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AppEduTV 3.0: Educational Application for Public Broadcasters in the Context of TV 3.0

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Abstract—This paper presents the design, development, and evaluation of AppEduTV3.0, an educational application designed for public broadcasters within the Brazilian TV 3.0 ecosystem. Grounded in the application-oriented architecture of TV 3.0, it uses interactive templates that allow broadcasters to integrate educational quizzes and multimedia content into their programming. The proposed solution supports three operational scenarios: connected households, non-connected households, and connected classrooms. It combines broadcast and broadband delivery, multisensory devices, and second-screen integration. The development process included both the prototyping of the application and the production of a customized TV program aligned with its interactive functionalities. The results highlight challenges and opportunities for integrating audiovisual production with software development in the context of TV 3.0. AppEduTV3.0 can serve as a reusable template for broadcasters, fostering interactive and personalized learning experiences. The study also identifies technical and organizational challenges that must be addressed for public broadcasters to fully exploit the capabilities of TV 3.0 in educational contexts.

Index Terms—Application Coding, TV 3.0, Educational Applications, Mulsemedia, Public Television

I. INTRODUCTION

As the next generation of the Brazilian Digital Terrestrial Television System (SBTVD), TV 3.0 marks a shift toward an application-oriented architecture for content transmission and reception, expanding the scope for interactivity and personalized viewing experiences. By integrating broadcast and broadband, TV 3.0 delivers audiovisual content alongside digital services, second-screen functionalities, and multisensory devices. This convergence of technologies opens new possibilities for educational applications that can tailor activities to individual viewer profiles and enhance learning through immersive experiences [8], [10].

In education, the blend of interactivity and personalized content supports the design of quizzes, games, and other activities that align seamlessly with linear programming. Multisensory effects can further strengthen student engagement and improve knowledge retention [1], [9], [13]

Yet, public and educational broadcasters may encounter both technical and organizational hurdles when implementing advanced TV 3.0 capabilities. These include bridging the gap between audiovisual production and software development teams, as well as reconfiguring workflows rooted in the conventions of linear television.

Against this backdrop, this study introduces and evaluates AppEduTV 3.0, an educational application designed as a reusable template for public broadcasters operating within the TV 3.0 environment. The application supports the creation of interactive quizzes synchronized with television programs, recommends supplementary video content, and incorporates multisensory and second-screen features, adapting to varied access conditions. Three usage contexts are examined: connected households, offline households, and connected classrooms.

The article is organized into sections that outline the design and development of the application, the production of a television program tailored to its features, and the challenges involved in integrating audiovisual content with interactivity in the emerging Brazilian next-generation TV landscape.

II. PROPOSED ARCHITECTURE FOR THE TV 3.0 ECOSYSTEM

The design of AppEduTV 3.0 is embedded within a conceptual TV 3.0 ecosystem tailored for public and educational broadcasters. As illustrated in Figure 1, this ecosystem was engineered to provide both technical and editorial support for the development of educational applications, streamlining production, configuration, and distribution workflows. Its architecture integrates content recommendation services, question repositories, response-tracking mechanisms, and a template server, enabling broadcasters to configure and deliver interactive applications quickly and in ways suited to different audiences.

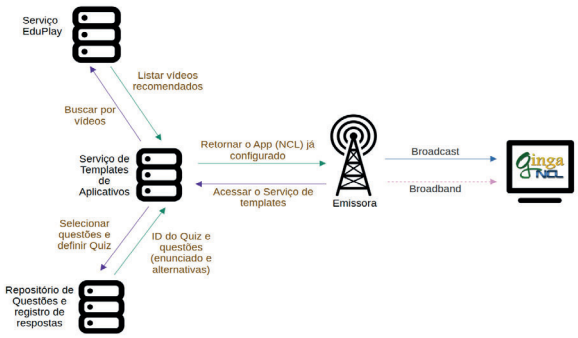

Figure 1 - TV 3.0 Ecosystem for Public Broadcasters

Figure 1 comprises the following components and their respective functions:

- **Broadcaster**: responsible for distributing the content (program and application).
- **EduPlay Service**: recommends videos to the Application Template Service.
- **Question Repository and Response Logging**: provides three functions: (i) suggesting questions to build the quiz or quizzes; (ii) registering the quiz (ID generation) for response tracking purposes; and (iii) subsequently recording the viewer's answers, when the scenario allows and this option is enabled.
- **Application Template Service**: server accessed by

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broadcasters to select a template type, complete the required fields, and download the application ready to be delivered alongside the program.

Example for the prototyped AppEduTV 3.0 application:

- The broadcaster's staff member (user) logs into the Template Server and selects the educational application template.
- When starting to fill out the template, the user must provide basic information such as the application name, logos, and text.
- The user enters the program's keywords [1] and target age group or groups. This information serves as the basis for the template's auto-fill recommendations. Multiple age groups may be specified, allowing the questionnaire and recommended videos to be adapted according to the student's (viewer's) age.
- The user can watch and select the videos recommended by the EduPlay Service for each age group. These videos become part of the application's recommendation list.
- The user can create the quiz for each age group either by typing each question and its options or by selecting from the questions recommended by the Question Repository. Next, the user specifies whether responses will be logged by the Repository, and a PIN (ID) for the questionnaire is associated with the application being filled out.
- The next step is to schedule the timing of the questions in relation to the program with which the application will be associated.
- Application completion information (text, images, etc.) can be filled in.

III. AppEduTV3.0 APPLICATION

This section describes the deployment of AppEduTV 3.0, its usage scenarios, and other aspects related to its execution in each context.

3.1 Application used as a proof of concept

AppEduTV 3.0 was implemented as a proof of concept to validate the educational application model. Although the full development of the Template Server was not completed, the prototype made it possible to assess key functional and technical aspects, such as quiz configuration, activity synchronization with television programming, and adaptation to different connectivity conditions.

The prototyped application includes the following functions:

- Enable execution in three distinct scenarios (see Subsection 3.2).
- Allow the viewer or viewers to interact with a set of questions in quiz format, including each question and its options.
- Enable the synchronization of each quiz question with a specific moment in the program's execution.
- Track the performance of the viewer or viewers during the quiz execution.
- Allow each viewer's responses to be stored on a dedicated server for subsequent pedagogical or statistical processing.
- Allow the recommendation of related videos (supplementary content) based on the program's theme.

To use the application, the broadcaster must have access to an application template server designed for the TV 3.0 environment. After selecting one, in this case AppEduTV 3.0, the broadcaster assigns a designated staff member to fill out basic information in order to associate the application with the program with which it will be deployed. This process includes providing:

- Definition of the quiz and activities:

  - Desired number of questions and answers.

  - Questions, options, and answers: these can be entered manually or retrieved from a server (such as Moodle or EduWeb [2] etc.) based on search terms and the intended education level. Examples include: (1) Lençóis Maranhenses, geography, history; (2) Portuguese language questions related to the program's audio, using natural language processing.

- Specify the moment, in seconds from the start of the program, when each question will be displayed;
- Server for storing the viewer or viewers' responses (referred to here as EduWeb), for cases where the responses are used in a social or educational context:
  - The questions can be stored on this server.
  - If a server is defined, it is important to use a unique questionnaire ID.
- Recommendation of supplementary videos:
  - Provide the terms and the education level indicator to search for videos in the EduPlay Service.
  - Accept or reject each result, selecting which and how many will be included in the videos recommended by the application.

3.2 Scenarios

The usage scenarios defined for AppEduTV 3.0 represent different access and connectivity conditions, enabling the evaluation of the application in real television reception contexts. The proposal includes configurations designed for both domestic use and educational use in classrooms, varying according to internet availability and the audience's interaction patterns:

- **Scenario 1**: The viewer, whose user profile is verified as a high school student, has access to an internet-connected television at home.
- **Scenario 2**: The viewer, with the same verified user

1 These keywords serve as search terms within the context of the Template Server. They can be provided by the program's producer or automatically generated by an AI algorithm using natural language processing.

2 Fictitious service prototyped in the context of this project for storing questions and options, as well as storing responses for subsequent processing.

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profile as in Scenario 1, has access to over-the-air television without an internet connection at home.

- **Scenario 3**: A class of students with access to an internet-connected television in the classroom watches a TV program and interacts with the app under the supervision of the teacher.

Based on these scenarios, prototypes for TV and Web/Mobile platforms were created, along with the proposed specification for the application.

3.2.1 Scenario 1

Scenario 1 presents an interactive, multimodal learning environment that integrates established technologies from the current stage of the SBTVD, such as broadcast and broadband transmission, with innovations planned for the future 3.0 standard of Brazilian television [1], [3], [4], [8], [13]. The main objective is to provide a personalized and responsive learning experience, leveraging the potential of emerging technologies to enrich the educational process.

From a practical standpoint, this scenario envisions a television program enhanced with a set of multiple-choice questions directly related to the content presented in the main broadcast. At the conclusion of the interaction, viewers gain access to supplementary materials designed to deepen their understanding of the subject matter. This capability is made possible through the integration of television services with EduPlay, a platform maintained by Brazil's National Education and Research Network that specializes in providing educational videos.

The operation of this scenario relies on five key components, as illustrated in Figure 2:

- broadcaster, responsible for delivering the main educational content through broadcast and broadband technologies; student, the target viewer who consumes the educational content and actively engages with the system; EduPlay service, the platform that manages the provision of additional content, fostering continuous learning;
- sensory effects renderers, such as smart lights and fans, as well as aroma diffusers, which synchronize their effects with the TV content to enhance immersion and engagement; and finally, second-screen devices, such as smartphones or virtual reality headsets, which provide additional features

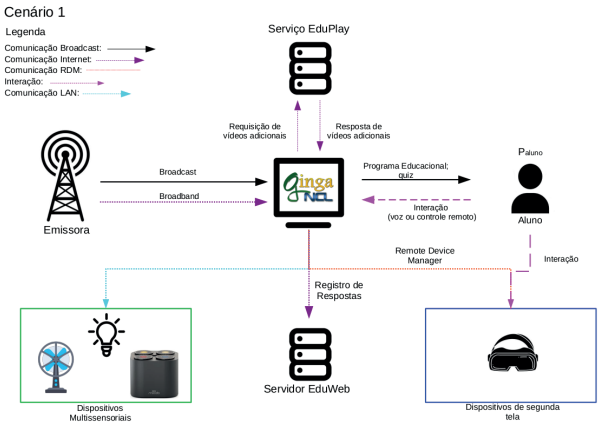

Figure 2 - Scenario 1 Architecture: Viewer WITH Internet Access

beyond those shown on television, expanding interactivity and contributing to both learning and application usability.

3.2.2 Scenario 2

Scenario 2 outlines a more streamlined interactive environment, centered on the student's direct engagement with content delivered via broadcast (see Figure 3). It presents the same educational application described in Scenario 1 but adopts a more linear and straightforward approach, in which interaction is limited to answering quizzes and does not involve advanced digital platforms or additional devices for sensory support or second-screen features. This configuration is well-suited for contexts where simplicity and accessibility are priorities, ensuring that the widest possible audience can participate, even without access to more sophisticated resources.

Regarding the components and interaction flow of this scenario, the broadcaster is responsible for the one-way transmission of content, while the viewer consuming the broadcast can interact through direct commands.

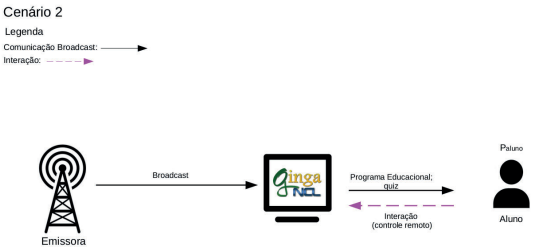

Figure 3 - Architecture of Scenario 2: Viewer WITHOUT internet access

3.2.3 Scenario 3

Scenario 3 employs the same educational application used in the previous settings, designed for teaching grammar and geography. However, it differs by emphasizing group interaction mediated by a teacher, creating a hybrid and collaborative learning environment.

Once again, the broadcaster remains responsible for delivering the educational content, including quizzes, via broadcast and broadband. Likewise, the EduPlay platform manages supplementary content, ensuring a dynamic integration between the learning experience and connected devices. These devices include multisensory equipment and second-screen tools, playing a central role in expanding both collective and individual interaction possibilities.

The EduWeb server functions as the central hub for managing content and processing requests from both students and the teacher, such as retrieving supplementary materials. The teacher acts as a mediator, coordinating device-based interactions and guiding students through the educational activities, while students actively participate individually or in groups, using connected devices to engage with the system.

It is also worth highlighting the CCWS and Remote Device Manager (RDM) technologies, which ensure the coordination and synchronization of local devices, enabling seamless integration across the various technological components.

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The combination of these elements results in a flexible educational approach that can adapt to different contexts. This model not only expands opportunities for collaborative learning but also fosters interactivity and personalized instruction.

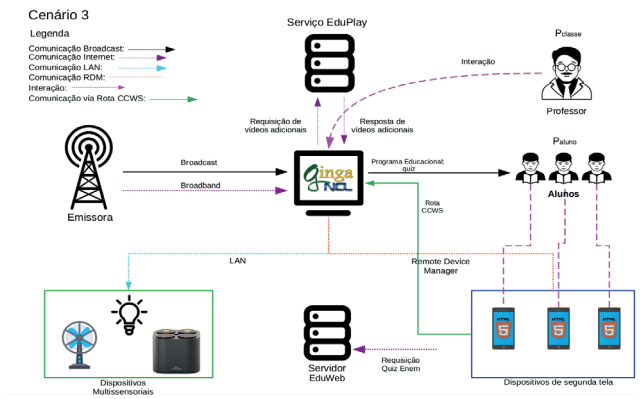

Figure 4 - Architecture of Scenario 3: Classroom WITH Internet Access

3. 3 Descriptive Diagrams of the Scenarios

The following activity diagram illustrates the behavior of the proposed application for Scenarios 1 and 3. In Scenario 1, the student accesses the application at home using an Internet-connected television. In Scenario 3, the application runs on a television in the classroom, also with Internet access. In TV 3.0, it is possible to create individual viewer profiles or group profiles. Thus, in a school setting, a group profile could be created to represent a class for a given subject.

he application begins by querying the viewer profile currently selected on the television to determine whether a single student is watching or a group profile is active, which indicates that a class is consuming the content. If the profile is individual and the student has a head mounted display (HMD), also known as a virtual reality headset, connected to the TV, the application presents additional content to be played on the headset, enabling greater immersion for the viewer [1], [6], [13].

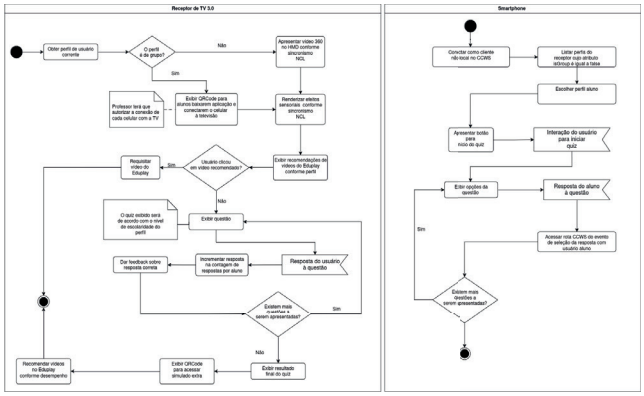

Diagram 1 – Activity diagram for Scenarios 1 and 3

Another feature of TV 3.0 is its ability to synchronize sensory effects with the audiovisual content being broadcast [9], [13]. Accordingly, the application can trigger sensory effects that correspond to the subject matter of the video lesson, provided the runtime environment includes the necessary effect rendering devices.

The viewer's profile is also queried by the application to provide video recommendations from Eduplay. If the viewer chooses to watch the recommended content, the application will redirect them to the Eduplay service and then terminate. If the viewer does not choose this option, they will continue watching the content broadcast by the station, which will present questions throughout the program, allowing the viewer to interact by responding to them. The display timing of each question is determined by the NCL application through temporal synchronization with the main video.

In Scenario 1, the student can answer the questions using either the remote control or voice interaction. In Scenario 3, the students in the classroom will interact with the TV application through a mobile device running a dedicated app capable of communicating with the program being displayed on the TV, as shown on the right side of Figure 5. Communication between the mobile device app and the TV application occurs via TV 3.0 WebServices.

In Scenario 2, the student uses the application at home on a television without Internet access. Without connectivity, the system cannot use effect renderers or VR headsets, so no additional virtual reality content or synchronized sensory effects are presented.

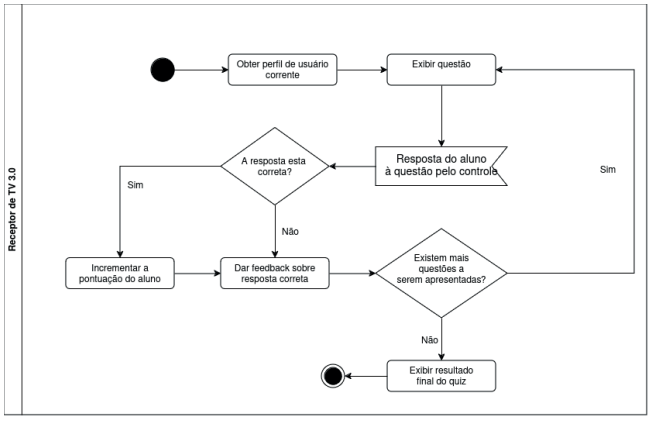

Diagram 2 – Activity Diagram – Scenario 2

The application first checks the viewer profile selected on the TV to determine the appropriate educational level. Since the broadcast must reach all audiences, the station transmits questions for both elementary and high school students. As the quiz progresses, the application records each response and displays the final score at the end.

3.4 Integration with services

In the context of the development project, two services would be used by AppEduTV3.0: one for content recommendation and another for storing questions and recording responses. The table below presents the application's "ideal" integration with these services.

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Table 1 – Services Integrated with AppEduTV3.0

Service	**EduPlay**	**EduWeb**	
Functionality	Video recommendations within the App	Selection of questions and quiz assembly	Storage of responses
Acess	via API	via API	via API
Parameters	- Search terms - Age group	- Search terms - Age group	- Quiz ID - Viewer ID - Question and Answer
Return	URL of recommended videos	- ID of the generated quiz (PIN) - Question, options, and answe	Subsequent access, outside the app cntext, for response analysis
Action in the App Template Service	Selection of videos to be recommended by the App	Selected questions will be associated with specific time points in the program	Not applicable

The decision to describe the EduWeb service was driven by the need for a quick solution with low integration complexity. This service can be divided into two distinct components: one for selecting questions and another for storing responses (directly linked to the mobile application, especially in Scenario 3).

3.5 NCL Application

The NCL application was designed and developed to structure interactive and multimedia services, delivering viewers a high-quality immersive and educational experience. As its foundation, it used a television program dedicated to showcasing the natural beauty and tourism significance of Lençóis Maranhenses National Park. The program was organized into distinct segments, including studio recordings, clips of the region's natural landscapes, interviews, and a mini-course in Brazilian Sign Language (Libras). Each of these elements was synchronized with sensory effects designed to enhance the application's level of immersion. For instance, the color palette emitted by a smart lamp matched the predominant hues in the video scenes, while scent diffusers and fans were activated during outdoor footage, giving viewers a heightened sense of presence within the depicted environment.

In addition, the application was designed to integrate virtual reality devices functioning as a secondary screen. These devices displayed supplementary content to what was being broadcast on television, expanding the possibilities for exploring the topic and enriching the experience from both educational and entertainment perspectives.

In the educational context, the application included six quizzes, each with four answer options, presented at strategic moments during the program and incorrect answers for each viewer. In Scenario 3, designed for group interactions, an additional scoreboard was included to tally the number of votes for each alternative (A, B, C, or D), fostering a collaborative dynamic among participants. Furthermore, each question was paired with a 60-second timer, after which the interaction ended and the program resumed as normal.

Finally, at the conclusion of the main program, two videos with supplementary content were suggested to viewers, offering an opportunity to deepen the knowledge acquired.

3.6 Ginga Implementation Dependencies

In the TV environment, the NCL application runs on the Ginga-NCL subsystem of the Ginga middleware. To enable the execution and validation of the application proposed in this project, the reference implementation of the Ginga middleware was used. While the reference implementation supports several TV 2.5 features, it does not implement GingaCC WebServices. GingaCC WebServices provides a set of services implemented as REST APIs, enabling an integrated experience between the broadcast environment and devices in the home environment, such as smartphones.

Thus, it was necessary to extend the Ginga reference implementation to support the execution of the application proposed in the project by adding the following functionalities:

- Implementation of a set of GingaCC WebServices APIs to enable the control of an NCL node by non-local clients connected to the TV.

Implementation in Ginga of notifications to GingaCC WebServices regarding changes in the state machine of NCL document nodes.. The questions ranged from grammar topics to information about the geography and biome of the Lençóis Maranhenses, fostering learning in an engaging and interactive way. To cater to different audiences, two sets of questions with varying levels of difficulty were created: one aimed at high school students and another for elementary school students. This differentiation was made possible by a feature that allowed for the selection of the viewer's profile, ensuring a personalized experience suited to each participant's level of knowledge.

Another noteworthy feature of the application was the implementation of a scoring system. In all scenarios, this counter tracked the number of correct

3.7 Mobile and EduWeb application

The mobile app's development began with screen prototypes, guided by diagrams and discussions among the research teams to define how the system would work (EduWeb server - mobile app - TV app). This process produced a set of prototypes and interaction flows that simulated each part of the system in action.

Specifically for the mobile app in Scenario 3, students log in to the EduWeb platform to access the quiz featured in the educational program. They can join using either a PIN (numeric code) or a QR code. Through the EduWeb server, students link their mobile devices to the content being broadcast on the TV. Until the quiz segment begins on the TV program, students can view a list of other "players" connected.

Figure 5 shows the mobile app's initial screens.

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(i) ..... (ii) ..... (iii)

Figure 5 - App screens - EduWeb access and Quiz

The first screen lets the student/viewer connect to the EduWeb service (i) for the purpose of storing their responses. Next, they enter the quiz PIN (identifier) for the quiz currently running alongside the program (ii). In Scenario 3 (a classroom setting), a message appears indicating that students are joining the quiz, and the teacher decides when to start presenting the questions (iii).

When the program starts a quiz, students have four buttons, each corresponding to one of the possible answers, and a limited time to choose an option. Once the timer runs out, they receive feedback indicating whether their choice was correct, along with a chart showing the percentage of students who selected each answer.

Figure 6 shows a set of app screens during the quiz. For each question displayed on the TV, the corresponding answer choices appear on the student's mobile app (i). After the student selects an answer or when the allotted time for the question runs out (in Scenario 3), the response is sent to the EduWeb service for storage, and the student is informed whether their answer was correct or incorrect (ii). In Scenario 3, once the quiz ends, a performance report for the entire class is displayed (iii).

(i) ..... (ii) ..... (iii)

Figure 6 - App Screens - Quiz Interaction

For the prototype implementation, intended for demonstration purposes, several technologies were used to speed up development: (i) the React framework, which simplifies building graphical interfaces by allowing TypeScript code to be written alongside HTML; (ii) the Vite tool, which automates the setup of front-end development environments and provides a preconfigured local development server; (iii) the Tailwind CSS framework, which offers single-purpose CSS classes to streamline HTML styling; and (iv) the socket.io module for Node.js (a JavaScript runtime), which enables event-based bidirectional communication, making it possible to replicate the interaction between the mobile device and the television.

Regarding the interaction between the mobile app and the EduWeb server, communication initially occurred through the exchange of event signals between the two. When connecting to a quiz, the viewer's mobile device triggered an event received by the server, containing the viewer's name and the quiz PIN. The server then validated the PIN and checked whether the time limit for new connections had expired, prompting the mobile app to take one of two actions: (i) display an error message indicating that the quiz had already started and no further connections were allowed, or (ii) redirect the viewer to a "waiting room" showing a list of other "players" connected to the quiz.

When it is time to start the quiz, the server sends an initialization event, which, once received by the mobile device, directs it to the answer selection screen for a limited time. After the user selects an answer, the mobile app sends this event to the server, which processes the necessary tallies and indicates whether the chosen option is correct. At the end of the time limit, the mobile app returns to the answer selection screen.

IV. APP INTEGRATION WITH THE TV PROGRAM

TV newsrooms are still not fully equipped to meet the content creation demands that come with the shift to App-Oriented TV and the capabilities of TV 3.0. This challenge is even greater for public and educational broadcasters. When we set out to develop an educational app for public TV, one of the first hurdles was finding content in formats that could make the most of the features we wanted to include and test. As a result, we had to produce an original TV program to integrate with the software, carefully aligning the timing of the audiovisual content with the app's interactive features to ensure a seamless viewer experience. This required not only adjustments to the script but also close collaboration between the audiovisual production team and the software development team.

While TV 3.0 technology allows app content to be overlaid onto any existing TV program, creating a fully integrated visual experience, our focus was on showcasing personalization through an interactive quiz that could be customized and adapted to different viewing scenarios. This required the media and the app to coexist, which allowed us to prioritize tailoring the content to educational and interactive needs while maintaining flexibility for use in various connectivity contexts.

The production of the Eduquiz program was guided by the capabilities of TV 3.0 and the educational requirements

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of the interactive app. This approach broke away from the traditional linear flow of TV production, as the goal was to integrate audiovisual elements directly with the app's interactive features.

4. 1 TV 3.0-Oriented Development

The production of the experimental program followed a workflow that was the reverse of traditional TV production. In the conventional process, editing is the final stage, but in this case, to adapt the program to the app's interactive features, the script was designed starting from the editing phase. Only then were the content segments arranged into a logical editorial sequence. The team began by defining the app's interactive features and then reverse-engineered the script and editing so that the audiovisual content would support and align seamlessly with those features.

First, existing content was curated, prioritizing materials that could be adapted for an interactive experience, such as short news reports and pre-recorded lessons. In the absence of a ready-made educational program in Eduplay's broadcasters' database, we used journalistic content (news reports) and Portuguese lessons in drop format (inserted into the programming as interstitials) to build the program's structure. As a result, the script was developed from pre-existing content already produced by TV UFMA—an endeavor that proved challenging, as it required sequencing materials that had not originally been conceived to connect with one another.

Before selecting the materials, it was necessary to first define which features would be tested, in order to identify content that could effectively demonstrate them. Once the materials were chosen, TV UFMA's journalist/scriptwriter received training to understand the technical possibilities of TV 3.0, including synchronization with the application and interaction personalization. This technical literacy was essential to align the program's script and structure with the new technological requirements, transforming what would have been a linear broadcast into an interactive experience blending media and software. This highlights the crucial challenge of fostering media literacy among content producers for next-generation television. From news to entertainment, television production is still conceived for linear consumption, and the limited interaction that is introduced typically takes the form of QR codes and website addresses for viewers to access - 21st-century substitutes for phone-ins. The software industry and the editorial/content production sector are not yet moving in sync. The two industries need to integrate, or else TV 3.0 features risk being underused due to a lack of native 3.0 content.

The media curation process selected materials suitable for Geography, Libras, and Portuguese lessons. The Geography-related content is a news report on the Lençóis Maranhenses. The Libras content consists of short interstitial segments with lessons and tips in Brazilian Sign Language. The Portuguese content is composed of short "drop" segments with tips on language use, also broadcast by the station as interstitials. These are standalone materials, each with its own production style, yet they are brought into dialogue through a script designed around the TV 3.0 features to be tested by the educational application.

Following the content curation and training on functionalities, the program was then scripted with consideration for:

- The program's educational objectives and the application's interactive features (personalizing questions according to the viewer's educational level; enabling synchronized interactivity between the TV program and mobile devices; operating across the three distinct scenarios described in the app's contextualization).
- Multidisciplinary planning: audiovisual professionals (journalist/scriptwriter and video editor), an education specialist, and software developers. This integration proved necessary from the project's conception to ensure that the content and interactive features were complementary.
- Script development considered the specific moments when interaction would occur. The presenter was tasked with instructing viewers on the available interaction options, ensuring they understood how to use the tools provided. Transitions between linear content and interactive moments were designed to include clear, intuitive instructions for the viewer.
- Reorganization of curated content allowed for an interactive audiovisual experience, even though the original materials were conceived for linear television. One of the videos had ambient sound (wind and water noise) added to enable the use of sensory effects supported in NCL 4.0 and NCL 360.
- Creation of objective, content-related questions (covering Portuguese and Geography in an interdisciplinary approach). Six questions were designed for elementary school and another six for high school.
- Since this was an educational program with a quiz format, the production team had to determine the exact moments when personalized questions would appear in the video. In a traditional linear educational program (such as a telecourse), questions and answers are embedded in the editing stage, with no possibility of customizing them to the viewer's educational level. With an application like AppEduTv3.0, the production team used 1-minute cards, with background audio, so that the quiz could be inserted by the app into the viewer's screen while preserving personalization according to the level of schooling. These cards replaced segments of the linear content and represented a break from the traditional approach to program planning.
- Seemingly simple, this form of breaking content linearity represents a significant shift in how scripts and edits are conceived: a program's content is now split between media and application, distributed along two distinct paths— audiovisual and software. This is not a trivial change and requires production teams to adapt, integrating software developers alongside scriptwriters and editors.
- While the audiovisual team scripted the main

content, the app developers worked on features such as question display and cross-device synchronization.

- Once the program was completed, the media–software integration stage began: synchronizing questions to appear at the correct moments in the program; adjusting quiz response times to fit the constraints of each usage scenario (with and without internet access, individual or group viewing); and integrating with second-screen devices and the mobile app.

The program's total fade (production and broadcast time) is 18 minutes. It is worth noting that the application developed could operate with any audiovisual content currently produced by an educational broadcaster; however, its features are fully leveraged only when the content is designed in alignment with the interactive possibilities of TV 3.0.

V. FINAL REMARKS

The AppEduTV3.0 project addressed both technical and conceptual aspects relevant to the educational use of TV 3.0 in public broadcasters. It resulted in the development of a prototype educational application and a set of guidelines for its integration into these broadcasters' production workflows. The project's activities included the application of Ginga-NCL standards and implementations, the incorporation of multisensory devices, the definition of complementary services, and the provision of interactivity via web page or mobile application.

During implementation, technical limitations were identified that prevented the full deployment of the planned features. These included the absence of a shared testing environment for Ginga-NCL, the lack of a Remote Device Manager implementation, and the need for adjustments to the CCWS module to enable communication between the TV set and the mobile application.

These constraints highlight the need for advancements in tools and normative implementations to enable the full adoption of interactive educational solutions within the TV 3.0 environment.

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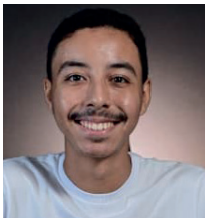

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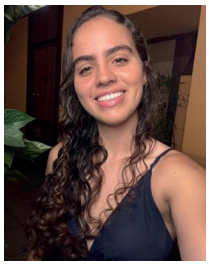

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