Research Article

Augmented Podcasts: A Low Bandwidth Solution for Effective Learning

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Abstract

The evolution of video has significantly transformed the ways in which educational content is delivered and consumed. Post the pandemic, the digital divide existing in the Indian educational system is more evident, which creates a requirement of low bandwidth educational technologies, without compromising learning effectiveness. This study proposes a new medium: Augmented podcasts (MP3 file + PDF file of the screenshots used in the lecture), an audio narration synchronised with slides, as a more bandwidth-friendly alternative to traditional video lectures. We compare the data consumption and effectiveness of augmented podcasts as an educational tool in comparison to traditional video lectures. The comparison is done based on three main levels of difficulty (low-medium-high) in the assessments of these lectures. The study employs a quantitative approach with an experimental design. Participants from urban areas of Mumbai were initially selected using purposive sampling. These participants were then randomly assigned to either of the two groups: the augmented podcast or video lecture group. Descriptive and inferential statistics, including Mann-Whitney U tests, were used for data analysis

In addition to a significant reduction in the data payload compared to video lectures, the findings reveal that augmented podcasts are equally as effective in promoting learning, with no significant differences observed in their test scores in low and medium level learning. However, findings reveal a significant difference in high-level learning. The research also highlights consistent engagement levels with augmented podcasts compared to video lectures, offering key insights for curriculum designers and educators to optimize instructional materials.

Keywords: Augmented podcasts, video lectures, digital divide, low bandwidth, scores, instructional materials

Introduction

The dynamic world of digital education is characterised by the pursuit of effective and accessible instructional methods and resources is a continuous challenge. The proliferation of online education is undeniable. MOOCs and online education with video content as a major component are an established format. However, disparities in internet connectivity persist as one of the major impediments for online education.

At the same time, technology providers are developing user-friendly, crossover technologies that allow users to access information anytime, anywhere on

multiple devices in different forms and formats (Evans, 2008). With exponential technological advancement, where media and technologies are becoming easier to mix, merge and evolve, it has added to the innovative ways to utilise them in education (Carson et al., 2021). With education becoming learner-centric, more autonomy lies with the learners leading to rise in asynchronous learning.

One of the popular asynchronous media amongst the millennial generation is Podcasts. The presence of multiple podcasting platforms, including those by tech giants, is a testimony in itself to the popularity. While the audio format of media has a long history in terms of radio, its resurgence in the form of Podcasts provides educators with a motive to experiment with its usage in learning as an easy-to-access media for learning (Besser et al., 2021). There are several types of podcasts which can be used in education (Forbes and Khoo, 2015). Nevertheless, recent research has also brought forth certain disadvantages, such as lack of visual cues, distractions, lack of interaction, and limited note taking, amongst others.

Despite these disadvantages, there have been multiple researches on various aspects of using podcasts in education (Gunderson and Cumming., 2022). Recognizing the need for a more accessible medium, this research investigates the potential payload reduction when transitioning from video lectures to a hybrid option of audio augmented with text. This study looks at augmented podcasts as an educational media as a solution for reducing the digital divide by addressing bandwidth without compromising learner engagement. By delving into the preferences and experiences of students, this study aims to discern the impact of this hybrid format on learning outcomes, engagement, and satisfaction. Through this exploration, the goal of this research is to contribute valuable insights that can inform educational practices and enhance the inclusivity of digital learning platforms in diverse settings.

Literature Review

The evolution of Web 2.0 has democratised content creation, broadening access and empowering contributors with greater control over content consumption. Numerous studies have examined aspects such as engagement, student perception, and motivation for using educational podcasts, along with the overall impact of media usage. Research across various fields, from the humanities to medical education, provides insights into the use, preferences, and impacts of different media in education. In all these media formats, the use of videos in higher education and, in particular, distance learning courses has increased significantly in recent years (Harrison, 2019). Post-pandemic, video-based solutions have quickly become the most sought-after alternative to in-person instruction (Wang et al., 2021). On the other hand, the increasing availability of podcasts before and during the peri-pandemic period reflects learners' growing preference for this medium as a valuable option for acquiring knowledge (Okonski et al., 2022). This leads to the subsequent inquiry regarding the methods for assessing the effectiveness of such educational interventions.

Typically, the effectiveness of educational interventions is measured using achievement scores. In education, experimental and quantitative methods, including surveys and test scores, are commonly used to assess

behaviour change and intervention effects. Another crucial area is the data payload, which influences policymakers and content creators to make informed decisions, ensuring accessibility and inclusivity.

With this background, the literature review of this study comprises three distinct sections. The first section reviews studies on the effectiveness of podcasts as educational tools. The second section examines literature comparing the effectiveness of audio media versus video lectures as educational tools. The final section sets the stage for the current study by presenting consumption and usage metrics and trends.

Effectiveness of Podcasts as an Educational Tool

Podcasts have been a popular informal education medium in Medical Education (Berk et al., 2020). Though there have been disadvantages like distractions, medical residents informed that podcasts gave them a broader sense of core content and personalised learning, as well as fostering their connections to communities- local and national (Riddell et al., 2020). Research studies have also put forth how podcasts were leveraged as a tool for continuing medical education during the pandemic (Tarchichi and Szymusiak, 2020).

The study of using podcasts as an instructional tool for a Leadership Education Course showed several benefits and preferences of students, especially in a post-pandemic world (McCarron and Yamanaka, 2022). Podcasts have been shown to provide opportunities for reflective inquiry, aid communities of practice and help negotiate theoretical and practical knowledge (Turner et al., 2021). Systematic Review of 17 studies podcasts aligns well with the principles of Universal Design for Learning (UDL) and serves as a unique way of engagement despite its limited impact on academic achievement (Gunderson and Cumming, 2022). Research has shown that listening to podcasts closely helps in identifying logical and coherent thinking, thereby improving students' analytical abilities and writing skills (Vandenberg, 2018). Following a socio-cultural approach, podcasts have shown to provide for establishing student agency in learning and collaboration (Carson et al., 2021).

Another study highlights the role of podcasts in education planning and asserts that podcasts can enhance active learning in Blended learning environments (Moore, 2022). An empirical study on best practices of using podcasts as "readings" revealed that students who read the podcast transcripts were able to score more than the students who heard only podcasts (Oslawski-Lopez and Kordsmeier, 2021).

Podcast vs Educational Videos as Learning Resources

Podcasts, though having only audio content, have been found to be effective in improving achievement scores as well as enhancing critical thinking, analytical thinking, problem-solving and deeper reflections, along with an increase in their respective scores in the domain of Business and Information System (Jager et al., 2023). A similar study (Yasmiatun, 2023) reported increased critical thinking skills along with better engagement in an EFL class. Musa (2021) found that both basic podcasts and vodcasts increased student achievement scores in the technical subject of woodwork as compared to the traditional methods of teaching-learning. A phenomenological study

by Nurani et al. (2023) showed that 76.92 per cent of students understood learning materials with podcast media using the Spotify platform as a learning resource. Ahmad (2023) found that an Information Technology course that used podcasts as micro-learning tools showed higher achievement, especially for female students.

Song and Marchionini (2007) put forth the term 'surrogates' (condensed representation of entire digital media) and studied the effectiveness and impact of three surrogates- audio, visual, text-based storyboard, individual and in combinations (e.g. storyboard + audio) which sometimes were not in sync. This study revealed that participants could combine these surrogates for learning even if they were not synced. The study also concluded that combined surrogates were preferred, effective, and did not compromise on learning efficiency as measured by

post-experiment tasks and questionnaires. It also brings up the question of the need to synchronise various multimedia channels. In yet another multimethod study (Ilin,2021) on the effectiveness of three media types (audio, video and e-text) in blended learning reports that user preference is the determinant in usage and hence in the resultant effectiveness of the particular media. The same study disclosed that for 13-year-olds, it was usefulness and enjoyment that dictated the preference.

The reviewed literature indicates the scope of studying podcasts as an educational tool in the learning environments that are becoming increasingly digital every passing day. It can be safely concluded that when it comes to media usage, the 'no -no-size-fits-all' paradigm becomes of utmost importance.

Podcasts as a new media: The digital footprints

India has a history of using audio mediums in the form of radio for freedom struggle and social reform. This may be considered as an ease and conditioning of people in India towards audio medium. In the modern days, this has to be looked at in terms of data usage/consumption of audio medium with a specific reference to podcasts for this study.

The digital population of India in 2023 is reported to be 6.92 million and smartphone users around 1 billion (Basuroy, 2023; Sun, 2023). Data consumption of video streaming and audio streaming has been reported and spoken about on various technical platforms. It has been reported that video streaming data consumption is between 100 MB to 7 GB per hour and the consumption for audio/podcast streaming lies between 43-144 MB per hour. According to a survey conducted in September 2023, 27 per cent of urban Indians listen to podcasts at least once daily and another 25 per cent listen to podcasts two-three times per week. Only 10 per cent of urban Indians reported never listening to podcasts. It is also interesting to note that the CAGR report predicts market penetration of podcasts in India to be around 43 per cent in 2024 after showing steady growth since 2019.

The use of podcasts as an educational tool in India and, thereby, its study is still in its infant stage. There have been studies that revealed its non-usage in Arts and Science Colleges and another one studying the motivation of Indian podcasters in general.

The Study

This quantitative study is part of a

larger mixed method research project that studies the efficacy of augmented podcasts as educational tools. Drawing from the reviewed literature, the present study focuses on studying the student achievement and engagement through the test scores with augmented podcasts vis-a-vis videos amongst students enrolled in an higher education institution in the urban area of Mumbai.

Operational Definitions

This research uses terms which are defined as follows in the purview of the given study.

1. Augmented Podcasts: A content format with two distinct files, MP3 and PDF, accessible on the same page of the Learning Management System (LMS). The user begins to play the MP3 file for audio content and instructions. Once the audio starts, the user opens the PDF, which contains the corresponding visuals. The instructions to navigate the PDF are provided in the MP3 file via a bell sound. Users have the flexibility to move back and forth in both the files independently.
2. Payload: The file size of the augmented podcast and the video expressed in KB/MB/GB.
3. Test Scores: Score obtained by students in the quiz on a particular topic covered in the video or augmented podcast during the experiment.
4. Effectiveness of Interventions: The difference in the test scores of two groups which were given two distinct interventions.

Research Questions

Using podcasts in a large, diverse and developing country of India cannot happen without considering technical feasibility despite being one of the world leaders in the use of Educational Technology. Considering accessibility and effectiveness as the backbone, this study is guided by the following research questions:

RQ1: How much is the payload reduction when a video lecture is converted into a hybrid option of using augmented podcasts?

RQ2: To what extent does the media (Video or Podcast) affect student test scores across different levels of question complexity/difficulty?

Hypothesis

The study puts forth a hypotheses guided by Research Question 2 by three levels of assessment questions:

1. H0: There is no significant difference in the test scores between learners who use augmented podcasts and those who use videos for low-difficulty tests.
2. H0: There is no significant difference in the test scores between learners who use augmented podcasts and those who use videos for medium-difficulty tests.
3. H0: There is no significant difference in the test scores between learners who use augmented podcasts and those who use videos for high-difficulty tests.

Methodology

1. Learning context

A broad and relevant topic was chosen for the experiment, in

order to get larger participation and generate comprehensive data. The SWAYAM course titled: 'Macroeconomics' was selected since it was appropriate to the curriculum of Commercial Banks and Banking System (Commerce). The course covers fundamental as well as advanced topics related to macroeconomics with a focus on application in the banking sector. The course is well structured with comprehensive content making it an ideal choice for this experiment.

To identify the most relevant content for the experiment, a review process was undertaken. The entire course was analysed focusing on the content of the video lectures that matched the objectives of the experiment as well as were relevant to the curriculum of Commercial Banks and Banking Systems. Out of all the available lectures, eight were deemed most suitable for the study on the basis of content, clarity and alignment with experiment goals.

2. Augmented Podcast: A distinct pedagogical innovation:

The key innovation in this study lies in the development of Augmented Podcasts (APs), a structured content format designed to enhance both pedagogical effectiveness and accessibility. Unlike conventional audio-based resources, an AP consists of two separate but synchronized files—an MP3 (audio) and a PDF (visuals/text)—made available on the same page within the Learning Management System (LMS). The learning experience begins when users play the MP3 file, which delivers spoken content along with navigation cues. Simultaneously, learners open the PDF, which contains corresponding visuals, diagrams, or textual highlights. A deliberate bell sound cue embedded in the audio guides learners through the content, signalling when to shift their focus within the PDF. This dual-format approach allows for independent navigation of both files, offering greater learner autonomy and flexibility compared to traditional linear video or audio formats.

The pedagogical intent behind Augmented Podcasts extends beyond simple file separation. Unlike direct audio extractions from video lectures, which often lack coherence when consumed independently, APs are carefully curated and edited to align with their medium. The integration of intentional auditory cues ensures a structured, engaging, and effective learning experience. Moreover, this format reduces file size constraints while maintaining rich, multimodal interaction—making it particularly valuable in bandwidth-limited environments. This innovation was conceptualized with the goal of maximizing accessibility, learner control, and cognitive engagement without the drawbacks associated with passive video consumption.

3. Preparation of Augmented Podcasts

Audio was extracted from the course videos, and saved as MP3 files. Additionally, chronological screenshots were saved from the video. These screenshot images were combined to make a single PDF file. The combination of this modified MP3 (with the marker sounds) and the PDF containing screenshots together form 'Augmented Podcasts'.

Figure-1: Screenshot of Augmented Podcast (MP3 and PDF combination) on the same page of Bookroll LMS

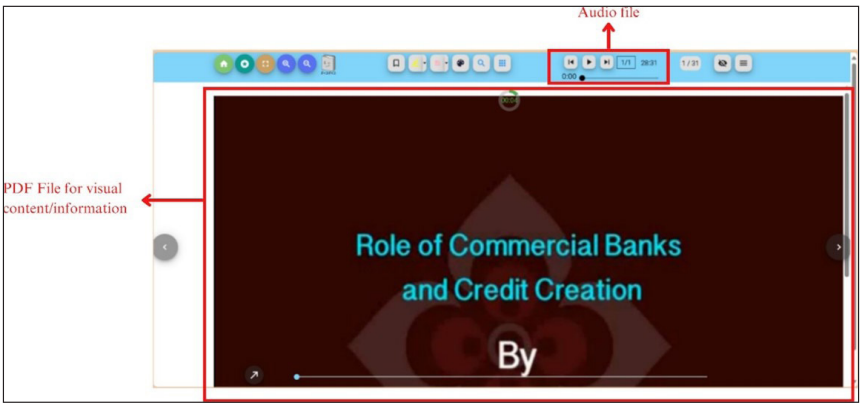

Figure 1 shows an example of Augmented Podcasts. Audio and visuals are operable separately on the same page of Bookroll LMS.

4. Functional Perspective on Payload and Media Comparison:

The comparison of payload (i.e., file size and bandwidth requirements) in this study is not intended as a direct quality comparison between videos and Augmented Podcasts (APs). Instead, it serves a functional purpose, examining whether a combined audio + text format—where both components can be accessed independently—can achieve comparable educational outcomes to video-based learning while significantly reducing bandwidth consumption.

Given the inherently larger file sizes of videos, which incorporate both visual and auditory elements, audio-based and text-based media provide a low-bandwidth alternative, particularly relevant in settings where internet accessibility and data costs are constraints. From a pedagogical standpoint, this study investigates whether the perceived necessity of video-based learning can be mitigated through well-designed Augmented Podcasts. Rather than positioning videos and APs as equivalent substitutes, the study explores their situational advantages—videos excel in visually intensive topics, while for theoretical or concept-heavy content, APs (a structured package of audio and text files) may provide an equally effective, yet more bandwidth-efficient, alternative.

This approach highlights the practical implications of APs in digital education, offering a scalable, adaptable learning format without compromising accessibility or pedagogical intent.

5. The Experimental Setup

This section will delve into three aspects of this study. (a) Online learningtoolsusedfortheexperiment, (b) Participant profile and (c) Research design and data collection.

Online Learning Tools

The augmented podcasts and the video were accessed by both the experimental group (AP) and the control group (AV) via two separate online learning tools. LA-ReflecT (for control group) and Bookroll (for experimental group).

- LA-ReflecT: It is a platform that lets teachers create engaging microlearning activities. Teachers

can design these activities using the authoring tool, and learners can access them through the viewer. LA-ReflecT seamlessly integrates with any LMS that supports the LTI protocol, providing a smooth learning experience for both teachers and students (Majumdar et al., 2023).

Figure-2: The Moodle LMS used to conduct the study

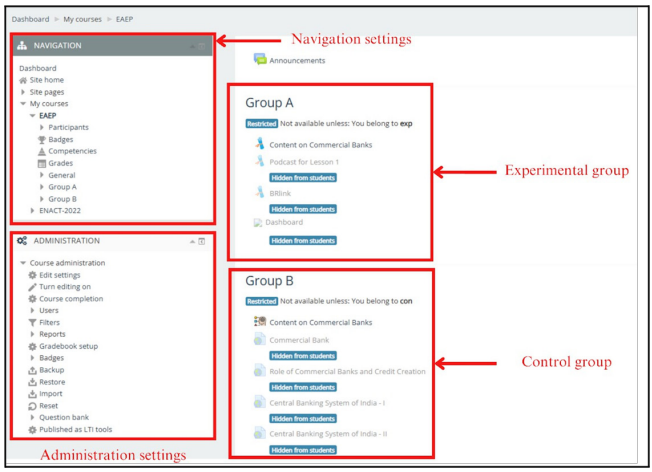

Figure 2 shows the Moodle LMS used for this study.

Two groups were created. Group A - experimental group and Group B - control group. Participants from each group can access the content of their respective group only. The figure also shows the navigation settings and administrative settings. The navigation settings help the instructor to navigate across the courses and let them access information such as badges, completion, grades, divisions. The administration setting allows the instructor to perform administrative-level tasks such as course editing, import/export, generating reports, etc.

- BookRoll: Developed by Kyoto University, is an online e-book system that allows students to view digital materials used in lectures (Ogata, Majumdar & Flanagan, 2023). To make augmented podcasts easily operable Bookroll was chosen as it allows learners to see audio and pdf in a single screen. Both these platforms could be accessed using mobile phones as well as laptops/ desktops.

Figure-3: Lecture materials shared on of Bookroll platform

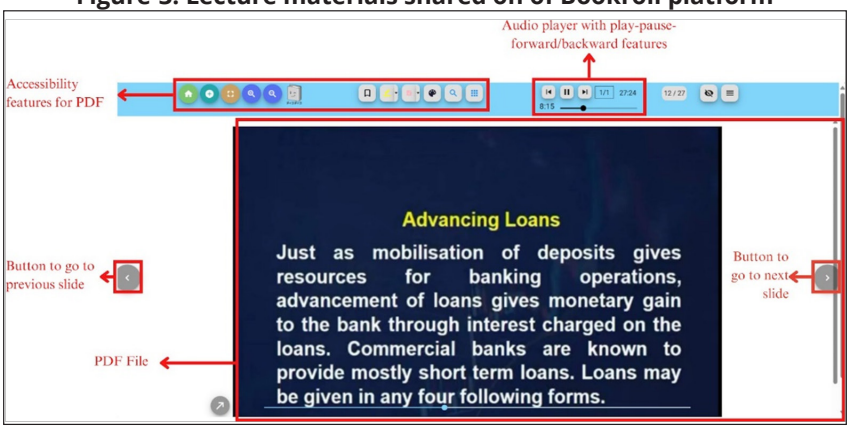

Figure 3 shows the UI feature of the Bookroll platform for accessing the augmented podcasts. At the top of the page, accessibility features such as full-screen, zoom-in, zoom-out, and search are provided. Besides these, an audio player with essential features such as play/pause and forward/backwards are available. The PDF is visible below the accessibility and audio tabs. Users can change the page by scrolling up and down, and they can navigate to the next or previous lecture with the arrow button.

Participant profile

The experiment employed purposive sampling to ensure that the participants were well-suited for the objectives of the study. An institute from Mumbai (1-tier city), known for its vibrant educational landscape and diverse student population was selected as the setting of the experiment.

The institute, located in the central and well-connected area of Mumbai, offers undergraduate and postgraduate programs in various domains. For this study, the focus was on undergraduate programs within the domain of commerce and banking. In the institute considered for study, students of B.Com Banking & Insurance were found to be a good fit. This selection was guided by the objectives of the study, which focused on media and its impact on achievement through test scores. The study compares two groups viz the Control group and experimental group. The control group (AV) consisted of 27 students, and the experimental group (AP) consisted of 35 students. Each group consisted of a balanced mix of male and female students. Due diligence was taken during the group formation that the groups were representative of the population under consideration.

Rationale for Conducting the Pilot in a Tier-1 City

The decision to conduct the pilot study in a tier-1 city was strategic and aimed at eliminating extraneous variables that could have confounded the study's findings. Factors such as inconsistent network speeds, data limitations, and infrastructural disparities often pose significant challenges in lower-tier cities and rural areas. By ensuring a stable digital infrastructure in the pilot phase, we were able to control for these external influences, allowing the study to focus exclusively on the comparative effectiveness of Augmented Podcasts (APs) versus traditional video-based learning.

Furthermore, this approach was instrumental in assessing usability, engagement, and pedagogical effectiveness under optimal conditions before considering wider implementation. The pilot study's insights serve as a foundation for future scalability, particularly for tier-2 and tier-3 cities, where bandwidth constraints and data costs remain substantial barriers to digital education. By first refining the design, content delivery, and navigation features of Augmented Podcasts in an ideal setting, we could better anticipate the challenges and adaptations necessary for more bandwidth-constrained environments.

This systematic approach ensures that when Augmented Podcasts are introduced in low-resource settings, their usability

and pedagogical efficacy have already been optimized, making them a more viable alternative to high-bandwidth-dependent video content.

Research Design and Data Collection

The experimental group was exposed to Augmented podcasts, while the control group was exposed to the video-format lectures. The experimental and control groups were closely monitored throughout the study to ensure the integrity of the experiment. Measures were taken to prevent the exchange of content in both formats between the groups, thereby eliminating spillage or dilution of experimental conditions. The strict monitoring ensured that the findings accurately reflect the impact of these media on student achievement in the test scores across levels of question complexity, providing valuable insights into their effectiveness as educational tools.

The study utilised post-test design only experimental research design. The test was administered for both groups to assess their understanding and retention of the course content consumed using two media. The test consisted of eight items validated by the subject experts to ensure their clarity, relevance and alignment with objectives. The test comprised four questions of low difficulty level, 2 of medium and 2 of high difficulty level. as per the cognitive demands required to answer these questions. This 50 per cent-25 per cent-25 per cent distribution of questions helped to maintain the norms of question paper blueprint as well as formed the basis of nuanced analysis of student score/performance across varying degrees of cognitive challenge.

Table 1 shows the difficulty level of all eight questions. The difficulty level of the distribution of questions ensured that the placement of questions varied. The difficulty level was slowly increased starting with a low level in the beginning, gradually increasing it. The high difficulty level questions were concentrated towards the end. Initial gradation provided a flavour and tempo, the in between low difficulty level questions gave a breathing space considering the cognitive load of the media which was needed for the high difficulty level questions towards the end.

Table-1: Classification of difficulty level of each questions

Difficulty level of each questions								
Question No.	1	2	3	4	5	6	7	8
Difficulty Level	Low	Medium	High	Low	Low	Low	Medium	High

The test was conducted via Google forms seamlessly integrated into the LMS. This integration facilitated smooth administration and efficient data collection. The scores generated from these tests formed the primary data sets used to test the hypotheses of this study.

Ethical Considerations

As per the requirements of the Institutional Ethical Committee (IEC), due diligence was maintained regarding student privacy and data security. Student information and consent was collected using a form called a Participant Information Sheet (PIS) as per the specifications of the IEC. The data is stored on a password protected personal computer of the Principal Investigator. The data will be stored securely for the standard time requirements.

FINDINGS AND DISCUSSION

Data Analysis

This study employs a rigorous quantitative research approach, utilising both descriptive and inferential statistical methods to analyse the data collected from the tests.

Descriptive Analysis:

Descriptive analysis was conducted primarily through percentage calculations. This analysis served two key purposes:

1. Quantification of File Size Reduction: The second aspect involved quantifying any reduction in file size, which was relevant in assessing the efficiency and accessibility of the media formats used. Although this is more ancillary to the primary research question, it provided insights into the technical advantages or disadvantages of each media type.
2. Comparison of Correctly Answered Questions: The first aspect of the descriptive analysis focused on comparing the number of correctly answered questions between the experimental and control groups. This aspect is further done in three stages: (1) comparing percentages questions-wise, (2) comparing percentages lecture-wise, and (3) overall comparison of percentages. By calculating the percentage of correct responses for each group, the study aimed to identify trends and differences in performance that might be attributable to the use of different educational media (video/podcast).

The findings of the current research are based on two major aspects: the payload reduction and effectiveness of augmented podcasts. While studying the comparative effectiveness of augmented podcast vs video lectures, test scores are used as measurement.

Reduction in Payload

While designing and creating multimedia content for educational purposes, an important factor is the payload - the file size. Lower payload helps in increasing accessibility of content. The current study is guided by Research Question that studies payload reduction in a bid to bring forth this point.

RQ1: How much is the payload reduction when an audio visual is converted into a hybrid option of using augmented podcasts?

Table 2 shows the payload (file size) of augmented podcasts and that of the video lectures. It is evident that the payload reduction of augmented podcasts is 88 percent that of the video file.

Table-2. Reduction of payload

	Lecture 1	Lecture 2	Lecture 3	Lecture 4
AV Payload	249.0 MB	258.7 MB	237.8 MB	276.3 MB
AP Payload	27.7 MB	29.2 MB	28.1 MB	37.8 MB
Reduction in size	221.3 MB	229.5 MB	209.7 MB	238.5 MB
% Reduction	**88.8**	**88.7**	**88.1**	**86.3**
Average % Reduction	**88.023**			

Taking an instance, the course examined in this study consists of 36 lectures, with the average video file size being 250 MB. Making the total storage requirement for the video files to approximately 9,000 MB (9 GB). In contrast, the same content in audio format has an average file size of 30 MB. Therefore, the total storage required for the augmented podcast files is around 1,080 MB (approximately 1 GB). Which can potentially address the digital divide by consuming low data in the areas of low network connections and taking less storage space.

Analysis of test scores

RQ2: To what extent does the media (Video /Podcast) affect student test scores across different level of question complexity/difficulty?

The analysis of question wise score comparing the two groups was carried out for a finer understanding of the difference in the scores as per the difficulty level as well as to understand the trend, if any. For this, the tool Google sheets was used. The graphs give a vivid picture of the nuanced differences in the scores as below.

Figure-3: Question wise comparison of AP and AV scores

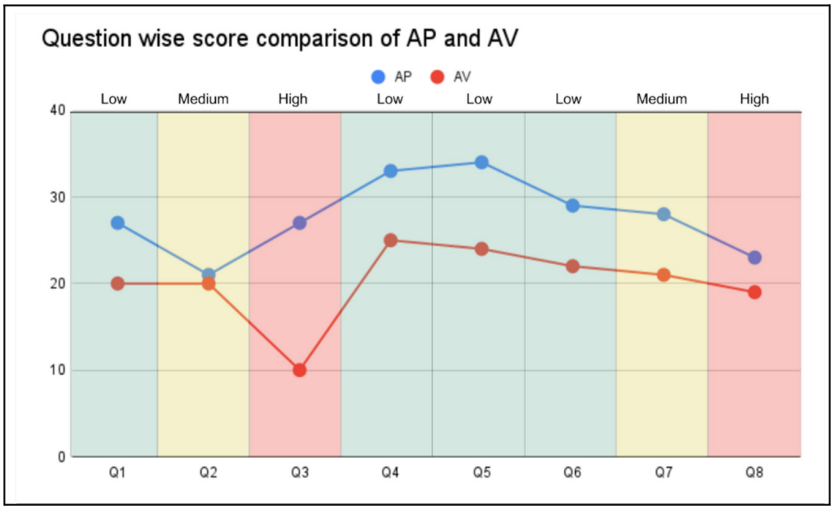

Figure 3 shows the graph mapping the scores with question numbers along with their difficulty level. It shows an observable difference in the scores of the two groups for every question, right from the first question, which was a low-level question. For the first question, the experimental group marked as AP in the legend scored higher than the control group labelled as AV in the legend. It is noted that the changes in the scoring pattern remain more or less the same irrespective of the media. The score displays a dip, a plateau and a rise at certain questions for both the groups. The analysis is indicative that in most cases, the difference in scores is dependent on the difficulty level of the questions and is independent of the media. There is an exception to this trend, as seen in Q.3, which is a high-level question. For this, there is a rise in the scores of the experimental group while a dip is observed in the scores of the AV group. Other than this, the scores followed the same pattern. In order to confirm this, a trend analysis was carried out.

Figure-4: Overall trendline of AP and AV scores

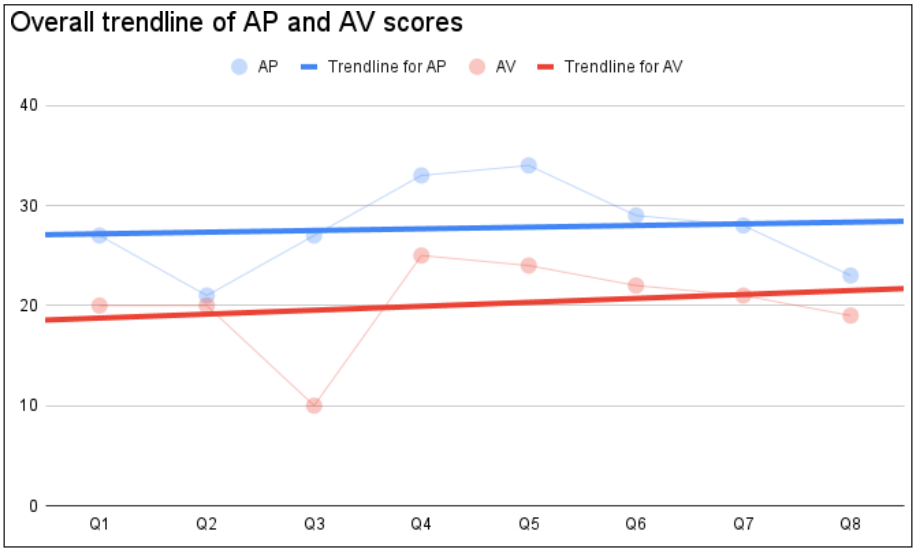

Figure 4 shows the trend analysis of the overall scores of the experimental and control groups. The trend lines confirm that both groups exhibit the same overall trend in their scoring. This is suggestive of the dependency of scores being independent of the media when seen overall. The gap in the trendline is indicative of the impact of the media. A tendency for scores to converge towards the average, thereby masking the distinct effects associated with varying question levels. Such findings underscore the importance of examining data at a more granular level to capture the nuanced impacts of media on high-, medium-, and low-level questions.

Questions 3 and 8 are both high-level questions. In question 3, there is a noteworthy gap in the scores of both groups. In question 8, the gap is similar to other questions. Upon further examination of the nature of both questions, it becomes evident that despite being categorized as high-level questions, they differ in the type of knowledge they assess. Question 3 requires the ability to synthesize complex concepts of policy and understand the relationships between ideas. Conversely, question 8 assesses higher-level classification integrating a factual recall. The consistent scores of the audio group in both questions could be because of the interactive nature of the audio + slides format, which allows learners to process information at their own pace. While video groups' drop in question requiring synthesizing could be because of the passive nature of the video while excelling in factual recall of question 8. It is clear that this necessitates further investigation in future research.

Descriptive Analysis of Quiz wise scores

The first step of determining effectiveness of the augmented podcasts was descriptive analysis of the test scores. Analysis was done question wise as well as lecture segment wise. The following tables show the analysis of the results.

Table 3 shows the percentages of question wise scores of both groups. It is worthwhile to note that the scores, which may be translated as engagement with media, remain consistent with the video lectures (AV group) for the first

two questions, unlike the augmented podcast (AP group). However, in Q.3 a sharp drop can be seen in AV, while AP remains consistent. It is evident from the table that though the students of the AP group showed lesser scores in the first two questions, the scores picked up in the next questions and remained consistent till Q.7. This hike in the AP group has dropped in the last question. In the AV group, from Q.4, there is a hike in the scores, which gradually decreases by Q.8.

Table-3: Quiz wise assessment scores of both the groups

		Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8
Question wise	AP	77.14%	60%	77.14%	94.29%	97.14%	82.86%	80%	65.71%
correct answers (%)	AV	74.07%	37.04%	92.59%	88.89%	81.48%	77.78%	70.37%	74.07%

Assessment scores of the students who took the augmented podcast and audio visual

Descriptive Analysis of Lecture wise scores

Table 4 shows the lecture wise percentages of scores of students of both groups. Each lecture had two questions based on the content. As noted above, in lecture 1 the percentage of students who gave the correct answer in group AP is lower as compared to group AV. After that, the percentages for lecture 2 are higher for group AP as compared to group AV. For lecture 3, a hike in the percentage of students with correct answers can be seen in both groups. For lecture 4, both groups had almost the same number of students with correct answers.

Table-4: Lecture-wise assessment scores of both the groups

		Lecture 1	Lecture 2	Lecture 3	Lecture 4
Lecture wise of	AP	68.57%	85.71%	90%	72.86%
correct answers (%)	AV	74.07%	64.81%	85.19%	74.07%

Assessment scores of the students who took the augmented podcast and audio visual

Descriptive Analysis of Overall Scores

Table 5 shows the overall percentages of both the groups. The overall score of AV is lesser than AP by almost 5 per cent.

Table-5: Overall assessment scores of both groups

Assessment scores of the students who took the augmented podcast and audio visual

Overall of correct	AP	79.29%
answers (%)	AV	74.54%

This difference in the percentages scores is pronounced due to the initial low scores in AV, which undermined the increase in the latter questions.

The above descriptive analysis shows that overall both the groups have performed equally irrespective of having different media to learn.

Inferential Analysis

At the outset, the collected data was checked for normality using the Shapiro-Wilk test (Khatun, 2021). The results revealed that the data collected was non-normal. This led to the application of Mann Whitney U test for inferential analysis. Mann Whitney U test is particularly suited for situations where the assumption of equal variances between groups may not hold, making it a robust choice for analyzing the test scores (Milenović, 2011). By comparing the scores of the two groups, the Mann-Whitney U test provided insights into the effectiveness of video versus podcast formats in enhancing student test scores.

This test was conducted to test hypotheses regarding the impact of the media formats on student test scores. The test was conducted on the scores obtained from both the experimental and control groups. This analysis aimed to determine whether there were statistically significant differences in performance between the groups that could be attributed to the use of different media formats.

Overall, this combination of descriptive and inferential analyses allowed for a comprehensive examination of the data, enabling the study to draw meaningful conclusions about the impact of educational media on student performance across different levels of question difficulty.

In order to further consolidate the findings, inferential analysis was carried out. This analysis was done for all three levels. Scores of each student for all the questions of the same level were summed together for both the groups. The Mann-Whitney was done between these level wise scores AP and AV.

Low-level questions

Question 1, 4, 5 and 6 were the low level questions. Table 6 shows the sum of all low level questions of each student in both the groups. As the data is not normally distributed Mann-Whitney U test was done.

Table-6: Scores of all low level questions in both the groups

Total assessment scores of the students for all low level questions who took the augmented podcast and audio visual

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
																29	30	31	32	33	34	35						
AP	4	2	4	4	4	4	4	4	4	4	4	4	4	1	4	3	3	3	3	3	1	4	4	3	3	3	4	4
																			4	4	3	4						

Mann-Whitney U test: The 35 participants (M= 3.51, SD = 0.81) who received the intervention of augmented podcasts were compared with 27 participants (M = 3.37, SD = 0.83) who received instruction via video lectures. There was no significant difference in the test scores between the two groups

p = 0.4028. The result is not significant at p < 0.05.

From the analysis of the low level questions, it is evident that both media have worked equally well for the learning of the low level questions.

Medium level questions

Questions 2 and 7 were medium-level questions. Table 7 shows the sum of all medium-level questions of each student in both groups. As the data is not normally distributed, the Mann-Whitney U test was done.

Table-7: Scores of all medium level questions in both the groups

Total assessment scores of the students for all medium level questions who took the augmented podcast and audio visual

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
										30	31	32	33	34	35														
AP	0	1	2	2	2	2	2	1	2	2	1	1	1	2	0	2	2	1	2	2	1	1	1	1	0	1		1	1
										2	1	2	2	2	1	2													
AP	1	2	2	0	1	1	2	2	2	2	2	0	2	1	2	2	1	0	2	1	1	2	2	-	-	-	-	-	-
										-	-		2	2															

Mann-Whitney U test: The 35 participants (M= 1.4, SD = 0.65) who received the intervention of augmented podcasts were compared with 27 participants (M = 1.51, SD = 0.70) who received instruction via video lectures. There was no significant difference in the test scores between the two groups p = 0.3753. The result is not significant at p < 0.05.

From the analysis of the medium level questions, it is evident that both media have worked equally well for the learning of medium level questions.

High-level questions

Questions 3 and 8 are high-level questions. Table 8 shows the sum of all high-level questions of each student in both groups. Since the data is not normally distributed, the Mann-Whitney U test was done.

Table-8: Scores of all high-level questions in both groups

Total assessment scores of the students for all high level questions who took the augmented podcast and audio visual

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
										30	31	32	33	34	35														
AP	2	2	0	0	2	2	1	2	1	2	1	1	2	2	1	2	1	0	2	0	1	0	2	2	2	2	2	1	2
													2	2	2	1													
AP	1	2	1	2	0	0	0	1	0	1	2	0	1	1	1	1	1	1	1	1	2	2	2	2	1	-	-	-	-
													-	-	-	-													

Mann-Whitney U test: The 35 participants (M= 1.42, SD = 0.73) who received the intervention of augmented podcasts were compared with 27 participants (M = 1.07, SD = 0.67) who received instruction via video lectures. There was a significant difference in the test scores between the two groups p

= 0.0381. The result is significant at $p < 0.05$.

From the analysis of the high-level questions, it is evident that both media have not worked equally well for the learning of medium-level questions. This needs further investigation. It is evident that both media have worked equally well for the learning of low and medium questions.

Usability and Engagement

While videos offer a passive consumption model, Augmented Podcasts (APs) require active engagement through interactive elements such as synchronized transcripts, clickable timestamps, and supplementary resources. This additional effort in navigation is not a drawback but a feature that deepens cognitive engagement and enhances learning retention.

- Active Learning Over Passive Consumption: Unlike videos, which often lead to passive watching, APs require intentional interaction—skimming through transcripts, revisiting key points, and engaging with supplementary materials. This aligns with cognitive load theory, where controlled effort leads to better retention.
- Personalized Pace of Learning: APs allow users to navigate based on their needs, spending more time on difficult concepts and skipping familiar ones. This control fosters self-regulated learning, which research suggests enhances motivation and comprehension.
- Mobile Optimization & Usability: The argument that APs demand extra effort is mitigated by the fact that modern podcast platforms are designed for seamless tap-and-scroll interactions, making them just as easy to use as video platforms, if not more so. It was also possible for learners to annotate the pdf of the slides whenever they felt necessary. This feature of additional learner autonomy and responsibility is not available in the video format.
- Cognitive Load Reduction: Videos often integrate multiple simultaneous stimuli (visual, auditory, textual), which can overwhelm learners. APs break this down by separating audio track, and the visual slides, allowing for more focused and self-paced learning.
- Screen Independence: Learners with visual impairments or those in scenarios where screen use is impractical (e.g., commuting) benefit from the flexibility of APs.

Conclusion

This research provides important insights into student engagement with augmented podcasts and video lectures, demonstrating that both media effectively support learning, though their strengths may vary depending on the complexity of the content. While no significant differences were found in test scores between learners who used podcasts and those who used videos in low- and medium-difficulty tests, a difference emerged in high-difficulty tests, where videos slightly outperformed podcasts. However, this does not diminish the potential of augmented podcasts, especially when paired with supplementary PDFs, which allow for content delivery that is both efficient and effective.

Augmented podcasts proved to be a novel and comparable alternative to video lectures, particularly for content that is less complex and does not rely heavily on visual elements. The combination of audio with text-based materials allows learners to engage deeply with the content, without the distractions that sometimes accompany

video-based learning. Their reduced data load makes them an ideal, low-bandwidth alternative, offering significant advantages in overcoming digital divide issues, particularly in regions where internet access is limited or unreliable.

For educators and curriculum designers, these findings highlight the importance of not relying solely on video lectures. Incorporating augmented podcasts into the curriculum can enhance accessibility and engagement, particularly for content that can be conveyed effectively through audio. The results of this study invite educators to re-examine how different media can serve different educational needs, encouraging a more balanced and inclusive approach to instructional design.

Future research should continue to explore the impact of these media by focusing on the qualitative experiences of students using augmented podcasts. Such studies would help uncover further nuances in student preferences and media consumption patterns, ultimately guiding the development of more personalised and effective educational content. Further research should also explore the impact of these media on other subjects which rely heavily on visual elements.

Future Research Directions

While this study establishes the usability and effectiveness of Augmented Podcasts (APs) in a controlled learning environment, certain aspects require further exploration. One key area for future research is optimizing APs for mobile accessibility. While it is currently functional on mobile devices, its seamless navigation, integration with learning management systems, and user experience across different screen sizes and operating systems warrant deeper investigation.

Additionally, transcripts and assistive features can enhance the accessibility of APs, particularly for learners with hearing impairments. Future research can explore how synchronized transcripts, interactive transcripts, or AI-generated captions may contribute to inclusivity without compromising engagement.

LIMITATIONS

Despite its contributions, this study has certain limitations. The study was initially conducted in a tier-1 city, where infrastructure issues like low bandwidth or unstable connectivity were not a concern. Although this helped control for extraneous variables, future research should examine APs in tier-2 and tier-3 cities to assess their real-world effectiveness across varied digital environments. This consideration was incorporated in the later stages of the experiment. This paper presents findings from the pilot study, which is part of a larger research project.

This study focused on concept-heavy content, where APs may serve as a viable alternative to videos. However, for visually intensive subjects (e.g., engineering diagrams, medical imaging), APs may have inherent limitations. Further research should investigate their applicability across different disciplines.

While APs encourage active engagement through navigation, the additional cognitive effort required might be a barrier for some learners, particularly those accustomed to passive video consumption. Future research should examine user preferences, cognitive load, and engagement levels in different learner populations.

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