An Approach to Measure the Pedagogy in Slides with Voice-Over Type Instructional Videos

Kushnara Suriyawansa[1], Lochandaka Ranathunga[1], Nuwan Kodagoda[2] and Nor Aniza Abdullah[3]

[1]Department of Information Technology, University of Moratuwa, Katubadda, Sri Lanka

[2]Department of Computer Science and Software Engineering, Faculty of Computing, SLIIT, Malabe, Sri Lanka

[3]Department of Computer System and Technology, Faculty of Computer Science and Information Technology, Universiti Malaya,50603 Kuala Lumpur, Malaysia

198029t@uom.lk
lochandaka@uom.lk
nuwan.k@sliit.lk
noraniza@um.edu.my

Abstract: E-learning provides a more suitable learning environment for educators and learners. Hence, the e-learning community has rapidly increased over the years. At present, e-learning environments use several materials to transfer knowledge to learners. Out of various types of materials, instructional videos have become the prominent source of information in popular e-learning environments. Instructional videos in e-learning can be categorised into many types based on the content presentation method. Voice-over slides are popular instructional videos at present. Since the instructional materials are a key component of an e-learning environment, maintaining the required quality of these materials is vital. Using proper pedagogy in instructional materials mainly enhances the quality. There are many pedagogical principles proposed over the years, and these principles address different features of all instructional materials. Therefore, it is necessary to derive the applicable pedagogical principles based on the features available in the instructional video to analyse the pedagogy in an instructional video. The investigation related to this paper aims to derive an approach to analysing and quantifying the pedagogy in slides with voice-over type instructional videos. In this study, a thorough literature review first identified the pedagogical principles applicable to slides with voice-over type instructional videos. Next, the prominence of the identified pedagogical principles was derived from a Likert-scale survey conducted by several Information Technology undergraduates. The survey response assigned a rank to each identified pedagogical principle. The rank was derived by the mean score obtained for each pedagogical principle. Next, one-way ANOVA tests were performed for the mean score of pedagogical principles to derive their prominence levels. The ANOVA tests were conducted by adding adjacent pedagogical principles with a non-identical rank until the ANOVA results claimed a significant difference in variances. A new level was defined when the ANOVA results showed a significant difference. This study proposed a pedagogical score calculation formula using these levels (derived from the statistical analysis) to derive a qualitative measure of the use of pedagogy in slides with voice-over type instructional videos. The pedagogical evaluators and content developers can use the proposed scoring method to quantify and compare the pedagogy in slides with voice-over instructional videos.

Keywords: Pedagogy, Pedagogical Principles, Pedagogical Analysis, Instructional Videos, Online Learning

1. Introduction

The increased dependency on e-learning has enforced the development of quality e-learning materials. Applying proper pedagogy or teaching methods generally helps improve the quality of any learning material. Thus, focusing on the pedagogical aspects is vital in preparing e-learning materials (Kim and Ko, 2017). Several pedagogical aspects of e-learning environments have been discussed over the years (Hubackova, 2014), which are proposed by focusing on various features of e-learning materials. Hence, a content developer must thoroughly analyse different pedagogical principles and identify the applicable once before implementing them in learning material. Alternatively, there is a difference in the impact level of implementing different pedagogical principles in an instructional video. Implementing a particular pedagogical principle may highly enhance the learning experience, whereas implementing another pedagogical principle may not have much impact on the learning experience. Therefore, a content developer must first focus on the pedagogical principle, which significantly influence on enhancing the learning experience. To achieve this, the content developer must clearly understand the impact level of different pedagogical principles on the quality of an instructional video. In addition, quantifying the application of pedagogical principles and deriving a pedagogical score will aid a content developer in further analysing and comparing the pedagogical implementations in an instructional video.

This study aims to derive a pedagogical standards model for evaluating the pedagogy of instructional videos with presentation slides and voice. Section 2 explains the different studies that have been analysed to identify pedagogical principles which apply to a content-independent pedagogical analysis of presentation slides with voice-type instructional videos. Further analysis of this study used the feedback obtained by undergraduates. They have followed slides with voice-over instructional videos as the primary learning medium to follow semester work during the second quartile in the year 2020. These undergraduates were from all four levels of Information Technology, Software Engineering, Interactive Media, Data Science, Computer System Engineering, Cyber Security, and Information System Engineering.

This study conducted a preliminary literature survey to identify pedagogical principles proposed in different research articles. The identified pedagogical principles were filtered only to select the standards commonly applicable for the domain of selected instructional videos in the study. A set of pedagogical standards were chosen from this literature survey to evaluate the pedagogy of presentation slides with voice-type instructional videos.

Next, the selected pedagogical standards were ranked by considering the result of a survey conducted using the set of undergraduates. The survey was designed to identify the importance of considering the pedagogical standards in presentation slides with voice-type instructional videos. The pedagogical standards model, *Pedaxonomy*, is defined using the ranking derived by analysing survey results. The main intention of the proposed Pedaxonomy model is to provide clear guidance for pedagogy evaluators to evaluate the pedagogy and derive a quantitative measure for the pedagogy in presentation slides with voice-type instructional videos.

2. Research Background

2.1 Popularity of e-learning

The rapid increase of advantages in information technology significantly enhances many fields such as business, health, finance, and education. Education is one of the main fields that have greatly improved by incorporating information technology (Al-fraihat et al., 2020). E-learning, or the learning conducted through electronic media, primarily using the internet, is implementing information technology in education (Welsh et al., 2003). In the study (Zhang *et al.*, 2004) quoted e-learning as the "modern learning in the era of the Internet". Over the years, several research studies have designated the educational advantages of e-learning, using many factors such as the effectiveness of the learning environment, the flexibility of time and resources, cost-effectiveness, higher consistency, and convenience for the learners (Al-fraihat et al., 2020) (Welsh et al., 2003) (Dongsong et al., 2004)(Javier et al., 2020)(Hayashi et al., n.d.)(Docebo, 2016)(Sirisuriya et al., 2018). The global COVID-19 pandemic during the year 2020 further confirmed the importance of e-learning (Agarwal and Kaushik, 2020)(Li, 2020)(Lin and Johnson, 2021). Most countries were locked down during this period, and none of the educational organizations could conduct traditional face-to-face learning. Thus, almost all educational organizations depend on e-learning materials (Gleason, 2021), further proving the prominence of flexibility and effectiveness of e-learning.

2.2 Role of instructional videos in e-learning

E-learning platforms are enriched with multiple learning materials to provide an effective learning environment for the learners. These materials include instructional videos, documented tutorials, presentation slides, forums, quizzes, and games. Out of these many learning materials, instructional videos are crucial in almost all well-known e-learning platforms such as Coursera, Udacity, edX, Khan Academy, etc. The research study by Javier et al. confirms that learning via instructional videos is more effective than learning via traditional face-to-face lectures (Expósito *et al.*, 2020). This study further claims that an instructional video increases learners' motivation, improves their memory and learning potential and offers a higher level of effectiveness through flexibility. The survey of Brecht (Brecht, 2012) shows that the use of instructional videos provides portability and control of learning to the learner, which improves the learning experience and reduces the dropout rates. Another study (Mendoza, Caranto, and David, 2015) shows that instructional videos generate creativity and motivate learners to explore the knowledge. This study also states that instructional videos create a stronger memory for learners, further describing the prominence of instructional videos. Hansch and co-workers (Hansch et al., 2015) confirmed that instructional videos are the primary content delivery method in e-learning environments. This study further discusses how instructional videos can be categorised based on the style or approach used in presenting the content. Some instructional video styles defined in this study are presentation slides with voice-over, talking-head, screencast, animation, conversation, and live videos. Among these

instructional videos, presentation slides with voice-over (also known as PowerPoint-narration) are one of the most popular instructional video styles in e-learning (Chen and Thomas, 2020).

2.3 Pedagogy of instructional videos

Knowledge transfer in an e-learning environment primarily depends on the quality and effectiveness of instructional materials provided in the background. Thus, in an e-learning environment, it is vital to maintain the proper quality of instructional materials to ensure the learners have a practical and smooth learning experience.

There are two key aspects to define the quality of instructional material: *The level of accuracy and relevancy* is one of the quality aspects which depends on the content of instructional material. *The quality level of pedagogy* is the other way of defining the quality of instructional material. Pedagogy can be defined as the techniques used in instructional material to transfer knowledge to the learners efficiently. Over the years, several studies have proved the importance of pedagogy in any learning environment (Hubackova, 2014)(Imbulpitiya, Kodagoda, Gamage, et al., 2019)(Watson, 2005)(Veniegas, 2006)(Mukti et al., 2000)(Seale and Cooper, 2010). These studies have emphasised the importance of proper pedagogy in a learning environment. Pedagogical aspects used in e-learning materials play a vital role in enhancing learners' learning experience. Several pedagogical evaluation techniques have been proposed to measure the pedagogy in a traditional learning environment. The majority of these pedagogical evaluation techniques are applicable to e-learning environments. In addition, few techniques are specifically proposed to evaluate the pedagogy in an e-learning environment (Govindasamy, 2001). Typically, a pedagogical expert must perform a thorough pedagogical evaluation and ensure that the e-learning material is up to adequate pedagogical standards before publishing any e-learning material. An appropriate pedagogical assessment is a challenging and time-consuming task. Thus, providing clear guidance for the pedagogical evaluation of e-learning materials is vital.

3. Analysis of literature on pedagogical principles for slides with voice-over type instructional video

Pedagogy of a learning environment has been a prevalent domain in the learning industry for several years. Over the years, studies have attempted to highlight various aspects of pedagogy. The majority of these pedagogical aspects focus on a traditional classroom learning environment. Pedagogy of the e-learning environment is an upcoming topic that has gained several researchers' attention. As a result, studies have proposed some pedagogical standards to concentrate on the aspects of an e-learning environment specifically. The current research focused on literature, mainly selected by considering the relevance of the proposed pedagogical aspects for slides with voice-over instructional video. Furthermore, the literature analysed in the current study has chosen well-established sources such as Mayer's multimedia principles and Gagne's nine instructions. In addition to these factors, the number of citations for the sources was also noted in selecting the most established literature for the current study.

Richard Mayer's "Multimedia Learning" and "Research-Based Principles for Designing Multimedia Instruction" have defined twelve principles to classify different pedagogical aspects in instructional multimedia content (Mayer, 2009a) (Mayer, 2009b). Most pedagogical standards defined for e-learning materials are based on these twelve principles. Mayer has researched to justify each of the twelve principles to confirm their validity. In (Mayer & Moreno, 2002), Mayer and Morena experimented with these principles, and the statistical analysis of this experiment further claimed the effectiveness of Mayer's multimedia principles. Multimedia principles proposed by Mayer are one of the most popular and well-established pedagogical guidelines for multimedia instructional content. The current study selected the seven best-suited principles for slides with voice-over instructional videos from Mayer's proposed multimedia principles. Other studies have also discussed most of these principles. Many of the other seven studies considered in the current survey discuss the concept of all six principles except the image principle. The Image Principle proposed by Mayer discusses a unique pedagogical aspect of instructional videos.

Robert Gagne's nine instructions are well-known guidance for instructional designing. This guidance mainly focuses on the behaviours of instructions used in a learning environment (Gagne & Wager, 1992). Gagne proposed these instructions in the early 90s when electronic media was not common in a learning environment. Although these instructions are proposed for a traditional learning environment, some selected aspects in these instructions are relevant for the pedagogical aspects in an e-learning environment. The two Gagne's instructions specified in the current study are two main pedagogical concerns in many studies. The signalling principle of

Mayer's principles discusses the same pedagogical aspect as the gaining attention of students. Informing objectives for the learners is similar to the elements discussed in Mayer's pre-training principle. Another study discussed here (i.e., Teoh & Neo, 2007) has also reported that informing the objectives for learners is an essential pedagogical aspect.

Brame's proposed principles for designing instructional videos is one study that discusses several principles in developing compelling instructional videos for learners (Brame, 2016). These principles have focused on different aspects of an instructional video. The first three principles, 3.1, 3.2, and 3.3 (refer to Table 1), are three of the most commonly discussed aspects among eight studies selected for this study. However, this study uniquely presents 3.4, 3.5, and 3.6 principles (refer to Table 1) as critical pedagogical aspects of an instructional video.

In a study (van der Meij & van der Meij, 2013), Hans and Jan have also proposed guidelines for developing instructional videos. This study has derived a set of detailed guidelines by addressing multiple sources in determining instructional quality. Other studies (considered in the literature of the current study) also discuss all five pedagogical aspects addressed in this study.

The online course design checklist of Minnesota State University (Minnesota, 2018) states some prominent pedagogical aspects of e-learning material. These aspects are directly applicable to slides with narration-type instructional videos. The pedagogical aspects of this study aim more at the fonts used in an instructional video. Although maintaining a standard style throughout the video has been discussed in some other studies, this study uniquely proposes the two principles, 5.2 and 5.3 (refer to Table 1).

The literature review (Stemler, 1997) has examined several elements that contribute to the effectiveness of multimedia instructions. This study has reviewed multiple quality aspects of any instructional material in an e-learning environment. Out of the nine pedagogical principles proposed in this study, 6.6 and 6.9 (refer to Table 1) are unique principles that discuss pedagogical aspects that are not captured by other studies considered in this literature review.

The study of Theo and Neo (Teoh & Neo, 2007) identified essential characteristics to maintain a positive mindset towards an online course. Other studies considered in the literature review have discussed all principles proposed in this study. Thus, none of the principles in this study can be claimed as unique pedagogical aspects of an instructional video.

Berk's research study on multimedia teaching with video clips (Berk, 2009) has discussed techniques and guidelines to design effective instructional video clips that can be used as a tool to invoke multiple intelligences in the audience. The pedagogical aspects focused on these techniques are familiar with the pedagogical aspects discussed in other studies of the literature review.

Table 1 presents a summary of pedagogical principles selected for the current study by analysing the aforementioned eight different sources.

Table 1: Pedagogical Principles from the Literature

#	Pedagogical Principle	Source Reference
1.1	Coherence Principle: Eliminating extraneous information provides a better learning experience	(Mayer, 2009a), (Mayer, 2009b), (Mayer & Moreno, 2002)
1.2	Signalling Principle: Organising learning material using a highlighting technique to emphasise important facts will provide an efficient learning environment	
1.3	Redundancy Principle: Having the learner focus on a single presentation through each channel, visual and verbal, will provide an efficient learning environment	
1.4	Pre-training Principle: An initial introduction to names and features of the key concepts in a learning material helps learners focus on the content casually	
1.5	Personalisation Principle: Using conversational style sentences in the learning material helps a learner understand the content easily	
1.6	Voice Principle: Use of a human voice rather than a machine voice provides a more effective learning experience for the learners	

#	Pedagogical Principle	Source Reference
1.7	Image Principle: Avoid using a static image of the speaker on each screen provides a more focusable learning environment for the learners	
2.1	Gain students' attention	(Gagne & Wager, 1992)
2.2	Inform students of the objectives Inform	
3.1	Use a proper signalling mechanism to highlight important information in the content	(Brame, 2016)
3.2	Maintain a short duration for a single video to not more than six minutes	
3.3	Use a conversational language in the video	
3.4	Use an enthusiastic tone and maintain a proper speaking rate in the narration	
3.5	Include interactive questions in the video	
3.6	Avoid using distractive background music	
4.1	Use a human voice for the narration	(van der Meij and van der Meij, 2013)
4.2	Use conversational style for descriptions	
4.3	Provide learners with a set of clear and simple tasks	
4.4	Use a good highlighting technique to emphasise essential facts	
4.5	Control the duration of the videos on average 3 minutes	
5.1	Consistent font sizes and styles throughout the video	(Minnesota, 2018)
5.2	Maintaining sufficient contrast between text and background	
5.3	Consistent design format throughout the video	
6.1	Maintain the simplicity in each screen by presenting only limited information from a single screen	(Stemler, 1997)
6.2	Limit the number of texts on the screen by having a maximum of three lines per screen	
6.3	Use a single font style on a screen	
6.4	Highlight text to emphasise points that require special attention	
6.5	Use a bright colour to highlight important information	
6.6	Use a significant contrast between the background colour and the text colour	
6.7	Use animations to demonstrate points on the screen	
6.8	Make the narration simple and in a conversational style	
6.9	Avoid pausing a screen for a long time for an extended narration to be over	
7.1	Use animations, images, sound effects, text information, and contrasting background colours to gain learner attention	(Teoh and Neo, 2007)
7.2	Dedicate a section to demonstrating objectives	
7.3	Use simple and clear language	
7.4	Explain the point	
8.1	Maintain a short duration without exceeding it to be 3 minutes	(Berk, 2009)
8.2	Use simple language in the context	
8.3	Use a limited number of characters on the screen	

This literature review discovered several pedagogical principles applicable to instructional videos. It was recognised that several studies have commonly discussed some pedagogical principles, such as using proper highlighting techniques to emphasise important factors, controlling the density of information, and using simple language to convey the information. In addition, some studies have also proposed some unique pedagogical aspects to be considered in maintaining the quality of instructional material. In the next stage of this study, the identified pedagogical principles were methodically analysed for designing and developing the Pedaxonomy model.

4. Methodology

4.1 Deriving an integrated and unique pedagogical principles list to analyse the pedagogy of slides with voice-over type instructional video

The literature review of this study identified the pedagogical principles related to instructional videos discussed in several studies. It revealed that multiple sources had discussed some of these identified principles. Thus, as the next step, all recognised pedagogical principles were clustered by considering how the addressed factor of each principle can be applied for a pedagogical analysis of slides with narration-type instructional video. This step aimed to develop a set of unique pedagogical principles by deriving an integrated code for each cluster with similar principles. Figure 1 describes all activities performed in this step.

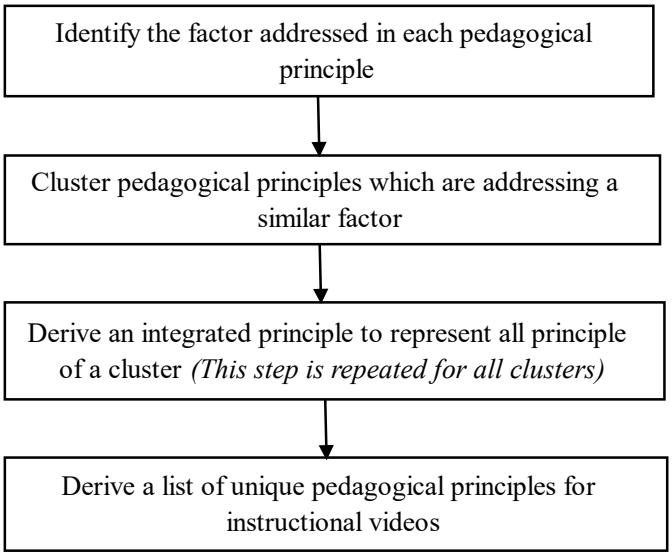

Figure 1: Steps involved in deriving the list of integrated pedagogical standards

Table 2 shows the clustering derived from this step, along with the integrated principle for each cluster. The list of the integrated principles is the list of unique principles derived from this step.

Table 2: Clustering of pedagogical principles and integrated pedagogical principles

Cluster			Integrated Principle
#	Principle	Reference	
1.1	Eliminating extraneous information provides a better learning experience	(Mayer, 2009)	An instructional video has limited content to control the information density at a given time
4.3	Provide learners with a set of clear and simple tasks	(van der Meij and van der Meij, 2013)	
6.1	Maintain the simplicity in each screen by presenting only limited information from a single screen	(Stemler, 1997)	
6.2	Limit the number of texts on the screen by having a maximum of three lines per screen	(Stemler, 1997)	
7.4	Keep the explanation to the point	(Teoh and Neo, 2007)	
8.3	Use a limited number of characters on the screen	(Berk, 2009)	
1.2	Organising the learning material using a highlighting technique to emphasise important facts will provide an efficient learning environment.	(Mayer, 2014)	An instructional video has used proper highlighting to gain the learner's attention and emphasise important information
2.1	Gain the attention of the students	(Gagne and Wager, 1992)	
3.1	Use a proper signalling mechanism to highlight important information in the content	(Brame, 2016)	
4.4	Use a good highlighting technique to emphasise important facts	(van der Meij and van der Meij, 2013)	
6.4	Highlight text to emphasise points that require special attention	(Stemler, 1997)	
6.5	Use a bright colour to highlight important information	(Stemler, 1997)	
1.3	Having the learner focus on a single presentation through each channel, visual and verbal, will provide an efficient learning environment	(Mayer, 2014)	The instructional video uses only one medium to be processed by each channel of the learner at a time
1.4	Providing a prior introduction to names and features of the key concepts in a learning	(Mayer, 2014)	

Cluster			Integrated Principle
#	Principle	Reference	
	material helps learners to focus on the content casually		The instructional video includes a list of objectives to guide the learner at the beginning
2.2	Inform students of the objectives Inform	(Gagne and Wager, 1992)	
7.2	Dedicate a section to demonstrating objectives	(Teoh and Neo, 2007)	
1.5	The use of conversational style sentences in the learning material helps a learner to easily understand the content	(Mayer, 2014)	The instructional video uses simple language and conversational style
3.3	Use conversational language in the video	(Mayer and Moreno, 2002)	
4.2	Use a conversational style for the descriptions	(van der Meij and van der Meij, 2013)	
6.8	Make the narration simple and in a conversational style	(Stemler, 1997)	
7.3	Use simple and clear language	(Teoh and Neo, 2007)	
8.2	Use simple language in the context	(Berk, 2009)	
1.6	Using a human voice rather than a machine voice provides a more effective learning experience for the learners	(Mayer, 2014)	An instructional video has a human voice in narration
4.1	Use a human voice for the narration	(van der Meij and van der Meij, 2013)	
1.7	Avoiding using a static image of the speaker on each screen provides a more focusable learning environment for the learners	(Mayer, 2014)	Instructional video does not include an image of the speaker continuously throughout the content
3.2	Maintain a short duration for a single video to not more than six minutes	(Brame, 2016)	Instructional video does not exceed the duration on which a learner can concentrate continuously
4.5	Control the duration of the videos to average 3 minutes	(van der Meij and van der Meij, 2013)	
8.1	Maintain a short duration without exceeding it to be 3 minutes	(Berk, 2009)	
3.4	Use an enthusiastic tone and maintain a proper speaking rate in the narration	(Brame, 2016)	An instructional video has an appropriate tone and a speaking rate
3.5	Include interactive questions in the video	(Brame, 2016)	The instructional video includes interactive questions
3.6	Avoid using distractive background music	(Brame, 2016)	Instructional video does not contain distractive background music
5.1	Consistent font sizes and styles throughout the video	(Minnesota, 2018)	The instructional video is designed with a consistent style
5.3	Consistent design format throughout the video	(Minnesota, 2018)	
6.3	Use a single font style on a screen	(Stemler, 1997)	
5.2	Maintain sufficient contrast between text and background	(Minnesota, 2018)	The instructional video has used the proper contrast between background and text
6.6	Use a significant contrast between the background colour and the text colour	(Stemler, 1997)	
6.7	Use animations to demonstrate points on the screen	(Stemler, 1997)	The instructional video uses animations, images, and sound effects to gain learners' attention
7.1	Use animations, images, sound effects, text information and contrasting background colours to gain learner attention	(Teoh and Neo, 2007)	
6.9	Avoid pausing a screen for a long time for an extended narration to be over	(Stemler, 1997)	Instructional video does not use the same screen without any change for a long time

A list of integrated unique pedagogical principles was defined as the result of this step to analyse the pedagogy of slides with voice-type instructional videos. The next stage of this study is to sort the list of unique pedagogical principles by ranking each item in the list.

4.2 Instrument Design

A survey was conducted using 145 undergraduates following an Information Technology degree to sort the unique pedagogical principles list. These undergraduates were engaged at different levels of diverse computing degree programmes such as Information Technology, Software Engineering, Interactive Media, Data Science, Computer System Engineering, Cyber Security, and Information System Engineering. The institute has used slides with voice-type instructional videos as the main scheme of lecture delivery during the stringent lockdown period due to the Covid-19 pandemic in 2020.

The undergraduates were provided with a survey towards the end of the semester, where they underwent several slides with voice-type instructional videos to learn the content. This survey was designed to determine the effectiveness level by considering the unique pedagogical principles identified. Due to the disparity of the content covered through the subject instructional videos in the survey, the pedagogical principles in the survey were carefully analysed to ensure that all principles focus on content-independent aspects.

4.3 Survey Implementation

The survey was structured using the Likert scale to get the undergraduates' individual opinions regarding the pedagogical principles. See the *Additional Files* section for the questions included in the survey alongside pedagogical principles focused on each question in the survey.

The questions on the survey addressed the aspects focused on the pedagogical principles list. The undergraduates were asked to give their opinion on the importance of these aspects using a Likert scale based on their experience in following slides with voice-type instructional videos. The Likert scale used in the survey had five options: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree.

Each survey response was a collection of these five options selected by an undergraduate as the level of importance addressed through each question. A rating for each option is given to analyse responses: Strongly Agree is 5, Agree is 4, Neutral is 3, Disagree is 2, and Strongly Disagree is 1. Depending on these ratings, all survey responses were converted into quantitative values. The next step of this study is to derive a statistically significant method for ranking the pedagogical principles based on the survey responses. The mean value of each pedagogical item in the survey result was selected to perform this ranking, where the higher mean value gets the highest ranking. Figure 2 shows the steps in the analysis of survey responses.

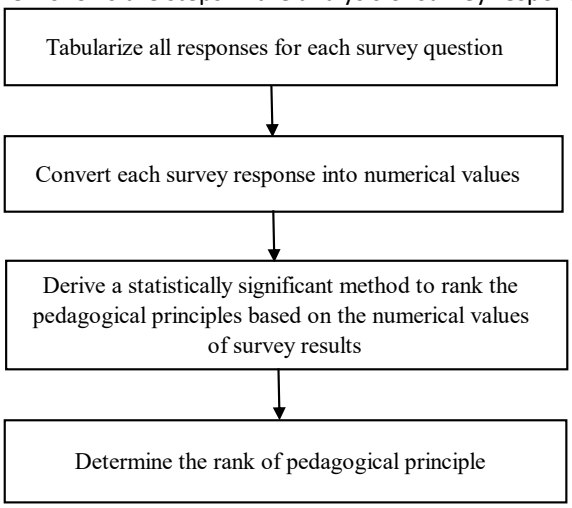

Figure 2: Steps used to analyse survey responses

5. Result and Analysis

Fig 3. illustrates the frequency distribution of numerical survey response values for each pedagogical principle.

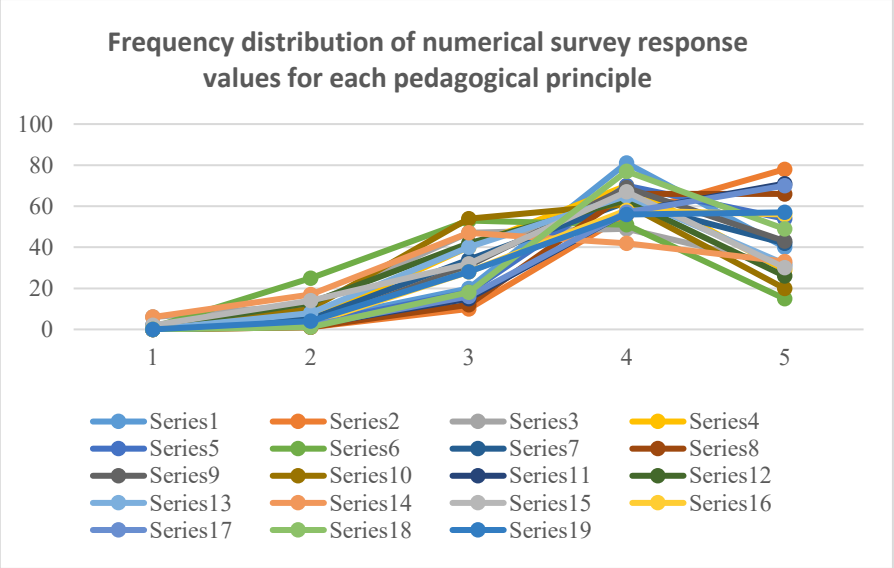

Figure 3: Frequency distribution of numerical survey response values for each pedagogical principle

Figure 3 concludes that all numerical data in survey responses do not have a normal distribution. Table 3 presents the series numbers and corresponding pedagogical principles, along with the mean score and rank based on the mean score.

Table 3: Series numbers and corresponding pedagogical principles with the ranking from the survey results

Series	Pedagogical Principle	Mean	Rank
Series 1	An instructional video includes a list of objectives to guide the learner at the beginning	4.08	P9
Series 2	An Instructional video has used proper highlighting to gain learners' attention and emphasise important information	4.46	P1
Series 3	An instructional video has a single visual to be focused on at a time	3.60	P17
Series 4	An instructional video does not include animation and a text to be focused on at the same time	3.37	P19
Series 5	An instructional video has a single topic to be focused on at a time	3.83	P12
Series 6	An instructional video has limited content to control the information density at a given time	4.21	P5
Series 7	Instructional video does not contain distractive background music	3.94	P11
Series 8	The instructional video uses images to gain learner attention	4.36	P2
Series 9	The instructional video uses animations to gain learner attention	4.06	P10
Series 10	The instructional video uses sound effects to gain the learners' attention	3.63	P16
Series 11	An instructional video uses proper contrast between background and text	4.36	P2
Series 12	An instructional video is designed with a consistent style	3.69	P15
Series 13	An instructional video does not use the same screen without any change for a long time	3.83	P12
Series 14	An instructional video does not include an image of the speaker continuously throughout the content	3.54	P18
Series 15	An instructional video includes interactive questions	3.75	P14
Series 16	An instructional video has a human voice in narration	4.15	P7
Series 17	The instructional video uses simple language and a conversational style	4.34	P4
Series 18	An instructional video has a proper tone and a speaking rate	4.20	P6
Series 19	Instructional video does not exceed the duration on which a learner can concentrate continuously	4.14	P8

The next step of this study defined a clustering for pedagogical principles. This clustering aimed to determine different levels of the pedagogical principles based on the significance claimed through survey results and ranking. The pedagogical principles were sorted according to rank to determine the most significant clusters initially. A distribution-free test, ANOVA, or analysis of variance by Kruskal-Wallis (Kruskal and Wallis, 1952) was selected to perform the statistical analysis in this step. The one-way ANOVA tests were conducted by adding adjacent pedagogical principles with a non-identical rank *(if the mean value difference of two ranks is less than 0.03, then the two ranks are considered identical*) until the P-value < α (0.05) and F > F crit in the ANOVA test.

When P-value < α and F > F crit in an ANOVA test, a cluster is defined by selecting all pedagogical principles with a higher rank compared to the lowest rank considered in the ANOVA test. Figure 4 illustrates the steps in clustering pedagogical principles.

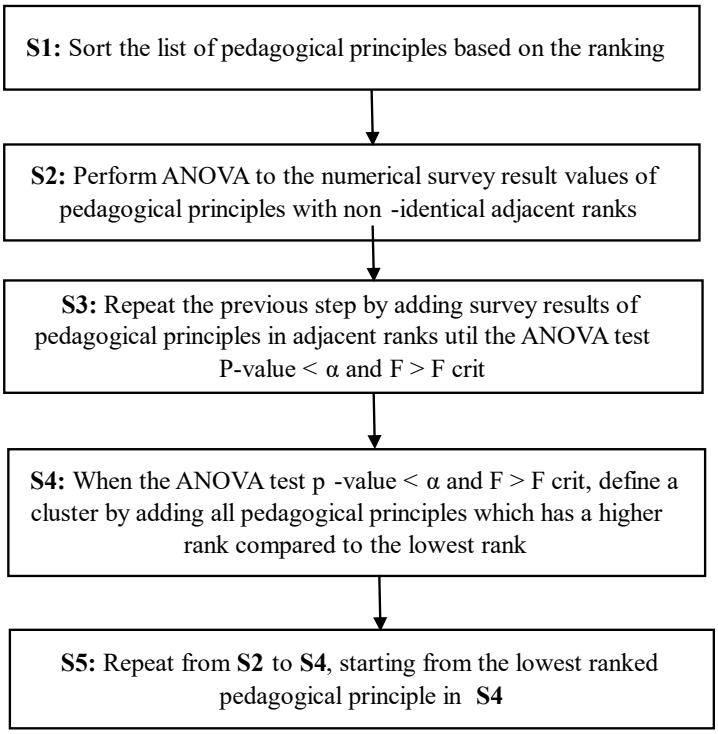

Figure 4: Steps used to cluster pedagogical principles

Table 4 shows the summary of results obtained in each ANOVA test, including the result of P-value, F and F-crit and the conclusion of each test *(Refer to the Additional Files section for the subjected pedagogical principles of each ANOVA test along with the result of P-value, F and F-crit, and the conclusion of each test).*

Table 1: ANOVA Tests and results with the conclusion

ANOVA Test No.	F	P-Value	F crit	F-F crit	Conclusion
01	0.7828	0.5038	2.6204	-1.8376	P-value > α and F < F crit. Therefore, cannot define a cluster
02	**2.9239**	**0.0126**	**2.2245**	**0.6995**	**P-value < α and F > F crit. Therefore, can define a cluster**
03	0.2580	0.8556	2.6204	-2.3624	P-value > α and F < F crit. Therefore, cannot define a cluster
04	0.9563	0.4438	2.2245	-1.2682	P-value > α and F < F crit. Therefore, cannot define a cluster
05	2.0753	0.0536	2.1076	-0.0322	P-value > α and F < F crit. Therefore, cannot define a cluster
06	**5.0499**	**3.38E-06**	**1.9455**	**3.1044**	**P-value < α and F > F crit. Therefore, can define a cluster**
07	0.4453	0.6409	3.0166	-2.5713	P-value > α and F < F crit. Therefore, cannot define a cluster
08	0.9495	0.4163	2.6204	-1.6709	P-value > α and F < F crit. Therefore, cannot define a cluster
09	1.6188	0.1676	2.3843	-0.7655	P-value > α and F < F crit. Therefore, cannot define a cluster
10	1.8615	0.0986	2.2245	-0.3630	P-value > α and F < F crit. Therefore, cannot define a cluster
11	**2.2191**	**0.0392**	**2.1076**	**0.1115**	**P-value < α and F > F crit. Therefore, can define a cluster**
12	2.1268	0.1458	3.8740	-1.7472	P-value > α and F < F crit. Therefore, cannot define a cluster

Four clusters of pedagogical principles were the result of the ANOVA tests in this step, as shown in Table 5.

Table 2: Pedagogical principles, clusters, and mean scores

Pedagogical Principle	Mean	Rank	Cluster
An instructional video uses proper highlighting to gain the learner's attention and emphasise important information	4.46	P1	1
The instructional video uses images to gain the learner attention	4.36	P2	
An instructional video uses proper contrast between background and text	4.36	P2	
The instructional video uses simple language and a conversational style	4.34	P4	
An instructional video has limited content to control the information density at a given time	4.21	P5	2
An instructional video has a proper tone and a speaking rate	4.20	P6	
An instructional video has a human voice in narration	4.15	P7	
An instructional video does not exceed the duration on which a learner can concentrate continuously	4.14	P8	
The instructional video includes a list of objectives to guide the learner at the beginning	4.08	P9	
The instructional video uses animations to gain the learner attention	4.06	P10	
Instructional videos do not contain distractive background music	3.94	P11	
An instructional video has a single topic to be focused on at a time	3.83	P12	3
An instructional video does not use the same screen without any change for a long time	3.83	P12	
The instructional video includes interactive questions	3.75	P14	
An instructional video is designed with a consistent style	3.69	P15	
The instructional video uses sound effects to gain learner attention	3.63	P16	
An instructional video has a single visual to be focused on a time	3.60	P17	
An instructional video does not include an image of the speaker continuously throughout the content	3.54	P18	4
An instructional video does not include animation and text to focus on at the same time	3.37	P19	

As a result of the comprehensive analysis conducted in this study, a set of pedagogical principles were ranked and clustered based on the significance of these principles in slides with voice-type instructional videos. Pedaxonomy is a pedagogical analysis model designed by considering these derived clusters. This model is built for instructional video developers or pedagogical analysers as guidance to achieve and verify important pedagogical aspects in slides with voice-type instructional video. The model consists of four levels: Level 1 includes the most fundamental pedagogical principles identified through the survey results. Principles in level 1 can be defined as the most important pedagogical aspects that have to be implemented in slides with a voice-over type instructional video. Thus, a content developer or pedagogical analyser must initially focus on level 1 pedagogical principles. After verifying the initial level pedagogical principles, a content developer or a pedagogical analyser can focus on the higher-level pedagogical principles. The significance level of pedagogical principles gradually decreases with the increased levels in the Pedaxonomy model.

Figure 4 is the Pedaxonomy model with four levels of pedagogical principles and pedagogical principle reference values (from P1 to P19) according to the REF column in Table 5.

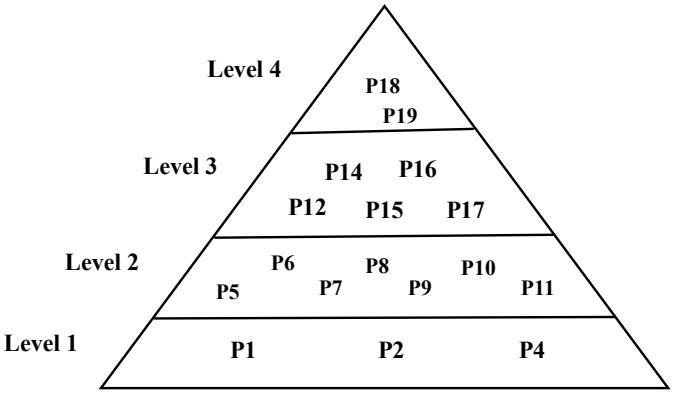

Figure 4: Pedaxonomy Model

The Pedaxonomy model evidently demonstrates an effective approach to implementing and analysing pedagogical principles in slides in a voice-over instructional video.

The next result of this study is an equation to derive a pedagogical score for presentation slides with voice-type instructional videos. Thus, weights (W_{L1}, W_{L2}, W_{L3} and W_{L4}) are allocated for each level in the Pedaxonomy model. These weights are allocated by considering the difference between the lowest mean score value at a lower level with the largest mean score value at a higher level.

Level 1 lowest mean score = 4.34
Level 2 highest mean score = 4.21
} Mean Difference = 4.34 – 4.21 = 0.13

Level 2 lowest mean score = 3.94
Level 3 highest mean score = 3.83
} Mean Difference = 3.94 – 3.83 = 0.11

Level 3 lowest mean score = 3.60
Level 4 highest mean score = 3.54
} Mean Difference = 3.60 – 3.54 = 0.06

The survey results proved that all pedagogical principles selected in this study significantly influence the learners' learning experience. Thus, the implementation of all these pedagogical principles must increase the pedagogical value. For altering this factor for all principles, the pedagogical principles in the lowest level of the model (level 4) were given the weight of 1. Weights of the next levels were given as the summation of the weight of the previous level and the mean difference between the current level and the previous level.

$W_{L4} = 1$ *(Weight of the highest level is assigned as 1)*
$W_{L3} = W_{L4} + 0.06 = 1.06$
$W_{L2} = W_{L3} + 0.11 = 1.17$
$W_{L1} = W_{L2} + 0.13 = 1.30$

Using the derived weights, a content developer of slides with voice-type instructional videos can derive the pedagogical score and the percentage of pedagogy by using the below equations to define the level of pedagogy implemented in the instructional video.

$$\text{Pedagogical Score} = \begin{aligned}&[W_{L1} \times (\text{No. of pedagogical principles implemented in level 1})] + \\ &[W_{L2} \times (\text{No. of pedagogical principles implemented in level 2})] + \\ &[W_{L3} \times (\text{No. of pedagogical principles implemented in level 3})] + \\ &[W_{L4} \times (\text{No. of pedagogical principles implemented in level 4})]\end{aligned}$$

$$\text{Maximum Pedagogical Score} = [1.30 \times (4 - 0)] + [1.17 \times (7 - 0)] + [1.06 \times (6 - 0)] + [1 \times (2 - 0)] = 21.75$$

$$\text{Percentage of Pedagogy} = (\text{Pedagogical Score} / \text{Maximum Pedagogical Score}) \times 100\%$$

6. Discussion

Voice-over slides are a commonly used instructional video style in many e-learning platforms. The authors in this study have focused on deriving an approach, specifically by analysing slides with voice-over type instructional videos. The comprehensive literature review conducted in the study could identify several pedagogical principles applicable for slides with voice-over type instructional video.

As the next step, a rank for the identified pedagogical principles was derived using a survey conducted for 145 undergraduates who followed several slides with voice-type instructional videos. The resulting ranks were

statically proven to be significant, hence used to determine the levels of pedagogical principles based on the importance of the learner's perspective. Using the derived levels of pedagogical principles, the Pedaxonomy model is proposed to define the values of distinct pedagogical principles in slides with a voice-over type instructional video. Level 1 of the Pedaxonomy model encompasses the fundamental and most prominent pedagogical aspects in slides with a voice-over type instructional video. Thus, violating the Level 1 principle may highly impact the quality of an instructional video.

In general, pedagogical principles become more specific with the increase of levels in the Pedaxonomy model. A content developer or a pedagogical analyser of slides with a voice-over instructional video can mainly focus on the lower-level pedagogical principles, as they are the most prominent pedagogical aspects derived through the survey. Through prioritising pedagogical principles demonstrated in the Pedaxonomy model, a content developer can gradually implement pedagogical aspects by initially focusing on the lower-level principles. Initial focusing on and implementing the lower-level principles will significantly improve the quality of slides with voice-over type instructional videos. Secondly, the content developer can aim at the upper-level pedagogical principles in the Pedaxonomy model. These principles will further enhance the quality of slides with voice-over type instructional videos.

A pedagogical analyser can use the Pedaxonomy model as guidance in evaluating the pedagogy in slides with voice-over type instructional videos. The Pedaxonomy model will aid pedagogical analysers to prioritise the aspects they focus on when evaluating an instructional video. It will be useful for a pedagogical analyser to compare different pedagogies used among slides with voice-over type instructional videos and define the instructional video with better implementation of pedagogy.

The model is defined purely based on the survey responses. Thus, having a fundamental pedagogical principle such as "including interactive questions in the instructional video" in the third level of the Pedaxonomy model might have happened due to the lack of experience of the subjected learners in having interactive questions. The model can be further enhanced by choosing learners for the survey, experienced in all pedagogical aspects.

The final result of this study has proposed an equation using the Pedaxonomy model, which the pedagogical analysers can use to derive a quantitative pedagogical score for slides with voice-over type instructional videos. The equation is derived by assigning different weights to the pedagogical principles at different levels. The highest-level weight (W_{L4}) was defined as 1 to ensure that each pedagogical principle implemented in an instructional video will contribute at least 1 to the final pedagogy value. The weight values of other levels (W_{L3}, W_{L2}, W_{L1}) are derived by getting the difference between the lowest mean score value in a lower level with the largest mean score value in the higher level and adding this difference to the weight of the higher level. Therefore, the equation captures the depth of difference from a lower level to a higher level in the Pedaxonomy model. Once the weights are derived, the pedagogical score equation is generated by assigning the derived weights for pedagogical principles. The pedagogical score equation can be used by the pedagogical analyser to effortlessly derive a pedagogical for slides with voice-over type instructional video. Pedagogical analysers can use the percentage of pedagogy to get a more precise and fully Pedaxonomy model-based value of the pedagogy implemented in slides with voice-over type instructional video. It is defined by dividing the pedagogical score of an instructional video from the maximum pedagogical score that can be gained from the pedagogical score equations, i.e. the pedagogical score obtained if all pedagogical principles in the Pedaxonomy model are implemented in the instructional video. From the pedagogy percentage, a pedagogical analyser can easily compare the pedagogy of slides with voice-over type instructional videos. The equations proposed in this study are entirely derived from values obtained through the analysis of survey responses. Thus, the survey itself can be considered a verification of the equations proposed in this study.

The Pedaxonomy model and the scoring methods proposed in this study are expected to assist pedagogical analysers in analysing slides with voice-over instructional videos. The Pedaxonomy model and the scoring method are designed by focusing only on slides with voice-over type instructional videos. Future versions of the Pedaxonomy model are expected to be designed by focusing on other types of instructional videos.

7. Conclusion and Future Work

A suitable pedagogical analysis is essential to ensure the quality of instructional material (Bhowmik, Roy, and Banerjee, 2013). Although several studies have focussed on the pedagogy of instructional materials, the majority

of these studies have not considered specific pedagogical factors in instructional videos. With the rapid popularity of e-learning, instructional videos have become a key source of instruction for learners. Thus, instructional video developers have identified many styles of instructional videos, such as talking heads, slides with voice, animation, and whiteboards (Hansch et al., 2015). Each of these styles uses different approaches and techniques to transfer knowledge to the learners. Even though some pedagogical aspects are common among all these instructional videos, there are many specific pedagogical aspects based on the instructional video style. Hence, identifying the specific pedagogical aspects suitable for the relevant video style is essential to performing a most suitable pedagogical analysis.

Focusing only on a single video style was a successful approach in deriving the precise and specific pedagogical principles model for slides with voice-type instructional videos. Learners are the primary users of instructional videos. Hence, these identified pedagogical principles were ranked based on a survey conducted by instructional video learners. The pedagogical principles model and pedagogy score calculation were derived based on this ranking. The content developers can successfully use the proposed results in this study to evaluate the pedagogy in slides with voice-over type instructional videos.

The future work of this study should use a similar approach to design future versions of the Pedaxonomy model to cover other instructional video styles. Violating some of the pedagogical principles in this study could have a negative impact on the pedagogical quality. The equation proposed here can be further enhanced by factoring in the negative effect of violating these pedagogical principles. The authors expect to adapt this enhancement via a second survey to determine the degree of negative impacts of violating the pedagogical principles.

References

Agarwal, S. and Kaushik, J. S. (2020) 'Student's Perception of Online Learning during COVID Pandemic', *Indian Journal of Pediatrics*. The Indian Journal of Pediatrics, 87(7), p. 554. doi: 10.1007/s12098-020-03327-7.

Al-fraihat, D., Joy, M. and Sinclair, J. (2020) 'Computers in Human Behavior Evaluating E-learning systems success : An empirical study', *Computers in Human Behavior*. Elsevier, 102(June 2019), pp. 67–86. doi: 10.1016/j.chb.2019.08.004.

Asanthika Imbulpitiya, Nuwan Kodagoda, Anjalie Gamage, and K. S. (2019) *Using Active Learning Integrated with Pedagogical Aspects to Enhance Student's Learning Experience in Programming and Related Concepts*. Springer International Publishing. doi: 10.1007/978-3-030-40274-7.

Berk, R. A. (2009) 'Multimedia Teaching with Video Clips : TV , Movies , YouTube , and mtvU in the College Classroom', *International Journal of Technology in Teaching and Learning*, 5(1), pp. 1–21.

Bhowmik, M., Roy, B. B. and Banerjee, J. (2013) 'Role of Pedagogy in Effective Teaching', 2(January), pp. 1–5.

Brame, C. J. (2016) 'Effective educational videos: Principles and guidelines for maximizing student learning from video content', *CBE Life Sciences Education*, 15(4), p. es6.1-es6.6. doi: 10.1187/cbe.16-03-0125.

Brecht, H. D. (2012) 'Learning from Online Video Lectures', *Journal of Information Technology Education*, 11, pp. 227–250. doi: 10.28945/1712.

Chen, H. T. M. and Thomas, M. (2020) 'Effects of lecture video styles on engagement and learning', *Educational Technology Research and Development*, 68(5), pp. 2147–2164. doi: 10.1007/s11423-020-09757-6.

Docebo (2016) 'Elearning market trends and forecast 2017-2021', *Docebo*, pp. 34–36.

Expósito, A. *et al.* (2020) 'Examining the use of instructional video clips for teaching macroeconomics', *Computers & Education journal*, 144(June 2019). doi: 10.1016/j.compedu.2019.103709.

Gagne, R. M. and Wager, W. W. (1992) 'Principles of Instructional Design (4th ed.)', *Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.*, p. 153.

Gleason, B. (2021) 'Expanding interaction in online courses: integrating critical humanizing pedagogy for learner success', *Educational Technology Research and Development*. Springer US, 69(1), pp. 51–54. doi: 10.1007/s11423-020-09888-w.

Govindasamy, T. (2001) 'Successful implementation of e-Learning Pedagogical considerations', *Internet and Higher Education*, 4(3–4), pp. 287–299. doi: 10.1016/S1096-7516(01)00071-9.

Hansch, A. *et al.* (2015) 'Video and Online Learning: Critical Reflections and Findings from the Field', *HIIG Discussion Paper Series*, 2. doi: 10.2139/ssrn.2577882.

Hayashi, A., Chen, C. and Ryan, T. (no date) 'The Role of Social Presence and Moderating Role of Computer Self Efficacy in Predicting the Continuance Usage of E-Learning Systems', *Journal of Information Systems Education*, 15(2), pp. 139–155.

Hubackova, S. (2014) 'Pedagogical Foundation of Elearning', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 131(2004), pp. 24–28. doi: 10.1016/j.sbspro.2014.04.073.

Kim, A. S. and Ko, A. J. (2017) 'A Pedagogical Analysis of Online Coding Tutorials', *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education - SIGCSE '17*, pp. 321–326. doi: 10.1145/3017680.3017728.

Kruskal, W. H. and Wallis, W. A. (1952) 'Use of Ranks in One-Criterion Variance Analysis', *Journal of the American Statistical Association*, 47(260), pp. 583–621. doi: 10.1080/01621459.1952.10483441.

Li, C. (2020) *The COVID-19 pandemic has changed education forever. This is how*, *World Economic Forum*. Available at: https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/.

Lin, L. and Johnson, T. (2021) 'Shifting to digital: informing the rapid development, deployment, and future of teaching and learning: Introduction', *Educational Technology Research and Development*. Springer US, 69(1), pp. 1–5. doi: 10.1007/s11423-021-09960-z.

Mayer, R. E. (2009) *Multimedia Learning*. Second Edi, *Multimedia Learning*. Second Edi. Santa Barbara: Cambridge University. doi: 10.1017/cbo9781139164603.

Mayer, R. E. (2014) 'Research--Based Principles for Designing Multimedia Instruction Overview of Multimedia Instruction', *Applying Science of Learning and Education*, pp. 1–12. Available at: http://hilt.harvard.edu/files/hilt/files/background_reading.pdf.

Mayer, R. E. and Moreno, R. (2002) 'Animation as an Aid to Multimedia Learning', *Educational Psychology Review*, 14(1), pp. 87–99.

van der Meij, H. and van der Meij, J. (2013) 'Eight Guidelines for the Design of Instructional Videos for Software Training', *Technical Communication*, 60(3), pp. 205–228. doi: 10.1080/10572252.2012.626690;

Moreno, R., Mayer, R.E., Cognitive principles of multimedia learning: The role of modality and contiguity (1999) Journal of Educational Psychology, 91 (2), pp. 358-368;

Moreno, R., Mayer, R.E., Engaging students in active learning: The case for personalized multimedia messages (2000) Journal of Educational Psychology, 92 (4), pp. 724-733;

Moreno, R., Mayer, R.E., Personalized messages that promote science learning in virtual environments (2004) Journal of Educationa.

Mendoza, G. L. L., Caranto, L. C. and David, J. J. T. (2015) 'Effectiveness of Video Presentation to Students' Learning', *International Journal of Nursing Science*, 5(2), pp. 81–86. doi: 10.5923/j.nursing.20150502.07.

Minnesota, S. U. (2018) *Online Course Design Checklist*, *MSUM Online*.

Mukti, M. a. *et al.* (2000) 'A pedagogical approach to multimedia courseware development to\nmotivate reading habit', *2000 TENCON Proceedings. Intelligent Systems and Technologies for the New Millennium (Cat. No.00CH37119)*, 1, pp. 134–139. doi: 10.1109/TENCON.2000.893557.

Seale, J. and Cooper, M. (2010) 'E-learning and accessibility: An exploration of the potential role of generic pedagogical tools', *Computers and Education*. Elsevier Ltd, 54(4), pp. 1107–1116. doi: 10.1016/j.compedu.2009.10.017.

Sirisuriya, S. C. M. D. S. *et al.* (2018) 'Significance of Interaction and Activities Factor in Pedagogical Evaluation Process of Web Based', *2018 13th International Conference on Computer Science & Education (ICCSE)*. IEEE, (Iccse), pp. 1–5.

Stemler, L. K. (1997) 'Educational Characteristics of Multimedia : A Literature Review', *Educational Multimedia and Hypermedia*, 6, pp. 1–16.

Teoh, B. S. and Neo, T. (2007) 'INTERACTIVE MULTIMEDIA LEARNING : STUDENTS ' ATTITUDES AND LEARNING IMPACT IN AN ANIMATION COURSE', *The Turkish Online Journal of Educational Technology*, 6(4).

Veniegas, O. P. (2006) 'Ensuring the Effectiveness and Quality of Learning Materials : How to Use and Evaluate Literacy / CE Materials', *Regional Center for Educational Innovation and Technology*.

Watson, S. (2005) 'The Importance of the Pedagogy Process .', *Nebula*, (June), pp. 141–152.

Welsh, E. T. *et al.* (2003) 'E-learning : emerging uses , empirical results and future directions', (December). doi: 10.1046/j.1360-3736.2003.00184.x.

Zhang, D. *et al.* (2004) 'CLASSROOM', *COMMUNICATIONS OF THE ACM*, 47(5), pp. 74–79.