals. Once learning goals are established, assessments can be created that measure the problem solving process, individual thinking, creativity, and collaboration. It is essential that instructors understand what affective assessments look like and how to use the assessments to drive their instruction. Thus, professional development time must be allocated for training, planning, and preparing assessments that align to learning goals and drive instruction as well training on how to find and use tools specific to their content areas. Through this deductive thought process, I was able to focus my problem of practice and research argument to hypothesize that video assessment methods are the only way to effectively and efficiently measure 21st century learning and understanding.

METHODS

There is consistent evidence of basic design and methodological flaws in many studies reviewed. In attempts to account for previous error, my research will combine critical analysis methods with quasi-experimental methods, capturing valid and reliable evidence of improvement as well as an analysis that explains the complex set of conditions that led to improvement. Hopefully this approach allows us to better understand what works, when it works, and why it works.

The study will take place over the course of an academic school year, but essentially will extend beyond the school year providing further research modifications and findings. The study will take place in a high school geometry course in a globally diverse, yet suburban school district in Michigan. The sample is not necessarily random as all of the participants are from the same school, have the same teacher, and are learning the same subject. However, according to the literature reviewed, research in this field must focus on specific participants and contexts as variation will occur according to the research demographics regardless (Bransford et. al, 2000; ITL Research, 2011). If the demographics are specified in the study, the research at least provides rationale for what works within the margins of that context and further research build on and modify accordingly to meet the needs of their own context and demographics. When reported, such trends and relations could then be analyzed in a meta-analysis across all research sites.

Moreover, with the failure of past research to provide objective, helpful evidence to guide practice, in addition to using multiple data sources and validated measures, my research will have control groups & an experimental group. Specifically, a control group where questions focus on computation, a control group that requires explanation and computation but the problem has been abstracted in the scenario, and an experimental group that receives a video clip scenario posing a question for their assessment. The assessments throughout the year will follow that structure, although the context of the problem and scenario will be the same for each group. An example is provided in the *methods* section. Further, all groups the will interact with the same course material, each other, and the instructor. Both groups will spend the same amount of time in the classroom and will have their math course in the morning hours of the day. In addition, both groups will engage in discussion and group work and will have access to math tools and manipulatives. Similarly, all groups will have access to the supporting infrastructure of the iPad and the networked applications. The main difference lies within the assessment model. Traditional standardized assessments look very different from carefully planned problem solving assessments that utilize the visual media capabilities of the iPad.

For this study, I will use three different assessment methods throughout the year: The experimental group will receive a video clip posing a question or scenario, one control group will receive a computation assessment that requires only plugging in and solving a formula, and the other control group will receive the same question as the experimental group, but the problem context will have done the abstracting for them- which means they only have to plug into a formula and then explain. **The goal is to compare assessment methods and gain an understanding of what each assessment method is *really* assessing as well as compare the affordances of the visual media assessment approach to the others.**

Here is one sample assessment developed by Greg Schwanbeck, an Apple Distinguished Educator:

Option 1: An 80 kg stuntman jumps off of a platform high in the air and lands on an airbag. The stuntman hits the airbag with an initial velocity of 45 m/s downward. 0.1 s elapses between the moment the stuntman first touches the airbag and the moment the airbag completely deflates and he comes to rest. Assume that the maximum force that the stuntman can experience and survive is 39200 N. Does the stuntman survive the fall?

Option 2: A stuntman jumps off of the top of a crane extended high up in the air. Below him is an airbag–a large inflatable cushion that has a thickness of 3 meters. When the stuntman comes into contact with the airbag, the impact deflates the airbag over a period of time, compressing the airbag from 3 meters thick to 0 meters thick while slowing him down to a stop. Explain, making reference to the impulse momentum theorem, why the stuntman is able to survive.

Option 3: * play video* http://youtu.be/3KwyftaLT-k
Explain, making reference to the impulse momentum theorem, why the stuntman is able to survive the jump

ANALYSIS

I will use both analytic and systemic approaches to analyze the data. I will use an analytic approach to identify causal relationships. Both groups will receive a pre-test and post-test for each math unit as well as a pre-test at the start of the year and a post-test at the end of the year, although the assessments will look different. A t-test will be used to identify differences between the group's understandings of mathematical skills and concepts throughout. Further, to understand the learning process that exists within the pre- and post-test outcome, I will log observations, interactions, think-alouds, etc. to keep record of changes that take place as learners interact with the curriculum. In sum, the analytic approach allows us to isolate particular attributes of the networked curriculum and then observe how learners interactions with them influences learning processes. Moreover, I will use a systemic approach to describe the patterns of relationships that exist amongst a system of components and events as they interrelate and jointly define each other in specific classroom situations. I will use quantitative methods to statistically analyze relationships between the variables over time, such as, but not limited to: iPad infrastructure, networking, visual media capabilities, classroom environment, discussion, instruction, effort, ability, perceived self-efficacy, enthusiasm, & achievement. This analysis over time can show how the relationships change as tools and strategies are introduced. Additionally, to gain a clear understanding of the context of use for the intended assessment model, I will produce a *micro*-ethnography by conducting qualitative data gathering methods through immersive classroom observations, samples of learning activities and students' work/assessments, video & photo documents, and interviews with students, teachers, & administrators. An analysis of the qualitative data, through forms of talk and nonverbal behaviors, will provide a detailed account of *how* social realities and problems are formed and maintained over the course of this yearlong study & *how* those findings in turn affect assessment methods and models. Moreover, the findings will help provide awareness & understanding of the constraints and possibilities for a visual media assessment approach within a public school context, where teachers & students have their own school-issued iPads with network access available during school hours and lessons are student-centered and utilize multimedia to support mathematical abstraction, problem solving, critical thinking, & collaboration, amongst other 21st century skills; yet, the findings will also provide insights regarding limited network access outside of school given the globally diverse population demographics, where approximately 60% of the participant population qualify for free or reduced lunch. As earlier literature disclosed, the results of studies such as this rely on several factors, including student/cultural demographics, subject, & instructional method. This report will provide valuable information for others who hope to replicate this study or use it to advance in their own field, context or subject by providing a detailed account of particular behaviors & social interactions for the given context, & will helps describe the *hows* and *whys,* such as but not limited to: why students utilized certain components within the iPad infrastructure or how students approach & complete the different assessment models. Then phenomenographic analysis will be used to determine the qualitative conceptual changes in big picture mathematical concepts, connections, and understandings as well as personal opinions and beliefs by reading individual reflections, think-alouds, and interviews that were collected throughout the year. This analysis provides detail about the social processes within which cognition is embedded, yet is often ignored in quantitative data. These methods combined provide insights as to how the networked curriculum causal elements interact with other variables in the classroom to influence learning conjointly. This method will provide evidence – both in design and in data analysis – that the visual media presentation of concepts and the processing capabilities of the networked iPad make possible an instructional method or learning environment that would not be possible through another method, which in this case would be the traditional textbook in digital form.

METHOD AND ANALYSIS RATIONALE

Studying specific educational problems, like the one I have proposed, serves many purposes. Not only will the findings further educational research by providing an evaluation of a networked-video assessment method as an approach for assessing mathematical abstraction and problem solving to secondary math students, the findings can also be used to improve teacher training. Perhaps the most significant contribution from this research is the solid evidence-based rationale that underscores the unique affordances of visual media technology, which in turn justifies the costs and complexities of integrating technology tools. All of these aspects are increasingly important as funding is necessary for visual media technology infrastructure yet current research reveals inconsistent impact and low usage by teachers, regardless of their access to resources (ITL Research, 2011). In addition, educational research needs input from educators in the field regarding relevant educational problems in specific contexts.