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Assessment of Interactive Video to Enhance Learning Experience: A Case Study

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***Abstract*—**In modern STEM classrooms, video learning holds an important place, since it offers flexibility of time, place and content. But a lot of improvement is needed to enhance the learning experience because conventional video lecture lacks interaction that is indispensable component of teaching – learning process. Interactive video is highly recommended to resolve this issue as it allows proactive and random access to video content and promotes learner – content interactivity by inserting interactive elements. Interactive kind of video facilitates students' engagement and active learning through incorporated interactive components. Present study employed two settings: learning using demonstrative video and learning using interactive video. It is observed that, students' performance enhanced significantly in the post video quiz of interactive video and thus interactive video leads to better learners' satisfaction. A study was carried out with 240 number of first year Engineering students for the course of Applied Physics. We collected data from post- video quiz performance and feedback from the students. The grades obtained by the students in post-video quiz for demonstrative and interactive videos were compared. For the interactive type of videos, the average marks scored were 82.79% and for demonstrative type of videos, average marks obtained were of 64.41%. This study brings forth superiority of interactive video over linear, demonstrative video as it offers enhancement of the level of conceptual understanding and attainment of desired learning outcomes through the management of cognitive and germane load by enhancing students' engagement through active learning.

***Keywords*—**cognitive load; demonstrative video; germane load; interactive video; Learning Design; learning outcomes.

***JEET Category*—Research**

I. INTRODUCTION

Learning is the process by which human beings acquire a tremendous variety of competencies, skills and attitudes. Teaching is a design science that promotes students' learning. Design science is an innovative, systematic and scientific process to cater learning. Learning design is a process of developing accessible and well structured lectures that help students to achieve desired learning outcomes. Teacher is posed as a designer as he is actively engaged in designing a learning environment by imaginatively applying learner-centred, collaborative, reflective and problem based approach to learning. Learning design involves meticulous designing of content and delivering the content while focusing on the desired learning outcomes. The Learning Design promotes the construction of comprehensive and transferable learning design patterns with deep consideration of effective content delivery. In order to be a capable and empowered learning designer, the teacher needs to adopt a design mindset. Traditional teaching learning process restricts the minds of faculty as well as students to a trodden path that leads to rote learning. It doesn't support transformation and innovation in the learning process. To just impart technical information is not the objective of higher education. Higher education aims to equip the students with a diverse set of abilities such as problem analysis, use of modern tools, solve societal and environmental problems, work in team and life long learning. To meet these demands, teachers are challenged to adopt innovative teaching methods with more emphasis on students' learning.

Technology incorporated in learning design encourages new learning experiences and enriches existing learning scenarios, thus triggering pedagogical innovation. It needs management of teaching aids. A teacher plans to use modern tools as teaching aids as an integral part of teaching – learning process. This includes the development of learning media to leverage outcome based learning. This requires conducive and attractive learning conditions for students. Video offers multifaceted tool to develop effective teaching - learning designs and it delivers information in an attractive and consistent manner. If the video is incorporated in traditional teaching- learning process, it serves as a keystone of many blended courses. It forms the main information-delivery system in online courses. Previous studies (Barbara & Flowers, 2020; Graber, 1990; Hughes, 2009; Mayer, 2009) suggest that the utilization of multiple signals enhances effectiveness of learning process as it helps to retain the information for longer. Through lecture videos, students learn by reading, seeing images and hearing narration simultaneously, thus enhancing retention (Barbara & Flowers, 2020; Graber,

1990; Hughes, 2009; Mayer, 2009). Thus, videos increase students' understanding and retention, thus improving outcomes. Video has a great potential to facilitate active and blended learning. Previous research has shown the ability of video to increase engagement of the students in the learning process enhancing cognitive and emotional learning (Dilani & Arezou, 2018; Greenberg & Zenetis, 2012). Thus it has a positive effect on students' perceptions of learning (Bravo et al., 2011). Thus video is a content rich and powerful medium. However, just delivering the information linearly in video format will not lead to in-depth learning (Karppinen, 2005). Non interactive- demonstrative video may lead to superficial learning because students are passive viewers and it leads to poor learning experience, a phenomenon called "couch-potato-attitude"(Anthia & George, 2016; Ertelt et. al., 2006). Demonstrative video creates apathy among learners rather than stimulating their interest in learning, making them a passive learner. One of the biggest drawbacks of the linear video is that it does not facilitate learner – learner, learner – content and learner – teacher interaction. Thus developing video as an effective tool in educational contexts, its pedagogical design with critical interactive elements is crucial and teacher needs to incorporate such elements in video that promote active learning. In an interactive video, students do not remain passive viewers, instead it helps to engage the students in active learning. Non linear videos are the interactive videos that embed interactive learning components that stimulate students' thinking and encourage autonomous learning. Interactive video is described as one of the most effective types of media that integrates different features like moving images, stories and content, all enriched with interactive elements (Chen, 2012). Interactive video ensures students' engagement, participation and helps students to pay full attention to the content of the video through embedded active elements (Zhang et al., 2006; Nives & Tomislava, 2020; Aladé et. al., 2016). Kolas et al. defined interactivity as a combination of elements that allows students to physically manipulate the platform to improve learning activity (Kolås, 2015; Onah et. al., 2014). Various interactive features viz embedded text, questions, prompts for generating discussion, reflective pauses, feedback, video links can be incorporated in the video to make learners' navigation more efficient, to test the learners' understanding at specific points in the video timeline and to encourage different types of interaction. Broadly there are two levels of interactions. In the first level of functional interactivity, constructive customized feedback is provided on students' response to particular activity. The second level of interactivity is dealt with cognitive interactivity and it stimulates cognitive and meta cognitive processes. Incorporated questions are designed in a way to provoke students' thinking to predict what would happen next in the video. Students are required to choose and organize the content and integrate it with their pre-existing knowledge. These interactive elements seem to have significant effect on learning (Anthia & George, 2016; Wouters et al., 2007). A significant element of interactive video is that it offers self directed learning environment (Anthia & George, 2016; Delen, 2014). In order to grab the students' attention and enhance their interest and engagement, videos are to be designed that provide optimal conditions for learning to occur. Effectiveness of video in teaching learning process can be enhanced by considering three elements: managing cognitive load; maximizing students' engagement and promoting active learning.

However, very few reports are available on the comparative study of influence of interactive video over demonstrative video on learning performance and learner satisfaction. In the present paper, we try to showcase some aspects of video pedagogy in context with videos that designed and developed by us for the first year Engineering students for the course of Applied Physics. The paper explores effectiveness of non linear interactive video over linear demonstrative video and the techniques by which interactive video can be used and promoted as a potential tool for active, flexible and blended learning in order to achieve desired learning outcomes. Physics is considered as hypothetical subject with abstract concepts hard to visualize. Properly designed videos with pictures and animations are well suited to illustrate the abstract or hard-to-visualize phenomena. With this aim, we developed properly structured videos with well organized on-screen text or symbols and animations to highlight important information. For this research, we used MOODLE (Modular Object-Oriented Dynamic Learning Environment) platform. MOODLE serves as a learning management system (LMS) as well as a content management system (CMS) with various features. H5P tool of MOODLE provides features to add different interactive activities to video to make it interactive video. For this experiment, we employed two types of video settings –

1. Demonstrative - linear video learning
2. Interactive video learning

Students' assessment is done with the help of in–video exercise and out-video quiz. A questionnaire was designed for survey and students' feedback was collected on effectiveness of interactive video. Data collection is based on students' assessment and survey conducted.

A. Objectives of This Paper:

1.To compare effectiveness of interactive video over demonstrative video

2. To weigh the potential of interactive video as an educational tool to attain defined outcomes in engineering education.

II. RESEARCH METHODOLOGY

Now a days, there is a focus on the study of interactive video. However, effectiveness of interactive video has not been assessed for self-regulated learning. In the present study we tried to assess the value of interactive video which is supposed to enable self-paced learning. As mentioned earlier, we studied following two cases –

1. Learning with linear, demonstrative video
2. Learning with interactive video

We designed and developed videos for first year Engineering students in the course of Applied Physics. Both demonstrative and interactive type of videos were developed and used as educational tools. Total number of students who participated in this exercise was 240. We created videos describing the concepts and applications of diffraction,

polarization, LASER, crystal structure analysis using Bragg's spectrometer and carbon nanotubes. To enable these videos serve as a productive part of a learning experience we paid attention to following three aspects,

1. Cognitive load
2. Student engagement
3. Active learning

Though video is a powerful tool for content delivery, it carries one drawback that students tend to skip some parts of video instead of watching full video. Hence students' engagement is a crucial factor in the learning process. The most important aspect to be considered while constructing educational videos is to include active learning elements that promote students' engagement. Also another important factor that affects students' engagement is length of video. It is obvious that as videos lengthens, students' engagement drops. Hence videos were developed with not more than 10 to 12 minute in duration. We used a conversational style in the video rather than formal language because, as it helps the learner to develop a sense of partnership with the teacher. Moreover the script was very carefully written with animated texts, visual elements, gif files etc added at appropriate situations. We used some illustrations to explain abstract phenomena.

A. Cognitive Load

While creating educational video, one has to consider cognitive load that is associated with amount of working memory resources used. Learning is not only collection of information. The collected information has to be processed and it happens in working memory. This processed information is stored in long-term memory. According to Cognitive Load Theory (CLT), working memory has a limited capacity (Paas et al., 2010). There are three aspects of memory load viz Intrinsic Cognitive Load, Germane Cognitive load and Extraneous Cognitive Load (Paas et al., 2010; Sweller et al., 1998).

1) Intrinsic Cognitive load (ICL)

It is the degree of interconnectedness between the different concepts explained in the video. For ex. – In physics, study of seven crystal systems would have lower intrinsic load while analysis of crystal structure using X – ray diffraction has a high intrinsic load due to its many levels of connectivity.

2) Germane Cognitive load (GCL)

These are cognitive activities included in the video that are necessary to achieve the desired learning outcomes.

3) Extraneous Cognitive load (ECL)

It is caused by the extra material which is not directly linked to the concept. This is result of a poor instructional design.

B. Student engagement

All the three aspects of cognitive load were considered while developing the videos. Functioning of working memory is based on audio-visual channels for collection and processing of information (Brame, 2016; Mayer and Moreno, 2003). We designed strategies to manage the cognitive load for both the channels to enhance learning. We designed content of videos in order to optimize ICL and reduce ECL using principles of cueing, segmenting and matching modality. Signaling or cueing principle (Brame, 2016; deKoning et al., 2009) is a means to highlight important information by effective use of on-screen text or symbols. We employed 6 X 6 principle that recommends maximum six lines with six words per line. To draw attention of the learners to a particular point, we used text animation, change in colour and other visual signals. It helps to hook learner's attention to the highlighted point of the video, thus reducing the extraneous load. It also helps learners to identify important elements from the content of video. It may increase germane load by emphasizing the interconnectivity between different points within the content explained in the video. Segmenting is the chunking of information to allow learners to deal with small fragment of information. We presented information step by step in the video, which helps learners to organize the incoming information and helps them to develop link between previous content and incoming information of the next step. We developed animations of certain physical phenomena and showed that animations of the processes on screen along with narration. Such use of both audio-visual channels helps to clarify the process by giving the learner two compatible streams of information and thus helps to enhance germane cognitive load. Unfortunately, many students tend to skip videos bypassing valuable assigned content and just solve post-video exercise. It leads to failure to fulfill objectives of learning.

C. Active Learning

To enhance the learning experience, it is necessary to incorporate active learning components into the videos. We used H5P tool of MOODLE to incorporate interactive elements in the video.

For this research, we developed demonstrative videos on 'concepts and applications of diffraction', 'polarization', 'LASER'. But, we added interactive features to the videos on 'crystal structure analysis using Bragg's spectrometer' and 'carbon nanotubes' using H5P tool of MOODLE. We used the interactive videos as a part of internal evaluation of a course.

H5P allows addition of different interactive elements to video viz added text, label, table, image, external link, navigation hotspot, different types of questions and summary at the end. These interactions helped to chunk the video into smaller fragments and enhance students' engagement. H5P has the "Prevent Skipping" feature. When this feature is enabled, it does not allow students to skip the part of video to jump ahead in the video. It compels the students to watch the entire video. Different interactive features added to video are,

i) Added text and label – We used 'add text' feature to highlight the most important point in the video. Added text or label appears at the specific instant in the video.

ii) External link – It is provided at specific time points with an aim to motivate students to dig deeper into subject and further explore the topic under discussion using additional resources given in the learning path. e.g. External video link to show rolling of graphene into carbon nanotube and properties of CNT.

iii) In-video questions – Question were added in different formats - multiple-choice, single-answer, true/false, fill in the blanks, mark the word, drag and drop as mentioned above. Inductive question is a type of logical question that

involves drawing a general conclusion from a set of specific observations. It involves widening of specific concept out into broader generalizations. We added inductive questions to check the understanding of concept and guide students to interpret the hypothesis presented. e.g. after explanation of properties of different types of carbon nanotubes, question is inserted in the video, 'which type of CNT can be used in CNTFET?' This is inductive type of question. These questions motivate students to watch the video carefully and prepare notes in order to be able to answer the corresponding questions.

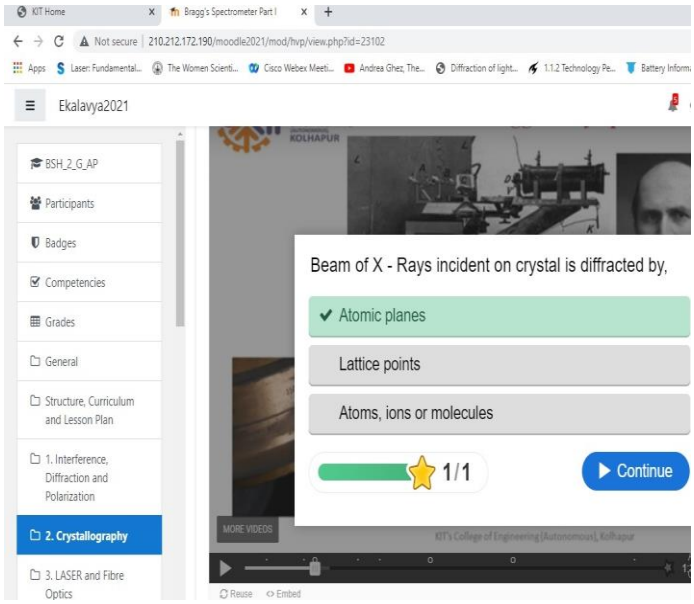

Fig. 1. Screenshot for in video question

Rhetoric questions expect the students to predict what would happen next in the video. These types of questions boost students' interest and motivate them to be more focused on the video in order to self validate their answers (Fig. 1). Moreover, while adding question, we chose the feature in adaptive setting that required students to answer the questions incorporated in the video before being allowed to continue. Students get immediate feedback on their answers. The grades are automatically generated in H5P. That's how students are informed whether the question was answered correctly. Multiple attempts were allowed to rectify the answer.

iv) Navigation hotspot – It is used either to guide the students to recollect the points previously discussed in the video or locate the content of special interest.

v) Summary – We added some statements at the end of video and students have to choose correct statements that summarizes the content.

MOODLE collects data on students' progress through lessons and performance on videos assignments. Progress and grade metrics are automatically generated by MOODLE as a grade book. Grades for in video tests and post video tests are obtained from grade book. Since multiple attempts were allowed for the in-video quiz to get the correct answer, grades for in-video quiz are not considered for analysis.

We provided both these types of videos to the students and conducted tests based on each video. The test questions were designed as per the different levels of Bloom's taxonomy viz remembering, understanding and applying. Attainment level of defined learning outcomes is calculated on the basis of students' performance in the post-video test. A separate questionnaire was designed to collect feedback from students on their satisfaction about the learning environment and on their perceptions about the self-regulated learning facilitated by interactive and demonstrative video. The questionnaire consisted of 11 questions. Feedback questions were designed to tap the learning experience, conceptual understanding and achievement of outcomes.

For example 'does the content in the videos triggered my interest? Do I have better control over the movement through the video, better attainment of learning outcomes and greater satisfaction? Does interactive video enhance my understanding and improve learning experience?

We compared the performance of students in post-video quizzes for both the types of videos. After this, we analyzed the feedback data collected from the students.

III. RESULTS AND DISCUSSION

In this modern digital world, there is paradigm shift in the nature of teaching – learning process. This transformation has occurred due to audio-visuality and multimodality principles incorporated in the education. This shift in the mode of teaching – learning process and the ways of students' engagement in learning process needs to be reflected pedagogically in the teaching plans and learning designs of the faculty. Constructivist approach to teaching emphasizes more on engaging students in the learning process rather than simply finding answer to a question. Cognitive information processing theory is an extension of the constructivist model of teaching - learning process. It proposes processes and structures for learner – content, learner – teacher and learner – learner interactions. With the availability of more interactive and richer media, a learner enjoys more flexibility to meet individual needs. In this sense, this research focuses on exploring video pedagogy to obtain practical solutions for the problems faced by teachers about students' engagement and attainment of learning outcomes. Interactive video enhances learner-content interactivity. Thus it triggers students' interest thereby improving learning experience.

A. Analysis of students' performance

We created the demonstrative videos on 'concepts and applications of diffraction, polarization, LASER' and interactive videos on 'crystal structure analysis using Bragg's spectrometer and carbon nanotubes.' We provided both these types of videos to the students on MOODLE platform and later conducted quiz based on these videos. Weightage for each quiz was 10 marks. The questions for the quiz were designed as per the various levels of Bloom's taxonomy viz. remembering, understanding and applying. The grades obtained by the students in post-video quiz for demonstrative and interactive videos were compared. For the interactive type of videos, the average marks obtained were 82.79% and for

demonstrative type of videos, average marks obtained were of 64.41%. Further question wise performance was analyzed for the attainment level of learning outcomes for demonstrative and interactive kind of videos. Performance of students is assessed for first three levels of Bloom's taxonomy and is given in the table1 given below. It is found that attainment of learning outcomes for these levels is enhanced in case of interactive videos as compared to demonstrative of videos. Thus it clearly indicates effectiveness of interactive kind of video over demonstrative kind of video.

1. ATTAINMENT OF LEARNING OUTCOMES

Type of Video/Bloom's Level	Demonstrative Type of Videos	Interactive Type of Videos
Level 1 - Remembering	72.5625	84.41667
Level 2 - Understanding	48.4375	84.03125
Level 3 - Applying	72.25	79.95

For Bloom's level 1 and 3, there is enhancement of 7% to 12% in attainment in case of interactive type of video. However, it is seen that for the level of understanding (Bloom's level 2), attainment level is greatly increased (35.6%) in case of interactive type of videos. It may be attributed to in-video exercises. The interactions chunk the video into smaller parts and allow learners to deal with small pieces of information and cope with the intrinsic cognitive load. Active involvement of students in learning process is promoted through cognitive activities included in the video viz solving quizzes, opening the external resources and summarizing the content. Such cognitive activities are necessary to achieve the desired learning outcomes. These activities increase learner-content interactivity thereby enhancing the conceptual understanding of the students and help to enhance germane load.

B. Analysis of Students' feedback

Statistical analysis of the data collected from students' feedback is presented below. The feedback questionnaire consisted of 11 questions to judge students' satisfaction about learning experience and students' perception about self-directed learning i.e. comparison between demonstrative and interactive videos. Questions were asked about content in the video, learning experience, level of understanding and attainment of outcomes.

1) Type of video preferred

97.6% students expressed their views in favour of interactive type of video.

2) Level of conceptual understanding

85% students opined that interactive kind of videos helped them to keep actively engaged in learning and enhance their level of conceptual understanding (fig. 2). Interactive kind of videos helped them better assimilate the concepts due to in-video exercise and they were able to develop linkage between those concepts.

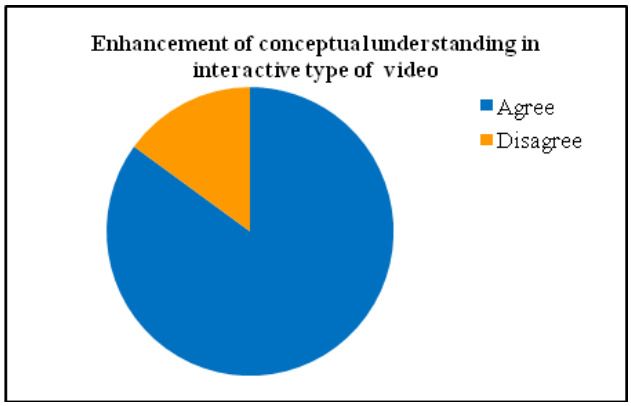

Fig. 2. Survey analysis for conceptual understanding

3) Attainment of learning outcomes

94.2% students said that interactive videos helped them to achieve higher grades in quiz (fig. 3). The students expressed that there was better achievement of learning outcomes in interactive kind of video as compared to demonstrative kind of video and it led to greater satisfaction towards learning experience.

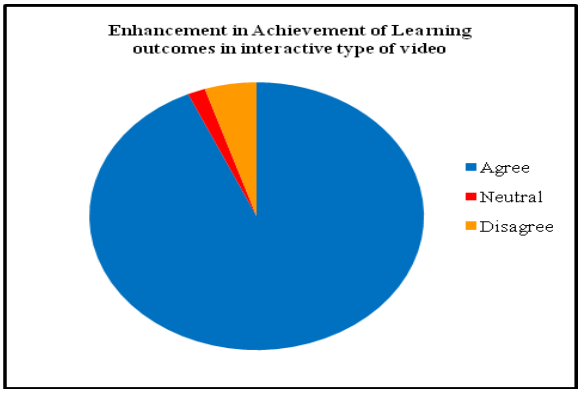

Fig. 3. Survey analysis for achievement of learning outcomes

The comments received from the students on the use of interactive videos were positive and encouraging. Few of the comments are illustrated below.

- Interactive videos with the well-organized pauses and active elements included in the video were especially beneficial to my learning.
- Interactive videos encouraged me to watch the video to full extent. I found it interesting and helpful in learning.
- Showing the 'original' videos created by faculty members aroused an interest to watch. It was having supplementary material related to academics. So it helped a lot to remember the things while attempting the QUIZ. It improved my ability to recall the things and relate it to the concepts learnt in the lectures.
- This is a great idea to help students learn new concepts in a more interactive way, and it helps us to understand the concepts easily.
- The videos helped me to understand the concepts in a better way. Especially those in-video questions were good. Because of that I paid more attention to the

content.

Although some of the previous research on videos reported higher attainment of learning outcomes as compared to that in a conventional classroom, its effectiveness to meet the learning needs of the learners is greatly limited due to lack of interactivity (Zhang et al., 2006; Hiltz, 2001). However interactive video provides strong student motivation and engagement (Zhang et al., 2006; Roblyer & Edwards, 2001) thus reducing this limitation by providing learners more control over the content and helps them to meet their learning needs. The number of embedded questions allows students to do self-evaluation and decide whether they need to focus more on particular segment of the video. Thus an interactive video-based learning system facilitates a constructivist learning environment because it provides more opportunities to explore interactivity capabilities and self-directed learning process and aids in the self-construction of competency of learning goals that result in high degree of learner's satisfaction and better performance (Zhang et al., 2006; Squires, 1999; Berge, 2002).

IV. CONCLUSION

Our study demonstrates that simply including video into teaching – learning process may not always be sufficient to meet the learning needs of individual learners. Interactive video is an effective and attractive educational tool to enhance students' learning experience. It offers unique features to incorporate active-learning elements into videos. Interactive video provides learners a control over random access to content and thus leads to higher learner satisfaction. In addition, the data on student progress and performance reveals that the higher achievement of learning outcomes at different levels as per Bloom's taxonomy occurs with interactive video rather than linear, demonstrative video. It suggests that learner – content interactivity plays significant role in improving effectiveness of learning. This study brings forth interactive video as a highly effective educational tool as it offers enhancement of level of conceptual understanding, attainment of desired learning outcomes through the management of cognitive and germane load by enhancing students' engagement through active learning.

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