Exploring Video Lecture Effectiveness for Elementary STEM Education: Instructor Presence, Video Quality, and Student Perceptions

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Abstract **– This research aims to investigate the impact of instructor presence and video quality on student outcomes in elementary STEM education. A total of 297 students participated, with 142 exposed to short video lectures and 155 to long video lectures. Google Form was used to collect opinions about video lecture effectiveness, satisfaction, and usage. Structural equation modeling (SEM) was utilized to analyze data. Empirical evidence showed a significant positive correlation between instructor presence, video quality, and student outcomes in the short video lecture group. However, one hypothesis was rejected, suggesting other factors influencing outcomes. In contrast, the long video lecture group confirmed only three hypotheses, suggesting a weaker relationship. The findings underscore the significance of addressing both factors when creating and delivering video lectures in elementary STEM education. The impact of these factors varies depending on the length of the video lectures, suggesting different approaches may be required. Continued research is called for to identify various factors that contribute to student outcomes in video lectures.**

Keywords **– E-learning, instructor presence, student perceptions, video lectures, video quality.**

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1. Introduction

The world has witnessed a rapid transformation in the field of education, as digital technologies have revolutionized traditional approaches to teaching and learning [1], [2], [3]. In particular, the COVID-19 pandemic has compelled many universities worldwide to move to online environment, further accelerating the adoption of digital tools [1], [4], [5]. While this has brought many benefits [5], [6], [7] such as increased flexibility and access to educational resources, it has also highlighted challenges, particularly for teachers and students in developing countries where language barriers and lack of resources can hinder effective learning [6], [8], [9]. One such challenge is the availability of online video content, which could be considered as crucial tool for increasing students' participation and understanding [6], [10].

Much of existing work has been devoted to creating video lectures for online learning on various platforms such as YouTube, Facebook, Coursera, etc. However, most online videos are in English, which is not the native language for many students and teachers in developing countries [6], [11]. This can hinder their ability to access and benefit from such resources [12]. In addition, while some videos have captions generated by artificial intelligence (AI), these captions may not always be accurate or helpful for non-native speakers [13]. Moreover, while there are various online learning platforms available, many require payment for access to courses, making them an unfeasible option for teachers and students in developing countries with limited financial resources [14].

Furthermore, the availability of high-quality video content that aligns with the current syllabus and educational reform is limited, leaving teachers with no option but to create their own video content [15].

This has led to discussions on the ideal length of videos for effective learning, with some arguing for shorter videos that are more engaging and can hold student attention, while others advocate for longer videos that provide more in-depth information [16], [17], [18]. Various research explored the effectiveness of video lectures on student learning outcomes in various contexts, including higher education [6], [19], [18], K-12 education [20], and teacher training programs [21]. However, few studies have focused on the impact of instructor presence and video quality on student outcomes in the context of short and long video lectures.

Against this backdrop, the present study aims to investigate the impact of instructor presence and video quality on student outcomes in the context of short and long video lectures. Specifically, it aims to compare the effectiveness, satisfaction, and usage of short and long videos, considering the role of instructor presence and video quality. In other words, the current study tries to answer the two main research questions:

RQ1: How do instructor presence and video quality influence the effectiveness, satisfaction, and usage of video lectures in elementary STEM education?

RQ2: To what extent do the relationships between instructor presence, video quality, and student outcomes differ between short and long video lectures?

As far as it is known, no previous study has explored the impact of instructor presence and video quality in the context of short and long video lectures, particularly in the context of developing countries where resources and language barriers are prominent issues. This study significance lays its ability to shed light on the optimal design and delivery of video lectures that can enhance student outcomes, particularly in the wider context. The study also contributes to the growing body of research on digital transformation in education, revealing insights into the role of digital tools in enhancing the effectiveness and accessibility of education for all. These results may have practical implications for educators, decision-makers, and educational institutions seeking to design and deliver effective online learning experiences. In summary, this study addresses a critical gap in the literature and aims to provide insights into the impact of instructor presence and video quality on student outcomes with respect to short and long video lectures.

2. Literature Review and Hypothesis Development

This section reviews the existing literature on video lectures, highlighting factors such as instructor presence, video quality, and video length, and their influence on learning outcomes. Based on these insights, hypotheses are developed to guide the current study.

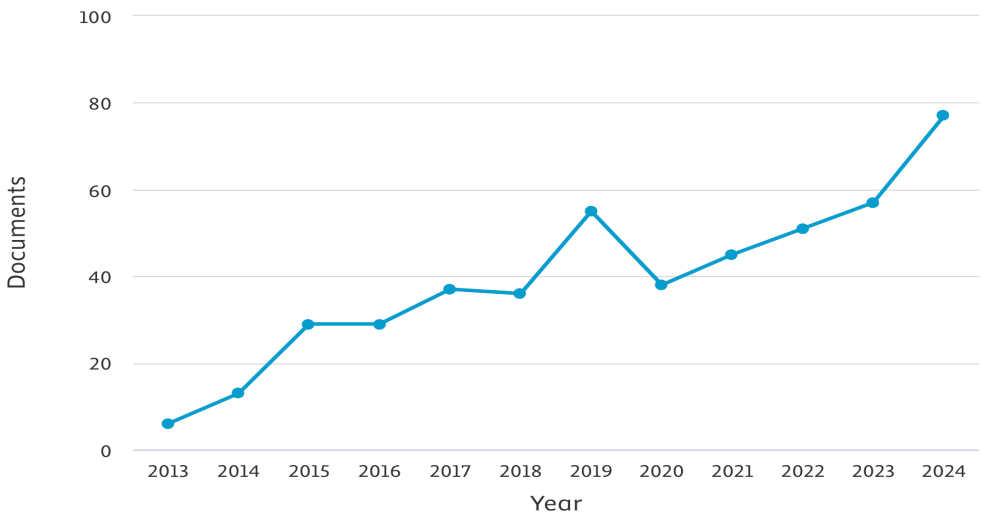

Figure 1. Publications related to video lectures from Scopus database

The rapid development of technology has greatly influenced the education sector, with digital transformation modifying the ways of educating. Specially, the COVID-19 has led to the widespread adoption of online teaching, resulting in an increased demand for digital learning resources, such as video lectures.

Figure 1 illustrates the progression of research on video lectures that have received significant attention from 2013 to 2024. It can be seen that the emergence of video-based content had been observed since 2020 and sudden increased in 2023.

However, the availability and quality of such resources may vary significantly, especially in developing countries where English is not widely spoken.

Many studies have investigated the effectiveness of video lectures in enhancing student learning outcomes. For instance, research [22] revealed that video lectures can significantly enhance student engagement and academic performance, especially when combined with other active learning strategies such as attending on time and maintaining active webcams. Similarly, a study [15] reported that video lectures can aid students' comprehending of complex mathematics ideas and strengthening their problem-solving proficiency. These findings imply that video lectures can be an effective media for teaching and learning. However, the effectiveness of video lectures can be impacted by an array of factors (e.g., the quality of the videos, the presence of the instructor, and the length of the videos). In terms of video quality, research has shown that high-quality videos with clear visuals and audio can significantly enhance students' learning outcomes [23]. In contrast, low-quality videos and poor audio and visuals can negatively impact student learning and engagement [24]. Moreover, instructor being visible in the video lectures can also impact student learning outcomes [25], [26]. Research showed that instructor presence, in the form of verbal and nonverbal cues, can enhance students' engagement and motivation to learn [26]. According to [26], students demonstrated greater motivation when the video lecture included the instructor as opposed to only slides and audio. The study also revealed that having the instructor appear on the right side in the video led to the highest levels of learning performance and satisfaction. Another important factor to consider is the length of the video lectures. While some studies have reported that shorter videos are more effective in enhancing student learning outcomes [16], [17], others found no notable difference variation in learning outcomes between short and long videos [27]. Nonetheless, it is worth noting that the optimal video length may differ based on the subject matter and the students' prior knowledge and learning styles [27].

In addition to these factors, the availability and relevance of digital learning resources can also impact their effectiveness.

For instance, some studies have found that outdated and irrelevant digital resources can negatively impact student's learning outcomes [24], [28]. Therefore, it is important for teachers to create or select digital resources that are up-to-date and relevant to the students' learning goals and objectives. Moreover, the accessibility of digital learning resources can also impact their effectiveness, especially in developing countries where access to technology and the Internet may be limited. For instance, students in developing countries face various challenges in accessing digital learning resources, such as lack of the Internet connectivity and a shortage of computers and smartphones [29]. Therefore, educators should take into account the accessibility of these digital resources when designing courses and choosing learning materials. Derived from the aforementioned literature studies, the following assumptions were made and evaluated in the current study:

- H1. Instructor presence has a positive effect on video quality.
- H2. Instructor presence has a positive influence on video lecture effectiveness.
- H3. Video quality has a positive impact on video lecture effectiveness.
- H4. Instructor presence positively affects video lecture satisfaction.
- H5. Video quality has a significant influence on video lecture satisfaction.
- H6. Instructor presence has a positive impact on video lecture usage.
- H7. Video quality has a positive effect on video lecture usage.

The conceptual model presented in Figure 2 was developed based on the assumptions that guided this study. The relationships between the constructs are represented by arrows and supported by 7 hypotheses (labeled 1 to 7).

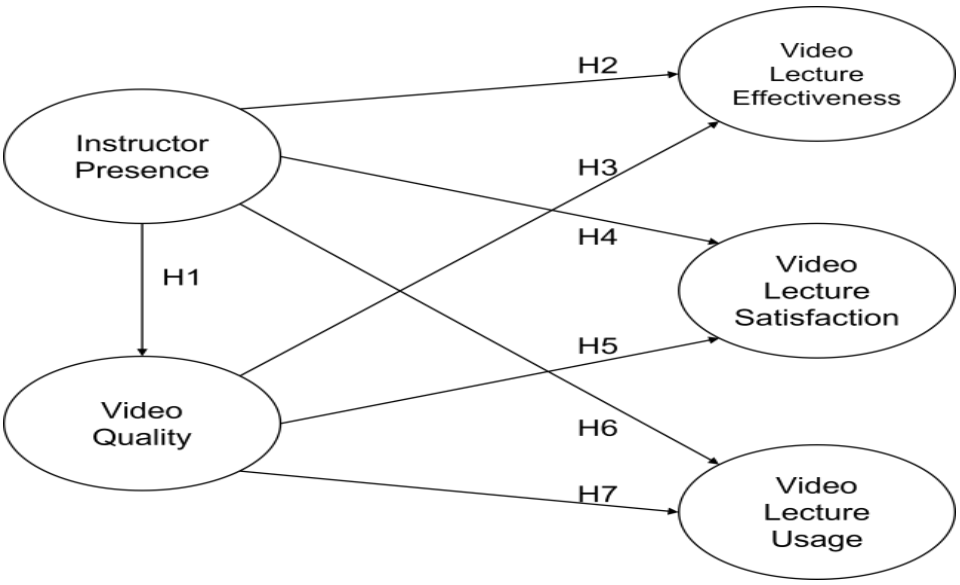

Figure 2. The proposed conceptual model

3. Materials and Methods

This section describes the experimental setup, participant demographics, data collection methods, and analytical techniques employed to evaluate the impact of instructor presence and video quality in short and long video lectures.

3.1. Experiment Design

A total of 301 primary students were recruited for the study, drawn from six class sessions that were all taught by the same teacher and focused on the same subject. Of the total participants, 142 students received short video lectures while the remaining 155 students received long video lectures. Due to their lack of attendance throughout the semester, four students were excluded from the study. The participants were chosen through a purposive sampling method, with the selection criteria being enrollment in courses that required video lectures during the semester. Participants were informed about the study through their course instructors and were given the option to opt-out if they did not wish to participate.

3.2. Sample and Data Collection

All participants were given access to the video lectures through YouTube channel. The short video lectures ranged from 10 to 20 minutes, while the long video lectures ranged from 21 to 50 minutes. Both types of video lectures were recorded by the same instructor using the same equipment and uploaded to YouTube.

The short video lectures focus solely on the primary content of the topic at hand, while redundant information is presented at twice the speed.

In contrast, the lengthy video lectures provide a more detailed explanation of the same content at a normal pace.

Fourteen video lectures, comprising of seven short and seven long lectures, were created for the experiment. Each video lecture focuses on one chapter of the syllabus.

At the conclusion of the semester, all participants were invited to complete a digital poll via Google Form. The questionnaire consisted of 17 items related to their perceptions of the video lectures, including effectiveness, satisfaction, and usage. The Likert scale was used for response choices, spanning from strongly disagree to strongly agree. Respondents were also asked to rate the instructor presence and video quality on a Likert scale from poor to excellent. The questions used in the study were adapted from previous research [29] and then customized to align with the specific setting of the current study. The survey was administered in the native language of the participants to ensure comprehension and reduce language barriers.

3.3. Data Analysis and Evaluation

To validate the assumption model, this study used the variance-based structural equation modeling technique (GSCA), that allows for the evaluation of both formative and reflective latent variables [30]. The technique has been applied to a variety of domains [31], [32] and has proven to be particularly useful in the analysis of complex models with multiple dependent variables.

It can be used to model both, construct-defining and construct-representing variables, offering a deeper examination of the connections among different constructs [30].

In addition, GSCA has been shown to be especially advantageous in scenarios where conventional structural equation modeling techniques may not be appropriate, for instance, when the data do not meet Gaussian assumptions or there is not enough data for estimation [30]. GSCA uses resilient estimation methods to mitigate these challenges, making it a versatile and effective approach for analyzing intricate data sets. The results produced by GSCA consist of model weights, including "factor loadings, path coefficients, and error variances". These estimates help in testing assumptions concerning the connections between the construct-defining and construct-representing variables.

4. Results

This section presents the key findings of the study, including the relationships between instructor presence, video quality, and video lecture outcomes, as analyzed using structural equation modeling.

Table 1 presents the estimates of loadings for each construct in the study. Loadings indicate the degree of association between the observed and the underlying latent variables. The estimates range from 0.715 to 0.951 for instructor presence, 0.832 to 0.951 for video quality, 0.81 to 0.915 for video lecture effectiveness, 0.853 to 0.864 for video lecture satisfaction, and 0.866 to 0.9 for video lecture usage. Overall, the loadings appear to be relatively strong, with all estimates exceeding 0.7 [33]. This indicates that the observed variables are good indicators of their respective constructs.

Table 1. Estimate of loadings

Construct	Indicator	Short Estimate	Long Estimate	95% CI (Short)	95% CI (Long)
Instructor Presence (IP)	IP1	0.715	0.648	[0.53, 0.813]	[0.125, 0.875]
	IP2	0.758	0.715	[0.615, 0.839]	[0.53, 0.900]
	IP3	0.843	0.689	[0.779, 0.893]	[0.457, 0.920]
Video Quality (VQ)	VQ1	0.933	0.794	[0.902, 0.958]	[0.729, 0.859]
	VQ2	0.832	0.808	[0.77, 0.882]	[0.762, 0.923]
	VQ3	0.837	0.834	[0.766, 0.891]	[0.783, 0.883]
	VQ4	0.951	0.842	[0.919, 0.970]	[0.762, 0.904]
Video Lecture Effectiveness (VE)	VE1	0.81	0.814	[0.722, 0.878]	[0.758, 0.863]
	VE2	0.915	0.672	[0.876, 0.942]	[0.583, 0.761]
	VE3	0.870	0.820	[0.788, 0.917]	[0.740, 0.885]
	VE4	0.855	0.787	[0.759, 0.933]	[0.709, 0.839]
Video Lecture Satisfaction (VS)	VS1	0.862	0.829	[0.816, 0.902]	[0.732, 0.873]
	VS2	0.864	0.746	[0.776, 0.906]	[0.648, 0.819]
	VS3	0.853	0.773	[0.766, 0.905]	[0.669, 0.843]
Video Lecture Usage (VU)	VU1	0.866	0.937	[0.782, 0.907]	[0.903, 0.958]
	VU2	0.900	0.915	[0.854, 0.928]	[0.875, 0.939]
	VU3	0.884	0.878	[0.831, 0.909]	[0.808, 0.911]

Table 2 shows the construct quality measures for each variable in the study. The PVE (Proportion of Variance Explained) values indicate the amount of variation in the collected variables that can be elucidated by the underlying construct. The PVE values for all dimensions are high (above the recommended threshold of 0.5 for all variables [33], ranging from 0.537 to 0.828, indicating that the selected measures are adequate in capturing the variability of the constructs. The Alpha values indicate the internal consistency of the constructs, or the degree to which the items in the constructs are measuring the same underlying construct.

The Alpha values for all dimensions are high (above the recommended threshold of 0.7 [33] except for instructor presence (0.69) in the short group and video lecture satisfaction (0.695) in the long group, ranging from 0.69 to 0.912, which indicates that the constructs have high internal consistency. The rho values indicate the reliability of the constructs, or the degree to which the constructs are stable over time and across different samples. The rho values for all dimensions are high, spanning from 0.75 to 0.938 [33], implying that the constructs are reliable.

Table 2. Construct quality measures

Construct	Metric	Short Video	Long Video
Instructor Presence	PVE	0.599	0.537
	Alpha	0.690	0.883
	Rho	0.817	0.750
Video Quality	PVE	0.792	0.703
	Alpha	0.912	0.859
	Rho	0.938	0.904
Video Lecture Effectiveness	PVE	0.745	0.594
	Alpha	0.886	0.776
	Rho	0.921	0.854
Video Lecture Satisfaction	PVE	0.739	0.614
	Alpha	0.824	0.695
	Rho	0.895	0.826
Video Lecture Usage	PVE	0.780	0.828
	Alpha	0.859	0.896
	Rho	0.914	0.935

The provided results in Table 3 were obtained through structural equation modeling (SEM) and were presented in terms of standardized regression coefficients with their corresponding standard errors, as well as the lower (LB) and upper (UB) thresholds of their 95% statistical intervals. The results indicate that for the short video lecture group, there is a notable positive correlation between instructor presence and video quality, and video lecture effectiveness, satisfaction, and usage. Specifically, the factor loadings for instructor presence → video quality (H1) and instructor presence → video lecture effectiveness (H2) are 0.523 (SE=0.066, 95% CI: 0.373 → 0.645) and 0.322 (SE=0.090, 95% CI: 0.156 → 0.505), accordingly. Additionally, the factor loadings for video quality → video lecture effectiveness (H3), video quality → video lecture satisfaction (H5), instructor presence → video lecture usage (H6), and video quality → video lecture usage (H7) are 0.364 (SE=0.100, 95% CI: 0.174 to 0.523), 0.374 (SE=0.086, 95% CI: 0.189 to 0.529), 0.321 (SE=0.096, 95% CI: 0.155 to 0.531), 0.353 (SE=0.096, 95% CI: 0.173 to 0.522), respectively. Although the hypothesis that including the instructor → satisfaction with the video lectures (H4) was proposed, it was not validated due to zero values appearing in the statistical intervals.

Table 3. Path coefficients

Path	Short (Estimate, 95% CI)	Long (Estimate, 95% CI)
Instructor Presence → Video Quality (H1)	0.523 [0.373, 0.645]	-0.068 [-0.159, 0.255]
Instructor Presence → Video Lecture Effectiveness (H2)	0.322 [0.156, 0.505]	0.036 [-0.312, 0.177]
Video Quality → Video Lecture Effectiveness (H3)	0.364 [0.174, 0.523]	0.464 [0.303, 0.597]
Instructor Presence → Video Lecture Satisfaction (H4)	0.160 [-0.090, 0.313]	0.035 [-0.163, 0.178]
Video Quality → Video Lecture Satisfaction (H5)	0.374 [0.189, 0.529]	0.302 [0.127, 0.494]
Instructor Presence → Video Lecture Usage (H6)	0.321 [0.155, 0.531]	-0.187 [-0.396, 0.032]
Video Quality → Video Lecture Usage (H7)	0.353 [0.173, 0.522]	0.356 [0.200, 0.499]

However, as for the long video lecture group, the relationship between instructor presence and video quality is weaker and less consistent, and only the factor loadings for video quality → video lecture effectiveness (0.464, SE=0.075, 95% CI: 0.303 → 0.597), video quality → video lecture satisfaction (0.302, SE=0.094, 95% CI: 0.127 → 0.494) and video quality → video lecture usage (0.356, SE=0.076, 95% CI: 0.2 → 0.499) are significant.

All other factor loadings for instructor presence and video quality in the long video lecture group are not significant, indicating that other latent variables might contribute more substantially in promoting effective learning outcomes for longer lectures.

Furthermore, the results indicate that video quality is an important factor for both short and long video lectures, with significant positive relationships between video quality and video lecture effectiveness, satisfaction, and usage.

Specifically, the factor loadings for video quality → video lecture effectiveness, video quality → video lecture satisfaction, and video quality → video lecture usage are 0.364 (SE=0.100, LB: 0.174, UB: 0.523), 0.374 (SE=0.086, LB: 0.189, UB: 0.529), and 0.353 (SE=0.096, LB: 0.173, UB: 0.522), respectively.

5. Discussion

This section interprets the results in the context of prior research, discussing theoretical and practical implications for designing video lectures to optimize learning outcomes.

The provided results from the study conducted through structural equation modelling (SEM) indicate that instructor presence and video quality significantly influence video lecture effectiveness, satisfaction, and usage for short video lectures. However, the relationship between instructor presence and video quality is weaker and less consistent for long video lectures, and other factors may play a more significant role in promoting effective learning outcomes for longer lectures.

Comparing these results with previous research, it is consistent with prior studies that have identified video quality as an important factor in promoting effective learning outcomes [23]. The study also provides additional insights into the importance of instructor presence, which was observed to have positive correlation with engagement and satisfaction in previous studies [25], [26]. However, the finding that the relationship between instructor presence and video quality is weaker for long lectures is unexpected and warrants further investigation. One possible explanation for this unexpected finding could be related to the attention span of learners, which may decrease over time for longer lectures. In this case, the role of the instructor presence may become less important, and other factors such as the design of the lecture or the pace of the delivery may become more significant in promoting effective learning outcomes [24], [17].

The results discussed above have both theoretical and practical implications for the use of short and long video lectures in promoting effective learning outcomes in online courses. From a theoretical perspective, the study provides evidence of the significant positive relationships between instructor presence, video quality, and video lecture effectiveness, satisfaction, and usage. This evidence is in agreement with prior research indicating the importance of these factors in promoting effective learning outcomes in online courses. However, the study also indicates that the relationship between instructor presence and video quality may be weaker and less consistent for longer lectures, hinting that alternative latent variables may carry out more weight in promoting effective learning outcomes for longer lectures.

From a practical standpoint, the evidence signifies the value of ensuring high-quality video lectures that incorporate instructor presence, particularly for short video lectures. Online course designers and instructors should focus on creating video lectures that effectively convey the instructor's presence and provide high-quality visual and audio content to enhance the learning experience. The study also suggests that efforts to improve video quality may have positive effects on video lecture effectiveness, satisfaction, and usage for both short and long lectures. Moreover, the study's finding that instructor presence was not significantly related to satisfaction with video lectures in the short video lecture group highlights the need for further investigation into factors that influence students' satisfaction with video lectures. This finding indicates that there may be other factors, such as course design or student engagement, that have a greater impact on student satisfaction with video lectures [24], [23]. Therefore, instructors and course designers should consider these additional factors when developing and delivering online courses. Overall, the theoretical and practical implications of the study suggest that online course designers and instructors should focus on creating high-quality video lectures that effectively convey the instructor's presence, particularly for short video lectures. Additionally, efforts to improve video quality may have positive effects on video lecture effectiveness, satisfaction, and usage for both short and long lectures.

The current research posed several constraints that must be acknowledged when understanding the outcomes. Firstly, samples were drawn from one university, which may affect the generalizability of the conclusions. It is possible that the results may not apply to other populations or educational settings, as student attitudes and behaviours may vary across different contexts [34]. Secondly, the study made use of self-report instruments to collect data, which could introduce skewed data and imprecision. For instance, students might provide socially desirable responses or may have difficulty accurately assessing their own learning and engagement. Additionally, self-report measures may not fully capture the complex nature of student experiences in online learning environments. Thirdly, the study overlooked controlling for other latent variables that could affect student engagement and satisfaction, such as prior knowledge, learning styles, and external factors like technology access and support. These variables may interact with the factors studied in the current research and impact the results. Finally, the study utilized a cross-sectional approach, restricting the potential to deduce cause-and-effect relationships between the variables studied.

Longitudinal or experimental approaches would offer more robust support for establishing causal relationships and allow for the examination of how these relationships change over time. Overall, while the current study provides valuable insights into student experiences in watching video lectures, the limitations should be considered when interpreting the results and planning future research.

To further improve this study, it is recommended to increase the sample size to enhance the generalizability of the findings. Additionally, future work could use a longitudinal design to examine the prolonged outcomes of the investigated variables on student learning outcomes. Furthermore, it would be beneficial to include other variables such as student motivation and engagement, prior knowledge, and learning styles, as these variables may also influence the effectiveness of video lectures. Researchers could also conduct a comparative study between different modes of online instruction, such as synchronous versus asynchronous, to explore their impact on student learning outcomes. Lastly, it would be useful to investigate the effectiveness of video lectures across different disciplines and academic levels, as the results may differ based on the subject area and student characteristics.

6. Conclusion

The study investigated the relationship between instructor presence, video quality, and video lecture outcomes with respect to short and long video lectures. The findings of the study suggest that the presence of the instructor has a significant positive effect on video quality, video lecture effectiveness, satisfaction, and usage in short video lectures. However, the relationship between instructor presence and video quality is weaker and less consistent in long video lectures, and other elements might have greater influence in promoting effective learning outcomes. Furthermore, the study highlights the importance of video quality in both short and long video lectures, with significant positive relationships between video quality and video lecture effectiveness, satisfaction, and usage. This finding suggests that educators and instructional designers should pay close attention to the quality of video lectures to improve student learning outcomes. Theoretical implications of the study include contributing to the literature on online learning and instructional design by providing insights into the role of instructor presence and video quality in video lectures. Practical implications of the study include providing guidance to educators and instructional designers on how to build and deliver effective video lectures for digital learning.

Overall, the study has important takeaways for the design and delivery of online learning environments, which are becoming increasingly important in today's digital age. The findings can inform the development of best practices for creating effective video lectures that promote student engagement, satisfaction, and learning outcomes.

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