Revealing the secret behind the innovative «One-video- fit for all» method in education.

Tonje Jin, Norwegian University of Science and Technology, Norway

ABSTRACT: This article delves into the innovative use of seamless branching videos in higher education, focusing on courses at the Norwegian University of Science and Technology (NTNU) in 2023. Seamless branching videos create personalized learning journeys, allowing students to interact with content that adjusts to their unique needs. This method notably boosts engagement and understanding, especially in intricate subjects like mathematics. The incorporation of AI technologies further refines the flexibility and effectiveness of these educational tools for future advancements. Our research indicates that seamless branching videos not only enhance traditional teaching methods but also present new challenges for educational implementation. The article offers insights into how these videos can revolutionize educational experiences and provides practical advice for educator's interested in adopting this technology. By outlining the benefits and overcoming potential obstacles, our goal is to make it easier for educators to embrace this innovative approach to enhance their teaching methodologies.

1. INTRODUCTION

As the introduction of branching videos in education is relatively novel, there is limited research and resources in this realm, potentially leaving many educators unfamiliar with the concept. Although branching videos have been utilized in movies and commercial industries, their application may not seamlessly align with the educational context. To address this gap, we will begin by elucidating the concept's educational utility.

In our 2023 study [1, 2], branching videos were integrated into mathematics courses for engineering and economics students, with a focus on mathematics as the primary example. The adaptable nature of branching videos is particularly well-suited for subjects with diverse levels of prior knowledge and student comprehension variations.

In lecture videos, students can access customized additional explanations based on their individual needs and existing knowledge. The practical application of mathematics can be tailored to align with the specific field of engineering they are studying, enhancing the relevance of the practical examples presented. This personalized approach has demonstrated efficacy in enhancing students' grasp of mathematical concepts and their real-world relevance [3]. Refer to Figure 1 for the flowchart illustrating this process.

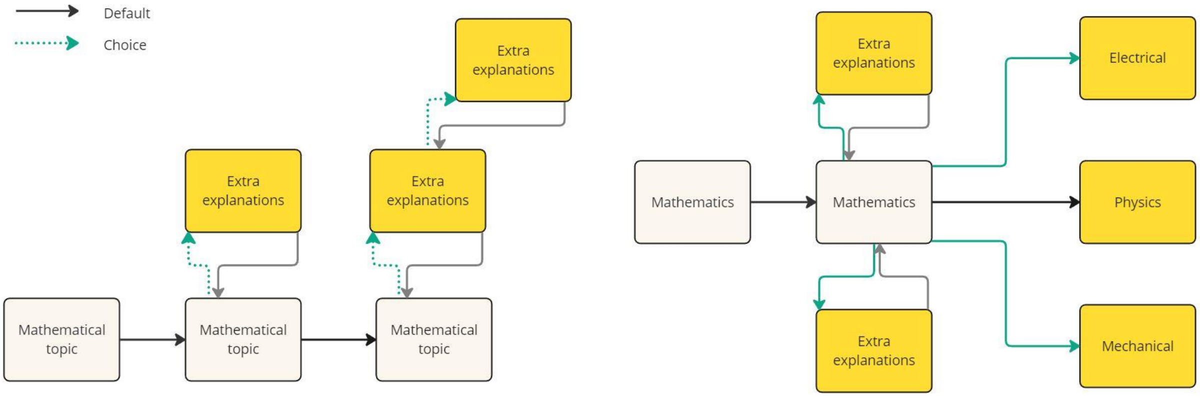

Figure 1 The provided flowchart illustrates the structured arrangement and progression of lecture videos within an educational setting.

In the lecture branching videos, consistent visual and audio quality maintains a seamless transition between video clips. By clicking the "i"- button, denoting information as depicted in Figure 2, students can access supplementary explanations without disrupting the viewing experience. This interactive feature ensures that the additional explanations seamlessly blend with the main video content.

Moreover, students can pose additional questions by utilizing the question button, located prominently in the top right corner of the screen. Clicking this button prompts an anonymous form to appear, accompanied by a thumbnail image indicating the relevant video segment. This dual function not only guides students on areas requiring clarification but also assists teachers in addressing specific queries effectively when creating additional explanatory content for the branching videos.

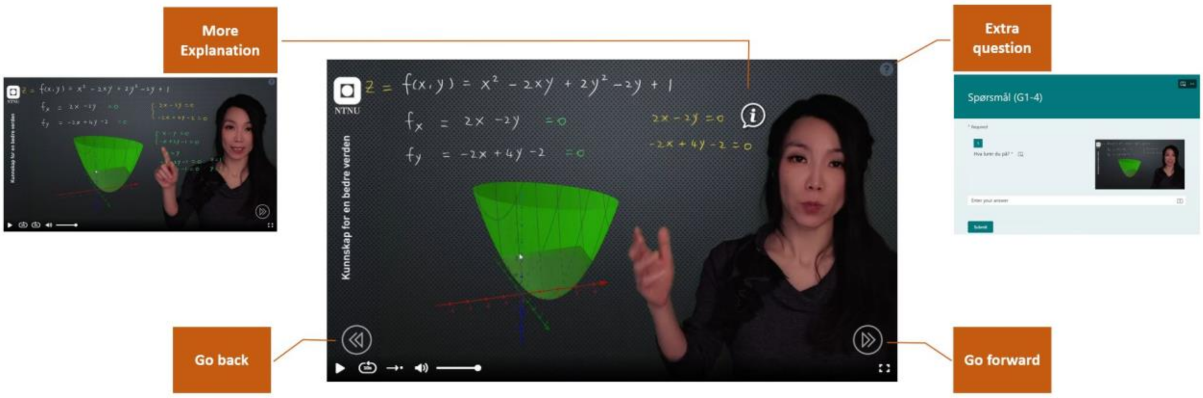

Figure 2 Student view and overview of the interactive components in lecture videos

Problem-solving videos present multiple approaches to tackling mathematical problems, varying based on students' unique thinking styles, understanding levels, and pre-existing knowledge. Through branching videos, students are encouraged to exercise creativity and delve into methods they personally find most logical. See Figure 3 for a visual representation.

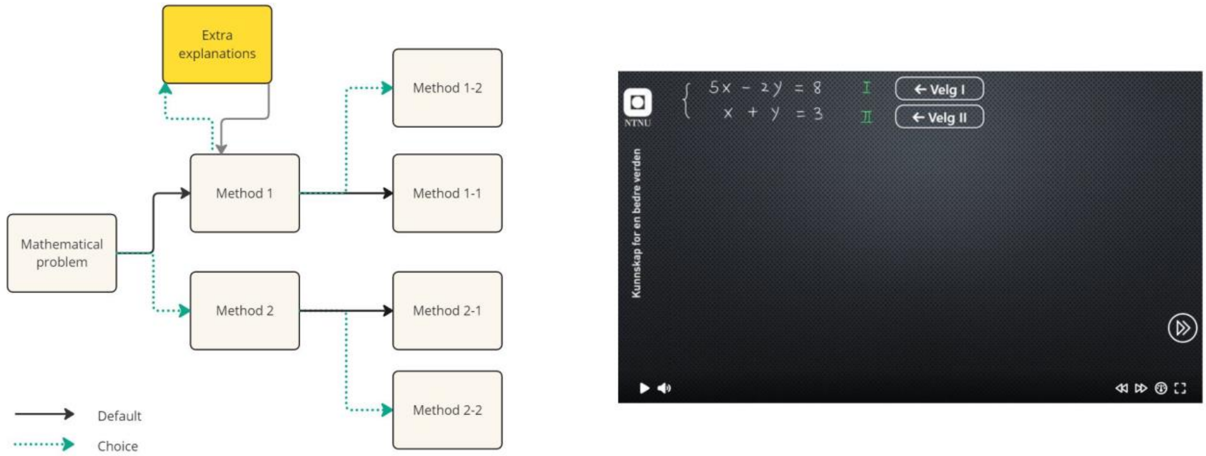

Figure 3 A personalized problem-solving flowchart and an example involving two equations and two unknown variables.

We implemented this technology in our previous empirical studies [1, 2] in mathematics courses at the Norwegian University of Science and Technology (NTNU) in 2023 for engineering students [4] and economics students [5]. Feedback from anonymous responses and exam result comparisons underscore the significant impact of seamless branching videos on education, hinting at their potential as a benchmark for future educational video formats.

Additionally, our exploration into integrating AI technology with seamless branching videos in our empirical studies, which will be the fundamentals of future educational development [4, 6]. Research illustrates that interactive videos notably enhance student engagement, information retention, and academic performance [7, 8].

However, caution is required to prevent cognitive overload that may stem from ineffective integration of interactive elements into video content [9, 10]. Incorporating gamified and personalized features into branching videos can significantly boost student engagement [11, 12, 13, 14].

For effective educational video delivery, maintaining student attention is vital. Here, keeping videos concise, usually around 10 minutes long, ensures optimal engagement and cognitive endurance [15, 16, 17]. The structured design of branching videos not only ensures smooth content delivery but also simplifies future updates, enhancing content relevancy and adaptability.

The video footage for the lectures follows the "Teach Us" method, enabling teachers to convey content using body gestures [18], thereby integrating interactive elements seamlessly to minimize distractions. The "Teach Us" method proves to be a compelling strategy in merging the advantages of face-to-face instruction into digital content [19, 20]. By leveraging teachers' body language and eye contact, elements crucial for enhancing the learning experience as identified by Stieff et al. [21], this method simulates the interpersonal dynamics of a traditional classroom. In doing so, interactive videos bridge the gap between digital and in-person education, providing a holistic and effective learning environment.

This structured approach aids in sustaining student interest and attention, leading to more effective educational outcomes. Despite the success of seamless branching videos and the interest they've generated, the lack of resources and research in this area poses a barrier to educators wishing to explore this innovative method. Sharing our experiences and processes aims to facilitate educators' exploration of this approach, lowering barriers for adopting this new educational technique.

2. CREATING SEAMLESS BRANCHING VIDEOS

In the forthcoming sections, we will delve into the production aspects of crafting branching videos and introduce the pedagogical approach that enhances this video format.

2.1 Planning

Both technical and content planning play pivotal roles in the effective production of branching videos. Technical planning aims to present content in pedagogically engaging manners, combining precision with educational creativity. This synthesis is crucial for developing content that not only facilitates learning but also captures visual interest.

Branching videos' inherent adaptability offers personalized content delivery by smoothly integrating multiple video clips into a coherent structure, necessitating careful planning to manage these clips and ensure a well-structured, clear, and efficient approach to content creation. For this project, we chose Miro [22], a digital whiteboard platform well-suited for establishing detailed plans due to its capacity to create flowcharts. We assigned separate Miro boards for each video topic, elegantly constructing an accessible flowchart for the branching video series using connection lines and shape tools. By creating multiple variations of branching videos across numerous frames, we could visualize and map out potential developments in detail. Flowchart for one of the branching videos, created in Miro is shown in Figure 4.

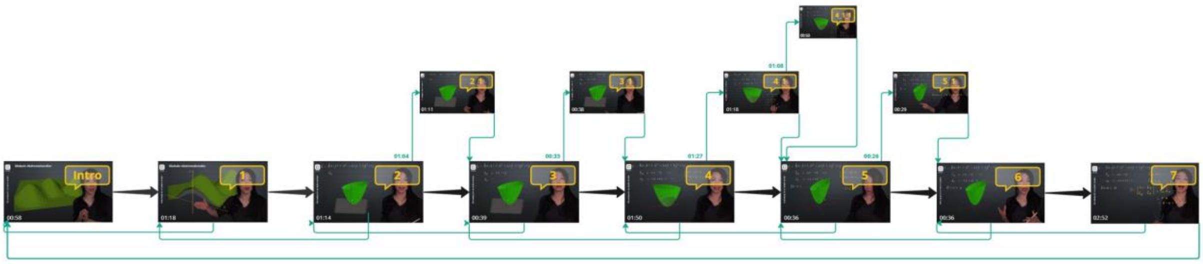

Figure 4 Flow chart of a Branching video created in Miro

To enhance workflow efficiency, clear and systematic naming conventions for video clips are needed, whether numeric, alphabetical, or otherwise. Aligning flowchart labels with video clip names is essential to avoid confusion. Annotations detailing appearance times and interactive element locations, distinguished by unique color codes or arrow styles, aid in differentiating interactive elements, with the duration of each clip documented.

Thumbnails displaying key content of video clips provide a clear overview. Standardized thumbnail selection, typically the last frame of each clip, along with a duration marker, enables a quick assessment of content sequence within the flowchart. Foundational video clips serve as a base path, prominently positioned at the flowchart's base, outlining the core journey for students with no immediate queries. To address anticipated and emerging student inquiries, transitions to appropriate branches are depicted on the roadmap. Teachers develop initial clips based on expected student questions, creating additional clips if further explanations are required. This dynamic approach makes the branching video format responsive to evolving educational needs.

The info-button, strategically located near potential points of inquiry, is designed to provide clarity while minimizing distraction. Extensive trials in our 2023 study determined an optimal display window of 10 seconds for info-buttons, balancing student response times with screen clutter risks from over-proliferation.

Apart from technical preparations, script development is equally crucial, tailored to the instructional designer or educator's preferences. Detailed scripting, fundamental for both primary and ancillary content in videos recorded in single sessions or segmented parts, is vital for a seamless branching video experience. The selection of educational video topics, driven by student input through anonymous surveys, focuses on the most requested subjects—especially those identified as challenging by students. In preparation for this innovative video format, a volunteer group was established to ensure smooth technical operations.

2.2 Technical Setup

The cornerstone of branching videos is the footage itself. Keeping face-to-face teaching benefits in mind, lecture videos were recorded using the studio-based "Teach Us" method [18] capturing the teacher alongside the content, as Figure 5, illustrates. On the other hand, problem-solving videos, designed to spark student engagement, primarily employed screen capture techniques.

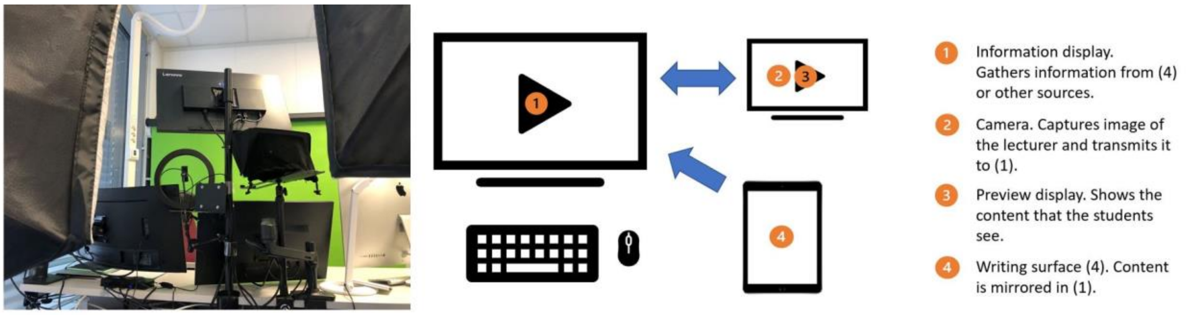

Figure 5 Studio setup for video recording using the "Teach Us" method, along with a simplified illustration of the arrangement [18]

Consistency in layout, style, and quality across all video clips was emphasized to maintain a continuous viewer experience. Interactive elements were visible, yet intentionally unobtrusive. Conditions for footage recording were set to guarantee uniform audio and visual quality, making transitions between segments fluid.

Careful planning is pivotal in lecture-based branching videos, which aim to offer personalized additional explanations. A clear line is drawn between the main mathematics video content and the supplementary explanation clips. Teachers often choose between two primary filming approaches: one is to record the main lecture assuming all students are well-prepared and add extra explanations later; the other is to film both the lecture and supplementary explanations simultaneously. The choice largely depends on individual teacher preferences. Regardless of the chosen method, proficient editing skills are indispensable. The successful application of editing, irrespective of the software used, ensures a smooth merging of video clips and harmony with the branching path. It also requires exporting footage in universally compatible formats like MP4, MOV, or AVI to ensure platform-wide compatibility for branching videos.

In this initiative, Adobe Premiere Pro [23] was selected for editing purposes. The subsequent phase involves organizing and categorizing video clips, assigning each a distinct editing file to differentiate between main content and branching narratives. Adhering to a systematic export convention with numeric or alphabetic markers simplifies post-production assembly. To streamline access and minimize visual clutter, all clips are arranged for quick visibility within the editing suite (see Figure 6a). As track density increases, condensing sequences through nesting enhances clarity (see Figure 6b), though individual inspection of sequences remains crucial for editing purposes. Reference markers, color-coded and labeled to denote clip beginnings and endings, further enhance clarity.

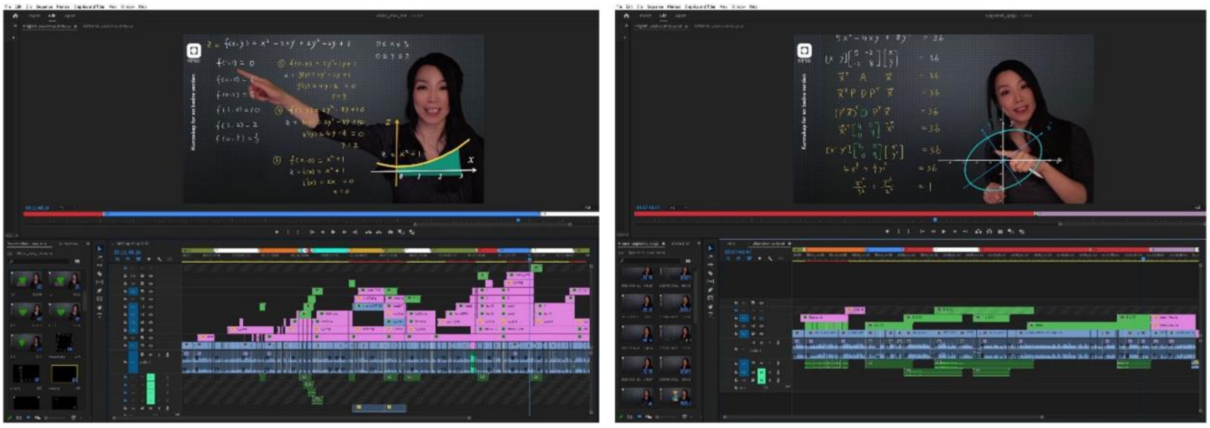

Figure 6 Screenshot from Premiere Pro, illustrating: a) Individual display of all elements, and b) Organization of elements into sequences

Upon preparing the video content, the next phase was assembling the branching path using dedicated platforms. For newcomers, identifying a suitable tool might be challenging due to learning curve, cost, and potential newness of the task.

In our work, over 15 potential branching video platforms underwent careful research and trials. Documented detailed findings guided our selection, based on project-specific needs. Regular documentation updates were key due to the evolving nature of technologies; the last such update occurred in summer 2023.

Each platform has its strengths, weaknesses, and unique suitability factors, therefore, selecting the "best" isn't realistic. Rather, considerations included a teacher's editing proficiency, video content, ease of learning the platform, and budget. A screenshot from one of our researched platforms, Adventr [24], illustrates clip sequencing consistent with planned branching paths (see Figure 7).

Figure 7 Screenshot showcasing how the video, as depicted in Figure 4, appears within the branching video platform, Adventr.

2.3 AI-integrations with branching videos

In this project, we also experimented with several AI-related technologies, particularly AI-powered voice control and AI-avatars.

AI-powered voice control was implemented in videos for engineering students. In these videos, students could navigate using voice commands, with click options still available. For instance, if students wish to access further explanation, they can utter pre-set commands like "Explain", "Why", or "Show me". These commands, defined by the teacher, can be spoken as part of a sentence, and will be recognized by the AI-powered voice control system. This approach allows students to feel as if they're engaged in a real-time conversation with the teacher, augmenting their engagement with the material.

The use of AI-avatars as presenters demonstrates another distinct approach within branching videos. While body gestures used by human instructors in lecture videos cannot be replicated by AI avatars, future development focus will be to enhance this area. Rather than creating more mathematics videos, an International Practical Shooting Confederation (IPSC) stage briefing branching video was developed [6] as depicted in Figure 8. This video allows the viewer to choose which stage they would like to view. Syntesia [25] was the AI-avatar platform selected for this initiative.

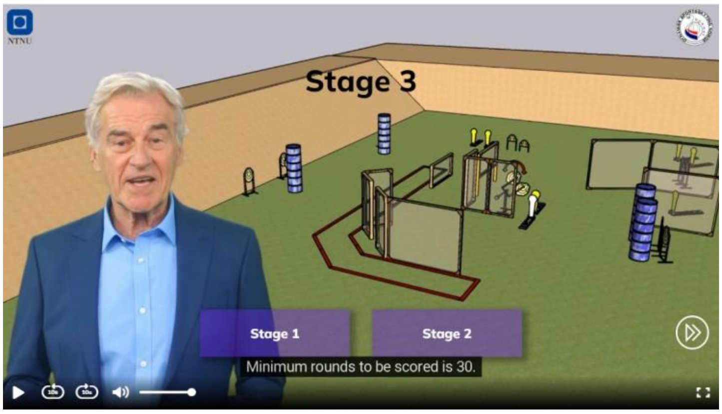

Figure 8 Screenshot showing an AI-avatar presenting the stage for IPSC.

The branching video, including a stage briefing, was shared in the Norwegian Range Officer Institute (NROI)'s private Facebook group. It received over two hundred views and positive feedback, as indicated by the 21 'likes' and 12 comments, on top of several face-to-face feedback. The range officers labeled the method as innovative and highly fitting for a comprehensive stage briefing.

Incorporating AI-avatars in educational branching video projects is part of future planning. The benefit of such integration is greater control over video footage consistency, both visually and audibly.

3. CLASSROOM IMPLEMENTATION

3.1 Testing and Iteration

Anonymous surveys were conducted among the class for suggestions regarding video topics. As these branching videos were created mid-to-late semester, students were challenged to suggest topics that they found most difficult to comprehend. We collected 23 suggestions from engineering students in Spring 2023 and 55 suggestions from economics students in Autumn 2023. The most requested topics were then selected for video production.

From the engineering students, the most requested topic was "Classifying by Change variable in a Quadratic Form," leading to two videos on this topic: one tackling a regular problem, and another an advanced problem. Topics such as "Global Extreme Values with Partial Differentiation" and "Global Extreme Values of Functions Defined on Restricted Domains" were also selected.

From the economics students, the top requested topic was the "Insertion Method", generating two videos: one with two equations and two variables, and another with three equations and three variables. Topics such as "Calculation of Annuity Loan" and "Calculation of Arrears Combined with Annuity Loan" were also chosen.

To ensure the quality and proper functionality of the videos, a group of students was involved in the testing phase. The goal was to refine the videos based on these students' interactions, and to get an overview of how intuitive this new method is for the students who had never experienced branching videos in education before and find out if there will be need to modify the videos to make it more intuitive for the students. Volunteers were solicited, with 39 engineering students and seven class representatives from the economics class participating. These testers received video links and a link to an anonymous feedback survey via email.

After the feedback from the surveys gathered though the test group of students, the branching videos were made available for the whole class as a part of the course resource in LMS, and all the students were invited to give feedback though a more structure anonymous survey which 71 participated—41 engineering students and 30 economics students.

3.2 Educational Impact

The testing phase proved to be immensely successful, with most students finding it straightforward to navigate through the branching videos. This outcome was a promising indication of the effective planning and thorough pre-testing procedures implemented before sharing videos with the student testers. Minor issues did arise, such as difficulty in locating the pause button on the video player. However, this was attributed to the design where the pause button only becomes visible upon movement in the video window, an intentional feature to minimize unnecessary distractions during video playback.

In our previous empirical studies [1, 2], Strong positive feedback was received from students across both testing groups. The consensus was that this novel video format was more engaging than other formats they'd been exposed to prior. More importantly, students felt that this method was more suited to their learning needs compared to conventional video types. Further evidence of the effectiveness of this method was reflected in the analytical data from the branching videos. Engagement rates comparison indicated a higher degree of student participation with the branching videos than with non-branching ones.

Notably, this level of success underscores the impact of initial planning phases on the efficacy of branching videos as educational tools. Importantly, it points to the potential of branching videos to significantly reshape contemporary digital learning environments by supporting enhanced student engagement and personalized learning experiences. This achievement also sets a precedential blueprint for future improvements and developments in this aspect of video-based learning methodologies.

4. OBSTACLES AND ADJUSTMENTS

The integration of seamless branching videos into educational practices, as demonstrated at NTNU, presents significant transformative potential. However, it also brings forward unique challenges that require thoughtful adaptation and strategic implementation.

One of the main challenges faced by educators is managing the multitude of possible video paths that can present learners with daunting choices, potentially disrupting their learning journey if not intuitively organized and curated. Tackling this challenge requires educators to limit and clearly define each pathway. This strategic reduction and clear delineation of choices can significantly minimize cognitive overload, hence ensuring that students can engage with the video content meaningfully without any confusion or distraction. This also helps the teacher to maintain a clear overview of by starting with fewer and simpler clips, especially for teachers who are new to branching videos. And the suggestions mentioned in the section about planning will also help reduce the confusion in the production phase.

Moreover, the complex production process of branching videos necessitates educators to initially focus on developing the core video content. Once the core content has been successfully covered, educators can then branch out to create supplementing content. This approach helps maintain both clarity and manageability during content creation, all while ensuring that the fundamental learning goals are effectively addressed.

These carefully considered adaptations not only assist in enhancing the usability and efficiency of branching videos but also cement their position within the future landscape of education. With an approach that introduces more personalized and interactive learning experiences, branching videos offer a sophisticated means of meeting diverse student needs. Their transformative potential spans from individual classrooms to wider communities, paving the way for a more dynamic, engaging, and inclusive landscape in educational pedagogy.

5. CONCLUSIONS AND FUTURE DIRECTIONS

Reflecting on the branching videos' implementation at the Norwegian University of Science and Technology (NTNU), it significantly enhanced student engagement and personalized learning.

Looking forward, we aim to refine integration techniques and increase the format's adaptability, allowing it to cater to a broader array of subjects and learning styles. Advancements in AI and interactive technologies open new possibilities for tailoring educational content, making it more intuitive, accessible, and engaging.

However, this journey also brings forth challenges such as managing the multitude of choices in video paths, maintaining content consistency, and dealing with the specialized demands of producing top-tier branching videos.

To address these challenges and improve the branching video approach, collaborations with educational technologists, instructors, and students are paramount. Their collective input can significantly drive progress within this framework. Additionally, identifying common pain points can shed light on effective solutions, thereby enhancing the overall user experience.

As for the role of AI, it's clear that technologies like AI avatars and voice controls can redefine branching videos, enhancing their interactivity and depth. These advancements could simulate a personalized learning experience similar to a one-on-one conversation with an instructor.

Future research directions in this field could deal directly with the long-term efficacy and comprehensive suitability of branching videos across various disciplines, the integration and utility of AI in branching videos, and continuously refining the methodology based on evolving needs within digital education.

The collective effort from various stakeholders in education can propel the evolution of branching videos. The goal is to ensure that branching videos remain as dynamic, relevant, and effective tools aligning with the fluctuating dynamics of digital education, leading us all to broader, personalized and engaging educational experiences.

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