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Systematic Literature Review of the Use of Rich Media in STEM and Related Education

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Abstract

The use of video in pedagogy is well established in the modern classroom with researched understanding of its benefits. Prior literature reviews provide a foundation for the impacts within a wide scope of environments and subjects. These reviews primarily have looked at students and faculty attitudes, learning outcomes, and the impact on attendance. The impact has been spread over general subject matter with little focus on the often challenging topics of STEM education. Many topics in STEM education are highly procedural, such as mathematical proofs or writing code or conducting experiments. Understanding the costs and benefits of using video to capture these types of topics would be valuable in maximizing the benefits or avoiding concerns within STEM topics.

This systematic literature review looks at the use of lecture capture and rich media within STEM and related education by looking at 30 articles from educational and STEM focused databases. Articles were selected which include findings on student and faculty attitudes, attendance, and learning outcomes as well as the impact of video and its best practices found through research. The findings within the STEM literature largely align with prior literature reviews in other subjects: video is popular among students and helps in their learning outcomes. Most research in this area focuses on video captured of the same lecture provided live in the classroom. This is shown to be effective, but some of the literature suggests further improvements to maximizing the value of both the technical merit of video as well as its pedagogical content. The goal is to determine the state of the use of video via lecture capture and prerecording in STEM education, its impact on students, and to gather recommendations and best practices from the literature.

Introduction

Digital education is clearly on the rise in formal and informal education. The use of video lecture is nearly mandatory in many settings, yet often the practice is pushed with little understanding of its impact on students. Lecture capture is a method being adopted in many traditional classrooms which allows the student to view a recording of a scheduled classroom lecture at a later time. An alternative use is prerecorded lectures, sometimes referred to as micro-lectures when the recordings are focused. The lectures may be available publicly, for the rest of the term, or in some cases only the week of the lecture. The recording may include audio only or both audio and video. Digital media is made available via streaming or some institutions allow downloads. The pedagogy when lectures are captured often remains unchanged, though instructors may choose alter their pedagogy to include the technology. The literature is full of evidence of all these variances and more.

Beyond the traditional lecture format, video is being used in "flipped classrooms" where the primary "lecture" is delivered via video to students. Time spent live between student and instructor is focused on more active learning activities. Students may be asked to watch videos before they enter the classroom, or as part of the flow of the time in class. One key is the student's learning is self-paced and the time in the classroom is not driven by the instructor as much as the collective needs of the students.

Either of these methods can also be used when a classroom goes entirely online. In 2013 it was reported that 6.7 million students (32% of total enrollment) took at least one course designated as "online", up 570,000 in 2013 alone (Allen & Seaman, 2013). In online only courses, the direct contact with an instructor may be entirely digital communications (e.g. e-mail, instant message), so video may be the only non-text communication between instructors and

students. Understanding the role, limitations, and best practices of digital education is essential towards maximizing student outcomes. It is also valuable to understand the how recording lectures, during or prior to class periods, has and should impact pedagogy. What are the considerations to be made for video-enabled classrooms? Are there particular elements of video that cater to or are harmful to learning STEM and related topics? Literature may have already identified best practices in use of video, or understanding the scope of what has been researched may help identify the need for further research on the use of video in STEM education.

Previous Reviews

Two systematic literature syntheses have been found on the use of recorded video in education. Milne and Brown (2011) targeted for the use of rich media learning at Massey University, covering published materials from 2008 through early 2011. Their review looks at student and faculty opinions on use of video, how recorded lectures impact attendance, and the value students mine from recorded lectures. Much of their discussion is on the value of rich media beyond simply traditional lecture, such as sharing student created recordings, preserving guest lecturers and producing focused summaries of materials for review. Milne and Brown report students generally feel positively about recorded lectures and that it helps in their overall performance. Staff views are less optimistic on positive impact of the use of video, primarily around a fear of reduced attendance hurting performance. Additionally they found faculty express concerns about their classroom 'mistakes' were being permanently captured, among other concerns. The findings are mixed on the impact on classroom attendance. They saw a drop in student attendance when video was introduced, though they did not seem to find negative impacts to student performance when missing classes as it is difficult to separate from other factors such as motivation. Finally they point out that in cases where recorded lectures are not

formally offered students may take capturing the lecture into their own hands with portable digital devices. Thus if recording is not formally offered, resourceful students will find ways to get recorded materials anyway.

In general Milne and Brown provide a foundation of some key ideas on recorded lectures. Students find videos valuable without harming learning outcomes, while concerns may exist from faculty. The structure of their synthesis does not lend itself to deeper understanding of trends in the data. It admits the impact on attendance is mixed, but without a clear mapping to outcomes. It also includes research across a wide subject matter that may or may not reflect the trends and demands within STEM education.

As part of the literature search in this synthesis, an additional systematic review was found conducted by Kinash, Knight, and McLean (2015). Kinash et al. follow a similar pattern, looking for impacts in attendance and achievement with some attention being given to student attitudes but more importantly changes in pedagogy. This review found materials largely focused in the area of business education with only one resource (Nashash & Gunn, 2013) overlapping with this review's search results. Since Nashash & Gunn has other interesting insights beyond just the reported categories and is targeted within STEM education it is not omitted. The findings from Kintash et al. follow the findings of Milne and Brown. They saw a drop in attendance with the introduction of video, yet also see improvements in student attitudes and outcomes. Their study does not address faculty attitudes.

While each of these studies provides a strong foundation for understanding the use of video in the general classroom, neither gives insight within the STEM fields, nor suggests any pedagogical best practices or improvements for the STEM classroom. This study seeks to provide that focused look within STEM research based literature.

Research Questions

The conclusions from prior literature show rich media and lecture capture has positive findings across many fields of study. The five years between these studies has shown significant growth in the use of lecture capture where in 2010 only 4.4% of classes used lecture capture (Green, 2010) in 2014 the number jumped to 13% (Green, 2014). Even as the use of recording tripled in this span, its rate of penetration is still low. Schools however show a strong will to adopt these techniques with 79% saying "lecture capture is an important part of the campus plan to deliver instructional content" (Green, 2014, p. 21). As little research or guidance is provided in these studies as how best to leverage video within pedagogy, particularly in the unique education that happens in the STEM field. This synthesis is seeking to answer the following questions.

1. What impact does video have (faculty/student perceptions, attendance, outcomes) within STEM education?
2. Are there ways in which STEM education can best utilize video?

Methods

Databases

The databases selected include Educational Resource Information Centre (ERIC), Educational Full Text, Compendex, and Scopus. These selections were chosen to provide a focus on Education topics within STEM subject matter as each database is either focused on STEM topics or has options to narrow search results by subject matter. Further details are described later in Table 1.

Search Criteria

The search process started with a common set of keywords including "lecture capture" or "rich media" and "learning". Searches in each database were limited to peer-reviewed articles or journals (as the database allows) as a means of driving higher quality in the literature.

Table 1

Search Results

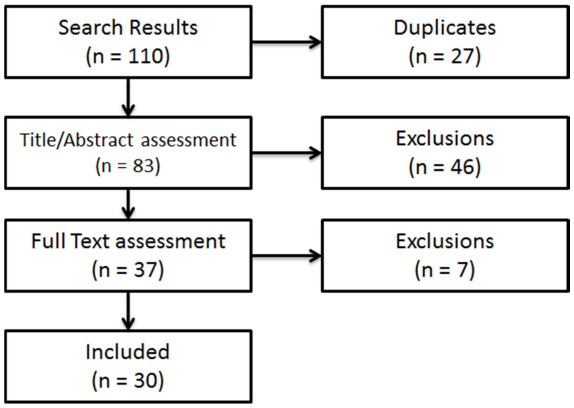
Database	Results	Notes on Search
ERIC	31	
Education Full Text	15	Results indicate articles with full text available, else 39
Compendex	20	
Scopus	44	Further limited to "engineering" and "computer science"

Selection Criteria

Article selection focused on articles researching the impact of recorded video on attendance, performance/learning, student/instructor attitudes or best practices. Best practices include both technology tips or pedagogical approaches on the use of video. The inclusion/exclusion process driven by the selection criteria is detailed in Figure 1. Note the results did not include the study from Milne and Brown (2011) as this was found prior to the search. The search results did include the article from Kinash et al. (2015) which were found as part of the search, but excluded upon Full text review as it does not include original research past its synthesis, but used as part of the prior literature understanding above.

Figure 1

Methods Summary



Results

The literature on the use of video is diverse both in subject matter and in geography. Literature includes a wide array of courses being taught in both high school and college settings. The subject matter span from medical training, to math, to STEM focused areas of the humanities, to traditional engineering topics. Articles were included from five continents with 17 of the 30 articles outside the United States showing a global interest in the use of video.

The results on video in the classroom are being reported around five topics: the impact on faculty perceptions, student attendance, learning outcomes, student perceptions, and best practices. The first four topics can be summarized as to the general impression of the impacts in the literature as shown in Table 2 with the full listing of finding shown in the Appendix. The number of studies reporting on faculty perceptions is limited, with none entirely studying faculty as a topic. The results are mixed, but no study suggests a fully negative view by faculty about video. Attendance generally is negatively or not impacted when lecture capture is available, with no study finding an increase in attendance. Learning outcomes and student perceptions are positive in general, with a few studies finding no impact to learning outcomes and one notable

exception where while students generally view lecture capture positively they note its limitations in capturing some types of classroom activities.

Table 2

Summary Findings on the Key Research Question Areas

	Included Discussion On	Negative Impact	No/Negative Mixed	No Impact	No/Positive Mixed	Positive Impact
Faculty Perceptions	5	-	2	1	-	2
Attendance	11	9	-	2	-	-
Learning Outcomes	23	-	-	3	1	19
Student Perceptions	18	-	-	-	-	18*

Faculty Attitudes

Within the included literature the question of faculty attitude was only touched upon in detail within two articles, with three others touching on it as part of other research. It may or may not be notable that these articles come from the areas of Veterinary and Nursing, possibly indicating a later adoption or non-traditional teaching styles comparable to other STEM related topics. For nursing faculty the concern perceptions revolved around

- Anxiety in adoption of the new technology
- Concerns about a 'third party' misinterpreting recordings with no context
- Loss of opportunity in the loss of face-to-face contact
- Understanding of the value this could bring to students

Freed et al. (2014) attributes the concerns of faculty to "technostress" as the faculty adjust to the new technology to get past the fear and self-doubt of using the new tools. Looking at Veterinary faculty and specifically collecting data on faculty attitudes Danielson et al. (2014) show no trends in the data. They feel the data set was small for strong conclusions though point out the faculty attitude was generally ambivalent. One common theme in the literature and from prior

reviews was a concern about the impact on attendance when video is used, thus the focus on attendance as the next topic.

Attendance

Nine of the eleven articles reporting on attendance showing some drop in attendance, while the other two showing no noticeable impact. The use of lecture capture does not seem to be a driver for a decrease in student attendance, but more of an enabler when students would miss class anyway due to unrelated reasons such as a long commute or early class (Gysbers, Johnston, Hancock, & Denyer, 2011). Students see the value of attending courses even when video is available. They like to be in class when the course is more interactive (Freed et al., 2014), as a way of removing distractions (Yoon, Oates, & Sneddon, 2014), to be part of the "university experience" or just out of habit (Gysbers et al., 2011). Many students use lecture capture as a way of catching up or reducing the penalty when they are forced to miss class.

The literature also reports how changes in attendance when recordings are included impact learning outcomes. Owston, Lupshenyuk, & Wideman (2011) find no correlation between attendance and learning outcomes. They even find that video has no impact on in-class behavior during lectures when lecture capture is available. Their study looked if lecture capture could change the nature of student engagement by allowing students to focus on the lecture rather than taking notes. Based on student responses, students neither asked more questions nor focused more on notetaking, though this may be influenced by the large class size. No place in the literature showed a drop in attendance due to video correlated to lower student outcomes. In fact, attendance may not correlate at all to student performance in some classrooms. Elmore & Gieskes (2013) report not only is student performance improved by lecture capture, but students

neither attending live lecture nor using lecture capture were successful in the classroom they studied.

Learning Outcomes

Beyond understanding the impact on learning outcomes and attendance, does video as part of the pedagogy help students perform better in class in general? Looking over the literature for this synthesis, twenty three of the papers found either no impact (3) or a positive impact (19) on learning, while not one reports a negative impact. These studies vary on the source of student performance data; many are able to go directly to retrieve student grades while others with used self-reported outcomes. Even as one of the studies that found no significant statistical difference in actual student grades, 43% of students reported the presence of lecture capture enhanced their performance in the class (Euzent, Martin, Moskal, & Moskal, 2011). Beyond simply showing a positive correlation between lecture capture and learning outcomes, one study was able to create a model to predict learning outcomes based on a 'video usage profile' (Brooks, Erickson, Greer, & Gutwin, 2014). The model attempts links student access patterns of videos to how well the student is progressing. They suggest this data could be used to look for at risk students and allow for an academic intervention.

The literature also includes trends on achievement categorized by student learning profiles. Lecture capture was reported to have the largest benefit for lowest achieving students (Owston et al., 2011). High achieving students were shown to use videos to jump directly to content they seek to review, while lower achieving students would review full lectures as part of their viewing habits. Data suggested students with less prior experience may benefit more from lecture capture, particularly when lectures are long, as long lectures were shown to be accessed more often than shorter ones (Johnston, Massa, & Burne, 2013). Johnson et al. also show that

students often access captured lectures more just before tests as a method of 'cramming'. This aligns with students self-selecting video to review, focusing on difficult concepts (McCunn & Newton, 2015). Several sources included further discussion the nature of student learners classifying them into 'deep' learners, interested in full comprehension, versus 'shallow' learners, who want to get enough information to succeed in the course (Freed et al., 2014; Vajoczki, Watt, Marquis, Vine, & Liao, 2011; Wiese & Newton, 2013). Students with the goal of mastering subject matter show positive gains when lecture capture is available, while lesser, and in some cases no gains are shown for shallow learners. This seems to build upon the idea of 'difficult concepts' being a driver for use of video as a method for students to gain deeper understanding. Lecture capture also is reported to be a positive factor in student retention for some challenging Chemistry courses (Revell, 2014).

Video within pedagogy is reported to be a valuable tool in aiding diverse student populations. Watt et al. (2014) sought specifically how the use of lecture capture can aid in Universal Instructional Design to improve access for students with disabilities. The goal of the study was to show video can benefit disabled students, though the findings were unable to be conclusive for a disabled population due to too few participants in that category. They were able to show lecture capture generally benefited all students. Several studies show the benefits of lecture capture to students learning in a second language (Brooks et al., 2014; Gysbers et al., 2011; Newton, Tucker, Dawson, & Currie, 2014; Revell, 2014; Shaw & Molnar, 2011; Sloan & Lewis, 2014; Snowball, 2014; Yoon et al., 2014). Recorded videos reduced the language barrier often faced in a traditional lecture. Video gives these students the ability to review topics and self-pace learning using 'pause' to separate challenges from language issues apart from the course content.

Less clear, but possibly present is the specific benefit to women while learning using lecture capture. While one study shows higher levels of video use by women from lecture capture (Wiese & Newton, 2013), others show less access by females than males (McCunn & Newton, 2015; Vajoczki et al., 2011). Vajoczki et al. go as far to state that females are more likely to be deep learners, which if correlated with the findings above, would imply deeper usage and learning opportunities. Each source seems to agree female learners are benefited by lecture capture, possibly even more so than males, though others show no difference in the benefits (Shaw & Molnar, 2011).

The findings from the literature included in this synthesis primarily report on the use of lecture capture over other forms of video. This is not to say that other forms of video did not show growth in student performance, but that they were largely combined with other pedagogical elements that may be the cause of performance improvements and thus are included but may not have shown video to be the largest factor in improved performance.

Student Attitudes

Video in the classroom receives universally positive response from students in the literature. The only exception, students realize that video is less valuable for capturing certain interactive classroom activities (Danielson et al., 2014). It is important to note that student perceptions do not view technology as a replacement for the classroom experience as there are many perceived benefits from face to face contact (Gysbers et al., 2011). Students value the discipline a classroom provides, the 'university experience', the chance to interact, and being present for the lectures in general. They view lecture capture as a supplement to the rest of the learning experiences (Pale, Petrovic, & Jeren, 2014).

A common theme within the literature is students enjoy the agency provided by use of videos (Nashash & Gunn, 2013). Students are given the choice of when/if to attend a lecture based on other real-world factors. They can choose to engage in lectures in different ways knowing the recording is there as a backup to aid or even improve in note taking (Nashash & Gunn, 2013). Several studies point out students enjoy the ability to use lecture material 'on the move' while commuting, exercising, or just generally detached from a desk and computer (Kinash et al., 2015; Nashash & Gunn, 2013). Video content particularly gives students the control of pacing of the learning. In a high school algebra class, the use of 'flipped classroom' to teach students via video not only improved performance but also the perception of students (Smith & Suzuki, 2015). In particular reports by students that the pace of instruction was both 'too fast' and 'too slow' were less commonly seen in the 'flipped' test group than the control group.

Reports on the use of video in the classroom are universally positive. The impact of video could even be a benefit to the perception of teachers, as the same instructor received higher scores in a section including lecture over the section taught without video (Euzent et al., 2011).

Best Practices

The literature did not include much direct research on the best use of video in the classroom pedagogy. The studies that do look at the content or design of the video focus on the technical aspects of video recording or the need to champion usage of video. With little reported findings, no specific trends can be reported so instead individual tips from individual sources will be provided.

A study on the proper formulation of videos used three formats to compare their effectiveness. The first format is a typical lecture capture with a video camera positioned to

capture the instructor and any presentation materials. The second includes audio narration from the instructor presented over the slides as the video content. The third provide the instructor as a picture-in-picture, where the video of the instructor is super-imposed over the content using 'green-screen' technology. The finding show the first and third format, where the students see the lecturer, are most effective in learning, as audio only provides the highest level of cognitive load for students (Chih-Ming Chen & Chung-Hsin Wu, 2015). This implies the best format is when the students see the instructor, though the research does not indicate if the constant presence of the instructor is helpful or if occasional association with the lecturer would be equally effective. It also may be limited as it was conducted in a Chinese classroom setting, so there may be cultural elements that do not translate globally.

In South Africa, lecture capture is looked to as a way to manage the increasing number of students in each class despite the lack of equivalent rise in resources (Snowball, 2014). The increase in enrolled students was offset using lecture capture and other blended learning methods. Use online resources offsets the problems of a large class such as "feelings of isolation amongst students, a lack of communication between lecturers and students; and the inability to offer frequent testing and feedback" (Snowball, 2014, p. 836). While the study does not recommend increasing class size, it is a strategy to counter the negative effects when larger classes are unavoidable.

One advantage described a potential benefit of lecture capture would be to improve students note taking, or at least engage further in the classroom. Video can be used as a resource to fall back on or to improve the quality of notes if their note taking is incomplete. An instructor or better yet the entire program should teach student how to make the best use of time when lecture capture is available (Owston et al., 2011). It may not be entirely obvious to students that

they can engage more fully in lecture, rather than splitting attention with notes. They may be using the lecture capture to backfill incomplete notes, yet not reflectively considering how they can take better notes to start. The simple act of addressing the capabilities of the technology and its potential benefits may further strengthen the pedagogical gains of video.

One seemingly simple improvement suggests to provide 'tagging' in the video content (Gorissen, van Bruggen, & Jochems, 2015). A tag represents a searchable word or phrase that aids students in finding a specific topic within the recorded materials. Gorissen et al. show that students who use tags perform better than those who watched the videos in their entirety. The tagging could certainly guide students to materials and save time. Tags are reported to reduce the 'friction' of using the technology by streamlining searching for topics, but may also encourage shallow learning as demonstrated by the higher level of use of the tagging interface leading up to exams.

An alternative to tagging longer videos is the development of micro lectures either as a supplemental resource to a live classroom or as a driver for a flipped classroom. In one study, additional micro lectures were provided to students studying engineering topics with some increase in outcomes, though not fully statistically significant (Nicholls & Restauri, 2015). Similarly pre-recorded lectures were created to allow a flipped classroom in a high school algebra setting (Talley & Scherer, 2013). In this study, the first classroom utilized traditional lecture in the classroom where the second used recorded lecture of the same content. The videos allowed students to review the materials in class or at home, as they chose. The teacher in the study's flipped classroom was available for student questions and spent no time in class lecturing. Students instead self-paced their time which not only improved learning, but student satisfaction in the flipped-classroom format over the lecture-based class. Note that video may

only have been the enabling technology to allow for other pedagogical elements to improve performance in this study.

Several sources touch on ideas of pure pedagogy. Newton et al. focuses mostly on the technology best practices in lecture capture but summarizes the pedagogical benefits as being "improved student performance and active control over learning" (Newton et al., 2014, p. 44). Tabor and Minch provide a detailed list of findings on pedagogy:

- Determine how digital media can complement existing course content and support student learning; video may not be appropriate for every course, or every topic
- Avoid asking students to do anything you haven't tried yourself; commit to understanding the technology and the time and effort required
- Develop clear instructions for student-produced video projects, setting expectations about the goals, time commitment, available technology and support
- Assign at least one project in small groups to allow students to learn from each other and share the time commitment
- Allow sufficient time to review publicly available media for appropriateness and reusability relevant to course content
- Carefully cover the use of intellectual property and web resources & determine how such content should be cited (i.e., credits page with numbered references throughout)
- Develop grading rubrics to establish expectations for student output and to translate existing project guidelines to digital media output
- Determine campus resources for course development (Tabor & Minch, 2013, pp. 216–217)

While many of these are not directly related to lecture capture, they express concepts that must be considered when moving to digital resources within the classroom.

Discussion[AAL1]

The first research question looked to see if the results found in the prior literature reviews were similar within STEM classrooms. Live classroom attendance may indeed be impacted by the use of video and lecture capture, but it is difficult to say that it is being caused by video technology. Students have many reasons to miss class, and including video reduces the consequences of a missed class, but it seems students still generally see the value of attendance.

Most importantly is the lack of any demonstrated connection between attendance and learning outcomes. At least for the courses enabling video, the pedagogy does not seem to demand students be present to learn at the same level as their peers who attend.

Learning outcomes across the board show improvements for students. Even if you contend that video enables shallow learners to 'cram' before exams, it is hard to say this is a fault of the technology over the choice of assessment not aligning to desired curricular outcomes. It is clear that student attitudes support the use of this technology in classes. Video technology certainly gives agency to the student in terms of attendance, pace of materials, and learning style which resonates with students more often than it chafes.

The question of faculty attitudes seems mixed. Within the sample of included literature, very few authors chose to even mention, much less research, faculty attitudes. While the initial adoption of video reports the most tension, the long term results seem to indicate instructors come to terms with or even embrace the technology. Similar to students making best use of video in their learning practices, instructors may benefit from a reflective look at how the use of video can enhance their teaching practices. How instructors perceive their design for interaction and the practiced reality in the classroom may need to be reconsidered.

> *"The five lectures in our study had very low levels of interaction; one lecturer remarked that he had never received any questions during the lecture. We were therefore surprised when 10% of the respondents said they chose to attend the live lecture because it gave them opportunities to interact with the lecturer and other students." (Yoon et al., 2014, p. 238)*

Even as we promote the benefits of interaction between students and teacher in a live classroom, our pedagogical choices may not be maximizing this outcome.

The majority of research seems report on the positive student outcomes when video is present. The conclusions on attendance seem to be clear, it is not seen in the literature as a factor

on learning. Students appreciate and positively perceive video though generally view it as a supplement rather than replacement for access to the instructor. Faculty attitude research is less present in the literature either due to saturation, a greater level of acceptance by STEM faculty, or perhaps resignation of the inevitable adoption of video. These trends in STEM literature align well to the prior literature reviews and may indicate future research can focus more on the best use of video in the classroom.

The second research question is looking for insight on best practices. The literature found spans a breadth of topics and covers classrooms around the globe. Very little is mentioned on how to maximize the value of video within the curriculum design. The studies that do detail how exams and quizzes were designed tend to be focused mostly on memorization and basic understanding. This leaves a gap in how video can be best applied to higher order learning goals, as described by taxonomies such as Anderson and Krathwohl's (Anderson, Krathwohl, & Bloom, 2001). While the evidence is presented that recorded lecture and videos support the current state of pedagogy in classroom settings, it does nothing to point towards ways to enhancing it. The benefits demonstrated in the literature are largely attitude, motivation and performance on existing tasks. There is some discussion that deeper learning is better enabled using video, but this largely is explained as "they can go back and review the hard/missing/unclear parts" rather than any alternative form of learning or using video as a tool to enhance deeper learning. The best evidence as provided to enabling virtues of video may be within Smith and Suzuki (2015) describing how video was premade, not recorded to enable a flipped classroom. The gains in student outcomes in the research group using video may in fact have little to do with the video, but more to the additional interaction the students in that group had available with the teacher.

Similarly the literature is incomplete describing best practices on the content of video and lecture capture. While some studies attempt are aid in startup efforts, better quality of video, or other technical topics, little is done to dissect the way material should be designed for video capture or its use in the overall course design. Many studies provide side notes such or tips as detailed in the results, but little is being researched on the effectiveness of what is being captured. STEM education is full of procedural tasks that require flawless execution step by step. Algebra requires precise manipulations and calculation of formulas. Chemical equations require exact balancing. Programming requires the conjunction of perfect syntax, proper tool use and the added benefit of the narration of logic the instructor can provide by vocalizing their thought process. Little is researched to show if these types of activities are better served by video, or if the complexities of the topic fall short of a full learning experience. The nearest literature to this is Talley and Scherer (2013) who recommend the use of video to teach the more science-based topics of math and biology within study of psychology. It would seem video could be used to great effect by students trying to understand and replicate procedures that require precise instructions.

A few studies within the literature hint at an alternative use of video in the classroom as an indirect measurement of student success. In their model, Brooks et al. (2014) point to using student access records of video as data to predict student outcomes. This model could be used to find students who need additional help before they even fall behind. Looking at the work of Owston et al. (2011), video usage patterns can be an indicator for finding 'deep versus shallow' learners. In both cases, the way students use video may be a tool to better understanding the maturity of a student not only in the subject matter but as a learner in general. Usage statistics could be a useful metric towards better understanding not just the value of video, but

improvements to the course design (content, assessment and pedagogy) and improving the capabilities of the students themselves. Further research may find ways we can leverage the watching habits of students to best aid in their full development as a student, improving note-taking, study skills, learning approach, or compensating for prior learning gaps. Video could be considered not only a 'passive mode' of delivering content, but an active mode for collecting data on student outcomes.

Limitations

The search criteria chosen poses some limitations as the keyword "video" is too common in literature to reasonably return manageable results. For example searching on "video" and "learning" within Scopus still limiting to the time frame of 2012-2015 within the focus of engineering and computer science still yields 5619 results. Thus it is possible that impactful findings are being missed as those articles are not using related keywords chosen.

Additionally, this literature review was conducted with a single author/reviewer. This removes the benefit of a second opinion and check against bias and interpretation.

Conclusions

The use of video in the classroom has been shown in many formats to be valuable both to student attitudes and outcomes. Nearly a decade of literature seems to consistently reaffirm that any loss of attendance is more than offset by the enhancements to the student and in many cases instructor experience. It would seem there are still many strides to be made in the adoption of this technology but also in its research. While basic research of the efficacy of lecture capture is possible, such research would be best conducted to explore explicit holes within the literature. There seems to be little on pedagogical best practices in producing videos or lesson plans including videos. Little has been documented on how to best prepare students for using videos

within their educational options. While the inclusion of video, specifically lecture capture, can easily be pointed to as being helpful, it does not mean we understand all the ways it is helpful or how to maximize its use.

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Appendix

The following is a summary of the findings from the included articles. The findings generally represent the research findings included as summarized by the author(s) though if the data is anecdotal it is noted as a comment.

Legend: x - no findings; + - positive impact; 0 - No impact; - - Negative impact
LC – Lecture Capture, PR – Previously Recorded

Table 3

Summary of Literature Findings

Article	Attendance	Learning	Attitude	Faculty	Subject Matter	Location	Video Type
(Brooks et al., 2014)	x	+	x	x	Chemistry	Canada	LC
(Chandra, 2011)	0	x	x	x	Computer Science	US	LC
(Chih-Ming Chen & Chung-Hsin Wu, 2015)	x	+	x	x	Document Writing	Taiwan	Both
(Danielson et al., 2014)	x	+	+-	0	Veterinary	US	LC
(Elmore & Gieskes, 2013)	x	0	x	x	Engineering	US	LC
(Euzent et al., 2011)	x	0	+	x	Economics	US	LC
(Freed et al., 2014)	-	x	+	0-	Nursing	US	LC
(Germany, 2012)	x	x	x	+	n/a	Australia	LC
(Gorissen et al., 2015)	x	+	+	x	Industrial Engineering	Netherlands	LC
(Gysbers et al., 2011)	0-	x	+	x	Biochemistry	Australia	LC
(Johnston et al., 2013)	-	+	+	x	Nursing	Australia	LC
(Mardis, 2014)	x	x	x	x	n/a	US	PR

Article	Attendance	Learning	Attitude	Faculty	Subject Matter	Location	Video Type
(McCunn & Newton, 2015)	x	x	x	x	Biochemistry	Canada	LC
(Nashash & Gunn, 2013)	0	+	+	x	Electronics	UAE	LC
(Newton et al., 2014)	x	x	x	x	n/a	Canada	LC
(Nicholls & Restauri, 2015)	x	0	x	x	Engineering Economics	US	Both
(Owston et al., 2011)	-	+	x	x	Health	Canada	LC
(Pale et al., 2014)	x	0+	+	x	Electrical Engineering	Croatia	LC
(Revell, 2014)	x	+	+	x	Chemistry	US	Both
(Shaw & Molnar, 2011)	x	+	+	x	Biochemistry	US	LC
(Sloan & Lewis, 2014)	x	+	x	x	Operations Management	US	LC
(Smith & Suzuki, 2015)	x	+	+	x	Math (K-12)	US	PR
(Snowball, 2014)	x	+	+	x	Economics	South Africa	LC
(Tabor & Minch, 2013)	x	+	+	x	IT Management	US	LC
(Talley & Scherer, 2013)	x	+	x	x	Physiological Psychology	US	Both
(Vajoczki et al., 2011)	x	+	+	x	Economics and Sociology	Canada	LC
(Walczowski, Dimond, & Waller, 2015)	x	+	x	+	Electrical Engineering	UK	PR
(Watt et al., 2014)	-	+	+	x	Social Science	Canada	LC
(Wiese & Newton, 2013)	0-	+	x	x	Nutrition	Canada	LC
(Yoon et al., 2014)	-	x	+	x	Math	New Zealand	LC