# The Impact of Video in the K-12 Classroom

A scoping study of instructional video research

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**Please cite as:**

Walsh, T., & Henderson, M. (2022). The Impact of Video in the K-12 Classroom: A scoping study of instructional video research. ClickView.
https://doi.org/10.26180/19614093



**Published 2022**
by ClickView
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Carlton VIC 3053
www.clickview.com.au

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# Executive Summary

Before the COVID-19 pandemic, Cisco predicted that 82% of all created content would be video (Cisco, 2018). Since the pandemic began in 2020, video consumption, in particular video streaming and short form video content, has risen significantly (PwC, 2021, Deloitte, 2021). Social media platforms TikTok and YouTube dominate the short form video content space (Statistica, 2022), and video has become a widely used tool in educational settings, both remote and in-person. These changing consumption patterns, together with the steadily increasing use of video for educational purposes, have been the focus of a growing body of research focused on measuring video's effectiveness as a learning aid.

To date, most of the research examining the effectiveness of video in education has been conducted in higher education settings (Carmichael et al. 2018). However, video is heavily used in the K-12 context, so the conclusions drawn from higher education studies may not be as relevant for school learners. Therefore, this literature review provides the field with a much-needed review of the empirical research on the impact of instructional video on K-12 learners and identifies gaps for further exploration. To achieve this, the authors examined seven systematic reviews that encompass 7,170 empirical research studies conducted over the last 50 years. Of these, only 77 of the papers included in those reviews were focused on K-12 learners. An analysis of the K-12 papers confirmed many similarities with findings from other sectors, but it also provided additional insights, unique to K-12 settings, that were not noted by the reviews.

While there are a wide variety of video types, this literature review focuses on those videos that have been created explicitly for instructional purposes. Instructional video aims to teach viewers something or offers help with a particular problem. The knowledge acquired from this type of video can be factual, conceptual, procedural, affective, or relational. In addition to focusing on videos that meet this description, we have also followed the lead of Fyfield et al. (2022) and used the definition of Ibrahim et al. (2012, p.220) to describe video itself as "a format of presenting information as a stream of dynamic visual and auditory content."

Overall, the literature review findings suggest that video can positively impact learning outcomes and motivate and engage young people in their learning. However, the research also showed no singular universal design that results in positive learning outcomes. There are a variety of factors, including video design principles, which have been shown to have a positive impact on learning outcomes. However, in some cases, the particular combination of principles can interact with each other and confound the results. The goal of trying to identify when and how video impacts on learning is made even more difficult by the fact that the research literature uses significant variation in the terminology, methods and approaches, as well as considerable diversity in the video types being studied. All of this makes it almost impossible to create definitive comparative judgments about which design or principle is most useful.

The findings of this literature review are a call to arms for video producers, researchers, and educators who need to find a common language, comparable empirical research, and reliable conclusions about what works and when to progress the use of video in education settings and deliver superior learning outcomes.

The key findings and recommendations of this report are summarized in the next section. The complete set of findings can be found at the conclusion of the report.

# Key Findings & Recommendations

## The state of the research literature

- There is a lack of consistency regarding the description of media used across research studies. Some studies, for instance, use the same terminology to refer to very different types of videos. This means that comparing empirical results is difficult, if not impossible.

- There is a lack of clarity and detail in the research literature regarding the description of the research designs and very few opportunities to view the media discussed. This means that findings are often unverifiable because the specific characteristics of the media tested (e.g., type and length of video), and the details of the research method (e.g., testing instruments) are not clear.

- The findings suggest a lack of communication between media industry experts, educators,, and educational researchers. The increased involvement by media experts in research efforts may help to define consistent and coherent terminology and standards that would support replicability and comparison of research and the dissemination of best practice.

### *Recommendation 1*

The media industry and the research community work together to develop a definitional framework for instructional video types and video design. This would provide a reliable mechanism for research comparison. It would also provide a common language that would enable educators and developers in the industry, as well as researchers, to describe the videos they use, create, and research. The terminology could conceivably become a new industry standard for meta-tagging and facilitate more effective indexing and searching. A robust definitional framework would also need to evolve as new media forms emerge.

*Recommendation 2*

Identifying effective design principles is challenging as the findings of empirical studies are often hidden within journals. This is often made more difficult when highly technical or theoretical language is used. Therefore, it is recommended that a centralized database, or clearinghouse of findings, similar to Appendix B, be built and maintained to provide a 'living' resource that is an essential international reference point for all instructional video developers and researchers.

*Recommendation 3*

Similar to the move for open data repositories in scientific research, it is proposed that there is a need for a video data repository whereby the video assets used by research papers can be stored for future reference. This will support secondary analysis of other researchers' findings and may help in the design of replication studies.

## The focus of research literature

- Most research on the impact of video in K-12 education has been conducted with STEM subjects in experimental conditions, and most studies aren't replicated. The lack of variability in the domain areas researched makes it challenging to discuss video impact in other disciplines, and the lack of authentic classroom studies means that the validity of the research is threatened. Finally, the lack of replication undermines the strength of the claims being made.

- Studies of K-12 settings represented less than 20% of the literature contained in the seven systematic reviews. The lack of research in K-12 learning environments means that it is difficult to make broad claims about video's effectiveness. Any recommendations made may not have a strong evidential base or be applicable in all contexts.

- A large proportion of studies focused on cognitive functioning, particularly information processing and memory. The impact of video on factors such as social skills, cultural values, metacognition, affect, relationships, and attitudes

has not been well explored. This means that using video to teach or engage students in these ways needs to be supported with more research.

- The impact of video on gender and age was not well reported in the studies examined. This means it's difficult to discuss whether video impacts genders and age groups in the same way. It also means that it's difficult to compare the effectiveness of video interventions on teaching and learning outcomes at different developmental stages.
- Most studies in the sample excluded students with disabilities from their results and discussions or did not report that they were part of the sample. Given that special education students make up 10% of the student population in Australia (Australian Institute of Health & Welfare, 2020), 12% in the United Kingdom (Gov.UK, 2021), and 14% in the United States (National Center for Statistics, 2021), reviewing disability as a factor within the results and discussion section, would be useful for practical applications of the findings in a real classroom setting.

### *Recommendation 4*

There is a need for research to be conducted that investigates the impact of video in relation to: K-12 non-STEM subjects, learner characteristics, and factors such as social skills, cultural values, metacognition, affect, relationships and attitudes.

### *Recommendation 5*

The extant research largely uses research designs that are useful to identify potential factors that lead to impact. However, the confidence of those results are often weak because the studies do not account for confounding factors, real-world contexts, issues of transfer or replication. In particular, the research field needs to pay greater attention to replication studies that report effect sizes.

### *Recommendation 6*

Include students with disabilities or special educational needs in studies and specify their participation in the results. It would also be useful to explore whether the video

intervention strategies used in special education research would help other students acquire high-demand workplace skills such as communication and collaboration.

### Broad findings related to video impact

- The use of video to develop factual and conceptual knowledge is the focus of more studies and therefore has the strongest support in both the K-12 literature and the broader literature. This does not mean that video only develops these types of knowledge. It means there are simply too few convincing studies relating to other impacts to allow for a strong comparison.

- Not all multimedia design principles (cf. Cognitive Theory of Multimedia Learning) are supported by research, and some have more support than others. While the work of Fyfield et al. (2022) has identified which principles have the most support in the literature, this work has highlighted that more research focusing on the impact of multimedia design principles is needed in K-12 educational contexts. This finding aligns with the broader body of work. However, some principles, such as pre-training that weren't supported in the Fyfield et al. (2022) review, were supported in the K-12 studies for this review.

- Cognitively efficient video design and appropriate implementation strategies may work best at helping all students better engage with and learn from video. However, many high-impact teaching strategies, such as metacognitive questioning techniques and retrieval practice, did not seem to feature in the learning designs from the studies. This apparent exclusion of these strategies in the K-12 papers, and the broader body of work, means it's unclear to what extent they could amplify the use of video in classroom environments, if at all.

- Video interactivity such as learner control, interloping tests and key prompts and questions appear to be well supported to enhance learning, motivation and engagement in video learning in K-12 learning contexts. However, the range of learning contexts for the studies favored middle and high school learners, and not primary or elementary level learners.

- The research in this review focuses on improving knowledge and skills. There are no studies that focus on higher order thinking skills such as creative and critical thinking.

### *Recommendation 7*

There is a need for a greater emphasis in research on design principles that are less supported in the literature and are used widely in video production, these are: the voice principle, drawing principle, guided discovery, the multimedia principle, the role of audio quality, speech rate, background music, the misconception effect and the inclusion of reviews are the end of videos.

### *Recommendation 8*

Researchers need to describe the exact learning environment in which the research tasks take place; most of the studies are vague. For example, clarity around if the studies are embedded in a real-world classroom as opposed to highly controlled experimental conditions, may help practitioners better understand how they can apply the learnings in their classroom context.

### *Recommendation 9*

Research is needed that assesses the effectiveness of video with higher order thinking skills, such as critical and creative thinking to help educators better understand how video can be used effectively to assist students in developing these skills.

# Introduction

Video is a common tool in contemporary education. Its popularity in educational settings was established almost a decade ago (Kay, 2013; Winslett, 2014), with subsequent researchers and professional bodies claiming that 80 – 90% of educators were using video in their classrooms regularly (Alison, 2015; Boclips, 2018). By all accounts, the value of, and dependency on, video as an educational resource has further increased in the context of COVID-19 with widespread rapid shifts to online learning experienced by many schools across the globe. For example, at the beginning of the pandemic (February 1st to May 1st, 2020 ), the most viewed videos on YouTube were educational in nature (YouTube 2021), and TikTok not only saw significant usage and download increases but launched its own educational initiative #LearnOnTikTok (TikTok, 2021). This dependency on video is supported by leading educational video specialists, ClickView, which reported a 138% increase in video demand over the course of 2020.

Given the extent to which video is being used for educational purposes both inside and outside of the classroom, it is important to uncover the impact it has in K-12 education – hence this literature review. However, we faced several challenges in preparing this paper. Firstly, there are relatively few empirical studies for K-12 compared to higher education. A second hurdle to understanding the impact of video in K-12 education is the inconsistent and confusing way in which educational research describes and reports on the use of video (Fyfield et al., 2022).

Despite these limitations, some promising research indicates that video can enhance learning and be a highly effective educational tool. It has been associated with an increase in students and teacher satisfaction (Kay & Edwards, 2021), motivation (Merkt et al. 2011), confidence (Cook et al., 2016), in some contexts, stronger academic performance (Boster et al.2006), improved learning outcomes (Adegoke, 2010), and the widening of classroom participation and its ability to encourage emotional and course engagement (Atwa et al. 2016). However, video should not be viewed as a panacea for teaching and learning challenges. It has

been shown to put up barriers to engagement, especially for those with challenges accessing technology (Lee et al. 2021).

As the education community continues to use video as an instructional tool, there will be a greater need for educators to know what good design and effective implementation looks like in all learning contexts. To better understand its impact on K-12 education, this literature review draws on the extant K-12 research literature to reveal the design and delivery factors that impact on learning.

# Method

The aim of this literature review is to describe and synthesize the empirical research literature relating to the impact of video in K-12 education. Initial scoping of the literature revealed a number of well-recognized systematic literature reviews that could serve as a corpus of data to support this report. However, it was also clear that most of these reviews either did not include or included very little research from K-12 learning contexts.

The author's initial scan also revealed a diversity of research designs including action research, experimental, quasi-experimental, and case study methods. There are a relatively small number of studies that report effect sizes, and those that do are not representative across the contexts, design characteristics, or forms of impact. As a result, it is not possible to conduct a typical meta-review. Instead, it was concluded that this report would be most useful by synthesizing the work done to date, with a specific and unique focus on the K-12 sector.

The authors adopted the method of conducting a search for systematic reviews of empirical research on the impact of educational video. These systematic reviews represent significant peer-reviewed analysis of the extant literature and provide a valuable touchpoint for an accepted understanding of the impact of video. We then embarked upon extracting the K-12 studies from these literature reviews. A close analysis of these K-12 papers allowed for context-specific refinement of the findings from the original literature reviews which were more general in nature.

## Search Strategy

A search was conducted for literature reviews, including systematic, rapid, and meta-literature reviews. The search was conducted in October 2021 using the ProQuest, ERIC, and A+ education databases. Search terms were built around the key constructs of video and education with exclusions around games (i.e. to exclude video games). Initially, six systematic reviews were identified. All systematic reviews had to include empirical studies that had taken place in K-12 learning environments. Those that only focused on higher education, for example, were excluded. A seventh literature review

(Fyfield, et al., 2022) was also identified as being in early release, but otherwise meeting the required inclusion criteria. In total the seven literature reviews canvased 7170 papers between the years of 1973 and 2021, with a final count of 77 included papers. As such, the insights drawn in this report are founded on a sizable sweep of the literature.

As noted, the goal of this report was not to just synthesize the impact of video in education, but to specifically understand its impact in K-12 contexts. Unfortunately, the literature reviews combined the findings of K-12 studies along with other sectors. As a result, the authors obtained full copies of the K-12 papers that were included in each of the seven systematic literature reviews. These were then individually analyzed for unique or differing insights to those found in the more general reviews. This resulted in a corpus of 77 papers (see Appendix B).

The 77 papers were analyzed according to 10 categories of codes: 1) methodology, 2) video type, 3) video duration, 4) video topic, 5) subject domain, 6) number of participants, 7) gender, 8) learning measures (recall, acquisition, transfer, proficiency), 9) factors, 10) impact. Details of the coding scheme are outlined in Appendix A, while the results are outlined in Appendix B.

# Seven Literature Reviews

Seven literature reviews relating to the use of educational video were written over the last decade (Table 1), of which only one specifically looked at video in K-12 education . The focus of this review was on flipped classroom learning (Lee et al. 2021). This section outlines seven systematic reviews of the impact of video on education, which includes the review discussed above. Published in the last ten years, the reviews chosen derived from a search of the literature. It is from these reviews that the research that will be discussed later have been extracted. These reviews can be divided into four broad themes: history of video, video design, learning design and learner characteristics as explained in Table 1 below.

| Review | K-12 papers | Focus |
|---|---|---|
| Berney and Bétrancourt's (2016) | 4/50 (8%) | Video design: animation versus static images |
| Castro-Alonso et al. (2019) | 8/46 (17%) | Learner characteristics, primarily gender, but also spatial ability and age |
| Fyfield et al. (2022) | 22/117 (18%) | Improving instructional video design: a systematic review |
| Kay (2012) | 4/53 (7.5%) | Historical context of video |
| Lee and Yeung (2021) | 15 of 15 (100%) | Video intervention: Flipped classroom K-12 science |
| Park et al. (2018) | 17/41 (41%) | Video intervention: Video modeling & prompting on people with intellectual disabilities |
| Soek et al. (2019) | 7 of 8 (88%) | Video intervention: Video modeling & prompting on learners with emotional and behavioral disorders |
| Total: | 77/330 (23%) | |

Table 1: Percentage of K-12 papers from each review

## History of Video

Kay's (2012) systematic review of the use of video podcasts in education, reviewed studies from 2002 to 2011 to provide an overview of the history of video, which Kay refers to as video podcasts. The review not only confirmed that videos have been used regularly in education for nearly 20 years, it also identified several benefits and challenges.

The key benefits of video identified in this review include:

- Positive affective and cognitive attitudes: Video podcasts were found to be enjoyable, motivating, interesting, and stimulating. Moreover, they were seen as useful, helpful, effective, easy to use, and in some cases, students believed that their performance increased as a direct result of using them.
- Control over learning: In particular learners enjoyed control over when and where they learned, what they needed to learn as well as the pace of learning.
- Improved study habits: This encompassed fostering more independence, increasing self-reflection, more efficient test preparation, reviewing material, and increasing contact with staff.
- Increased learning performance. Higher scores in tests and improved team and technology skills were recorded. Additionally improved teamwork and observable changes in practice were also seen after the use of the video podcast, eg: sunscreen use.

The key challenges identified in this review included a variety of technical problems, a preference of some students for lectures over video, and reduced class attendance. Methodological concerns included an insufficient description of video podcasts examined, a challenge echoed by Fyfield et al. (2022), limited sample selection and description, and the absence of reliability and validity estimates for data collection tools.

## Video Design

Video design refers to the design elements used to create educational videos that may enhance learning.

Video design was the focus of two systematic reviews and provides some insight into design elements that may be favorable for increasing engagement and learning.

Fyfield et al. (2022) conducted a systematic review that looked at 117 papers, 22 of which were in a K-12 context. Their review examined the impact of instructional video through “the most common theoretical lens used to design and evaluate

instructional videos […] the Cognitive Theory of Multimedia Learning (CTML).” (pg.1) Whilst this review was unique, in that it identifies the principles of video design that have been shown to improve learning from instructional videos, it excluded several other perspectives. Whilst design principles are often talked about in the literature, there is no comprehensive list of principles that have been shown to improve learning. This review however identified the principles of video design that are the most supported in the literature which offers a guide of sorts to people creating instructional video content.

There are six principles of instructional video design that have the strongest support in literature: coherence, integrating learning activities, the embodiment principle, video length reduction and segmentation. There were mixed findings regarding principles such as modality, redundancy and presenter’s face suggesting that more research is needed to “identify the boundary conditions of these principles” (Fyfield et al., 2022 pg.10). It is important to note that modality and redundancy have been well supported in learning from static media, hence the need to conduct further research.

The authors identified that six of the principles in Mayer’s (2014a) list of effective design principles have only been studied in two or less papers where the media was instructional video. Those that had not been studied at all were the voice principle and the drawing principle. One study looked at the guided discovery, and two studies at pre-training and the multimedia principle. Nine principles were identified in the review that are not well supported but relate to design elements common in video design: audio quality, speech rate, background music, and others such as the misconception effect, and reviews at the end of videos.

We identified a number of challenges with the literature such as a lack of replication of studies, inconsistent measures of learning across the studies, a poor description of media, and whether the diverse video styles can in fact be compared.

Berney and Bétrancourt’s (2016) systematic review also discussed design elements that may enhance the learning from video. They suggested that dynamic visualizations, (animation, simulations and video), are better instructional materials than static ones, (stills, illustrations and photos). With findings similar to the meta-

analyses of Höffler and Leutner (2007) and Castro-Alonso et al. (2019), using 140 pairwise comparisons of animated versus static graphic visualizations, they found higher learning gains with animation over static graphics with an effect size of g=0.226. The review suggested that iconic representations are more effective than abstract ones. The meta-analysis also revealed that video, described as animation, was significantly more effective for learning factual and conceptual knowledge, and the cognitive activities of remembering, understanding, and applying (Berney and Bétrancourt's, 2016).

## Learning Design

Learning design relates to both the strategies and interventions used with video to enhance its effectiveness in a learning setting. Three of the seven systematic reviews explored the effectiveness of the video interventions of flipped learning (Lee & Yeung, 2021), video modeling and prompting (Park et al., 2019; Soek et al., 2018). Unlike the reviews discussed earlier, one of the reviews, Lee & Yeung (2021) included all K-12 studies. A further review (Soek et al., 2018) included all but one K-12 study. It should be noted however that these two review sample sizes were significantly smaller than the others (fifteen and eight studies respectively). This is unsurprising, given much of the work in this field is not in K-12 educational contexts.

Lee and Yeung's (2021) scoping review was the first ever review of flipped classrooms in K-12 science education. It only included studies that used instructional video as part of a pre-class activity. The review found that when video was used as part of a flipped classroom intervention it had a positive impact on motivation, engagement and attitude, but mixed findings on academic performance. Additionally, this review identified several student-related, faculty-related, and operation related challenges to using video as part of a flipped classroom intervention. These included the difficulty of ensuring students watch the video before the lesson (Gariou-Papalexiou et al., 2017; Kettle, 2013; Lo et al., 2018; Slemmons et al. 2018; Sookoo-Singh and Boisselle; 2018; Yousefzadeh and Salimi, 2015), difficulty in finding instructional videos (Lo et al., 2018; Olakanmi, 2017; Zainuddin, 2018), and students reluctance and lack of motivation for pre-class learning (Gariou-Papalexiou

et al., 2017; Lo et al., 2018; Sookoo-Singh and Boisselle, 2018; Yousefzadeh and Salimi, 2015).

The reviews of Park et al. (2019) and Soek et al. (2018) both evaluated the use of video interventions in teaching skills to learners with intellectual and emotional behavioral disabilities. They identified the strategies most often used to effectively teach these skills – including  error correction, reinforcement and self-regulation strategies – as well as the limitations of their research which included a limited population size and variation of search terms, as well as the need for generalizability – across settings, populations, target behaviors in the real world contexts, and subjects.

## Learner Characteristics

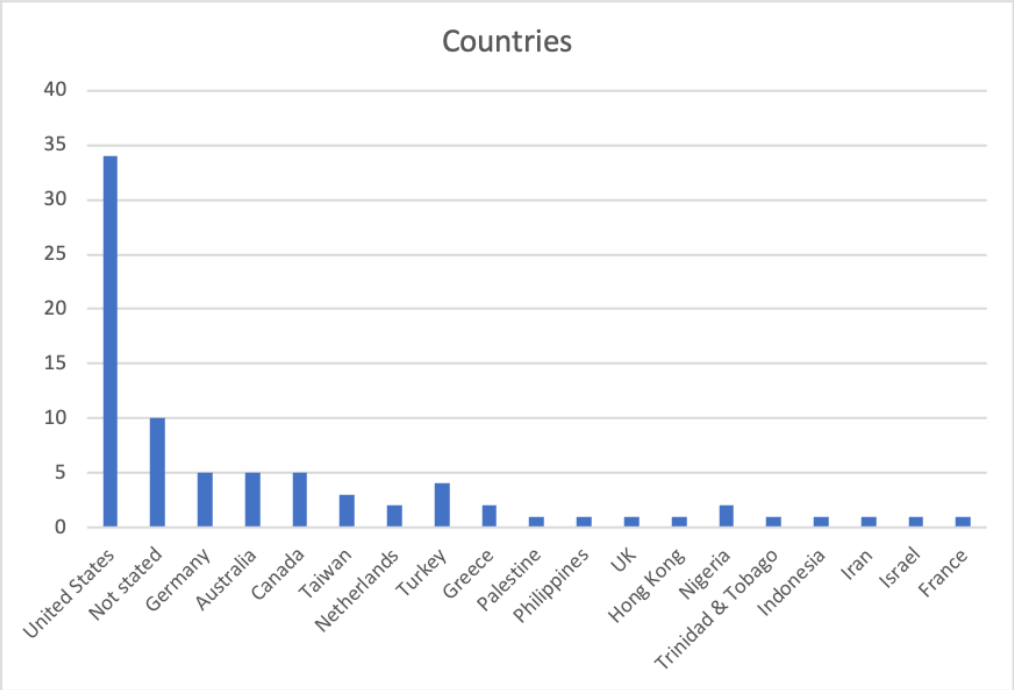
Finally, learner characteristics and video efficacy were the focus of the review of Castro-Alonso et al. (2019). This review explored whether gender is advantageous when using video as an educational tool. Whilst not the focus of the review, spatial ability and age were also discussed. The review observed that both gender and spatial ability were rarely discussed in relation to the impact of video in experimental studies. They claim that gender and spatial ability “deserves more attention as a participant characteristic” (pg. 363), because males and those with high spatial ability (more often males), seem to benefit more from video. Furthermore, they observed that “dynamic visualizations (video) were more effective for elementary school students (g+ = 0.53), than for middle school students (g+ = 0.44), than for university students (g+ = 0.19)” (pg. 375). Noting that whilst all studies reported on age, none discussed their effectiveness as a learning tool in the same terms.

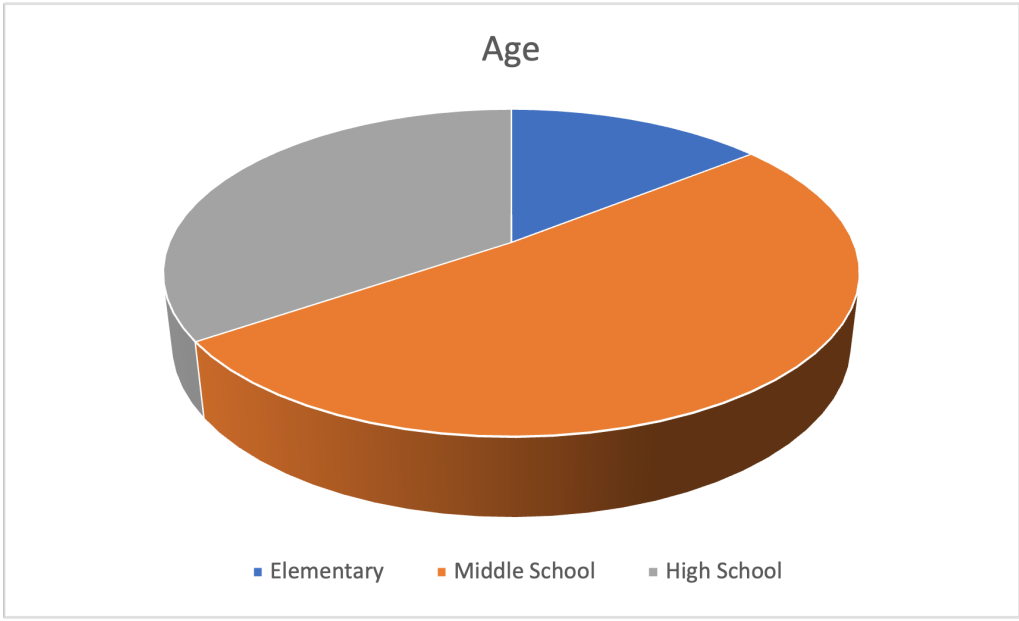
The seven systematic reviews suggested that videos have been regularly used in education for over 20 years (Kay, 2012), that dynamic visualizations may be more effective educational tools than static ones (Berney and Bétrancourt, 2016; Castro-Alonso, 2019), some principles of video design are more supported in the literature than others (Fyfield et al., 2022), gender, spatial and educational level may impact the effectiveness of video (Castro-Alonso, 2019), and that video interventions such as flipped classrooms and video modeling and prompting may improve student engagement, and help in the development of life and social and emotional skills (Lee

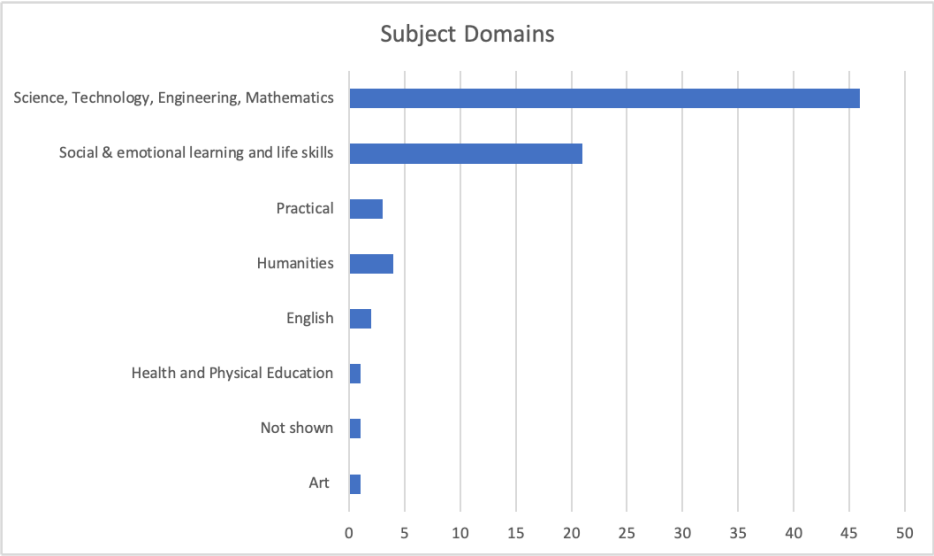
& Yeung, 2021; Park et al., 2019, Soek et al., 2018). The paucity of K-12 research however, as evidenced in these reviews and in Table 2, means that any discussion of the impact of video in K-12 education needs to consider what is known in the broader context. To discover the gaps, the focus of this review will be on the K-12 papers from the seven systematic reviews outlined in Table 1.

# Results and Discussion

The online searches and reviews conducted revealed that the bulk of the research on video in education is in non-K-12 learning environments. The literature reveals that video makes an impact on academic outcomes, memory, skill development, motivation, engagement, self-regulation, attitude, and social interaction. From the seven systematic reviews, which included 330 articles, 77 (23%) focused on K-12. If we excluded reviews that focused on flipped classrooms and special needs interventions, the number of research papers in this review would be lower (Table 1).






To date, the largest portion of the research in K-12 video education is in the United States. The notable absence of countries like China is surprising. This may have been because of the inclusion of papers only written in English as well as the limited search terms. A wider search may have revealed different results.

To discuss the impact of video in K-12, the age levels are divided into three level groupings – elementary (P/K-4), middle school (5-8) and high school (9-12). Elementary levels were least represented, appearing in only 15% of the papers. In comparison, 34% of the studies focused on  high school and 55% on middle school learners. This suggests a need to conduct research in elementary levels to better understand its impact as a learning tool.

Finally, STEM subjects were most favored by researchers across all levels (59%). The high number of studies in the social, emotional and life skills category (27%) can be attributed to the fact that two of the systematic reviews focused on special needs participants.

To explore the impact of video, this literature review is divided into the following two sections.

1. Types of videos: A discussion of the challenges faced when researching video in K-12 education.
2. Types of factors and impact: The factors and impact of video in the K-12 research is divided into three themes: video design, learning design and learner characteristics.

# Types of Videos

Developments in internet technologies, social media and communication have allowed video to grow in prominence in advertising, education and social media (Taslibeyaz, 2015). Consequently, a proliferation of video types has emerged, accompanied by a number of typologies. These include:

1. Kuomi's (2014) Potent Pedagogic Roles for Video,
2. Hansch et al.'s (2015) Video Affordances for Online Learning,
3. Chroriamopoilos's (2018) Taxonomy of Asynchronous Instructional Video Styles,
4. Fyfield's (2020) Classification of Instructional Video Styles, and
5. Kose et al.'s (2021) Classification of Instructional Videos.

All of these typologies evaluate video from different perspectives, and none have been adopted universally (Köse et al., 2021). However, there is a need for a universal framework because the empirical research on video in education lacks consistency and clarity. Fyfield et al. (2022) point out that there is poor description of media including diversity of video styles, which makes the "true impact of video" in education impossible to determine (Yildirim, 2014). The various typologies classify either the type of video, the techniques used in video or the learning purpose of the video. Each of the approaches is described in the next section.

## Potent Pedagogic Roles for Video

Koumi (2006) Potent Pedagogic Roles for Video considers the techniques and teaching functions of video in cognitive, experiential and affective domains. This taxonomy includes 33 categories of pedagogical roles for video techniques and teaching functions (Figure 1). The categories were created with insight derived from expert teachers' opinions, and content from both a UK Open University Broadcast and Audio-Visual Allocations Subcommittee and a BBC run Educational TV for Development course in the 1980s and 1990s. Initially describing 18 functions, it grew to 33 categories.

| 1. Facilitating COGNITION |
|---|
| 1 composite images, e.g. split screen, superimposition<br>2 animated diagrams exploring processes<br>3 visual representation/analogy/metaphor<br>4 illustrating concepts with real examples<br>5 modeling a process by judicious simplification<br>6 juxtaposition of contrasting situations<br>7 condensing time by editing real life<br>8 narrative (story-telling) power through pedagogic design of visuals, audio, commentary |

| 2. Providing realistic/amplified EXPERIENCES otherwise inaccessible |
|---|
| 1 movement with synchonous location sound<br>2 viewpoints e.g. aerial, undersea, microscopic, extreme close-up<br>3 places e.g. dangerous/overseas locations<br>4 3D, by good lighting & moving object or camera<br>5 slow motion / fast (time lapse) motion<br>6 people/animals interacting, real or drama<br>7 chronological sequence and pacing of behavior<br>8 resource of material for viewers to analyze<br>9 one-off or rare events/resources<br>10 staged events e.g. dramatize enactments, complex experiments |

| | 3. Nurturing AFFECTIVE characteristics |
|---|---|
| activation<br>resolve<br>motivation | 1 galvanize/spur into action, provoke viewers to get up and do things<br>2 motivate a strategy e.g. by showing its success<br>3 stimulate appetite to learn, e.g. reveal the fascination of the subject |
| activation<br>resolve<br>motivation | 4 change the attitudes/appreciations, e.g. engender empathy<br>5 alleviate leaner's isolation by showing/hearing the teacher or peers<br>6 reassurance, encourage self-efficacy<br>7 authenticate academic abstraction by providing empirical confirmation<br>8 create a sense of importance, e.g. by using famous presenters |

| 4. Demonstrating SKILLS |
|---|
| 1 manual/craft: making learning aids, cookery, joinery, painting, designing<br>2 body movement: dance, fitness routines, athletics<br>3 reasoning: problem solving, planning brainstorming<br>4 interpersonal: counselling, interviewing, teamwork, classroom teaching<br>5 linguistic/expressive: language, singing, recitation, authoring, non-verbal<br>6 studying: researching information, collaborative learning, exam strategy<br>7 technical: laboratory, mechanics, nursing |

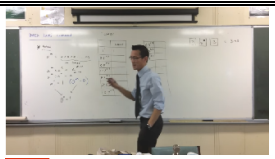
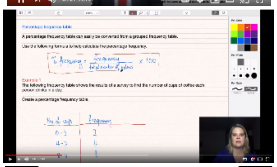
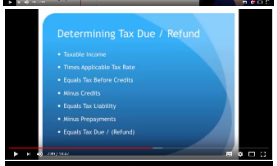
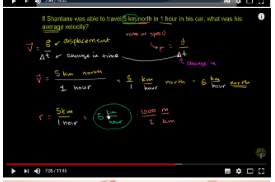
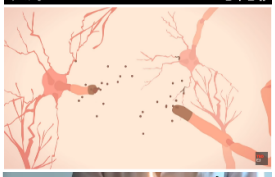
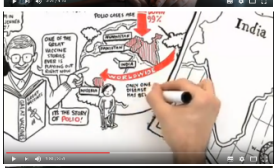
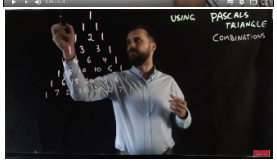
Figure 1. Potent Pedagogic Roles for Video: Techniques and teaching functions to facilitate learning. (Kuomi, 2014)

## Classification of Instructional Video Styles

Fyfield's (2020) Classification of Instructional Video Styles (Figure 2) identifies 19 instructional video types used in education. The classification lists the nineteen video types, provides descriptions, examples and links to the media for individual viewing.

**Table 3:**

*Classification of Instructional Video Styles*

| Name | Code | Description | Example title | Example Screenshot |
|---|---|---|---|---|
| Lecture capture | LC | Instructor is filmed delivering a traditional lecture with or without live audience | Eddie Woo: What is 0 to the power of 0? |  |
| Picture in picture superimposed | PIP | Image of instructor is superimposed over PowerPoint slides | Open Tuition: Introduction to the Financial Accounting Exam |   |
| Screencast | SC | Screencast of instructor's screen with or without image of instructor's face in separate box. | Aimee Shackleton: Percentage frequency tables |  |
| Voice over slides | VS | Instructor's voice narrates over PowerPoint slides | Gordon Hensley: Introduction to Taxes Video Lecture 1 |   |
| Narrated Tablet (Khan Style) | NT | Instructor narrates while manipulating a virtual tablet by drawing and using the cursor | Khan Academy: Introduction to vectors and scalars |  |
| Animated declarative | AN | Instructor narrates over bespoke animations | TED-Ed: What happens when you have a concussion? |  |
| Live action how-to | LHT | Narrated live demonstration of a particular skill/process | Teachinglearninguoit: How to light a Bunsen burner |  |
| Whiteboard animation | WB | Instructor narrates while a (real or simulated) hand draws on a white background | Gates Foundation: Bill Gates: Vaccines save lives |   |
| Lightboard lesson | LB | Instructor delivers a lesson facing the camera, while writing on a clear glass surface | Joel Speranza: Using Pascal's triangle to calculate combinations |   |

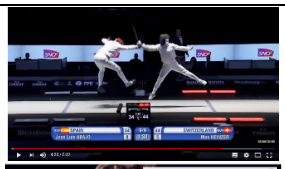
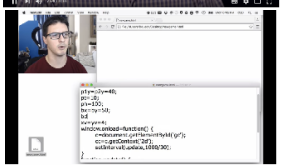
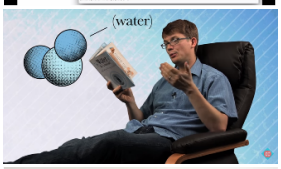
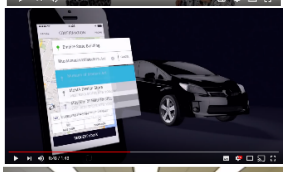
| | | | | |
|---|---|---|---|---|
| Documentary style | DOC | Live action to camera narrated in a traditional documentary narrative style | Vox: Fencing explained |  |
| Interview/Dialogue | ID | Host interviews experts or ordinary people | Capture Your Flag: Simon Sinek on Learning How Not to Manage People |  |
| Worked Example | WE | Expert actually performing a process, such as tutorials, code-along examples | Gamkedo: Coding an HTML5 Canvas Game with JS in 5 min 30 sec |  |
| Infotainment Combined | COM | Combination of animation and live instructor capture in an entertaining, light hearted manner | Crash Course: Water - Liquid Awesome: Crash Course Biology #2 |   |
| Dramatisation | DRA | Dramatic recreation of process or context intended to model a concept | NSW volunteering: Listening skills for conflict resolution |  |
| Advertisement | AD | Videos that are designed to promote or explain a product to potential consumers. | Gamechangers: Uber Case Study |  |
| Memory Aid | MA | Songs, Rhymes, or Poems to help students memorise or learn a concept | Lauren Misretta: Lab Safety Rap (Teachers) |  |
| Live Capture | LCR | Live footage of an event or demonstration | Optical Data Corp: Alkali metals in water |  |
| Talking Head | TH | Presenter in close-up talks directly to camera | Little Art Talks: The Meaning of Appropriation |  |
| Animated how-to | AHT | Narrated animated demonstration of a particular skill/process | Integral Fire Protection: How to use a fire extinguisher |  |

Figure 2: Classification of Instructional Video Styles, Fyfield (2020)

## Video Affordances for Online Learning

According to Hansch et al. (2015), there are nine types of instructional video, when defined by their affordances for online learning (Figure 3), and 18 video production styles (Figure 4). This typology was created from videos used in online MOOCs (Massive Online Learning Courses) and is similar to Fyfield's (2020) classification of instructional video.


Figure 3: Video's affordances for online learning (Hansch et al. 2015)

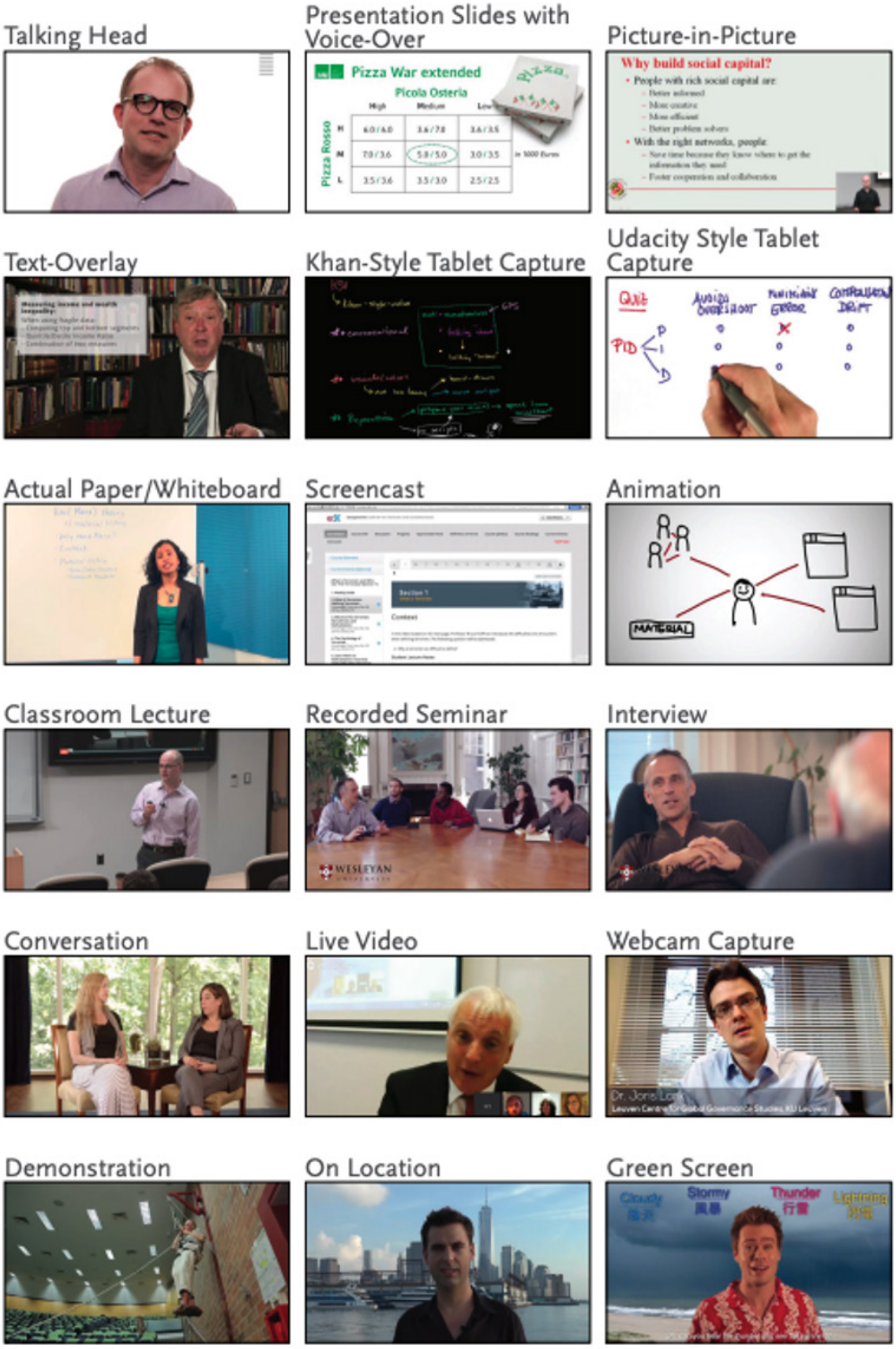
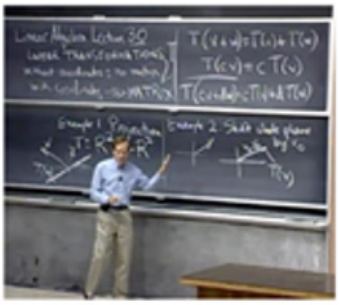
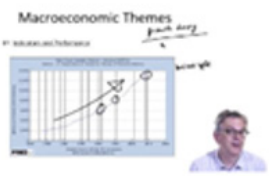



Figure 4: 18 Video Production Styles (Hansch et al. 2015)

## Taxonomy of Asynchronous Instructional Video Styles

Chorianopoulos' (2018) Taxonomy of Instructional Video Formats (Figure 5) further develops the earlier work of Santos-Espino (2016). It suggests that two dimensions determine the style of instructional videos; the level of human presence (human embodiment) and the type of instructional media (e.g., animation). Surveying the research literature and contemporary video-based courses across a number of academic disciplines, this taxonomy does not classify the video styles based on popularity, learning effectiveness or suitability to a particular pedagogy.

*Index of Instructional Video Styles*

| Index | Screenshot | Human embodiment | Instructional media | Source |
|---|---|---|---|---|
| □ |  | instructor, audience | animation | TED |
| ○ |  | instructor | blackboard | iTunesU |
| ◇ |  | pentip | blackboard | Khan Academy |
| ▷ |  | hand | blackboard | Udacity |
| ▽ |  | talking-head | slides, pentip | Coursera |

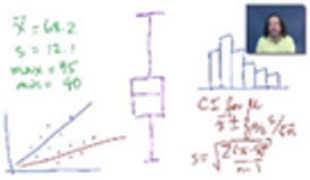
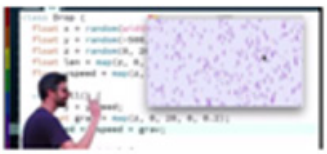
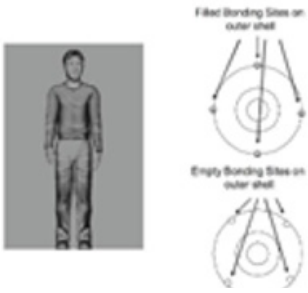
| | | | | |
|---|---|---|---|---|
| ✧ |  | talking-head | slides | Coursera |
| ☆ |  | talking-head | pentip | Coursera |
| × |  | talking-head | instrument | MIT OpenCourseware |
| ◁ |  | people | instruments | MIT OpenCourseWare |
| ◎ |  | people | no media | Coursera |
| ◉ |  | instructor | live coding | YouTube |
| ⊙ |   | robot | slides | Research |
| X |  | animated human | slides | Research |

Figure 5: Taxonomy of Asynchronous Instructional Video Styles Chorianopoulos (2018)

## Classification of Instructional Videos

Köse et al.'s (2021) Classification of Instructional Videos classifies video types based on eight main dimensions: interaction, connection, screen design, sequence, component, image format, instant, and subject/content (Figure 6). Developed using different approaches from 42 systematic analyses, the typology suggests that video should be examined based on these eight dimensions.

| Dimensions | Sub-components of dimension | Description |
|---|---|---|
| Interaction | Non-interactive | Having active rights to stop, fast forward or rewind a video, and so |
| | Interactive | |
| Connection | Online | Internet access requirement for video playback |
| | Offline | |
| Screen design | On-screen tutor | How objects are located in the video screen |
| | Khan Academy videos | |
| | In-class videos | |
| | Interview, convesation, demonstration etc. | |
| Sequence/ priority | Sequential | The sequential feature refers to video that have independent parts, and transitions between according to the rules determined by the vide designer |
| | Non-sequential | |
| Components | Audio, motion image and text | Components included in the video |
| | Audio, image and text | |
| | Audio and text | |
| Image format | 2D | Two or three dimensional |
| | 3D | |
| Instant | Asynchronous | Live video feed broadcast to an online audience or not |
| | Synchonous | |
| Subject/ content | Conceptual | Whether the subject shown in the video has individual and independent parts or not. For example, performed in a way that each step must be done in a specific order |
| | Processive | |

Figure 6: Classification of Instructional Videos ( Köse et al., 2021)

All of these taxonomies adequately classify instructional video, but very few look to the media industry or discuss that as part of their approach. This apparent lack of engagement with the media industry may be because there isn't  an easily accessible, widely used typology of video styles that the media industry refers to. Whilst 'industry speak' is similar across those who create digital media, marketing and advertising

video materials, an easily accessible, authoritative set of terms and definitions, seems non-existent.

It is also important to make a distinction between video and film.. Many resources that talk about cinematic language are easily accessible online via the British Film Institute (BFI), New York Film Academy, and Australian Screen. However, for educational instructional films (or video), a definitive, easily accessible, go-to-guide is lacking. This is probably unsurprising given the increase in short form educational video content in the past 20 years. However, the issues faced in academia in defining video will not easily be solved by looking for guidance from the media industry.

## The Problem with Defining Video

Just as there is inconsistency in how video types are described in education, educational research and the media industry, the definition of instructional video is just as problematic. The problem can be illustrated by looking at the definition of instructional video in the seven systematic reviews. Defined by Winslett (2014) as a “meta-genre”, instructional video is described in the systematic reviews in the following ways:

- Animation (Berney and Bétrancourt, 2016)
- Dynamic visualizations (Castro-Alonso et al., 2018)
- Video and worked example podcasts (Kay, 2012)
- Video modeling (Park et al., 2019; Soek, et al., 2018)

As discussed earlier, video in this review is defined as video used for instructional purposes, meant to teach people something, with the knowledge acquired from watching them being factual, conceptual, procedural, affective and relational. As shown, the current state of play around how media is described in academic research is problematic. However, in the next section, an attempt at describing the factors and their impact will be made to better understand the effectiveness of video in K-12 education.

## Types of Factors and Impact

There are several factors or “moderators” that have been identified in the literature that, when combined with or included in video, lead to significant impacts on academic performance, skill development, attitude to learning, motivation, and engagement.

These factors fall within the following three themes:

- Video Design (Fyfield et al., 2022; Berney and Bétrancourt, 2016),
- Learning Design (Castro-Alonso et al., 2019; Park et. al.2019; Soek et al. 2019; Fyfield et al., 2022; Lee & Yeung, 2021), and
- Learner Characteristics (Castro-Alonso, et al. 2019; Kay & Edwards, 2012).

Each of the themes will be discussed in the following sections.

# Video Design

In this literature review, video design refers to the design elements that are used in the creation of instructional video. The systematic reviews of Fyfield et al. (2022) and Berney and Bétrancourt (2016) provided some insight into design features that may enhance learning. Fyfield et al. (2022) and Berney and Bétrancourt (2016) both drew on Cognitive Load Theory or Cognitive Theory of Multimedia Learning (CLTM). The CLTM is the most popular theory applied to instructional video Fyfield et al. (2022). Grounded in neuroscience, the Cognitive Load Theory of Multimedia first proposed by psychologist Richard Mayer in the 1990s, is a sub theory of cognitive load theory applied to multimedia learning.

Through the theoretical lens of CTML, Mayer developed a set of multimedia principles to analyze the instructional efficiency and effectiveness of video. The 15 principles, “often uncritically applied to the production of instructional videos” (Fyfield et al., 2022, p.1) are divided into three categories that relate to different cognitive processing; extraneous, essential and generative. In 2022, Fyfield et al. identified a further 16 principles in their systematic review and evaluated which of the principles have the most support in the literature.

Of the 31 principles identified in their review; six principles received the strongest support: coherence, integrating learning activities, the embodiment principle, learner control, video length reduction and segmenting. These principles were studied “at least six times and were replicated in twice as many studies as they failed” (Fyfield et al., 2022, p.9). Of those that had the strongest support in the literature, 15 were analyzed in K-12 environments (Table 2). Modality and redundancy had confounding or inconsistent findings, and other principles such as the voice principle, pre-training, audio, background, rate of speech and the multimedia principle have never or have rarely been studied. Interestingly, whilst the pre-training principle itself has been little studied, it was identified as a significant factor in several of the K-12 studies used in this review. The impact of that principle will be discussed in the Learning Design section of the report.

A total of 33 of the 77 K-12 papers discuss video design, and most of the research looks at the effectiveness of multimedia design principles through the lens of the CTML. The principles listed in Table 2, and the K-12 papers listed in this review will be discussed in the order in which the principle appears on the table. Through the analysis of the K-12 specific papers we also identified an additional principle – storytelling – which is discussed at the end of the section. The pre-training principle, which has strong support in reviews other than Fyfield et al. (2022), will be discussed in the learning design section rather than the video design section.

Table 2 (see Appendix D) summarizes the 32 principles identified and highlights the K-12 studies from this review that relate to each of those principles. While Fyfield et al.'s (2022) review identified 31 principles in instructional video studies, not all of these were represented in the studies in K-12 contexts. In our close analysis of the 77 K-12 papers featured across the systematic reviews, only 18 of the principles were represented. It is important to note that this does not mean the additional principles are not relevant or impactful, it is simply that they have not been tested in a K-12 environment. This highlights a need to conduct more experimental research across the principles in K-12. Table 2 lists all 31 principles identified by Fyfield et al. (2022) and reveals which ones have been specifically applied in a K-12 context. Of the six principles identified in Fyfield et al.'s (2022) review, segmenting had the strongest support in the K-12 papers. Signaling, which was not in the six identified in Fyfield's review, had strong support in the K-12 context. This is because one of the studies derives from the review of Berney & Bétrancourt (2016).

Another principle – storytelling – has been added to the generative processing principles. One of the key goals of CTML is to foster generative processing, a form of processing that allows a learner to make sense of the information that they are consuming. It's well established that humans find it easier to remember events and facts when they are part of an overarching narrative (Buchan, et al. 2020; Cohn-Sheehy et al., 2021, Zak, 2015). The use of a narrative to help students better understand concepts and procedures was found to be effective in one study in this review. Whilst very few examples have been identified in this review, given its well-established effectiveness in other contexts, we felt its inclusion is important.

## Coherence

The coherence principle refers to the removal of words, audio and graphic text that does not support instructional goals. This principle also assumes that the learning process is hindered when a learners' working memory is overloaded with seductive details (interesting but irrelevant content) that do not contribute to the learning goals (Mayer, 2009). Coherence was identified in ten studies by Fyfield et al. (2022), of which three affirm Mayer's (2009) claim that "people learn better when extraneous material is excluded rather than included," (p.89).

The inclusion of seductive details was shown to disrupt the learning process in Shen et al. 's (2006) study of net games in a secondary physical education class. The inclusion of a seductive 'motivational strategy' in a video, (a story about a sneaky fox intended to heighten the student's curiosity and interest in the topic), was found to directly interrupt the students' recall of "important learning content transferring problem solving in learning net games," (pg. 498). The study demonstrated that whilst seductive details could motivate students, they may also distract them from the key learning goals.

Saeker et al. (2006) also explored whether seductive details, such as descriptions of personal experiences of students with attention deficit hyperactivity disorder (ADHD), would influence high school students' attitudes towards these students. The descriptions of personal experiences were designed to highlight the injury caused by six of the 12 common myths about those with ADHD. The findings suggest that the intervention may have enhanced the learning of the six facts but interfered with the learning of the others. Therefore, the researchers concluded it did not alter the behavior it was intended to influence. Finally, Kulgemeyer (2018) explored whether a 'coherent theoretical framework' to develop science explanation videos would lead to higher student achievement. Based on the research literature on instructional explanations, seven factors were identified and a framework of 14 criteria was created (Appendix C). The criteria were created to intentionally remove extraneous elements that did not support the instructional goals of the science explanation videos. The participants in the study gained significantly in declarative knowledge, but it's less

certain if they acquired conceptual knowledge. The findings do suggest however that using a similar framework to develop science videos may be impactful.

Coherence has strong support in the empirical literature beyond K-12 (Fyfield et al., 2022), and which is affirmed in this closer inspection of the K-12 papers. The results of the three K-12 studies suggest that the exclusion of seductive details was found to support learning outcomes. It is worth noting that none of the studies were conducted in an elementary classroom environment in which distracting details would presumably be even more detrimental.

## Signaling (or Cueing)

The signaling (or cueing) principle suggests that multimedia materials become more effective when signals (or cues) are added to guide the learner's attention to the relevant elements of the material (van Gog, 2014). Seven of the 13 reviews in Fyfield et al. (2022) demonstrate the effectiveness of this principle. One additional study was found in the review of Berney and Bétrancourt (2016). Fyfield et al. (2022) note that principles such as signaling, can encompass a range of design interventions, such as "shading or illuminating key content (de Koning et al., 2011), including an arrow to guide attention (Lin etal., 2016), gradually revealing or animating detail (Fiorella & Mayer, 2015), or guiding text (Boucheix & Guignard, 2005)" (pg.9). In a K-12 context, five studies suggested that when paired with other multimedia principles it can positively impact learning.

Boucheix and Guignard (2005) found that incorporating signaling cues for the explanations in the video, guided 'attention towards what must be watched,' and when coupled with a self-paced presentation rhythm, the ability of the learner to explain the gearing system improved.  Similarly in a further study, cueing appeared to enhance comprehension and transfer performance for cued and uncued information when used with a self-explanation intervention (de Koning et al. 2011). Cueing included relevant elements in the animation to be illuminated and stand out against the rest of the animation, with all non-cued elements visible. This intervention included a cueing duration so that students could provide elaborated self-explanations on the cued system to reinforce the learning.

Spanjers et al. (2012) also found the combination of signaling and segmentation to positively affect learning outcomes when pauses and cues were included to give learners additional time to perform the cognitive processes necessary for learning. It was also found to help reduce mental effort. Finally, Yung and Pass (2015) found that cueing by an animated pedagogical agent not only had a positive effect on learning performance, but also on instructional efficiency. This was because it directed the learner's attention in such a way that they could acquire an adequate mental representation of the task.

Signaling had some support in the literature. In the K-12 studies reviewed, the use of signals (or cues), paired with other multimedia strategies, enhanced learning in middle and high school students. Further studies into the effectiveness of this principle in videos for elementary audiences are needed.

## Redundancy

The redundancy principle suggests "that redundant material interferes with, rather than facilitates, learning, and occurs when the same information is presented concurrently in multiple forms or is unnecessarily elaborated" (Kalyuga and Sweller, 2014, pg. 247). Fyfield et al. (2022) identified 13 studies that investigated this principle. Only five of those studies were successful. Fyfield et al. (2022) suggest that "more research needs to be completed to identify the boundary conditions of th[is] principle, which may lie in the transience of video media, or other principles beyond length or video type" (pg. 10). Three K-12 studies in this review researched this principle and none of them found that the use of text or subtitles with animation had a negative learning effect (Fyfield et al., 2022).

Adegoke (2010) reported that "the concurrent use of animation, narration, and on-screen text in an instructional interface resulted in significantly better learning outcomes in physics when compared to using animation with text alone or animation with narration alone." (pg. 743) Additionally, students who learned physics in the computer-based multimedia environment tended to achieve better learning outcomes than their colleagues who learned physics in the teacher-based environment. Lin et al.'s (2015) findings are similar. When animations were played segment by segment

with narration and subtitles at the same time, it did not seem to interfere with learning. The researchers surmised that when animation, subtitles and narration were presented at the same time, learners could choose to temporarily ignore the subtitles and focus on the animation and narration only. This was because the amount of information may have been too large for the visual system to process. This claim was further validated by the evidence from eye movement data which showed that the students in the animation + subtitles + narration group, spent the same amount of time and performed equally as well as the animation + narration group.

Finally, Roscoe et al. (2015) explored whether partial redundancy would influence learning gains when it was manipulated, not by changing the quantity of text included on screen, but by manipulating the degree of overlap in the teaching of writing cohesion. The results of the study indicate that variations in the degree of partial redundancy did not significantly influence learning gains. Even though learning gains were made, it wasn't the degree of redundancy that influenced it.

The redundancy principle was not supported in the literature for this review in the studies conducted in middle and high school learning environments. These findings are consistent with findings in the broader research literature (Fyfield et al., 2022). No studies in this review focused on elementary learning and further research should be conducted to discover its usefulness as a multimedia design principle in all K-12 contexts.

## Segmentation

The segmentation principle states that humans learn better when information is broken down into bite-sized segments (Clark and Mayer, 2011). Segmentation was identified in 13 studies by Fyfield et al. (2022), of which eight papers were specific to K-12 contexts. Within those eight papers, two studies demonstrated the impact of segmentation in video design. Six additional papers demonstrated that it contributed to improved learning performance (Hasler et al, 2007; Kay & Edwards, 2012; Kulgemeyer, 2018; Van der Meij, 2017), greater engagement (Van der Meij, 2017), helped ameliorate the negative effects transience (Wong et. Al, 2012), and aided learner efficiency and accuracy (Boucheix and Forestier, 2017).

Spanjers et al. (2012) incorporated pauses and cues at the boundaries of the segments in the videos. This gave learners additional time to perform the cognitive processes necessary for learning and helped reduce mental effort.

In a study of middle school virtual experiments, Chang (2017) found that structured segmented prompts led to behavioral engagement but not necessarily an improvement in learning. It was when minimal guidance was given that learning gains were found, suggesting that minimal critical guidance such as the use of a guiding question, may help students with their learning via the use of video.

The above papers show that segmentation is a potentially valuable design feature. However, segmentation is also found alongside several other design principles such as inclusion of learner control elements like stopping and pausing (Hasler et al., 2007), video length reduction, pauses, signaling (Van der Meij, 2017), the personalization principle and worked examples (Kay & Edwards, 2012). Moreover, the impact of combining different combinations of design principles helped students acquire life skills (Zisimopoulous et al, 2011), demonstrate increased learning performance (Hasler et al., 2007), facilitate task completion (Van der Meij, 2017) and helped to motivate and engage students in their learning (Kay & Edwards, 2012). Finally, middle school students learned concept mapping procedures when the video included segmented sections and learner control (Leahy & Sweller, 2016).

Beyond these K-12 studies, segmentation has strong support in empirical literature (Fyfield et al., 2022). The results of the K-12 studies suggest that segmentation is a design principle that can contribute to improved learning outcomes and engagement in middle and high school learning environments, either on its own or with other multimedia principles. None of the studies in this review were conducted with elementary aged students so further research is needed to understand whether this principle can have a similar impact in this context.

### Video Length Reduction

Video length reduction had strong support in the literature, in that shorter videos led to greater learning gains (Fyfield et al. 2022). Guo et al.'s (2014) analysis of MOOCs data found that the median engagement time for videos less than six minutes long

was close to 100%. That is, students tended to watch the whole video. As videos lengthened, however, student engagement dropped off.

A total of 12 studies identified by Fyfield et al. (2022) reported on this principle, but only one was in a K-12 context. A further three studies were found in Lee and Yeung (2021), and Park et al. (2018) that reported on the impact of video length.

Slemmons et. al (2018) investigated whether in a flipped classroom, short videos improved performance on quizzes, improved long-term retention in unit tests and improved attitudes towards content compared with long videos. The study showed that short-term retention of material did not seem to be influenced by the length of the video, but that longer-term retention was higher for males and students with learning disabilities when the videos were shorter. It was also observed that students were more engaged and focused, and seemed to have higher rates of retention of the video content. The scholars suggested this is because there is a higher degree of connection with the course material during short videos. They concluded that it may have led to greater retention over long periods and a more positive outlook regarding the material and course overall. Another flipped classroom study supported these findings: Atwa et. al. (2016) found that when videos, as a pre-class activity, were over 10 minutes long, students become disengaged.

Shorter video lengths were also found by Kay and Edwards (2012) to be preferred by middle school students in a study of worked examples to teach mathematical concepts. When students were asked about their opinion of the length of the videos, (2 – 8 minutes), although most thought that the length and pace of the video clip they watched was appropriate, 20% said they were too long. Finally, in a study of teaching students with intellectual disabilities daily living skills, Cannella-Malone et al. (2011) observed that video prompts that were short and included voice overs were more effective than other interventions.

Video length reduction has much support in empirical literature (Fyfield et al., 2022), and the four K-12 studies described support the findings of researchers such as Guo et al. (2014), that shorter videos lead to greater learning gains and engagement. All four studies measured retention, perception or learning in middle school and high

school learning environments. Further research on ideal viewing times for short form video content at different K-12 levels is needed.

## Transience

Transience is when video loses advantages over static media when too much information is presented too quickly (Fyfield et al. 2022). Transience has some support in the literature, with six studies in the review of Fyfield et al. (2022) investigating its impact. Three of the six studies were in K-12 learning environments. The findings suggest that when the multimedia principles of segmentation, signaling and learner control are included in video design, the pace of the information that is presented is slowed down, ameliorating the effects of transience.

Boucheix and Forestier's (2017) study of middle school students learning how to tie nautical knots found that when the learning time was shorter because the steps were segmented, participants needed less time to learn how to tie the knots. In this study, the use of shorter segmented animations over longer animations and static pictures was the condition that worked best. The researchers suggested that because the amount of information in the shorter videos did not exceed the working memory, and the combination of observation and practice may have helped the learner make meaningful cues.

An earlier study by Boucheix and Guignard (2005) found that for immediate comprehension, animation was more effective than static graphics for teaching middle school students about gearing systems. The use of signals seemed to guide the attention towards what was watched in the video and seemed to improve the ability of the learner to explain the technical device. For more long-term learning gains signaling and an element of active learning in the form of learner control of the video seem to be most effective. Finally, Wong et al. (2012) found, in another study, that reducing the length of segments, helped "ameliorate the negative effects of transient information" (pg. 449) on performance tests. Participants started with a success rate of below 30% and during training this increased to 80%. The results indicated that the videos contributed to task completion, and learning practical tasks (Wong, 2012).

Transience has some support in the empirical literature (Fyfield et al., 2022). The K-12 studies suggest that when the multimedia design principles segmentation, signaling and learner control are included in the video design, they contribute to the slowing down of the presentation of information. This enabled learners to complete tasks and learn skills effectively. All K-12 studies were conducted with middle school participants, therefore research at elementary and high school levels would help researchers understand if these design principles would have a similar effect on learning outcomes.

## Worked Examples

Worked examples are an effective teaching strategy that can reduce student cognitive load, and help learners focus on demonstrating and understanding what success looks like (Department of Education and Training, 2020). Three studies in Fyfield et al.'s (2022) review investigated its impact. One of those studies was in a K-12 learning environment.

A middle school study in Canada demonstrated the impact of worked examples to teach mathematical concepts (Kay & Edwards, 2012). The worked example podcasts were designed to consider multimedia principles such as segmentation, and the personalization principle. They were found to be effective learning and engagement tools in teaching procedural mathematical skills: exponents, circumference of a circle and multiplying monomials. The researchers found that the format was liked by 77% of the participants in the study, and 80% found the worked example clip easy to follow. Interestingly, whilst 41% found the clip boring, 86% indicated they preferred this form of instruction over a textbook. Finally, the average percent increase for all three grades (years 6, 7 and 8) who participated in the study was 66%, demonstrating the intervention's impact on the student's short term learning performance of the concepts.

## Learner Control

Learner control is an instructional strategy where learners can exercise some level of control over the events of instruction. Students make decisions regarding the sequence, pace and flow of instruction. Allowing learners to have control over their learning can not only accommodate individual differences but can motivate and help

students develop self-efficacy (Hannafin, 1984; Vu et al., 2021). Learner control as a multimedia design principle says that students should be given control over playback. It is a principle that has strong support in the literature with 14 studies in Fyfield et al.'s (2022) review demonstrating its impact. Nine studies conducted in K-12 contexts, demonstrated the effectiveness of incorporating learner control features in the video. Two of the nine K-12 studies were from the reviews of Kay (2012) and Park et al. (2019).

Effective learner control elements include play, pause and stop buttons (Marbach-Ad et al., 2008; Hasler et al., 2007), functions to change the speed and orientation of objects (Chien and Chang, 2012), and the ability to flip pages on the screen (Leahy & Sweller, 2016; Lin et al., 2015). Often used with other principles of multimedia design, it seems to be a significant contributing factor in the reduction of cognitive load (Chien & Chang, 2012), the facilitation of better learning outcomes (Chien & Chang, 2012; Hasler et al., 2007; Arnone & Grabowski, 1992; Marbach-Ad, 2008), and an increase in learner engagement and motivation (Kay & Edwards, 2012).

Finally, Boucheix and Guignard (2005) found that animations were most effective and generated the 'most intense activity' when students were in the self-controlled (learner control) modality. Interestingly, none of the studies discuss video playback speed, as a motivating feature or intervention. Playback speed is a feature found with higher education students to not only increase the amount of content they watch but also increase their likelihood of getting higher grades (Lang, et al., 2020).

Whilst learner control seems to have a positive effect on a student's learning, this is not always the case. One study found that whilst elementary students demonstrated persistence and curiosity via a museum led, interactive video lesson, greater learning gains and more interaction was observed when teachers provided advice rather than giving the students free reign. (Arnone & Grabowski, 1992). Moreover, Bernay and Bétrancourt's (2016) systematic review, revealed that animations that were system-paced, or in other words animations which provided no control over the pace, were more effective for learning than any modalities of learner paced animation. This finding is inconsistent with the studies discussed above and in the systematic review of Fyfield et al. (2022) who found that learner control in the form of "the use of pause/play

buttons and scrubbing control (the sliding position controller included in most video playback platforms), [was] effective in a range of contexts" (Fyfield et al., 2022, pg.9).

Two studies from the reviews of Park et al. (2019) and Kay (2012) demonstrate the impact of learner control on the learning outcomes of students with disabilities. Self-directed video prompting was more effective than video modeling to develop self-regulation and life skills in students with intellectual disabilities. Self-directed video prompting is a form of simultaneous prompting in which a model is broken down into a series of video segments. Life skills included washing dishes and ironing clothes, whilst self-regulation skills included regulating reactions, inappropriate behaviors and controlling impulses. In the self-directed intervention, learners independently navigated through the short video segments as they completed the task (Cannella-Malone, Brooks, & Tullis, 2013). Finally, giving students with autism control of the 'video delivery system', was shown to be an effective strategy to help them learn how to transition between locations and activities within school (Cihak et al., 2010).

Learner control has a strong support in both the broader research on the impact of video in education (Fyfield et al., 2022) and also in a K-12 context. The K-12 studies supported the fact that learner control can have a positive effect on learning outcomes with students across the learning levels and with disabilities. Although the review of Bernay and Bétrancourt (2016) found that less control was more effective than greater control, the studies discussed and the review of Fyfield et al. (2022) seem to suggest that this isn't the case.

## Reviews

The review principle suggests that videos should end with a summary of the content to help learners retain information (Fyfield et al. 2022). It is supported in three studies in Fyfield et al.'s (2022) review. Of those studies, two of them are in K-12, and specifically demonstrate the important role reviews play in helping learners retain information. Van der Meik (2017) investigated the effectiveness of using a video tutorial to teach elementary and secondary students how to use software. In the theoretical model created to construct videos (Figure 7), videos were enhanced with instructional features that "were intended to be particularly effective insofar as they addressed four

key processes in observational learning (i.e.: attention, retention, reproduction and motivation)", (pg. 164) and included signaling, user (learner) control and segmentation.

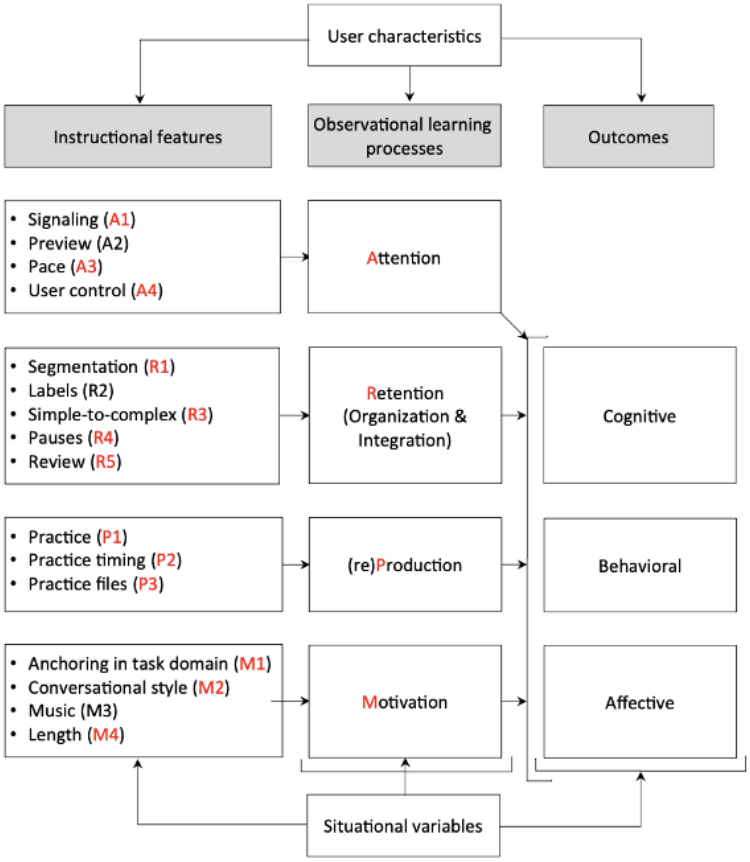



Figure 7: Theoretical model created to construct videos. Highlighted features were incorporated in the design of the tutorial.

A review task was included at the end of the video. Engagement data showed that videos were played almost completely (93%), even though the reviews were seen by around a third of the participants as less engaging (32%). Interestingly, motivation increased significantly regardless of whether a review was included, and task performance increased significantly from pre-test (29%) to training (84%) and post-test (71%). The findings suggest two things: firstly, how-to videos engaged the learners, suggesting that the instructional features rather than the review may have contributed to this outcome. Secondly, the post-test results were higher with the inclusion of the review (84%) than without (71%). This suggests that with or without the review the intervention was effective, but more effective when the review was included.

Similarly, Kulgemeyer (2018) created a framework for developing effective science explanation videos (Appendix C). The framework included reviewing elements.

Gains in declarative knowledge, and minimal gains in conceptual knowledge were demonstrated by the students who watched videos created using this framework. Whilst the review itself cannot be seen to be the only impactful factor, it seems to have contributed to the learner's success and confirms the findings of van der Meik (2017).

Of the three empirical studies in Fyfield et al (2022), two of the studies that demonstrate the impact of this principle are in K-12 contexts. These studies suggest that adding a review of the content at the end of a video seems to help learners in the acquisition of declarative knowledge, support task completion and raise learning. Neither of these studies were in elementary classes, and thus research on its effectiveness at those levels would be useful.

### The Embodiment Principle

The embodiment principle suggests that people learn more deeply from on-screen agents that display human-like gestures, movement, eye contact and facial expressions (Mayer, 2014b). It is a principle that has been supported in a range of contexts from primary to tertiary level and was identified in eleven studies by Fyfield et al. (2022). Three studies in this review demonstrated the impact of this principle on learning, instructional efficiency and students' emotions.

Elementary and middle school students who observed a gesturing avatar in a mathematics video were more likely to transfer and generalize their knowledge, solve problems more quickly and learn more. The avatar gestures included 'content' gestures designed to reinforce content, for example the pointing gesture, and 'bimanual beat' gestures intended to increase charisma and appeal, such as open hands (Cook et al., 2016). In a similar study a 'pedagogical agent' (animated instructor) that gestured, waved hands and signaled important content to focus the learner's attention on important concepts, had a positive effect on learning performance and instructional efficiency on secondary student's learning of the cardiovascular system (Yung and Paas, 2015). Finally, anthropomorphic design, (lifeless objects taking on human facial expressions and gestures), attention grabbing color and sound effectively elicited positive emotions among grade 7 students (Uzun & Yildirim, 2018).

The embodiment principle is supported in a range of contexts from primary to tertiary level. In this review the studies were in elementary and middle school learning environments. The studies suggest that avatars and anthropomorphic designs may help learners better understand concepts and skills.

## Interactivity and Guided Discovery

Interactivity and guided discovery are two design principles that are less supported in the literature (Fyfield et al, 2022). Interactivity refers to the inclusion of controllable content within the video design, for example questions. Guided discovery is the inclusion of interface elements that provide hints and feedback as the learner solves problems (Fyfield et al., 2022) Four studies in the Fyfield et al. (2022) review and one in the review of Berney & Bétrancourt (2016) investigated the impact of interactivity, and one (Fyfield et al., 2022) supported guided discovery. However, only one study was in a K-12 context, and it included both principles.

In a study of middle school virtual experiments, Chang (2017) found that by providing students with structured prompts, also known as guided discovery, students were more engaged than if they had minimal guidance. However, the intervention did not improve learning outcomes. Chang (2017) reported that less structured scaffolding resulted in better learner efficiency, suggesting that minimal critical guidance such as a guiding question, may help students with their learning via the use of video.

## Emotional Design

Emotional design “tr[ies] to make the core elements in a lesson more emotionally appealing [by] giving them human-like features (for example, symmetrical faces with facial expressions) and rendering them in enjoyable colors” (Clark & Mayer, 2016, p. 224). Four studies in Fyfield et al.’s (2022) review investigated the effectiveness of emotional design, with only one occurring in a K-12 context. Interestingly, this is the only study not to have failed, suggesting that emotional design elements may be more effective on younger learners.

Uzan and Yildrim (2018) investigated what impact incorporating different design approaches had on middle school students’ positive emotion, mental effort and learning. The researchers found that emotional design induced positive emotions

among students and found that as the emotional design features increased, so did the positive emotions. Furthermore, students who viewed the video with a colorful design invested more mental effort than those who watched a video with a neutral design. However, when anthropomorphic design and sound effects were used, the least amount of mental effort was observed. Finally, colorful design in the form of attention-grabbing, saturated or bright colors, affected recall but not transfer of learning.

### Integrated Learning Activities

Integrated learning activities are practice activities that are included within or at the end of a video (Fyfield et al., 2022). Moreover test-enhanced learning, also known as the testing effect or retrieval practice (the process of retrieving facts from memory), has been shown in many to increase long-term retention of concepts or facts (Roediger & Butler 2011; Roediger & Pyc 2012). The effectiveness of integrating learning activities into video has strong support in the empirical literature. Seven studies in Fyfield et al.'s review reported on its impact, although only one was conducted in a K-12 context.

Szpunar et al. (2014) found that interrupting a 21-minute video lecture with repeated tests helped boost the actual performance of high school statistics students to the level of predicted performance. Additionally, it appears that interpolated testing does the best job of fostering both a high level of predicted and actual learning. It was also observed that interpolated tests helped the learners to marginally reduce mind wandering and reliably increase notetaking and retention.

Whilst integrating learning activities has strong support in the wider empirical literature, more research in K-12 contexts is needed to better understand how this principle can be applied to this context.

### Storytelling

Humans find it easier to remember events and facts when they are part of an overarching narrative (Buchan, et al., 2020; Cohn-Sheehy et al., 2021, Zak, 2015). Moreover, when students make connections to their personal experience and background knowledge, they are better able to comprehend what they are reading and watching (Nobels & Ortega-Dela Cruz, 2020). Storytelling is not a principle defined in the review of Fyfield et al. (2022). However it is a design principle that the researchers

identified in the review of Park et al. (2018) and has been included in this report as a new design principle.

One study in Park et al.'s (2018) review demonstrated how the use of storytelling devices and the inclusion of real-world problem examples in a video helped middle and high school students with intellectual disabilities learn mathematics facts and skills. Embedding mathematical problems within a story helped the learners apply knowledge to real world applications (Galloway et al., 2013). The videos in this study were used as an anchor to instruction and were enhanced with verbal and physical prompts from the teacher. Learners were able to demonstrate the use of the Pythagorean theorem to solve real-life scenarios such as using a ladder and finding a dimension on a screen. The findings further indicate that students with disabilities should not be limited to low expectations of their capabilities in maths. Moreover, the researchers suggested that similar interventions could be used with all students to help them in the development of mathematical skills (Galloway et al., 2013).

## Conclusion

There is much yet to be discovered about what does and does not work when designing videos for education. The studies reveal that the findings in the K-12 papers reflect the broader body of literature. In this K-12 review an additional principle, storytelling, was added to the list of principles but further research into its effectiveness as a generative processing principle is needed.

At times, a lack of clarity around the video elements made it challenging to adequately identify additional principles that may have been effective. Furthermore, most of the studies in this section were in middle and high school learning environments. Further research into the effectiveness of these principles in elementary education is needed to see if multimedia design principles are effective across all age groups. It is important to note that the K-12 papers do not represent all the principles shown in Table 2. That does not mean that those principles excluded are not relevant or effective. However, it does affirm the need for further research that explores these principles in relation to the contextually significant differences of K-12.

# Learning Design

Learning design relates to both the strategies and interventions used together with video to enhance its effectiveness in a learning setting. In Brame's (2017) much cited, but uncritical view of the principles of design (Fyfield et al. 2022), claims that video is most effective when design and implementation work together. Given that the inclusion of implementation strategies enhances the impact of video, it is interesting that so few interventions were identified or reported upon in the studies in this review.

Of the K-12 papers reviewed, learning design interventions such as pre-training, flipped classrooms, video prompting and modeling were shown to increase academic achievement, motivation, and engagement, and contributed to the development of social, emotional, self-regulation and life skills. Other strategies and interventions that may also help enhance video instruction, such as metacognitive questioning, and reflective practice, are not included because they were not discussed in the papers in this review.

Learning design interventions are arranged in the order of most reported to least. Each section will discuss the intervention, and the factors and impact of that intervention. The interventions include:

- flipped classrooms,
- video modeling and prompting, and
- pre-training.

Whilst only three interventions are reported in this review, within these interventions there are many sub-categories that will be discussed that help make the intervention effective (Table 3). While little supported in the Fyfield review, pre-training, a multimedia principle, is well supported from studies from the other systematic reviews.

**Learning Design**

| | Total | EL | MS | HS | Intervention | Supportive Factors | |
|---|---|---|---|---|---|---|---|
| 1 | 15 | | 15 | | Flipped Classroom | Interventions included with video task before class:<br><br>• Watch-Summarise-Question Method<br>• Gamification activities<br>• Active learning activities<br>• Retrieval practice (Onlline quizzes)<br>• Note-taking<br>• Online Discussions<br>• Reflections | Atwa et a. (2016); Camiling (2017); Cetinkaya (2017); Gariou-Papalexiou et al. (2017); Kettle (2013); Leo & Puzio (2016); Lo et al. (2018); Olakanmi (2017); Schultz et al. (2014); Sezer (2017); Slemmons et al (2018); Sookoo-Singh & Boisselle (2018); Stratton et al. (2019); Yousefzadeh & Salimi (2015); Zainuddin (2018) |
| 2 | 7* | 3 | 3 | 3 | | Reinforcment & praise | Blood et al. (2011); Chu & Baker (2015); Taber-Doughty, Patton, and Brennan (2009); Burton, Anderson, Prater, & Dyches (2013); Mechling and Swindle (2012); Mechling, Ayres, et al. (2015); Fernstermacher et al. (2006) |
| | 4* | | 2 | 2 | | Error Correction | Cannella-Malone, Brooks, and Tullis (2013); Cannella-Malone et al. (2016); Zisimopoulos, Sigafoos, and Koutromanos (2011); Gardner and Wolfe (2015) |
| | 5* | | 3 | 3 | Video modelling & prompting | System of least prompts & most to least prompts | Van Laarhoven and Van Laarhoven-Myers (2006); Alberto, Cihak, and Gama (2005); Wu, Wheaton, and Cannella-Malone (2016); Cihak, Alberto, Taber-Doughty, and Gama (2006); Galloway, Collins, Knight, and Bausch (2013); |
| | 2 | | 2 | | | Student created video | Cumming et al. (2008); Alexrod et al. (2014) |
| | 2 | 2 | | | | Self Regulation strategies | O'Reilly et al. (2006); Blood et al (2011) |
| | 1 | 1 | | | | Role-play | Young-Pelton et al. (2015) |
| 3 | 9* | 1 | 4 | 4 | Pre-training | | Boster et al. (2006); Boster et al., (2007); Cannella-Malone et al, (2013); Ozkan (2013); Rieber (1991); Van Laarhoven and Van Laarhoven-Myers (2006); Wu et al., (2016);Cihak, Alberto, Taber-Doughty, and Gama (2006); Cihak, Ayers et al., (2010) |

* Studies were across multiple age groups

EL Elementary (P/K-4)
MS Middle School (5-8)
HS High School (9-12)

Table 3

## Flipped Classroom

Flipped classroom is a classroom intervention where students learn some course content before class either via instructional media, such as videos, or podcasts or via text-based materials. Theoretically class time is freed from explicit teaching to allow for more interactive learning activities, such as group discussions. (Bishop & Verleger, 2013).

Instructional video is one of the most common strategies for the delivery of pre-class content in a flipped classroom (FC) learning environment (Abeysekera &

Dawson, 2015; Giannakos et al., 2014; Lo and Hew, 2017a; Seery, 2015). It is claimed that video is more effective than text-based materials in helping K-12 students prepare for class (Grypp and Leubeck, 2015). Lee and Yeung's (2015) review identified 15 studies, all of which were in a K-12 context. In this review, each of the researchers used video as part of a pre-class activity for the FC intervention. In addition to using instructional videos in pre-class learning, online quizzes and discussions, note-taking, web and text-based materials, and reflective tasks were also used. Other pre-class interventions such as the watch-summarise-question method (Stratton et al., 2019) and gamification activities (Zainuddin, 2018), may have also contributed to the learner's enjoyment of learning, increased engagement and intrinsic motivation.

Studies of FC interventions that utilized video reported a number of enhancements:

- increased subject skill development (Camiling, 2017),
- improved academic performance (Atwa et al., 2016; Cetinkaya, 2017; Leo & Puzio, 2016; Lo et. al., 2018, Olkanmi, 2017; Schultz et al., 2014; Sezer, 2017; Yousefzadeh & Salimi, 2015; Zainuddin, 2018),
- greater engagement in FC (Gariou-Papalexiou et al., 201; Lo et al., 2018; Olakanmi, 2017; Slemmons et al., 2018; Stratton et al., 2019; Zainuddin, 2018),
- greater motivation in their studies in general (Sezer, 2017; Sookoo-Simngh & Boisselle, 2018; Stratton et al., 2019; Zainuddin, 2018),
- a more positive attitude to the subject (Sezer, 2017), and
- greater social interaction before class (Zainuddin, 2018) and during class (Lo et al., 2018; Olakanmi, 2017; Zainuddin, 2018) was demonstrated.

In the above studies, video was only one part of the learning design and as a result the positive outcomes cannot be ascribed to video alone. However, of the 15 studies that used instructional video as part of a flipped classroom (FC) intervention, nine demonstrated "positive effect of the efficacy of FC with video and academic achievement" (Lee & Yeung, pg. 90)

Using video, however, as part of a pre-class task is not without its challenges. The challenges highlighted in the studies included:

- the videos being too long (e.g.: Schultz et al., 2014),
- the school infrastructure not being able to support students ‘at home’ access to videos (e.g.: Kettle, 2013),
- time-consuming video searches (Kettle, 2013),
- problems were encountered finding suitable instructional videos (Lo et al., 2018; Olakanmi, 2017; Zainuddin 2018), offering student access to pre-class materials (e.g.: Slemmons et al., 2018), and
- there was a general lack of enthusiasm and motivation by students for doing pre-class work (eg: Lo et al., 2018; Slemmons et al., 2018; Sookoo-Singh & Boisselle, 2018, Yousefzadeh et al., 2015).

Overall, the studies in the review support the use of instructional video as a preferred pre-class activity in the FC learning environment.

Video is one of the most common instructional strategies in an FC intervention. These studies revealed the circumstances in which FC can contribute to increased motivational and learning gains, despite some of the challenges that were identified in middle school learning environments. FC with video in elementary and high school environments may reveal different results.

## Video Modeling & Prompting

Video modeling is a teaching method that instructs students to watch a short video depicting the target skill followed by a request to apply what they saw in the video (Alberto, Cihak, & Gama, 2005). Video prompting, however, is similar, but differs slightly in that students are shown a sequence of steps and in between each step, the students are asked to perform the actions they see in the video (Alberto et al., 2005; Cihak, Alberto, Taber-Doughty, & Gama, 2006).

Video modeling and prompting are widely used to develop academic skills, functional/daily living skills, and social skills for individuals with disabilities

(e.g., Cannella-Malone et al., 2016; Kellems et al., 2016; Spivey & Mechling, 2016; Yakubova, Hughes, & Hornberger, 2015). Video modeling and video prompting are the focus of the reviews of Park et al., (2018) and Soek et al. (2019). Of the 49 studies in these two reviews, 25 were conducted in K-12 demonstrating that the interventions effectively teach students self-regulation, life, and academic skills.

In the following sections the impact of video modeling and prompting will be discussed together via the strategies that were used with the intervention. These included:

- Reinforcement and praise
- Error correction
- System of least prompts and most to least prompts
- Student created video
- Self-regulation strategies
- Role play

## Reinforcement and Praise

Research has demonstrated that reinforcement, either positive or negative, works by increasing the likelihood of a behavior (Walinga, 2021). Reinforcement and positive reinforcement, or praise, were strategies used in nine of the studies in the reviews of Park et al. (2018) and Soek et al. (2019), with video modeling. Seven of the studies discussed this strategy in a K-12 context.

Blood et al. (2011) found that video modeling, reinforcement and self-monitoring was most effective in teaching elementary students with emotional behavior disorders (EBD) on and off task behaviors. Slimily, Chu and Baker (2015) found that video modeling and positive reinforcement had an immediate and positive influence in decreasing half of their participants' inappropriate social behavior, and the other half's occurrences of asking for help. Furthermore, the skills did not disappear after the intervention ceased. Additionally, library skills were developed by students with

intellectual disabilities who used video modeling, praise, video audio prompts (Taber-Doughty, Patton, and Brennan, 2009), and positive reinforcement. They also found an increase in correct fine and gross motor tasks in elementary students (Mechling & Swindle, 2012), and when coupled with repetition, they were successful in teaching daily living skills to high school students (Mechling, Ayres, et al., 2015). Finally, video self -modeling via an iPad, and positive reinforcement were used to effectively implement interventions to improve the academic performance of students with autism and intellectual disability. The intervention allowed students to independently access technology and prompt themselves through the completion of functional maths skills without a teacher's assistance (Burton, Anderson, Prater, & Dyches 2013).

The K-12 studies demonstrate that video modeling with reinforcement and praise was a successful intervention in teaching life skills in students with disabilities. These findings are consistent with the broader body of work.

## Error Correction

Error correction is an important strategy to teach skills to students with intellectual disabilities. Tactics include verbal statements, modeling, delay and remedial trials. (Hoffert et al. 2022). This strategy was used in seven of the studies in the reviews of Park et al. (2018) and Soek et al. (2019) with video prompting. Four of the studies discussed are in a K-12 context.

The use of error correction and video prompting was demonstrated in three studies to help students with intellectual disabilities develop daily living skills. Cannella-Malone, Brooks et al., (2013) and Cannella-Malone et al. (2016) found that the use of video prompting, error correction, short video length and pre-training helped middle and high school students develop daily living skills. Most maintained the skills three weeks later. Cannella- Malone et al. (2016) and Gardner and Wolfe (2015) found that error correction and using the 'most to least prompts' system can be effectively used in the school setting to teach leisure activities, and daily living skills. Similar to the studies above, the mastered skills were maintained after the intervention was withdrawn. Similarly, Zisimopoulos et al. (2011) found that the combination of video prompting and error correction helped develop internet skills in students with an intellectual disability.

The K-12 studies demonstrate that video prompting with error correction is an effective intervention in the teaching of life skills in students with disabilities. These findings are consistent with the broader body of work. None of the studies were in an elementary school environment which suggests further research is needed

## System of Least Prompts or Most to Least Prompts

The system of least prompts (SLP), also known in the literature as most to least prompts, is a practice that involves defining and implementing a hierarchy of prompts to assist students in the learning of a skill (Neitzel & Wolery, 2009). It's an intervention that is used with both video modeling and video prompting. This strategy was used in eight of the studies in the reviews of Park et al. (2018) and Soek et al. (2019), five of the studies discussed are in a K-12 context.

Van Laarhoven and Van Laarhoven-Myers (2006) and Cihak et al. (2010) observed that students with intellectual disabilities could develop life skills, such as transitioning between locations and activities within school, when video modeling was used with the system of least prompts. In both studies, the students continued demonstrating the skills after the intervention had ceased. Video prompting with the system of least prompts was an effective intervention in teaching high school and middle school students daily living skills. Moreover, they were able to apply what they learned to novel situations after the intervention had ceased (Wu et al., 2016). Video prompting and the system of least prompts was also found to be an efficient and effective instructional approach for teaching functional skills (Albert et al., 2005). Finally, Wu et al. (2016) found that video prompting, the system of least prompts and pre-training helped students develop daily living skills and retain the information long after the intervention had ceased.

## Student Created Video

Video production as an instructional strategy has led to positive learning content outcomes, facilitated connections to the content, and has been shown to increase student motivation and engagement (Norton & Hathaway, 2010). Two studies in the reviews of Park et al. (2018) and Soek et al. (2019) discussed the impact of using video modeling with student created video. Both studies were in a K-12 context.

Students with emotional behavioral disorders who created their own multimedia as part of a social skills program, found the task motivating. The researchers reported that the combination of traditional social skills and multimedia authoring was more efficient at developing social skills as well as the students' knowledge of the social skills (Cumming et al., 2008). Alexrod et al.'s (2014) study of middle school students with ADHD and ODD, found that students showed greater compliance and less aggressive behavior after the intervention. It was also observed that the effects were generally maintained after the intervention was withdrawn.

## Self-Regulation (Management) Strategies

Self-regulation or self-management strategies include self-evaluation, self-control and self-reinforcement. Self-regulation is an important skill that helps people succeed in their learning and social relationships. Two studies in the reviews of Park et al. (2018) and Soek et al. (2019) demonstrated how video modeling and self-management strategies could help develop a student's ability to demonstrate appropriate on-off behaviors and self-management skills. Blood et al. (2011) successfully implemented an intervention of video modeling, self-monitoring and reinforcement to improve the behavior of students with emotional behavioral disorders. O'Reilly et al. (2006) also used video modeling self-management strategies and feedback to help students improve their prosocial behavior in the school year. The intervention had an immediate effect, decreased aggressive behavior and the intervention continued throughout the school year.

Video modeling and prompting, when combined with error correction, positive reinforcement, prompting and self-management strategies helped students with intellectual disabilities and emotional behavioral disorders develop self-regulation, life and academic skills. These findings are consistent with the broader body of literature. Whilst the interventions described have been used with learners with disabilities, it's likely they may also be effective in teaching key 21st century skills such as communication, critical thinking and creative thinking skills to all learners too.

## Pre-Training

The pre-training principle posits that people learn more deeply from a multimedia message when they know the names and characteristics of the main concepts (Mayer, 2014a). Moreover, the adoption of teaching approaches that actively engage students from the outset can enhance the student experience (Yorke and Longden, 2008), as well as help them understand the task or better use the technology required to complete the task effectively. Pre-training was underrepresented in the research examined and was identified in two studies by Fyfield et al. (2022), none of them in a K-12 context. Nine studies identified pre-training as an effective intervention with video.

Pre-training (induction) before video streaming resulted in what the scholars claimed was a 'substantial impact' on the examination performance of 3932 elementary and middle school mathematics, science and social studies students. The experimental group improvement exceeded the control group by 12.6% (Boster et al., 2006; Boster et al., 2007), and suggests that video streaming may contribute to increased student learning. An earlier study by Reiber (1991) also found that students who received practice (pre-training) before the video intervention, took significantly less time to answer the post-test questions than those who didn't, and were more intrinsically motivated by the task.

Pre-training was further demonstrated to be an effective intervention when combined with video modeling and prompting in the teaching of life and mathematical skills to students' intellectual disabilities (Cannella-Malone at al, 2013; Ozkan, 2013; Van Laarhoven and Van Laarhoven-Myers, 2006; Wu et al., 2016). Pre-training interventions included how to use apps and devices like an iPod touch and Mini to view video assets.

Whilst pre-training is little supported in the systematic review by Fyfield et al. (2022), it was found to be an effective intervention to teach students how to better use tools, and to help them access media. It seems particularly effective when used to induct students in the best way to use and access streaming services.

## Conclusion

Like video design there is much to be uncovered about what works and does not work when designing effective interventions to use with video. Many high impact teaching strategies like metacognitive question techniques, for example, were not discussed in these studies. This may be because the reporting of the method was inadequate or the nature of the research design itself did not allow for it. What the studies included do reveal is that using video as part of a flipped classroom intervention may prove effective, if barriers such as motivating students to complete the pre-class tasks were removed. Additionally, when interventions typically used to teach skills to students with disabilities were combined with strategies such as reinforcement and error correction, long term learning effects were shown. Finally, pre-training and multimedia principles are highly effective as a learning design intervention.

A lack of clarity around the description of some of the methods meant that some of the strategies that were used with video may not have been reported on. A more robust description of the method is therefore recommended. Furthermore, most of the studies in this section were in middle and high school learning environments. It is important to note that the K-12 papers do not represent all the strategies and interventions that could be used for impact. Further research into learning design interventions in elementary education is needed to see if we are to better understand what strategies work best when using video for learning.

# Learner Characteristics

The learning characteristics of students can influence how they learn, and there are many theories and models that try to explain how people learn based on personal preferences, individual strengths, and factors like motivation and learning environment. All seven systematic reviews described various characteristics of the learners as part of the participants, for example gender, but most did not discuss those characteristics as variable in the outcomes. The focus of the Castro-Alonso et al. (2019) review was on learner characteristics, primarily gender, but also spatial ability and age. In particular, they observed that “many of the empirical studies [...] fail to provide the gender ratios for the whole sample or the individual conditions being compared” (pg.362), and this is reflective of how few papers overall but in particular in the K-12 context, discuss this. Only five papers discussed the relationship between instructional video and K-12 learner characteristics, in particular: age, gender, motivation and spatial ability (Table 4).

| Total | EL | MS | HS | Learner Characteristic | |
|---|---|---|---|---|---|
| 2 | | 1 | 1 | Age | Kay & Edwards (2012); Schultz et al., (2014) |
| 2 | | | 1 | Gender | Schultz et al. (2014) |
| 2 | 1 | 1 | | Intrinsic motivation | Reiber (1991); Cummings et al (2007) |
| 1 | | | 1 | Spatial ability | Hoffler and Leutner (2011) |

EL Elementary (P/K-4)
MS Middle School (5-8)
HS High School (9-12)

Table 4

## Age

Video has been shown to have “a positive impact on learning enjoyment for school children (e.g., Bétrancourt and Chassot 2008), university students (e.g., Jaffar 2012), and adults (e.g., Türkay 2016)” (Castro-Alonso et al., 2019 pg. 362). However, this enjoyment does not always mean learning takes place. The effects of age and a

person's ability to engage with and understand visual classroom content using media is little discussed in the broad literature on video in education (Castro-Alonso et al., 2019), and even less if we look at the K-12 studies. Some work has been done on age and computer related behavior, but less is known about age and video (Castro-Alonso et al., 2019). What we know about age comes from the systematic review by Castro-Alonso et al. (2019).

None of the K-12 articles extracted from the review of Castro-Alonso specifically focused on age as a moderating factor for impact. What the researchers did observe however, is that dynamic visualizations (video) seem to be more effective for elementary school students (g+ = 0.53), than for middle school students (g+ = 0.44), than for university students (g+ = 0.19). This observation differs from a study that was extracted from the reviews of Kay (2012) and Fyfield et al. (2022). A study of middle school students' ability to learn mathematical concepts from worked example video podcasts, found that age was not a significant factor on learning performance or their attitude toward the use of video (Kay & Edwards, 2012).

One of the challenges in the literature, and highlighted in Kay's (2012) review, is that whilst all studies give the year level or age of the participants, most do not analyze or discuss whether it is a moderating factor. Greater insight into the effectiveness of video learning and motivation on different age groups would help educators better understand in what circumstances and what types of videos are most effective.

## Gender

There is much interest in gender and learning, and the ways in which gender can influence learning, motivation, and engagement (Korlat et al. 2021). Like age, the significance of gender was little reported in the studies in the seven systematic reviews. Of the K-12 studies, most reported on the gender makeup of the class, but only two (Kay & Edwards, 2012; Schultz et al., 2014) made observations about gender in their results. The review of Castro-Alonso observed that gender was often neglected as a potential variable when looking at the impact of video in education. They observed that classes with fewer females found video more effective, but that this effectiveness disappeared when the ratio of males to females was reversed. In other words, males

may benefit more from videos than females. However, they did note that this area of research needs further investigation.

A study of a flipped high school Chemistry class observed that when video and reflective practice activities as a pre-class activity was supported in class retrieval practice, and active and collaborative learning strategies, males performed better than females on their test scores. Whether this was because of the use of video, or because of the other interventions described was not discussed (Schultz et al., 2014). In that class, 55% of the student population were female, which supports the observation made in the Castro-Alonso et al. (2019) above.

Whether gender is an important consideration when we look at the impact of video in K-12 education is unknown. Whilst there is some research that suggests “there is a repeated pattern of small, but statistically significant differences in computer attitude, ability and use that often favors males” (Kay, 2012), we cannot make a similar claim about the impact of gender on video learning. Whilst some information is known around video design and gender, less is known about learner characteristics in the same context. Castro-Alonso (2019) and Kay (2012) argue that gender deserves more attention as a participant characteristic in experimental studies because reviews don’t use it as a variable. Understanding how each gender interacts with and learns from video may help educators create more impactful lessons and choose media more appropriate for their audience.

## Intrinsic Motivation

When students have intrinsic motives for learning, they “become more likely to attach meaning to their work, explore new topics, and persist in the face of learning challenges” (Vansteenkiste et al. 2004). Self-determination theory (SDT) represents a broad framework for the study of human motivation and suggests that when people are motivated to grow and change, they become self-determined. People become more self-determined when they master tasks and learn different skills (competence), feel a sense of attachment and belonging to people (relatedness), and feel in control of their own goals and behaviors (autonomy). Moreover, engaging in activities for an inherent reward is more motivating and engaging than carrot and stick rewards (Skinner &

Belmont, 1993; Ryan & Deci, 2000). Intrinsic motivation was discussed in only two of the K-12 studies in this review and was not discussed at all in any of the systematic reviews as an important moderating factor.

Reiber (1991) found elementary students were more engaged in video when the video included structured and interactive simulations and practice activities. This was demonstrated when they were given a free choice situation and they “overwhelmingly chose to return to the practice activity” (pg 318). Moreover, Cummings et al. (2007) found that when participants were involved in the creation of multimedia assets, it not only motivated them in their learning but was more efficient in helping them develop social skills. In these two examples, one significant similarity is that students were given autonomy and control over their tasks, a key component in developing intrinsic motivation. The important role of autonomy has been discussed earlier in the video design section with reference to learner control. Further research through the lens of self-determination theory may reveal more about this learner characteristic.

### Spatial Ability

Spatial ability or viso-spatial ability has been defined as “the ability to generate, retain, retrieve, and transform well-structured visual images” (Lohman, 1996), and research has found that males are better at spatial tasks than females (Zell et al., 2015). It is because of these types of findings that some believe that males may find learning from video easier (Castro-Alonso et al., 2019). As a learner characteristic, spatial ability is little reported in the broader work on video in education. However, Castro-Alonso et al. (2019) did explore whether having spatial ability positively or negatively impacted a learner’s understanding of STEM video tasks. In their review, eight of the 46 studies they reviewed were K-12, and only two specifically looked at spatial ability and learning from video.

Hoffler and Leutner (2011) discovered that high-visualization (spatial) ability was found to play a crucial, but also rather specific role in learning with animations and static pictures. Participants with high visualization ability were able to interpret both static pictures and animations. However, those with low spatial ability performed worse with animated learning of factual knowledge. These results differ from an earlier study

by Hoffler et al. (2010), who observed that even highly developed visual learners had better understanding when learning with static pictures than low developed visual learners. It made no difference to low developed visual learners whether they learned with animation or static pictures. This suggests that animation may be beneficial to low developed visual learners, however more research needs to be conducted to understand whether this is the case.

Whilst research has found males to be better at spatial tasks than females (Zell et al., 2015), it is uncertain whether spatial ability makes it easier to learn from video. It is a characteristic like the ones previously discussed, that has not been thoroughly analyzed. More work is needed to understand the conditions in which spatial ability hinders or enhances learning with video.

## Conclusion

Of the three areas that have been looked at in this report - video design, learning design and learner characteristics - the least is known about which learner characteristics are beneficial for learning with video. Certainly, a greater understanding of the learner characteristics that are best suited to learning with video would help educators choose video and make learning design choices with video that meet the needs of all learners.

# Challenges in the Literature

There are several limitations in the literature that make it challenging to talk about the impact of video in K-12 education, which are outlined below.

## Description of Media

The lack of consistency in how media is reported makes it challenging to adequately assess the impact of video. This challenge was also identified by Fyfield et al. (2022) and Kay (2012) in their systematic reviews. This lack of consistency brings into question the validity of some of the claims that are made in the literature.

## Descriptions of Methodology

The lack of consistency in the descriptions of the processes that took place during the experiment, and access to media assets, make comparisons challenging. A standardized way of describing media and methodology would lead to more effective discussion of results and more confidence in the findings.

## A Focus on STEM

Most of the research papers in this review are in STEM. A wider search and different search terms may have identified different findings. However, most of the papers in the seven systematic reviews were conducted in STEM learning environments. This makes using the findings in other subjects and areas challenging.

## Age

Most of the research on the impact of video in education has been conducted on adult participants. More research in K-12 education needs to occur across a variety of age levels. It was revealed that there were very few studies in elementary education (PK-4) to draw upon. Of the studies in this review only 15% were in an elementary learning environment. A wider search and different search terms may have identified different findings.

## Gender and Special Needs Education

Very few studies discuss the impact of video on gender or students with disabilities or special needs. An understanding as to how these factors are impacted by video would be helpful to practitioners. Moreover, whilst gender was mentioned as part of the discussion on participants, it was not analyzed as a measurable outcome.

## Cognitive Functioning

A large proportion of the studies focus on cognitive functioning, particularly information processing and memory. The impact of video on factors such as social skills, cultural values, metacognition, affect, relationships and attitudes is not well explored. Different search terms may provide a more diverse sample.

## Limited Search Terms

The focus on K-12 educational settings means that some important factors and their impact may have been excluded. However, more research into the impact of video specifically in K-12 education is needed across most subject areas and with all types of students. Furthermore, this review was limited in scope because of time. A more thorough analysis with more search terms and less reliance on systematic reviews may yield a more diverse sample.

# Conclusion

Instructional video is a ubiquitous tool in education. Whilst there is a growing body of research, there is a lot that is unknown about its impact on K-12 education. Less than 20% (n=77) of the studies from the systematic reviews were in the K-12 setting. This review examined 77 K-12 studies and seven broad systematic reviews of the impact of video in education. The review revealed a number of broad findings relating to the impact of video in K-12 educational contexts and confirmed that while the research literature for both higher education and K-12 are very similar, the differences will be highlighted in the following paragraphs.

The use of video to develop factual knowledge is the focus of more studies and therefore has the strongest support in the literature. It is important to note that this does not mean that video is necessarily better at these things. There are simply too few convincing studies relating to other impacts to allow for a strong comparison. Moreover, the use of video may improve learning outcomes. However, the lack of clarity around the description of media, means that it remains uncertain how effective it really is, because it is difficult to understand if there are video formats that have a greater effect than others.

In all, 26 of the studies in this literature review explore the effectiveness of multimedia design principles. The review revealed that not all multimedia design principles (cf. Cognitive Theory of Multimedia Learning) are supported by research in a K-12 context, and some have more support than others. Clearly, more research focusing on the impact of multimedia design principles is needed, especially in elementary educational settings. Some principles with little support in the systematic review of Fyfield et al. (2022), such as pre-training, had more support in the K-12 papers in this review. Furthermore, a further principle, storytelling, was identified as an impact factor.  Finally, cognitively efficient video design and appropriate implementation strategies may work best at helping all students better engage with and learn from video. However, many high impact teaching strategies, such as metacognitive questioning and retrieval practice do not seem to be featured in the learning designs from the studies, or in the broader literature. The apparent exclusion of these

strategies means it's unclear to what extent they could be effective with the use of video in classroom environments.

Design principles appear to be more effective when they work with at least one other. For example: the embodiment principle and signaling (Yung & Pass, 2015). This means that when we talk about the effectiveness of a principle, it's uncertain whether it's the combination of principles or a principle alone that is more or less effective. Finally, design principles like video interactivity and learner control are reported on regularly, and seem to enhance learning, motivation and engagement in video learning. However, the range of learning contexts for the studies favors middle and high school learners, not elementary. Therefore, more research is needed to further understand the impact.

Learning design interventions were less discussed in the K-12 studies and this is consistent with the broader body of work. In the flipped classroom, video modeling, prompting, and pre-training all had strong support in the literature, but are featured less in the higher education literature in the seven systematic reviews. Importantly, video as part of the flipped classroom intervention was only one element that may have led to a positive impact. We cannot claim its inclusion was the reason behind positive results. Finally, video modeling and prompting were found to be particularly effective in a K-12 context to teach skills to students with intellectual, emotional and behavioral disabilities.

The report revealed that most of the studies of the effectiveness of video in K-12 education had been conducted in STEM subjects, and experimental conditions. This finding is consistent with the broader body of research. The lack of variability in domain areas makes it challenging to make claims about its effectiveness in other domains, and experimental conditions mean that the validity of the research is threatened. A large proportion of the studies focus on cognitive functioning, particularly information processing and memory. The impact of video on factors such as social skills, cultural values, metacognition, relationships, and attitudes are not well exploited.

Furthermore, gender and age are not well reported either, and most studies excluded or did not mention the inclusion of students with intellectual and emotional behavioral disabilities or special needs as part of the sample. Given that special needs

populations make up anywhere between 10 - 15% (Australian Institute of Health & Welfare, 2020; Gov.UK, 2021; National Centre for Statistics, 2021) of a student population, the inclusion of such information is likely to be of use to the education community.

A lack of consistency in the research literature regarding the description of media was revealed in the review. This means making comparisons of empirical results almost impossible. Moreover, a lack of clarity and detail in the literature regarding research designs, means findings are often unverifiable and the details of the research method are unclear. It is therefore recommended that the media industry and academia work together to create an evolving universal definitional framework so that we can all better understand the impact of video in education. Finally, an analysis of the literature has led to a number of recommendations which are listed in the executive summary.

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# Appendix A

## Coding

In total there are 10 categories of codes: 1) methodology, 2) video type, 3) video duration, 4) video topic, 5) subject domain, 6) number of participants, 7) gender, 8) learning measures (recall, acquisition, transfer, proficiency), 9) factors, 10) impact.

| Variable | Description | Sorting Criteria | | | Example/s | |
|---|---|---|---|---|---|---|
| Method | Methodology used to collect data | EX | Experimental | | | |
| | | QE | Quasi Experimental | | | |
| | | AR | Action Research | | | |
| Video Type | Style of Video Used or Intervention employed (where applicable) | AN | Instructional Animation | Narrated animation which includes all types of animation 2D, 3D, infographic & motion graphics. This type of animation is used to provide instructions for immediate performance or task or to support more permanent learning of a subject matter or concept. These videos are often a replacement or support explicit instruction, and sometimes referred to as an explainer. | Developing a Growth Mindset | |
| | | AHT | Animated 'How To' | Narrated animated demonstration of a particular skills/process | How to Describe 3D Shapes | |
| | | BD | Boards | Instructor narrates while a (real or simulated) hand draws on a white or black background. This is done on whiteboards, tablets, light boards | Changing education paradigms | |
| | | DRN | Instructional Dramatisation / Narrative | Dramatic recreation or narrative of a process or context intended to model a concept | Respectful relationships | |
| | | DOC | Documentary | The use of moving images or interviews with narration involved in real events to provide a factual report on a particular subject. | Off Country | |
| | | ID | Interview or Dialogue | Interview with experts or ordinary people with or without a host. | Migration Case Study | |
| | | IMM | Instructional Mixed Media | Narrated mixed media animation. Mixed media is when more than one medium is used, ie: live action & motion graphics. This type of animation is used to provide instructions for immediate performance or task or to support more permanent learning of a subject matter or concept. It usually is in replacement of or support of explicit instruction and sometimes referred to as an explainer. | Materials and their Properties | What is International Women's Day? |
| | | INU | Instructional Video Unspecified | Instructional video for immediate performance or task or to support more permanent learning of a subject matter or concept. In replacement or to support explicit instruction. It is either unclear or unspecified what this video looked like. | | |
| | | LA | Live Action Instructional | Live action scripted video that is used to provide instructions for immediate performance or task or to support more permanent learning of a subject matter or concept. In replacement or to support explicit instruction.This is in the form of a green screen and presenter or talking head, and sometimes referred to as an explainer. | What is emotional literacy? | |

| Variable | Description | Sorting Criteria | | | Example/s | |
|---|---|---|---|---|---|---|
| | | LHT | Live Action 'How to' | Narrated live demonstration of a particular skill/process | Dissections for the Science Classroom | |
| | | LC | Lecture Capture | Instructor / expert is filmed delivering a traditional lecture with or without live audience. | Differentiating Logarithmic Functions | |
| | | SSC | Slideshow/Screencast | Instructional or 'how to' video with teacher/expert talking head or voice over and smartboard or slides | Calculating the size of the labour force | |
| | | WE | Worked Example | Expert performing a process such as a tutorial. These are usually represented in the following ways: screencast, lightboard, whiteboard, tablets | Essay Annotation | |
| | | NS | Not sure | | | |
| | | U | Unsatisfactorily described | | | |
| Domain | Main instructional domain of video/s | ARTS | Art, Design, Drama, Music | | | |
| | | ENG | English | | | |
| | | HPE | Health and Physical Education | | | |
| | | HUM | History, Economics, Geography, Civics & Citizenship | | | |
| | | PRAC | Practical | | | |
| | | SEL | Social and Emotional Learning & Life skills | | | |
| | | STEAM | Science, Technology, Engineering, Mathematics + Art | | | |
| | | STEM | Science, Technology, Engineering, Mathematics | | | |
| Age/Context | The learning context or level in which the research tooks place | EL | Elementary | Grades PK-4 | | |
| | | MS | Middle School | Grades 5 - 8 | | |
| | | HS | High School | Grades 9 - 12 | | |
| | | | | | | |
| Learning Measures | | RE | Recall | Recall performance of learners reported | | |

| Variable | Description | Sorting Criteria | | | Example/s | |
|---|---|---|---|---|---|---|
| | | TR | Transfer | Transfer performance of learners reported | | |
| | | AC | Acquisition | Acquisition of skill of learners reported | | |
| | | PR | Proficiency | Proficiency performance of learners reported | | |
| | | | | | | |
| Impact Category | Each paper has been categorised into at least one of the Blooms et al (1956) three domains of learning. | AF | Affective Domain | Growth in feelings or emotional areas (attitude & self) | | |
| | | CO | Cognitive Domain | Mental skills (knowledge) | | |
| | | PS | Psychomotor Domain | Manual or physical skills (skills) | | |
| Special groups | Where there are special populations have been divulged, this has been noted as a way of providing differentiation and nuance to the results. | ADHD | Attention deficit hyperactivity disorder | Characterised by an ongoing pattern of inattention, impulsivity and/or hyperactivity that interferes with functioning and development. | | |
| | | ASD | Autism spectrum | A complex developmental condition involving persistent challenges with social communication, restricted interests and repetitive behaviour. | | |
| | | DF | Deaf | | | |
| | | DS | Disability (unspecified) | | | |
| | | EBD | Emotional, behavioural disorders | These disorders include: anxiety, bipolar, psychotic, obsessive-compulsive, attention deficit, attention deficit hyperactivity, oppositional defiant disorders, and autism. | | |
| | | ESL | English second language | | | |
| | | FC | Flipped classroom | An instructional strategy in which the traditional lecture and homework elements are reversed. | | |
| | | HPS | High performing students | | | |
| | | ID | Intellectual disability | Characterised by significant limitations in both intellectual functioning and in adaptive behaviour, which covers many everyday social and practical skills. | | |

| Variable | Description | Sorting Criteria | | | Example/s | |
|---|---|---|---|---|---|---|
| | | ODD | Oppositional defiant disorder | Characterised by uncooperative, defiant and hostile behaviour towards peers, parents, teachers & authority figures. | | |
| | | LD | Learning disability | Characterised by significant limitations someone's ability to learn in one or more specific academic areas, such as reading, writing or maths. | | |

# Appendix B

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Galloway, Collins, Knight, and Bausch (2013) | USA | EX | ID | AHT | 120 - 240 | Academic skills | SEL | 4 | 25% F | HS / MS | Video Design (VD), Learning Design (LD) | VD (Real world example of Maths skill + narrative stories to teach maths concepts)<br>LD (video as an anchor, VP + verbal and physical prompts) | Young people with intellectual disabilities demonstrated they could use the formula for the Pythagorean theorem quickly and with few errors. The intervention was effective in teaching participants the skill, and it was seen by the teachers as an intervention that was easy to use with students. | Cognitive | Transfer (novel stimuli) |
| Gardner and Wolfe (2015) | USA | EX | ASD or ID | AHT | 60 | Daily living skills | SEL | 4 | 50% F | MS & HS | Learning Design | VP<br>• Error correction (SLP) | Students with intellectual disabilities were able to acquire daily living skills and were able to maintain their performance over time. | Psychomotor | Acquisition |
| Gariou-Papalexiou et al. (2017) | Greece | NE, AR | FC<br>(4 x with unspeficied learning disabilities) | LHT/SSC | NS | Biology - photosynthesis | STEM | 17 | 52% F | HS | Learning Design | FC<br>• Planning Framework: Bloom's Taxonomy, FILLP pillar<br>• Before class: active learning activities with video<br>• In class: active & collaborative learning activities | No significant difference between pre and post test. Teacher observation indicated greater student involvement and active participation in the educational process in the FC. | Affective | N/A |
| Hasler et al. (2007) | Australia | EX | NS | AD | 225 | ne | STEM | 72 | 100% M | MS | Video Design | LC (stop/pause function)<br>• Pacing<br>* Segmentation | The significant group differences regarding test performance were obtained only for more difficult, high element interactivity questions but not for low element interactivity questions. This suggests that more interactivity is recommended in videos. | Cognitive | Recall |
| Höffler and Leutner (2011), exp 2 | Germany | EXP | NS | AN | 300 - 600 | surfactants cleaning dirt | STEM | 43 | 41% F | HS | Learner Characteristics | Spatial ability (known as high spatial visualisation ability in the study) | High spatial-visualisation ability was found to play a crucial, but also rather specific role in learning with animations and static pictures. Learners with low spatial ability, performed worse with animation the learning of factual knowledge and comprehension than those that had high spatial ability. | Cognitive | Recall |
| Höffler et al. (2010) | Germany | EXP | NS | AN | NS | photosynthesis | STEM | 60 | 62% F | HS | Learner Characteristics | Spatial ability (known Highly developed visual learners (HDV) in the study) | Highly developed visual learners (HDVL) had better results in understanding when learning with static pictures (and were then significantly superior to low developed visual learners (LDV)), while for LDV, learned better with animations over static pictures. Which means that animations may be beneficial to those who have LDV. | Cognitive | Recall |
| Kay & Edwards (2012) | Canada | QE | NS | WE | 141/314/449 | Mathematics | STEM | 136 | 47% F | MS | Video Design | WE (LC + segmentation + signalling + personalisation principle + video length reduction) | The results of this study indicate that the worked example (WE) video (podcasts) had a significant statistical and practical impact on middle school students' short-term learning performance for three mathematical concepts. Other findings around student attitude included: 80% of students found the WE easy to follow, 79% believed it helped them understand the problem and concepts better, 60% experienced no confusion. 45% felt the length was too long, 57% felt that the clips would be helpful for homework, and 58% as a revision tool. Almost 90% believed that the WE was better than using a textbook. No significant difference in learning for grade level or age was observed. | Cognitive & Affective | Recall |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boucheix and Guignard (2005) | NS | EX | NS | AD | 100/250 | Gearing systems | STEM | 123 | NS | MS | Video Design | Signalling + LC (self controlled pace of the presentation, specific to each learner)<br><br>Transience | For immediate comprehension, animation was more effective than static graphics. The signalling in the video seemed to guide attention toward what must be watched in the animation, and seemed to improve the ability of the learner to explain the technical device. For more long term learning gains signalling and an element of active learning in the form of learner control of the animation seem to be most effective. | Cognitive | Recall / Transfer |
| Burton, Anderson, Prater, and Dyches (2013) | USA | EX | ID | AHT | 180 - 300 | Academic skills | STEM | 4 | 100% M | MS | Learning Design | VSM<br>• Positive reinforcement | Video self modelling (VSM) via an iPad was demonstrated to be an effective option for teachers implementing interventions to improve the academic performance of students with autism and intellectual disability. The VSM intervention allowed participants to independently access the technology and prompt themselves through the completion of functional math skills without teacher assistance. | Cognitive | Transfer (novel stimuli)/ Proficiency |
| Camiling (2017) | Philippines | QE | FC (HPS) | INU | NS | Skills | STEAM | 24 | NS | EL & MS | Learning Design | FC<br>• Planning Framework: 5E instructional model + FILP pillar<br>• Before class: active learning activities with video<br>• In class: active & collaborative learning activities | Students in FC had significantly higher basic process skills according to the mean test scores than those in the TC. Interesting comments by students about the pre-class video. "I enjoyed watching the videos at home." "When are you going to give the next video?" "I rewatched it many times." | Cognitive | Recall |
| Cannella-Malone et al. (2011) | USA | EX | ID | AHT | 3 - 16/7. 1/1-15/5. 1/198/115 | Daily living skills | SEL | 7 | 29% F | MS | Video Design | •VP<br>• Short video length<br>• Voice over instructions | Video prompts that are short and have voice over instructions were more effective than video modelling on its own (VM) in helping students with disabilities develop living skills. | Psychomotor | Acquisition |
| Cannella-Malone et al. (2016) | USA | EX | ID | AHT | 5-23/164 | Leisure skills | SEL | 3 | NS | HS | Learning Design | VP<br>• Error correction<br>• Most to least prompts | This study demonstrated that video prompting can be effectively used in a school setting to teach leisure skills. All mastered skills were also maintained after video prompting intervention was withdrawn. The results also demonstrated that the student's preference for the activity changed positively after the intervention. | Psychomotor | Transfer/ Proficiency (novel setting) |
| Cannella-Malone, Brooks, and Tullis (2013) | USA | EX | ID | AHT | 11.2/20.02 | Daily living skills | SEL | 4 | NS | HS | Learning Design | VP<br>• Error correction<br>• Pre training | All students were able to learn the skills with instructor-directed video prompts. Most maintained the skills 2 - 3 weeks later. The study also found that the iPad touch is an effective video prompting device. | Psychomotor | Acquisition |
| Cetinkaya (2017) | Turkey | QE | FC | INU | NS | Science | STEM | 74 | NS | MS | Learning Design | FC<br>• Planning Framework: Assure Instructional Design model<br>• Before class: personalised active learning activities with video<br>• Active & collaborative learning activities | Post test results showed a positive significant difference in achievement in favour of the students in FC. | Cognitive | Recall |
| Chang (2017) | Taiwan | EX | NS | WE | NS | Buoyancy (virtual experiments) | STEM | 128 | 47% F | MS | Video Design | • Guided discovery<br>• Interactivity | Providing structured prompts that outlined a framework for students inquiry with the simulation led to more efficient behavioural engagement, compared with minimal guidance. This intervention did not show that it improved learning outcomes. Less structured scaffolding resulted in better learning efficiency which suggests that scaffolding using minimal critical guidance, such as a driving question approach may help students in their learning. | Cognitive | N/A |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ChanLin (2001) | NS | EX | NS | AN | NS | Physics | STEM | 714 | NS | MS | Learning Design, Video Design | LD (Prior knowledge)<br>VD (problem solving tasks/ scenario based problems + signalling) | Animated and graphic representations facilitated assimilation of scientific knowledge, and mathematics scores and may have been beneficial to those with prior knowledge. Novice learners did not benefit from the use of animation, they found it confusing. | Cognitive | Recall / Transfer |
| Chien and Chang (2012) | NS | EXP | NS | AN | NS | Abney Level topographic measure | STEM | 27 | 100% F | HS | Video Design | Full-Learner Paced Animation (FLPA) which included the control of | Full Learner Paced Animation (FLPA) imposed less cognitive load on learners. Learning of practical performance & understanding increased and a higher | Cognitive/ Psychomotor | Proficiency |
| Chu & Baker (2015) | NS | EXP | EBD | LHT | 180 - 300 | Appropriate & inappropriate behaviour | SEL | 4 | 50% F | HS | Learning Design | VSM<br>• verbal reinforcement | VSM effective as a single treatment. Significant gains in behaviour were observed even after the cessation of the intervention. The findings of the present study revealed that VSM intervention appeared to have an immediate and positive influence on decreasing two participants' inappropriate social behavior and on increasing two other participants' occurrences in requesting help. The skills acquired in the intervention phase were generalized to other settings in the school besides where the intervention took place. Furthermore four participants maintained their acquired skills once they were no longer receiving the intervention. | Affective | Acquisition |
| Cihak, Alberto, Taber-Doughty, and Gama (2006) | USA | EX | ID | AHT | 4 | Daily living skills | SEL | 6 | 100% M | MS | Learning Design | VP<br>• System of least prompts | Video prompting helped students with intellectual disabilities develop functional skills. | Psychomotor | Acquisition |
| Cihak, Fahrenfrog, Ayres, and Smith (2010) | USA | EXP | ASD | LHT | 120 - 300 | Life Skills (transitioning between locations & activities within school) | SEL | 4 | 25% F | EL | Learning Design | • Video modelling (VM) using video iPod<br>• pre-training using the model-lead-test procedure<br>• SLP | Prior to the study, students required consistent teacher assistance to transition successfully from place to place. In all instances, VM and the use of the video iPod resulted in independent transitions, although additional prompts were required at times. Moreover, student inappropriate behaviors decreased to zero levels during transitional situations. | Psychomotor | Transfer/ Proficiency |
| Cook et al. (2016) | NS | EX | NS | WE | NS | Mathematics | STEM | 65 | 52% F | EL & MS | Video Design | Embodiment principle | Participants who observed the gesturing avatar learned more and solved problems more quickly. Participants who learned more quickly were also more likely to transfer and generalise their knowledge. | Cognitive | Recall / Transfer |
| Cumming et al. (2008) | USA | EXP | EBD | LHT | NS | Social skills | SEL | 25 | NS | MS | Learning Design | VM<br>• Teacher intervention<br>• The creation of student generated social skills videos | Participants found developing multimedia motivating. The combination of traditional social skills training & multimedia authoring was more efficient at developing social skills and a students knowledge of social skills. | Cognitive & Affective | Acquisition |
| de Koning et al. (2011) | Netherlands | EX | NS | AD | 305 | Cardiovascular system | STEM | 90 | 30% F | MS | Video Design | • Signalling<br>• Self explanation | The results showed that learners who generated self-explanations with a cued animation yielded higher performance on inference and transfer, (but not retention) tasks than learners who generated self-explanations with an uncued animation and learners who did not self-explain. Thus, test performance of learners in the cued self-explanation condition indicates that they had developed a more thorough conceptual understanding of the causal relations in the cardiovascular system. Hence, they were better able to apply the learned information to novel tasks. Moreover, the cued self-explanation condition seems most efficient for learning, that is, learners had a higher performance without investing more mental effort to obtain this performance. | Cognitive | Recall / Transfer |
| Fernstermacher et al. (2006) | USA | EXP | EBD (ADHD) | LHT | NS | Skills - Problem solving, argumentation, self-control & accepting negative responses. | SEL | 4 | 100% M | EL/MS | Video Design & Learning Design | VM<br>Interactive computer facilitated social skills training program. Implementing direct instruction with feedback + reinforcement in a clinical setting | The results of this study indicated that children with ADHD who participated in an interactive, computer–facilitated social skills training program demonstrated and maintained gains in behavioral enactment of social problem–solving skills. Improvement in demonstrated problem–solving subskills was evident for all participants. In addition, treatment gains were generally maintained at 3 and 6–week follow–ups. | Affective | Acquisition |

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| Gardner and Wolfe (2015) | USA | EX | ASD or ID | AHT | 60 | Daily living skills | SEL | 4 | 50% F | MS & HS | Learning Design | VP<br>• Error correction (SLP) | Students with intellectual disabilities were able to acquire daily living skills and were able to maintain their performance over time. | Psychomotor | Acquisition |
| Gariou-Papalexiou et al. (2017) | Greece | NE, AR | FC (4 x with unspeficied learning disabilities) | LHT/SSC | NS | Biology - photosynthesis | STEM | 17 | 52% F | HS | Learning Design | FC<br>• Planning Framework: Bloom's Taxonomy, FILLP pillar<br>• Before class: active learning activities with video<br>• In class: active & collaborative learning activities | No significant difference between pre and post test. Teacher observation indicated greater student involvement and active participation in the educational process in the FC. | Affective | N/A |
| Hasler et al. (2007) | Australia | EX | NS | AD | 225 | ne | STEM | 72 | 100% M | MS | Video Design | LC (stop/pause function)<br>• Pacing<br>* Segmentation | The significant group differences regarding test performance were obtained only for more difficult, high element interactivity questions but not for low element interactivity questions. This suggests that more interactivity is recommended in videos. | Cognitive | Recall |
| Höffler and Leutner (2011), exp 2 | Germany | EXP | NS | AN | 300 - 600 | surfactants cleaning dirt | STEM | 43 | 41% F | HS | Learner Characteristics | Spatial ability (known as high spatial visualisation ability in the study) | High spatial-visualisation ability was found to play a crucial, but also rather specific role in learning with animations and static pictures. Learners with low spatial ability, performed worse with animation the learning of factual knowledge and comprehension than those that had high spatial ability. | Cognitive | Recall |
| Höffler et al. (2010) | Germany | EXP | NS | AN | NS | photosynthesis | STEM | 60 | 62% F | HS | Learner Characteristics | Spatial ability (known Highly developed visual learners (HDV) in the study) | Highly developed visual learners (HDVL) had better results in understanding when learning with static pictures (and were then significantly superior to low developed visual learners (LDV)), while for LDV, learned better with animations over static pictures. Which means that animations may be beneficial to those who have LDV. | Cognitive | Recall |
| Kay & Edwards (2012) | Canada | QE | NS | WE | 141/314/449 | Mathematics | STEM | 136 | 47% F | MS | Video Design | WE (LC + segmentation + signalling + personalisation principle + video length reduction) | The results of this study indicate that the worked example (WE) video (podcasts) had a significant statistical and practical impact on middle school students' short-term learning performance for three mathematical concepts. Other findings around student attitude included: 80% of students found the WE easy to follow, 79% believed it helped them understand the problem and concepts better, 60% experienced no confusion. 45% felt the length was too long, 57% felt that the clips would be helpful for homework, and 58% as a revision tool. Almost 90% believed that the WE was better than using a textbook. No significant difference in learning for grade level or age was observed. | Cognitive & Affective | Recall |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kay and Edwards (2012) | Canada | QE | NS | WE | 141/314/ 449 | Mathematics (exponents, circumference of a circle & multiplying monomials) | STEM | 136 | 47% F | MS | Video Design | • Pause/play & dragging tool<br>• Design principles - segmentation, key elements written down to avoid cognitive overload, clear visuals to illustrate key aspects of the problems, important information highlighted to focus student attention, personalisation principle, video length reduction. | The results of this study indicate that the worked example video podcasts had a significant statistical and practical impact on middle school students' short-term learning performance for three mathematical concepts. Moreover most students found it easy to follow, believed it helped them understand the concepts better, was better than using a textbook, and felt the clips would be useful as a revision tool. | Cognitive & Affective | Recall |
| Kettle (2013) | UK | NE | FC | SSC | NS | Physics | STEM | 12 | NS | HS | Learning Design | FC<br>• Use of an LMS<br>• Before class: active learning activities with video<br>* In class: active & collaborative learning activities | FC students found in class activities to be effective & enjoyable but watching videos to be ineffective and unenjoyable. | Cognitive & Affective | N/A |
| Kulgemeyer (2018) | Germany | QE | NS | LC | 271/286 | Cars aquaplaning | STEM | 176 | NS | HS | Video Design | Coherence | Greater gains in declarative knowledge were gained by the students who watched the video that had been created using the framework. | Cognitive | Recall / Transfer |
| Leahy and Sweller (2016) | Australia | EX | NS | SSC | 663 | Contour maps | HUM | 171 | 100% M | MS | Video Design | • Segmentation<br>• Multimedia combination<br>* WE<br>• LC<br><br>Transience | When the animation is segmented in multimedia presentations positive learning outcomes ensued. Learning achievement was also higher when learning control was a learning intervention that was used. | Cognitive | Transfer |
| Leo & Puzio (2016) | USA | QE | FC | SSC | NS | Science (Biology) | STEM | 71 | NS | MS | Learning Design | FC<br>• Use of an LMS<br>• Before class: active learning activities with video<br>* In class: active & collaborative learning activities | Two quizzes and one post test demonstrated statistically significant gains in FC learning. The qualitative results suggested that students may have benefited from the active learning strategies and enjoyed learning through FC. Students in FC performed better on assessments of scientific knowledge. | Cognitive & Affective | Recall / Transfer |
| Lin et al. (2015) | Taiwan | EX | NS | AD | NS | Heat transfer | STEM | 192 | NS | MS | Video Design | LC (active control mode, flipping pages forwards and backwards) | The active-control mode was found to be better than passive-control mode for learning. The active-control mode included the ability to flip pages forwards and backwards. | Cognitive | Recall / Transfer |
| Lo et al. (2018) | Hong Kong | QE | FC | WE | NS | Science (Physics) /Maths/ ICT | STEM | 324 | NS | MS | Learning Design | FC<br>• Planning Framework: Merrill's First Instruction<br>• Before class: active learning activities with video<br>• In class: active & collaborative learning activities | Levels of student achievement significantly higher in FC. Teachers also pointed out that any instructional videos lasting more than 10 minutes were too lengthy and caused disengagement. | Cognitive & Affective | Recall / Transfer |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marbach-Ad et al (2008) | Israel | EX | NS | AN | NS | Genetics | STEM | 248 | NS | HS | Video Design | • LC (play, pause & pace)<br>• Interactive video tasks (virtual building of molecules)<br>• Immediate feedback | The study found that animation may be beneficial when teaching dynamic processes. Learner control, interactivity and immediate feedback were also found to facilitate learning and may help overcome difficulties in perception and increase engagement. Finally, the computer animation activity seemed to help students to better understand each of the processes (DNA replication, transcription, and translation), but was less useful in explaining the global idea (the central dogma) of how DNA molecule codes for protein. | Cognitive | Recall / Transfer |
| Mechling and Swindle (2012) | USA | EX | ASD & ID | AHT | 180 - 300 | Fine Motor and Gross Motors tasks | PRAC | 6 | 33% F | EL | Video Design (VD), Learning Design (LD) | LD (VM + positive reinforcement)<br>VD (zooming, voice-over, video perspective) | An increase in the number of fine and gross motor tasks correctly performed followed after the introduction of video modelling intervention. In addition, features of video captions that promoted correct task performance included: (i.e., zooming, voice-over, video perspective). | Psychomotor | Acquisition |
| Mechling, Ayres, Bryant, and Foster (2014a.) | USA | EX | ASD & ID | AHT | 113 / 226 / 203 | Daily living skills | SEL | 3 | 66% F | HS | Learning Design | CVM<br>• Error correction | CVM alone may be an effective intervention to help students with ASD & ID complete tasks. More research is needed to understand the types of tasks. | Psychomotor | Acquisition |
| Mechling, Ayres, Bryant, and Foster (2014b.) | USA | EX | ID | AHT | NS | Daily living skills | SEL | 3 | 66% F | HS | Learning Design | VP | VP was more effective than VM and CVM for students to complete multi stepped daily living tasks for students with a moderate intellectual disability. | Psychomotor | Acquisition |
| Mechling, Ayres, et al. (2015) | USA | EX | ASD & ID | AHT | NS | Daily living skills | SEL | 4 | 100% M | HS | Learning Design | VM<br>• Verbal praise<br>• Repetition | The results indicate that the use of generalised materials (video) to teach daily living skills was less effective than using video models. However, video prompting with the use of verbal prompts + other instructional strategies meant that generalised materials could be used to develop the skill. | Psychomotor | Transfer/ Proficiency (novel stimuli) |
| Merkt et al. (2011) | Germany | MM | NS | DOC | 984 | Post-war German society | HUM | 212 | 63% F | HS | Video Design | LC (start/stop, forward, rewind) | Interactive features more were effective than enhanced interactive features (timeline, navigations, table of contents) in enhancing learning and motivation. | Cognitive & Affective | Recall / Transfer |
| O'Reilly et al. (2005) | NS | EXP | EBD | LHT | 300 (10 x 30) | Skills - self-management | SEL | 2 | 100% M | EL | Learning Design | VM<br>• Video Feedback<br>• Self management interventions<br>• Reinforcement | The findings of the study revealed that video feedback coupled with a self-management intervention appeared to have an immediate and positive influence over these students' social behaviour in the schoolyard context, decreasing their aggressive behaviour while concurrently increasing or maintaining their pro-social behaviour in a school year. | Affective | Acquisition |
| Olakanmi (2017) | Nigeria | QE | FC | SSC | NS | Science (Chemistry) | STEM | 66 | 43% F | MS | Learning Design | FC<br>• Before class: active learning activities with video<br>• In class: active & collaborative learning activities | Student scores of conceptual understanding of the rate of chemical reactions were significantly higher in FC. The findings suggested that FC benefits students to encourage active learning through interactions with peers and teachers. | Cognitive & Affective | Recall |
| Ozkan (2013) | Turkey | EX | ID | AHT | NS | First Aid | SEL | 3 | 66% F | MS/HS | Learning Design | VM & Peer Video Modelling (PVM)<br>• Pre-training | Both peer and video modelling were equally effective in teaching first aid skills to children with intellectual disability. | Psychomotor | Transfer/ Proficiency (novel stimuli) |
| Rieber (1990) | USA (Texas) | EXP | NS | AN | NS | Newton's Law of motion | STEM | 119 | 54% F | EL | Video Design | Learner control - The ability to manipulate science concepts & principles whilst watching the video and the incorporation of practice tasks. | Animation and practice activities influenced students' application learning of the material. It was believed that students in the animated graphics condition would be in the best position to retain, retrieve, and apply the lesson information because they were given the most precise representations, illustrations, and examples. It was also believed that cognitive practice would promote deeper levels of mental processing than the other practice conditions. | Cognitive | Recall |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rieber (1991) | USA | EXP | NS | AN | NS | Newton's Law of motion | STEM | 70 | 49% F | EL | Video Design | Learner control - The ability to manipulate science concepts & principles whilst watching the video and the incorporation of practice tasks. | Results showed that students successfully extracted incidental information from animated graphics without risk to intentional learning but were also more prone to developing a scientific misconception. In addition, when placed in a free-choice situation, students overwhelmingly chose to return to the practice activity consisting of the computer simulation This study provides evidence to suggest that certain computer practice activities contain intrinsically motivating appeal for elementary school students. | Affective/ Cognitive | Recall (almost near transference) |
| Roscoe et al. (2015) | USA | QE | NS | SSC | 300* (5 x 20) | Writing cohesion | ENG | 90 | 51% F | HS | Video Design | Partial redundancy | Students improved significantly in cohesion-building strategies & understanding of the effects of cohesion in writing quality, but it's unlikely this was due to the influence of partial redundancy. | Cognitive | Fail |
| Ryoo & Linn (2012) | USA | EX | NS | AN | NS | Biology | STEM | 167 | NS | MS | Video Design | • Animation effect<br>• Interactivity<br>• Questions<br>• Active learning prompts | The study found that dynamic visualization (video) gave students a more accurate view of the unseen, complicated process of energy transformation at the molecular level in photosynthesis than static illustrations. Students also gave more detailed explanations than those in the static group. | Cognitive | Transfer |
| Saecker et al. (2010) | USA | EX | ADHD (6.45%) DS (2.9%) | LC | 344/453 | ADHD | STEM | 62 | 62% F | HS | Video Design | Description of personal experiences were supplemented by the speaker in the video. | Findings suggest that including the descriptions of personal experiences (DPE) may have enhanced learning of the information that was highlighted by these descriptions. However, the DPE interfered with learning the other facts. This suggests that providing DPE does not alter behavioral intentions. | Cognitive & Affective | Recall |
| Schultz et al. (2014) | USA | QE | FC | WE/S SC | 600 - 900 | Chemistry | STEM | 61 | 55% F | HS | Learning Design | FC<br>• Before class: reflective practice activity with video<br>• In class: retrieval practice + active & collaborative learning activities | Students in FC had a significantly higher mean test scores than TC for all 8 assessments. Gender different was also significant in that males performed better than females. Most students viewed the intervention favourably. | Cognitive & Affective | Recall, Proficiency |
| Sezer (2017) | Turkey | QE | FC | SSC | NS | Science | STEM | 68 | 46% F * | MS | Learning Design | FC<br>• Planning Framework: SCLT<br>• Before class: active learning activities with video<br>* In class: active & collaborative learning activities | FC generated a larger increase in student academic achievement scores and motivation scores than TC. Interview findings found that FC had a positive effect on student perceptions of the science course. | Cognitive & Affective | Unsure |
| She and Chen (2009) | USA | EX | NS | AD | NS | Mitosis | STEM | 24 | NS | MS | Video Design | Multimedia effect | The results indicated that both groups performed about the same level on their post-test, with the animation-narration group performed only slightly better than the simulation-narration group on retention-test. | Cognitive | Recall |
| Shen et al. (2006) | USA | QE | NS | LHT | 360 | Net Games | SPO | 240 | 43% F | MS | Learning Design | Seductive details | The results show that seductive details interrupted students' recall of important learning content and transferring problem solving in learning net games. It is suggested that the function of seductive details on learning should be considered when design effective motivational strategies in physical education. Seductive details-based motivation strategies can inhibit learning even in PE. | Cognitive | Recall / Transfer |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slemmons et al (2018) | USA | QE | FC (DS = 13% ) (ESL = 4% ) | INU | 240 - 420 / 600 - 1500 | Science (Chemistry) | STEM | 154 | 49.5% F * | MS | Learning Design | FC<br>• Planning Framework: CLT, CTML<br>• Before class: active learning activities with video<br>* In class: active & collaborative learning activities | There were higher rates of retention, engagement & focus when learning from short videos. The researchers found that when assessments followed short videos results were slightly higher than from longer videos. While short-term retention of material did not seem to be influenced by video length, longer-term retention for males and students with learning disabilities was higher following short videos compared to long as assessed on summative assessments. Students self-report that they were more engaged, had enhanced focus, and had a perceived higher retention of content following shorter videos. | Affective | N/A |
| Sookoo-Singh & Boisselle (2018) | Trinidad & Tobago | NE,AR | FC | INU | NS | Science (Chemistry) | STEM | 27 | NS | MS/HS | Learning Design | FC<br>• Planning framework: SCLT<br>• Before class - active learning activities with video<br>• In class - active & collaborative learning activities + SCLT | Academic achievement was not significantly affected by the FC intervention. However, motivation was positively affected by FC. Most students attitude towards the FC intervention was positive. | Affective | Fail |
| Spanjers et al. (2012) | The Netherlands | EX | NS | AD | 120* | Probability | STEM | 161 | NS | HS | Video Design | Segmentation (pauses & cues - temporarily darkening the screen at the boundaries of segments) | Segmentation in the form of pauses and cues were found to facilitate learning. Pauses in videos were found to positively affect posttest achievement without affecting mental effort. The cues in the videos reduced the mental effort in studying animations (less effort needed), reducing cognitive load. | Cognitive | Transfer |
| Stebner et al. (2017) | Germany | EXP | NS | AN | 73 | surfactants cleaning dirt | STEM | 283 | 47% F | MS | Video Design | Multimedia effect | The presence of visualisations and narration was necessary to achieve a better understanding, (comprehension), of the content presented. An instructional advantage of animation over static pictures was demonstrated, with process animations with animation significantly superior to non narration conditions. | Cognitive | Recall |
| Stratton et al. (2019) | USA | QE | FC | SSC | NS | Science | STEM | 154 | 45% F | MS | Learning Design | FC<br>• Before class: Watch-Summarize-Question method with video<br>• In class - active & collaborative learning activities | Student survey data indicated that most students enjoyed learning in FC and experienced increased engagement. | Affective | N/A |
| Szpunar and Schacter (2014) | USA | EX | NS | LC | 1260 | Statistics | STEM | 54 | NS | HS | Video Design | Intergrated learning activities | Interpolating a lecture with repeated tests helped to boost actual performance to the level of predicted performance, whereas a single test following the lecture served to lower unrealistic judgments of learning. It appears that interpolated testing does the best job of fostering both a high level of predicted and actual learning. The researchers further demonstrated that interpolated tests helped high-school students to marginally reduce mind wandering and reliably increase note taking and retention | Cognitive & Affective | Recall |
| Taber-Doughty, Patton, and Brennan (2009) | USA | EX | ID | AHT | 2:02 - 2: 17/ 3:18 - 4:11 | Daily living skills (library skills) | SEL | 3 | 100% M | MS/HS | Learning Design, Video Design | LD (VM + praise)<br>VD (inclusion of audio prompting in video) | Video modelling was found to be effective in the acquisition of library skills. Skill acquisition and increased independence during intervention were apparent for all students. | Psychomotor | Transfer/ Proficiency (novel setting) |
| Thompson and Riding (1990) | USA (Texas) | EXP | NS | AHT | 160 | Pythagoras Theorem | STEM | 108 | 50% F | MS & HS | Video Design | Animation - in particular animated diagrams | The improvements in understanding due to the use of animation was significant but small. | Cognitive | Recall |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uzun and Yildirim (2018) | Turkey | QE | NS | AD | NS | Energy conservation | STEM | 106 | 46% F | MS | Video Design | Emotional design (colourful + anthropomorphic/embodiment principle) | Emotional design induced positive emotions among students. It seems that multimedia material in which the combination of interesting sound effects, facial expressions (anthropomorphism of lifeless objects and facial expression of human characters) and attention-grabbing colors was found to be much more effective in producing positive emotions than multimedia material that used attention-grabbing colors only. | Cognitive & Affective | Recall /Transfer |
| Van der Meij (2017) | NS | EX | NS | AHT | Review videos: 276 (Review section 20 - 25) Demonstration videos: mean = 74 | Microsoft Word | STEM | 77 | 59% F | MS | Video Design | How-To Video Framework<br><br>• Signaling<br>• Preview<br>* Pace<br>* User control (LC)<br>• Segmentation<br>• Video length<br>• Pauses<br>• Conversational style (pe<br><br>• Reviews | The design of a 'how-to' video, (which included segmentation, short video length and pauses), supported task completion and engaged the learners. All of the videos were played almost completely, regardless of whether they appeared at the start, in the middle or at the end of the tutorial. Even when viewed only partly, reviews can effectively raise learning, therefore how-to videos need special instructional support to enhance learning. | Affective | Proficiency |
| Van Laarhoven and Van Laarhoven-Myers (2006) | USA | EX | ID | AHT | NS | Daily living skills | SEL | 3 | 33% F | HS | Learning Design | VM<br>• Pre-training<br>• Prompting (SLP) | The intervention was effective in increasing independent responding in students with intellectual disabilities and in learning daily living skills. | Psychomotor | Transfer/ Proficiency (novel setting) |
| Wong et al (2009) | Australia | EX | NS | AHT | NS | Other | PRAC | 82 | NS | MS | Learning Design & Video Design | VM (Animation demonstrating skill)<br><br>Transience | Instructional animations that foster motor skills were shown to be superior to the equivalent static graphics in developing these skills. | Psychomotor | Acquisition / Proficiency |
| Wong et. al (2012) | Australia | EXP | NS | AN | 250 (22 x 66) | origami folding | PRAC | 66 | 58% F | MS | Video Design | Segmentation | The segmented videos effectively supported task completion and learning. The negative effects of transience was shown to be ameliorated by reducing segment lengths. | Psychomotor | Proficiency |
| Wu, Wheaton, and Cannella-Malone (2016) | USA | EX | ID & DF | AHT | NS | Daily living skills | SEL | 4 | NS | HS | Learning Design | VP<br>• Pre-training<br>• Prompting (SLP)<br>• Activity schedule | All participants successfully acquired a variety of independent living skills using video prompting. All participants were able to follow novel activity schedules for a minimum of one week, and one participant was able to follow the schedule for 4 weeks. | Psychomotor | Transfer/ Proficiency (novel setting & stimuli) |
| Young-Pelton et al. (2015) | USA | EXP | EBD | LHT | 300 (10 x 30) | Reading instruction | ENG | 4 | 100% M | EL | Learning Design | VSM<br>• role play | Results indicated VSM was an effective intervention for increasing active learning responses and behaviors and for reducing behavioural difficulties during reading instruction. | Affective | Acquisition (8 weeks) |
| Yousefzadeh & Salimi (2015) | Iran | QE | FC | SSC | NS | English, Science, Arabic, Maths, Geography | STEM | 50 | NS | MS | Learning Design | FC<br>• In class: active & collaborative learning activities | Student average scores of achievements in FC were higher than those in TC. Students enjoyed the intervention. | Cognitive | Recall / Transfer |
| Yung and Paas (2015) | Taiwan | EX | NS | AD | NS | Cardiovascular system | STEM | 133 | 49% F | MS | Video Design | Signalling (via pedagogical agent - animated instructor, gestures, waving hands and pointing to words to focus the attention) | The results indicated that cueing by the pedagogical agent (avatar) had a positive effect on learning performance and instructional efficiency. | Cognitive | Recall |
| Zainuddin (2018) | Indonesia | QE | FC | INU | NS | Science | STEM | 56 | NS | HS | Learning Design | FC<br>• Planning Framework: SDT<br>• Before class: active learning activities and gamification with video<br>• In class: active & collaborative learning activities and gamification | The gamified flipped class (GFC) fostered better intrinsic motivation and engagement because of the pre-class activities, pre-class competition, student learning autonomy and students' social engagement. | Cognitive & Affective | Recall |

| Authors and Year | Location | Method | Special Groups | Video Type | Duration (sec) | Topic | Domain | Population | Gender | Level | Factors Category | Factors Explained | Impact | Impact Category | Learning Measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zisimopoulos, Sigafoos, and Koutromanos (2011) | Greece | EX | ID | AHT | 4s - 29s | Internet Skills | HUMS | 3 | 33% F | MS | Learning Design (LD), Video Design (VD) | LD (VP + error correction)<br>VD (time delay + segmentation + CTD) | Video prompting was effective in promoting rapid acquisition of internet skills for students with an intellectual disability. | Psychomotor | Transfer/ Proficiency (novel stimuli) |
| | | | | | | | | 10581 | | | | | | | |
| | | | ADHD (attention deficit hyperactivity disorder)<br>ASD (autism spectrum)<br>ESB (emotional behavioural disorder)<br>DF (deaf students)<br>DS (disability general)<br>ESL (english second language)<br>FC (flipped classroom)<br>HPS (high performing students)<br>ID (intellectual disability)<br>ODD (oppositional defiance disorder)<br>NS (not sure) | | | | | | *average of multiple experiments | | | CLT (cognitive load theory)<br>CTD (continuous time delay)<br>CTML (cognitive load theory of multimedia)<br>CVM (continuous video modelling)<br>FC (Flipped Classroom)<br>LC (learner control)<br>LD (learning design)<br>SCLT (student-centered learning theory)<br>SDT (self determination theory)<br>SLP (system of least prompts)<br>VD (video design)<br>VP (video prompting)<br>VM (video modelling)<br>WE (worked example) | | | |

# Appendix C

From: A Framework of Effective Science Explanation Videos Informed by Criteria for Instructional Explanations

| Factors | Feature | Description |
|---|---|---|
| Structure | 1. Rule-example, example-rule | If the learning goal is factual knowledge, the video follows the rule-example structure |
| | | If the learning goal is a routine or procedural knowledge, the video follows the example-rule structure |
| | 2. Summarising | The video summarises the explanation |
| Adaptation | 3. Adaptation to prior knowledge, misconceptions and interest | The video adapts the explanation to a well-described group of addresses and their potential knowledge, misconceptions or interests. To do so, it uses the 'tools for adaptation' |
| Tools for adaptation | 4. Examples | The video uses examples to illustrate a principle |
| | 5. Analogies and models | The video uses analogies and models that connect the new information with a familiar area |
| | 6. Representation forms and demonstrations | The video uses representation forms or demonstrations |
| | 7. Level of language | The video uses a familiar level of language |
| | 8. Level of mathematization | The video uses a familiar level of mathematization |
| Minimal explanation | 9. Avoiding digressions | The video focuses on the core idea, avoids digressions and keeps the cognitive load low. In particular, it avoids using too many 'tools for adaptation' or summaries |
| | 10. High coherence | The video connects sentences with connectors, especially 'because' |
| Highlighting relevancy | 11. Highlighting relevancy | The video highlights explicitly why the explained topic is relevant to the explainee |
| | 12. Direct addressing | The explainee is getting addressed directly, e.g. by using the second-person singular instead of the passive voice |
| Follow-up learning tasks | 13. Follow-up learning tasks | The video describes learning tasks the explainees can engage with to actively use the new information after the video |
| New, complex principles | 14. New, complex principle | The video focuses on a new science principle that is too complex to understand by self-explaining, e.g., because there are frequent misconceptions |

*Kulgemeyer, C. (2018). A framework of effective science explanation videos informed by criteria for instructional explanations. *Research in Science Education,* 1-22. https://doi.org/10.1007/s11165-018-9787-7.

# Appendix D

## Video Design

| | Total | Fail | EL | MS | HS | Principle*** | Definition*** | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | **Extraneous Processing Principles** | | |
| 1 | 3 | | | 1 | 2 | Coherence*/** | Only instructional material directly related to the key learning goal should be included. | Kulgemeyer (2018); Saecker et al. (2010); Shen et al. (2006) |
| 2 | 4 | | | 3 | 1 | Signalling*/** | Important information should be highlighted to learners | Boucheix and Guignard (2005); de Koning et al. (2011) Spanjers et al (2012); Yung and Paas (2015); ChanLin (2001) |
| 3 | 3 | 3 | | 1 | 2 | Redundancy* | Written text should not be added when narration is present | Adegoke (2010); Lin et al. (2015); Roscoe et al. (2015) |
| 4 | | | | | | Spatial Contiguity* | Related elements should be presented in close physical proximity on the screen (also called split attention) | |
| 5 | | | | | | Temporal Contiguity* | Related elements (eg. narration and visuals) should be presented at the same time | |
| 6 | 8 | | | 6 | 2 | Segmenting*/** | Longer videos should be broken into meaningful chunks | Spanjers et al. (2012); Chang (2017); Hasler et al (2007); Kay & Edwards (2012); Leahy & Sweller (2016); Szpunar et al., (2014), Van der Meij, (2017); Zisimopoulous et al (2011), Wong et al (2012) |
| 7 | | | | | | Background music | Avoid including distracting background music | |
| 8 | | | | | | Audio Quality | Audio should be clear, with no distracting hissing or interference | |
| 9 | 4 | | | 3 | 1 | Video Length Reduction ** | Shorter videos are more effective than long ones | Atwa et al. (2016); Canella-Malone et al (2011); Kay & Edwards (2012); Slemmons et al. (2018) |
| 10 | | | | | | Perspective (1st superior) | Videos shot from the learner's perspective are more effective than third person perspective | |
| 11 | | | | | | Presenter's face | Avoid including the presenter's face when alternative visuals are displayed | |
| 12 | | | | | | Sound Effects | Avoid including sound effects | |
| | | | | | | **Essential Processing Principles** | | |
| 13 | 9 | | 2 | 3 | 4 | Pre-Training* | Learner's should be introduced to key names and characteristics before the lesson | Boster et al. (2006); Canella-Malone et al, (2013); Ozkan (2013); Reiber (1991); Van Laarhoven and Van Laarhoven-Myers (2006); Wu et al., (2016) |
| 14 | | | | | | Modality* | Use spoken narration rather than written text | Leahy and Sweller (2016); Lin et al. (2015); Saecker et al. (2010) |
| 15 | | | | | | Multimedia* | Use words and pictures rather than words alone | |
| 16 | | | | | | Speech Rate (Fast superior) | Speech rate should be faster than conversational speaking rate | |
| 17 | 4 | | | 4 | | Transience | Video loses advantages over static media when too much information is presented too quickly | Boucheix and Forestier (2017), Boucheix and Guignard (2005); Leahy and Sweller (2016); Wong et al. (2012) |
| 18 | 1 | | | 1 | | Worked Example | Include completed guidance/examples when solving problems/learning skills | Kay and Edwards (2012) |
| 19 | 5 | | | 4 | 1 | Learner Control | Students should be given control over playback | Marbach-Ad et al (2008); Chien & Chang, (2012); Leahy & Sweller (2006); Lin et al (2015); Hasler et al (2007); Kay & Edwards (2012); Arnone & Grabowski (1992); Cannella-Malone, Brooks, & Tullis, (2013); Cihak et al., (2010) |
| 20 | 2 | | | 1 | 1 | Reviews | Videos should end with a summary of the content | Kulgemeyer (2018), Van der Meij (2017) |
| | | | | | | **Generative Processing Principles** | | |

## Video Design

| | Total | Fail | EL | MS | HS | Principle*** | Definition*** | |
|---|---|---|---|---|---|---|---|---|
| 21 | | | | | | Personalisation* | Narrations should use first/second person conversational speech | |
| 22 | | | | | | Voice Principle* | Narrations should be recorded in a human voice rather than synthesised, machine voice | |
| 23 | 4 | | 1**** | 3 | | Embodiment Principle*/** | Videos should include human movement/gestures, such as showing hands when assembling | Cook et al. (2016); Yung and Paas (2015) Uzun & Yildirim (2018) |
| 24 | 1 | | | 1 | | Guided Discovery* | Interface should provide hints and feedback as learner solves problems | Chang (2017) |
| 25 | | | | | | Self-Explanation* | Videos should prompt students to explain the learning goal to themselves | de Koning et al. (2011); Lin et al. (2015) |
| 26 | | | | | | Drawing* | Leaners should be encouraged to draw the learning goals | |
| 27 | | | | | | Dialogue | Videos that show dialogue between an instructor and learner outperform straight declarative videos | |
| 28 | 1 | | 1 | | | Emotional Design | Warm, high saturation colours and anthropomorphisms should be used in videos | Uzun and Yildirim (2018)***** |
| 29 | | | | | | Misconceptions | Conceptual videos should dispel common misconceptions at the start | |
| 30 | 1 | | | | 1 | Integrated Learning Activities** | Integrate practice activities, either during pauses in the presentation or following the video | Szpunar and Schacter (2014) |
| 31 | 1 | | | 1 | | Interactivity | Videos that include learner controllable content outperform standard playable video | Chang (2017); Fernstermacher et al. (2006) |
| 32 | 1 | | | 1 | 1 | Storytelling | Videos should include storytelling elements and real world examples to help explain concepts and procedures | Galloway, Collins, Knight, and Bausch (2013) |

* Mayer (2014) principles

** Principles Identified by Fyfield et al (2021) to have the most support in the literature

*** Fyfield et al (2022)

**** Cook et al (2016) conducted their study in both EL & MS classes

***** Included as the embodiment principle

| | |
|---|---|
| EL | Elementary (P/K-4) |
| MS | Middle School (5-8) |
| HS | High School (9-12) |
| Fail | Failed experiment |