Integrating Podcasts into MOOCs: Comparing Effects of Audio- and Video-Based Education for Secondary Content ⋆

Daniel Koehler[0000−0003−3121−3888], Sebastian Serth[0000−0003−1236−6600],
Hendrik Steinbeck, and Christoph Meinel

Hasso-Plattner-Institute, University Potsdam
Potsdam, Germany
`{daniel.koehler, sebastian.serth, hendrik.steinbeck}@hpi.de`

Abstract. Multimedia learning methods can enrich any online learning scenario. However, traditional Massive Open Online Courses (MOOCs) often put the learner into classroom-like situations without considerably varying presentation formats. By conducting a study and analysis of multimedia elements such as interviews and podcasts, we lay a foundation for future research in the field of multimedia learning. This research studies video-based and audio-based education methods for secondary learning content. We explore both the conscious and subconscious effects of the different formats. In our quantitative assessment of more than 900 learners, we did not observe any significant differences in quiz performance between learners of the two groups. Although our recurring learners are used to video-based learning methods, the audio-based teaching methods were accepted and rated "easy to follow" by more than 80% of our learners. However, we observe that the learners enjoy *traditional podcasts* with a single presenter the least. Our work adds to the field of multimedia online teaching and shows that enriching courses with audio-based education methods proves beneficial for asynchronous learning offers.

Keywords: podcasts · MOOCs · multimedia learning · online learning

1 Introduction

Teachers in traditional secondary and tertiary education classrooms have learned to apply varying teaching methods to keep the learners' attention [19]. Such variation has already seen tremendous success. Nevertheless, few online-learning courses use variable teaching methods or a variety in presentation formats to increase learner engagement. Notably, the COVID-19 pandemic of recent years

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triggered an incredible growth of online education [1]. While traditional education such as from schools or universities has moved online, many additional offers for personal and adult education in the form of Massive Open Online Courses (MOOCs) have been created [13,2]. Unfortunately, recent studies show that the current state of MOOCs concerning learner interaction and educational best practices is not en-par with face-to-face learning, yielding less learner success. [14,9].

Traditional online courses primarily consist of video material interlaced with additional exercises such as multiple-choice quizzes to engage the learners and ensure that the course content is appropriately understood. Trends show that the use of interactive learning content (e.g., drag-and-drop exercises or H5P[1] elements) has already increased largely [5]. Nevertheless, new knowledge in online education is still primarily provided in video-based learning or as additional literature proposed in the course.

In addition to visual learning, people consume much information and knowledge by simply listening. This behavior has been observed over the last centuries, for example, by the ongoing popularity of (informational) radio [17]. However, recently, podcasts as a sole medium of entertainment and information sharing have seen a massive surge of consumers. Podcasts have increasingly become a part of everyday life as seen in rising listener counts, such as the increase of 30% in podcast listeners over the past three years[2]. Similarly, podcasts have started being used more and more as a medium for traditional education, which had to move online [11,3,21,20].

To identify possibilities to improve online education, we conducted a study to evaluate if educators can integrate podcasts into online education as a video-equivalent teaching medium. Therefore, we formulate the following research questions:

RQ1. How does the form of content presentation (e.g., podcasts, interviews, videos) affect learners' perception? (c.f. Section 4.1)
RQ2. How do audio-based teaching methods compare to video-based education in regard to learning success? (c.f. Section 4.2)
RQ3. Which differences regarding learner acceptance and learning success can a teacher observe when comparing audio-only and video-based education? (c.f. Section 4.3)

2 Background and Related Work

Traditionally, video-based online education in the context of MOOCs features audio-visual learning items — *videos*. These are usually open to any student to watch and learn the content.

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[1] H5P is a JavaScript Framework for interactive exercises, Website: `https://h5p.org/`
[2] Statistics from `https://www.buzzsprout.com/blog/podcast-statistics` (Retrieved Feb. 5th, 2022)

Very similar regarding the availability and openness are *podcasts*. They convey knowledge in an audio-only format. Podcasts can be seen as the continued development of radio, proliferating and available on almost any topic of interest on various streaming platforms such as Spotify or Apple Podcasts [18]. Educational podcasts often rely on additional material such as the so-called show-notes, often referencing texts or articles available for download to the listeners [6].

2.1 Comparing Audio-Based and Video-Based Education Methods

To the best of our knowledge, despite the rising popularity of podcasts and the positive aspects they provide, the impact of the delivery medium of educational material on learner success is not yet investigated thoroughly. Some fellow researchers explicitly exclude the comparison from their work [8].

Comparisons between audio- and video-based education have been performed with a small group of students (N=94) by Shqaidef et al. in the field of dental education [16]. Their research identified that no significant difference exists between the two learning groups for basic knowledge, such as easy recall tasks. However, for analytical questions, the scores of students experiencing video-based education were significantly higher. Limitations of their work are the relatively small group of assessed students. Further, in-depth study material, namely the printed presentation slides, was provided to the students. The way of knowledge presentation is therefore not considered audio-only anymore.

Fellow researchers Daniel and Woody have studied 48 students of a psychology course using podcasts for delivering *new content* [7]. However, they explicitly state that "the use of audio podcasts remains untested for delivering *secondary content* that reinforces, extends, and contextualizes the primary concepts of a course or concept". Further, they raise awareness for the challenge of carefully selecting fitting content for audio-only education, as educators can not convey every learning item or topic without visual support similarly effectively.

Our study fills in the gaps of previous research by comparing the learning success of different forms of content presentation using videos and podcasts.

3 Study Material and Study Design

The following sections describe the content presentation forms to be studied, the study design, and the execution of the same.

3.1 Learning Material for the Study

In previous work, we discussed our process of selecting appropriate content to teach in an audio-only podcast [10]. We decided on using podcasts for *secondary content* in new learning items, which we added to our course, within so-called *Deep Dive* sections. In those sections, we reiterate key learning content, highlighting interconnections or differences between various terminologies, technologies, and functionalities previously explained. To gain a holistic view of the impact

of the presentation medium, we created three *Deep Dive* sections for our study. These multiple *Deep Dive* sections allow room for subjectivity regarding the perceived difficulty or learning result between the different learning topics.

For example, one of our *Deep Dive* elements in our online course on cybersecurity reiterates on digital signatures. In previous learning elements, the technical background of digital signatures has been presented, which leaves the *Deep Dive* to target practical implementations and the security goals achieved with digital signatures.

3.2   Content Presentation Forms

In previous work, we assessed which presentation methods might be suitable for evaluation in more detail [10]. We decided to offer the learning content from the *Deep Dive* sections using three different teaching methods as shown in Table 1.

Table 1. Overview of the different presentation forms and the thereby manipulated variables.

Presentation Method	Number of Presenters	Video Available
Interview Video	2	Yes
Interview Podcast	2	No
Traditional Podcast	1	No

Interview Video Learners in our MOOC platform are used to video-based education formats. As the control group for visual education, we present content from two speakers in an interview format without any additional visualizations.

Interview Podcast One of the elements under close survey for this work is our *interview podcast*. To ensure that we teach the same content as in the corresponding interview video, we took the audio from the video and presented it as an audio-only podcast.

Traditional Podcast Finally, we evaluate the impact that the number of presenters in a podcast has by comparing a single presenter to multiple presenters. After recording the interviews, we recorded this audio to ensure we presented similar content in the one-person podcast. Hence, we picked the significant questions from the interview podcast and elaborated on the same ideas and challenges while only having one presenter.

With our approach of recording the different elements, we are confident that the knowledge and content we present in all three podcast variants are the same. To assess the learners' learning success, we provided identical quizzes and tests, regardless of the content variant they had.

3.3   Study Design

We performed the study in the context of one of our Massive Open Online Courses. Our study plan is preregistered with *osf.io*[3] and thus available to fellow researchers[4] .

As presented in Table 1, the two main variables that we modify within this study are the *Number of Presenters* as well as the *Availability of Video Content.*

In our online course and study, we presented learners with a total of three *Deep Dive* sections in which we compared the different presentation methods. In each section, users are first shown the *learning item*, i.e., the interview video or one of the two audio-only podcasts. Afterwards, learners answer a *content quiz* and finally, they are asked to complete one *survey* for feedback in each *Deep Dive* section. Users are assigned to one of the three different forms of content presentation when they visit the first *Deep Dive* section. This assignment is performed in a round-robin principle and stays consistent for the other *Deep Dive* sections. Thus, we present a single user content in only one of the presentation forms throughout our course.

As we collect feedback from learners with one survey for each of the three *Deep Dive* sections, we have fine-granular data, which further allows us to reflect on changes in the users' answers. These might occur because a specific topic might have been more or less suitable for the podcast format as the others or because the learners' perception could change over time, i.e., with repeated presentation of a specific learning medium.

Survey Design The perception of learners was measured using a quantitative survey questionnaire. Due to the high count of participants in a MOOC, we are confident that a survey is the only reasonable proxy for quantitative measurement of learners' perceptions. We asked the learners to answer it after consuming the respective learning material. The survey was optional, and we did not offer rewards or incentives.

We divided the surveys into multiple question groups. First, we asked the users to provide feedback on the content of the learning item. This feedback is collected using various 5-point Likert scale [12] questions. While the learning content remained identical during all the different learning variants, this question block allows us to capture subconscious differences among the users and their understanding of the content.

The next block of 5-point Likert scale questions targeted the *type* of learning content. Recurring users in our online courses are used to traditional education videos, showing the teacher and presentation slides. This section explicitly required the users to assess whether they liked and enjoyed the new type of learning (i.e., our interview video or podcasts).

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[3] Open Science Framework, Website: `https://osf.io`

[4] *Survey Preregistration: Consuming Security: Evaluating Podcasts to Promote Online Learning Integrated with Everyday Life*: `https://osf.io/grqek` (DOI: 10.17605/OSF.IO/GRQEK

The third block of 5-point Likert scale questions references the connection between the presenter and the learner. We attempted to identify whether the learner felt that a particular form of teaching might be particularly engaging or boring.

Finally, we calculated the Net Promoter Score (NPS) [15] of our *Deep Dive* sections. The NPS assesses the likelihood of users recommending an experience to friends and divides them into *promoters*, *passives* and *detractors* based on their responses. The final score (ranging from -100 to $+100$) allows us to compare the different formats against each other easily.

3.4   Learning Success

Besides the questionnaires we asked the users to fill out, we collected implicit feedback on the learning items by providing the learners with an ungraded quiz in the learning platform. This provides us with quantitative data to measure the learning success of the different presentation forms. Therefore, we prepared our course so that learners of any content variant first consume their *Deep Dive* learning content. Next, we present them with the survey for their particular variant. Finally, they can take an ungraded quiz to evaluate their learning success from the previous learning item. Those quizzes followed the same design as usual ungraded quizzes offered after each video unit, ensuring that learners are already familiar with the format. Assessing the success of a teaching form by comparing learners' success for the different groups in the quiz helps us derive implicit insights on the content presentation.

4   Results and Analysis

We performed the study in this work performed alongside a cybersecurity MOOC in English language. 3,969 Participants have initially registered with our online course, out of which 1,186 participants (42% of active learners, i.e., those visiting at least one item) have completed the course. As described in Subsection 3.3, we randomly assigned the learners into three groups to be able to compare the different learning and content presentation types. For each learner, we offered a total of three *Deep Dive* elements in which we presented the learning content in the assessed form. We presented the learners with the same presentation form across all three *Deep Dive* sections. Each of the *Deep Dive* elements was accompanied by one survey per group of learners. Additionally, each *Deep Dive* element was accompanied by an identical quiz for learners of all three groups. Table 2 shows the exact number of participants and completions per learning element in the course.

We derived the NPS over all of the nine different learning items out of the three presentation categories. The calculated scores rank the *Interview Video* the best (NPS: 7) followed by the *Interview Podcast* (NPS: -4) and finally the *Traditional Podcast* with an NPS of -7. In the following sections, we analyze in more detail which aspects of the teaching content were particularly liked or disliked by the learners.

Table 2. Overview over the enrolled number of learners in the course and the corresponding rate of completion of the different surveys, quizzes and learning items. *Quiz Completions* showing unique users, some of which took the quiz without previously accessing any of the learning items.

		Interview Video	Interview Podcast	Traditional Podcast
Course Enrollments			3,969	
Active Learners			2,815	
Deep Dive 1	Interacting Users	312	280	302
	Survey Results	142	111	104
	Quiz Completions		1,121	
Deep Dive 2	Interacting Users	231	225	213
	Survey Results	104	79	76
	Quiz Completions		909	
Deep Dive 3	Interacting Users	192	176	173
	Survey Results	65	59	56
	Quiz Completions		874	
Course Completion			1,186 (42% of Active Learners)	

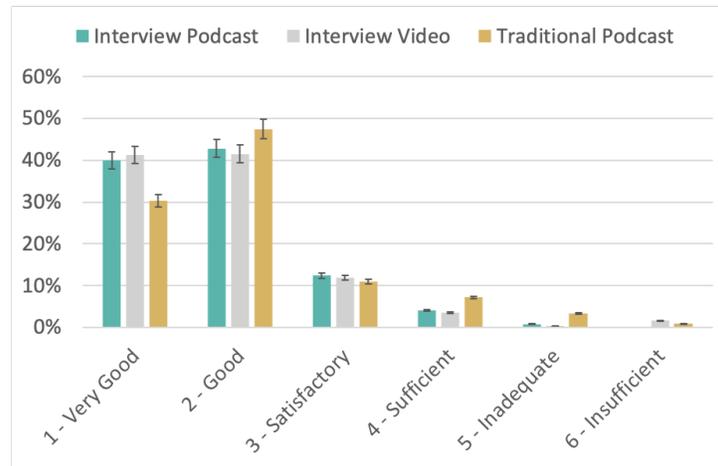## 4.1 Acceptance of new Presentation Formats

Fig. 1. Distribution of the school grades that the learners assigned to the learning content. Whiskers show standard deviation. N=804

Independent of the actual learning success, in the field of lifelong learning and adult education, keeping learners' attention and motivation is of particular

importance [4]. We, therefore, tested the overall acceptance of our *Deep Dive* elements and the three different presentation formats by asking the learners to rate the items using school grades ranging from *1 - Very Good* to *6 - Insufficient*. Figure 1 shows that the lowest-rated content out of the three was the *Traditional Podcast* with an average grade of 2.18. The next-best rated type of learning was the *Interview Video*, which was on average graded with a 2.03. With another 15% increased grade, *Interview Podcast* was the best-graded type of learning item at an average grade of 1.73.

To judge the acceptance of the new education formats, we further assessed access statistics of the different learning items. Throughout all learning items, we observe that 91% of active course participants at that point also access our optional Deep Dives. This falls in line with statistics from other courses in which 92% of learners accessed optional items.

4.2 Analysis of Learning Success

The main target for any education form is to convey knowledge. We retrieved implicit feedback on the quality and success of educating learners by assessing their performance during the course and, e.g., weekly graded exams.

Figure 2 shows a box-plot of the course performance that the learners of the three different presentation forms achieved. The course performance is almost identical for all three variants (Median: 0.86), with non-significant differences in-between the three groups (measured with a one-way ANOVA, $p = 0.68$). We thus conclude that all three presentation formats fulfilled the task of providing and reinforcing knowledge to our learners. This verifies results from related work identifying that for teaching basic knowledge, audio-based and video-based education serve equally good [16]. The $\times$ indicated in the chart marks the mean course performance (Interview Video: 0.83; Interview-Podcast: 0.82; Traditional Podcast: 0.82).
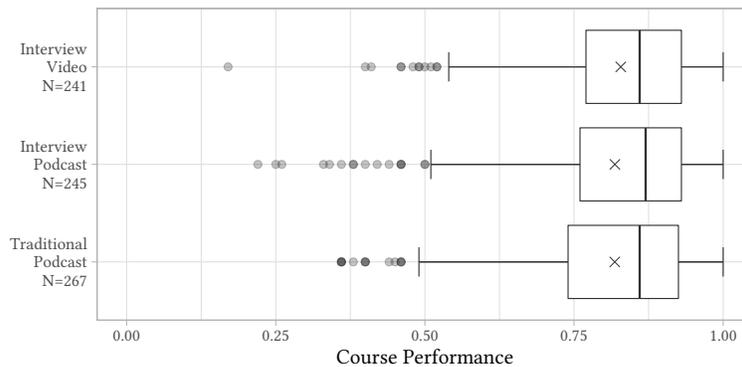

Fig. 2. Course performance of learners partitioned by the different Deep Dive presentation formats. Black lines mark median values, $\times$ the mean. N=753

Having identified that all three presentation methods yielded similar good results regarding the learners' course performance, we also analyzed the learners' conscious feedback on whether they understood the presented content. The Likert scale presented in Figure 3 containing the results of our first *Deep Dive* section shows two major results:

(1) The content in all three education forms was understandable to at least 89% of our learners.
(2) The surveys show a differentiation of eight percentage points between learners agreeing with the question of whether the content was understandable between the variants *Video* (89%) and *Interview Podcast* (97%). This finding is particularly surprising, as the (audio-) content in the interview podcast was identical to the spoken content in the video. This could indicate that being forced to concentrate on audio-only content might lead to learners understanding that content better.

However, the results from the other two *Deep Dive* sections do not confirm that hypothesis. Both other surveys show the comprehensibility of the *Traditional Podcast* slightly worse than that of the Interviews, with the *Interview Videos* rated best (*Traditional Podcasts*: 89%, 89%; *Interview Podcasts*: 93%, 94%; *Interview Videos*: 96%, 97%). It appears to be generalizable that content prepared by two speakers in the form of an interview or dialogue is better understandable.
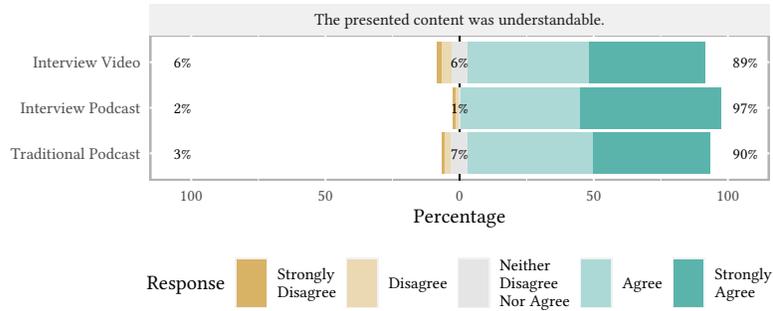

Fig. 3. Likert scale answers whether the content was understandable, as taken from the surveys of *Deep Dive* 1, N(Total)=357

4.3   Comparison of the Presentation Forms

Having identified that the content appealed to the learners and adequately served its function in educating our participants properly, we analyzed and considered other variables closer.

Table 3. Overview of learners' preferences for modified variables. Highlighted are the stronger preferred variants. Color-coded in Mint-Green are cases where user preference is identical to the way the variable is presented. Highlighted in Beige are the cases where learners preferred a different variant than the one they experienced.

	Variable	Interview Video	Interview Podcast	Traditional Podcast
Speaker	**Count**	2	2	1
	Preferred Single	5%	15%	33%
	Preferred Multiple	86%	66%	24%
	Indecisive	9%	19%	43%
Media	**Video Available**	Yes	No	No
	Preferred Video	53%	45%	44%
	Preferred Audio	30%	20%	23%
	Indecisive	17%	35%	33%

In our survey, we collected feedback on the two modified variables (*Video Availability, Number of Presenters*) for all learning types. Table 3 provides an overview of the results for the different presentation forms. For each of the variables and the respective presentation method, we highlight how the variable is used in the offered teaching content and which option of the variable is preferred by the learners as taken from the surveys.

Number of Speakers One of the variables we experimented with was the number of speakers in the learning element. Therefore, some of our questions asked the users to imagine the other presentation forms they did not experience. One example of such are learners of the *Interview Podcast* being presented with the statement "I think multiple speakers are confusing for audio content". In the surveys, 66% of learners disagreed with that statement, implying that they preferred multiple speakers. Table 3 highlights such feedback.

For the *Number of Speakers*, the data shows stronger tendencies towards two speakers as seen in the 66% or even 86%. However, this does not appear to be of universal truth, as the listeners of the *Traditional Podcast* responded with a (slight) tendency toward a *Single Speaker*. One might argue that learners tend to prefer the variant which they experienced. However, the listeners of the *Traditional Podcast* with only one speaker were most indecisive. We conclude that the learners who listened to only one presenter in a podcast were least happy with their way of presentation.

Video Availability For *Video Availability*, the hypothesis from before — that learners tend to prefer the variant of the variable that they have been presented with — does not appear to hold. Of the learners who watched a video, 53% selected that they preferred it. However, even for learners who did not watch a video, the majority (45% and 44%) would have preferred to see a video in

addition to the podcast. The same applies to the indecisive learners: The learners presented with a podcast showed twice the amount of indecisiveness.
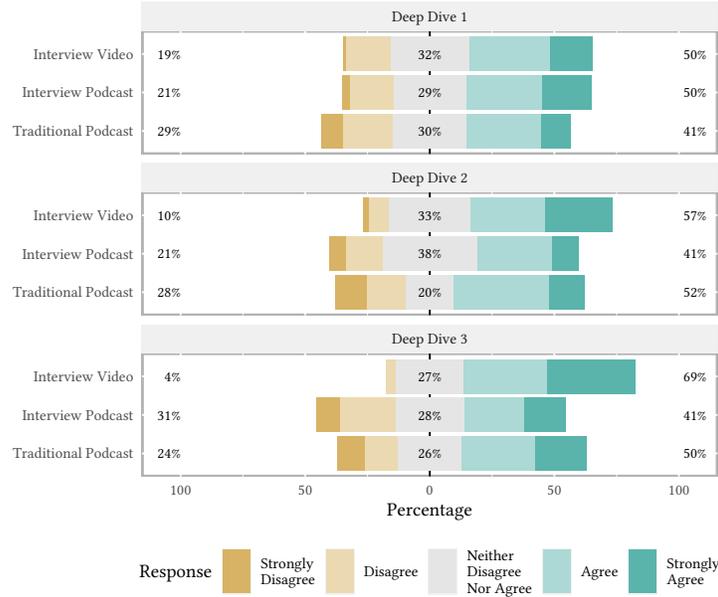

Fig. 4. Answers to the statement "I'd like to see more content in this form" grouped by the different *Deep Dive* elements.

We observe similar results when analyzing whether the learners are interested to see more content in the presented form. User's interest for more *Interview Podcasts* has decreased from 50% to 40% throughout the three *Deep Dive* sections. However, at the same time, interest in more content in the form of *Interview Videos* has increased from 50% to 69%. Therefore, we conclude that while one standalone podcast is retrieved positively, recurring learning content is most positively perceived in video form. Since videos are the primary way of presenting content in our MOOCs, this result aligns with the expected outcome.

5   Limitations

The study at hand was created in the very narrow context of cybersecurity with a relatively limited sample of learners (on average survey completions per Deep Dive N=265). Further, we presented podcast elements for the first time in this MOOC, which could lead to a "novelty" effect for our learners. On the other hand, our learners are used to video-based education and might have biased the results against podcasts.

6   Future Work

Our study opens the research space for comparing audio-only to video-based education, particularly for secondary content. However, some questions are still missing generalizable answers. Therefore, we aim to investigate the following ideas and questions in future research:

1. The regular video units and podcasts we presented in the course were of similar length, with 10 to 15 minutes on average. Platforms such as Apple Podcasts or Spotify feature popular podcasts with lengths of up to 90 minutes. As such, the optimal length of a podcast remains to be evaluated.
2. In future online courses for broader audiences, we will reiterate similar experiments and the questions at hand. This should help normalize, e.g. the "novelty" factor that podcasts had in the study at hand.
3. In our videos and podcasts, both the interviewer and the interviewee are members of our teaching team. However, educators could use the interview format to integrate experts on a specific topic. We aim to investigate the impact of different interview partners and their level of expertise on the learner's interest in the interview-based learning elements.

7   Conclusion

The presented work tackles one deficit of current online courses: the lack of diverse content presentation methods and not relying on visual information. To enable more diverse and inclusive learning formats, we investigated the effects of using audio-only podcasts compared to video-based online education for secondary learning content.

Previously, the question of whether audio-based education might be of a substantial benefit or a suitable alternative to video-based online education was often omitted or barely touched by other research [8,7,16]. Similarly, we hardly see podcasts integrated into established online learning platforms, such as the platform operated by us, openHPI[5], or other (international) platforms such as Coursera or Edx.

Our study compared three different presentation methods: (1) *Interview Video*, (2) *Interview Podcast*, (3) *Traditional Podcast*. Learners were randomly assigned to the different education groups. Throughout the course, we presented them with three *Deep Dive* learning items in their respective education format, followed by a survey and a content quiz to evaluate active feedback and subconscious learning results. We were able to derive the following results regarding our research questions:

RQ1. How does the form of presentation affect learners' perception?

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[5] `https://open.hpi.de`

We identified that the learners perceived the educational character of the presented content throughout all three methods positively (80%, 82% and 83%). When asked to assign school grades from 1 (*Very Good*) to 6 (*Insufficient)* to the different course items, the *Interview Podcast* scored best, with an average grade of 1.73 (*Interview Video*: 2.03; *Traditional Podcast*: 2.18).

RQ2. How does audio- and video-based teaching contribute to learning success?

Our study did not show significant differences in learning success between the analyzed groups. Instead, all learners performed similarly well with averages of about 86% performance in the course. Regarding the conscious feedback, our surveys show that, generally, the content of the *Interviews* was rated slightly (6%) better understandable throughout all learning items.

RQ3. Which differences can be observed when comparing audio-only and video-based education techniques?

Our analysis shows a tendency towards multiple speakers compared to a single speaker. Further, comparing the availability of video, learners preferred video-based education. However, this might be because our recurring learners are used to video-based education.

Comparing results between the different *Deep Dive* sections raised the assumption that the *Interview Podcast* is primarily appreciated if only used rarely, e.g., once or twice per course. This is supported by the fact that over the three *Deep Dive* sections, the appreciation for the *Interview Podcasts* dropped (by 23%). In contrast, the appreciation of *Interview Videos* has increased by 38%.

7.1   Takeaways for Researchers and Teachers

The essential question of this work on video- or audio-based education still shows indecisiveness amongst learners. We account this uncertainty to personal preferences, a relatively small amount of survey answers, or the inconclusiveness of learners used to video-based education. However, we see that no presentation form is superior for learning success. Video-based and audio-only education methods can account for specific needs during an online course. As a seldom integration of podcasts for multimedia learning showed great resonance by the learners, we advise any content creator, educator, or teacher to identify the content they can add as an interview-styled podcast to their courses.

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