Access to Escape: Didactic Conception and Accessible Game Design of a VR-Escape Room for Accessibility Education

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***Abstract*—*Access to Escape* is a Virtual Reality (VR) Escape Room, aimed at sensitizing computer science students to the importance of digital accessibility. Since these students will develop digital content in the future, this target group is an important starting point to create awareness towards the topic. This article outlines the development of a VR game based on the viewpoints of Accessibility Education, Game Accessibility, and accessible VR to offer access to a wide range of people. The primary objective is to address the research question of what steps are necessary to create an accessible VR game and what the design process should entail to achieve this goal. The first step involves developing a didactic conception to create an educationally valuable learning offer. A guide by didactic expert Kerres is presented, which supports the development process of a didactic design including the application to the VR-Escape Room. The development process of *Access to Escape* also showed that the Game Accessibility Guidelines (GAG) workflow offered a low-threshold starting point, for example, by making the vast amount of accessibility guidelines more tangible. Here, it should be emphasized that the prioritization, as suggested by the workflow, must not lead to the exclusion of any applicable guidelines, since every guideline is needed to guarantee an accessible game experience. However, during the implementation process of our VR-Escape Room, it became apparent that many resources and a well-defined time schedule are needed to achieve a fully accessible game. To counteract this issue, more information material and open-source solutions are needed to meet all accessibility requirements. An evaluation of the first development phase of *Access to Escape* showed that the VR-Escape Room is a suitable format for educating about accessibility and, based on these results, further steps regarding the development are discussed such as the use of Artificial Intelligence, a multiplayer mode or the transfer to other topics.**

Index Terms*—*Accessibility Education; Virtual Reality; Game Accessibility; Escape Room; Didactic Design.

I. Introduction

With the increasingly digital nature of everyday life, the importance of digital accessibility moves further into focus. This makes it necessary to bring the topic closer to developers of digital content. As a possible solution, we developed *Access to Escape* providing a low-threshold starting point for dealing with digital accessibility [1]. As computer science students represent the future developers of digital products, it is necessary to educate these stakeholders on the importance of digital accessibility and teach them methods for implementing inclusive software. Using an immersive learning format such as a VR game, it was aimed to sensitize the players by making barriers more tangible and thus relatable. Although gamification and VR technology offer benefits such as the mentioned immersion, they also introduce new challenges, including the need for accessible VR gaming experiences. To design an accessible VR-Escape Room, we formulate the following research question:

"What does the design process for creating an accessible VR game entail, and what implementation steps are necessary to achieve this goal?"

To address the presented research question, we will first give an overview of the related topics in Section II, which includes Accessibility Education, Game Accessibility, and Accessible VR. Then, in Section III, we outline the considerations made regarding the didactic design of the learning offer. Section IV will offer an overview of the implementation of *Access to Escape*. We will explain the game story and the corresponding learning goals, how we implemented the GAG workflow, and demonstrate the outcome of the implemented accessibility features. The evaluation of the developed VR-Escape Room is presented in Section V. The lessons learned and limitations of the VR-Escape Room will then be discussed in Section VI. Finally, in Section VII, we summarize our findings and formulate tasks for future work.

II. Disciplines of Accessibility

For a successful implementation of our research objectives, it is necessary to consider different disciplines of digital accessibility. *Access to Escape*, for one, represents a tool for learners to grasp the content related to digital accessibility. For another, the VR game needs to be accessible so it can be played by every learner. The following subsections address the topics necessary to achieve the objectives. The teaching of accessibility and connected specifications will be discussed. Further, the requirements for accessible game design and inclusive VR applications will be examined.

A. Accessibility Education

Accessibility Education is a broad field in which learners are supposed to acquire various competences: Initially, they need to develop theoretical understanding and procedural knowledge regarding accessibility [2]. Only with the aid of this foundational knowledge, learners can develop technical skills in this discipline.

To teach these skills, educators need resources that can teach accessibility while considering the current knowledge and skill set of students [3]. As digital accessibility is still not a widespread mandatory subject at every university, it is necessary to create such learning materials that provide a low-threshold introduction to the subject, so even students who do not have any prior educational knowledge about digital accessibility can have easy access to the content.

In order to provide that simple introduction to the topic, it is beneficial to make barriers tangible and thus provide learners with a realistic experience [4]. For example, Kletenik and Adler [5] developed three games in which the players are confronted with simulated disabilities to raise awareness of accessibility. It became apparent that the students who played these games increased their empathy for people with impairments or disabilities and also their motivation to design more accessible content.

These results provide a constructive basis for the development of additional learning materials. However, in future conceptualizations, the following insight could be considered, which could further enhance the awareness-raising effect: To make simulated barriers even more immersive, VR technology has the potential to create experiences that make them as tangible as possible [6].

B. Game Accessibility

Game Accessibility describes the subarea of game development that addresses the removal of barriers for people with impairments or disabilities [7]. It should be emphasized that removing the barriers, and by that, creating an accessible game, is limited by the game rules. Games often include intended barriers, which represent the challenges of the game story. If those challenges were removed, the intention and / or the entertaining character of the game could be compromised.

For the development of accessible games that comply with the corresponding game rules, the Game Accessibility Guidelines (GAG) [8] by the International Game Developers Association (IGDA) have been established in different elaborations [7], [9], [10], [11]. The GAG [8] are guidelines, which are based on an online survey that gathered methods to make games more accessible to different user groups. The current version (May 2021) includes 122 guidelines that can be classified according to motor, cognitive, visual, auditory, linguistic, and general barriers. Each of these six groups is classified again into three subgroups (basic, intermediate, and advanced). The classification into these subgroups depends on the following three factors:

Reach: People benefiting from meeting the requirements.

Impact: Qualitative difference for players.

Value: The cost incurred for implementation.

The *basic guidelines* [8] describe accessibility features that make playing easier for a large number of players and are also easy to implement. The *intermediate guidelines* [8] include features that require additional planning and resources, but are still easy to implement and reach many players. Finally, the *advanced guidelines* [8] involve complex modifications and high costs. Although only a few specific players benefit quantitatively from these modifications, they have a very high qualitative value for those players.

The need for each guideline of the GAG is emphasized by a realistic use case, making the traceability of a barrier easier for developers [8]. Further support provided by the guidelines are the listed best-practice games that have particularly well implemented the respective guideline.

Regarding the implementation of accessible games, the following workflow is recommended by the IGDA [8]:

1) *Familiarize:* Before the implementation phase begins, the guidelines must be considered, since a variety of requirements can already be met through simple design decisions in the conception phase.
2) *Evaluate & plan:* In the second phase, it must be investigated which guidelines will be relevant and applicable in the context of the planned game to create a reduced subset of requirements to be implemented.
3) *Prioritize & schedule:* The selected requirements from the second phase are prioritized according to the available resources and scheduled in the development plan.
4) *Implement:* To achieve the best results, experts and players with a disability or impairment should also test the game during the implementation phase.
5) *Inform:* Players should be made aware of the implemented guidelines in tutorials and loading screens, as there is a risk that they will go unnoticed in various menu settings.
6) *Review & learn:* Information on how often players have used accessibility features helps future projects when conducting the third phase, especially when prioritizing requirements.

C. Accessible VR

The use of VR is steadily increasing and is becoming a more prevalent tool in education. This makes access to VR technology even more important. The developer manual of the company Oculus emphasizes that accessible VR applications can reach a wider range of users [12]. VR applications are considered accessible when people with different types of visual, auditory, mobility, perceptual, and cognitive impairments can interact with the given content. The manual presents procedures for seven application areas of a VR application, which partly overlap with the GAG and the Web Content Accessibility Guidelines (WCAG) [7]. The sections of the manual are presented in the following:

User Experience (UX) and User Interaction (UI) [12]: To achieve an inclusive UX, game developers must first become aware of exclusive UX design. As an example of such an

exclusive design, the chosen size of the play area is mentioned: Players with a limited movement area could experience a below-average or even unplayable user experience. Only when the game can be completed without blockages or external help, an inclusive UX design is achieved. It must be constantly tested to see if this is the case. For example, it is useful to play the game with disabled sound or color filters. Also, the use of auditory, visual, and haptic interaction possibilities makes the UX more inclusive.

Controls and Interactions [12]: The predefined controls of a game can hinder players, for example those with motor impairments, from interacting with the game. To improve this situation, selection options and alternative types of interaction should be presented. Modifications help not only people with disabilities but also all players. For example, the ability to re-assign control keys not only helps players who cannot fulfill the default input requirements due to motor impairments but also benefits habitual players who prefer personalized interaction.

Movement and Locomotion [12]: In order for the movement of players in the virtual world to be feasible for everyone, among other things, developers must consider how a person who cannot move in the real world could still move around in the virtual world. For example, navigation via joysticks eliminates the barrier for players who cannot move freely in the real world.

Display [12]: Personalizing screen displays, such as variable brightness settings, is now standard on many devices. In VR applications, this personalization is even more important because the complete occupancy of the visual space and the proximity to the human eye pose a risk of sensory overload. A personalized display prevents this danger for all players, with and without impairments. For example, the ability to enlarge text elements or objects in the virtual world can support people with visual impairments.

App Design [12]: Elements of app design can support the accessibility of VR applications. For example, a clear and mandatory tutorial at the beginning of the game provides the opportunity to become familiar with the game mechanics. Clearly defined rules and objectives help players stay focused on the game. Through such methods, the basic understanding of the game can be simplified for all players. Additionally, the game can be made more accessible by adding a Guiding Character. For players who were unable to process auditory, visual, or haptic signals, these characters can, for example, provide additional hints.

Audio [12]: In addition to the possibilities of visual and haptic interaction, audio offers another form of communication. Short and simple audio tracks can signal actions and processes. However, despite the advantages of sound, the option should be kept open to deactivate it without loss: People who, for example, have difficulty concentrating and therefore choose to turn off the sound, must not experience any loss of information.

Captions and Subtitling [12]: Captions refer to the textual reproduction of spoken dialogues. Whereas, subtitling refers to the translated textual reproduction of spoken foreign-language dialogues. These forms of information transfer help a variety of people: players with hearing or cognitive impairments, players who do not understand the game language, and players who prefer to read dialogues instead of hearing them.

III. Didactic design

We created the didactic design of *Access to Escape* using Kerres' guide [13]. To support the development process of learning offers the guide uses various analysis and decision steps. In the following, the individual steps will be briefly introduced and applied to the VR-Escape Room.

A. Contexts

According to Kerres, the educational context of the learning offer has to be defined first [13]. Here, a distinction is made between three types of contexts into which a learning offer can be classified: Formal education describes intended institutional education with the aim of a degree such as school or university education. Non-formal education does not aim at a degree but it is still intended and organised. In contrast, informal learning is unintentional and takes place in everyday life, for example, through conversations.

Access to Escape is a virtual learning environment that enables knowledge acquisition through independent interaction with the game assisted by educators. Currently, the game is not embedded in a university lecture and thus constitutes a learning offer in a non-formal education context. However, if the game will be offered in connection to a course it can be considered as part of formal education.

B. Stakeholder

The learners' characteristics need to be identified and thus the target group will be defined. To enable this identification, Kerres introduces several attributes including *number of participants*, *level of education* and *motivation* [13]. Special focus is on the prior knowledge of the learners. In addition, other actors such as teachers, as well as the constellation between the participants are important.

The VR-Escape Room is primarily intended to enable computer science students to identify and ideally remove barriers. This target group should be made aware of barriers as early as possible in their studies, so that these barriers can be taken into account in the further course of their education.

C. Educational Concern

Based on the used guide, a learning offer aims to solve an educational problem [13]. For this, it is necessary to first identify the problem and then formulate an educational concern in concrete terms. In this context, the understanding of education must be determined: Kerres distinguishes between *Education as Disposition*, where the goal is the development of competences, *Education as Transaction* with the goal of developing qualifications, and *Education as Transformation*, where the aim is personality development.

The educational problem that we try to solve with our learning offer is the insufficient presence of digital accessibility in the study field of computer science even though those students will create digital content in the future. With this in mind, the educational concern can be formulated as follows: *Digital accessibility must be considered and implemented by developers of digital content. However, there is a lack of awareness of digital barriers and the opportunity to get familiar with the topic easily.* The understanding of education regarding the learning offer can be split up into all three categories. The learners should be empowered to identify and preferably eliminate barriers (*education as disposition*). The obtained knowledge can support the learners career opportunities as digital accessibility gains importance due to the digitisation of everyday life (*education as transaction*). Further, *Access to Escape* gives learners the opportunity to be sensitized to barriers and thus expand their view of the environment (*education as transformation*).

D. Teaching Objectives

Teaching objectives are structured within the context of the *competence domain* and *competence dimensions* and categorized by *performance levels* [13]:

Competence domains include the *subject competence* (understanding and knowledge about the world), *self competence* (regulation of one's actions) and *social competence* (interaction with others).

The *competence dimensions* describe *knowledge*, *motor or cognitive skills*, and *attitudes, values, and norms* each regarding objects, individuals, and oneself.

Within the context of competence domains and dimensions, various *performance levels* can be achieved. Learners may *recall* knowledge about subject competences, *comprehend* them in greater depth, or achieve even higher levels of performance.

The VR-Escape Room intends to teach subject competence related to accessibility, which is why the performance levels are applied to said competence domain. Regarding the dimension "knowledge", learners are supposed to achieve the following performance levels:

Remembering: Learners can recognize and reproduce barriers they have encountered during the game; *Understanding*: Learners can find examples of similar barriers and explain why such a barrier is a hindrance; *Apply*: Learners can apply the acquired knowledge by identifying and removing barriers.

Further, the learners should develop *skills* in the *cognitive phase*, which means the barriers are known and can be described verbally and also in the *associative phase* meaning the possibilities to remove a barrier are known and can be applied.

Lastly, the VR-Escape Room is supposed to affect the *attitudes* of the learners in the following aspects:

Attentive: Learners are willing to engage with new norms and values; *Reacting*: Learners voluntarily pay attention to digital barriers as they continue to study and integrate their knowledge into further developmental tasks; *Values*: The learners recognize the importance of digital accessibility and take it into account in their further work; *Adopting Values*: Learners adopt the learned values into their value system.

E. Selection of the Teaching Content

Based on the teaching objectives (see Subsection III-D), the teaching content for the competence dimensions "knowledge", "skills", and "attitudes" must now be defined. Using different *positions* offered by Kerres [13], the teaching content for the VR-Escape Room was identified:

Position A: "Teaching content can be justified by future requirements and qualification needs." [13] - Increasingly, employers are obliged to provide a barrier-free presence [14], which requires qualified employees. They should know and be able to apply the basic concepts of digital accessibility. *Position B: "Teaching content should enable an educational experience that changes the person. (transformation)"* [13] - By confronting learners with real-life challenges, a formative experience should be made possible. Thereby the learners are sensitized to barriers and their consequences. *Position C: "Teaching content can be defined based on an analysis of tasks to be performed."* [13] - Since the range of topics in digital accessibility is very broad, the teaching content must be made concrete. Tasks can look like so:

For example, if the task is to develop a low-barrier website, the WCAG must be considered (*Step 1: Finding the Guidelines*). Understanding the specific barriers (*Step 2: Understanding the success criterion*) and the corresponding solutions (*Step 3: Understanding the Solutions*) are a necessity for creating barrier-free access to a website. The modular structure of the guidelines allows the definition of clearly delimited tasks from which teaching content can be derived. Each success criterion deals with one barrier and thus corresponds to one potential task. Further, the validity of the WCAG is not exclusively limited to web content. For example, correct language markup of texts must also be available in a game or other applications. Selected WCAG success criteria that are universally applicable are therefore suitable teaching content.

Considering these positions, the following teaching contents could be identified: speech markup, alternative text, representation of color, heading hierarchies, and appropriate button size.

F. Didactic Principles

Learning offers can be structured as more expository or exploratory [13]. The former describes a step-by-step introduction and practice of the teaching content. The latter conveys teaching content through the direct confrontation with complex problems.

The VR-Escape Room consists of elements of both principles. Explorative elements are the *flatly structured teaching material*, which do not build upon each other, the *non-formal learning situation* since the teaching contents do not belong to a formal course, the very *diverse target group* consisting of students of different levels of knowledge and learning motivations and the *self-study learning habit* of the target group. Further, the playful VR learning offer can trigger intrinsic

motivation among students (explorative). If instructors choose to use the game alongside a lecture and reward it, for example, with bonus points, it can also stimulate extrinsic motivation in students (expository). Another expository element is the limited prior knowledge of the target group. According to the module handbook, students have little exposure to digital accessibility [15].

G. Learning Times

The learning process is characterized by three components, which are stimulated to different degrees by the learning offer [13].

Learning by *reception* includes learning by taking in and processing presented information. The component *communication* refers to the learning theory behaviorism, which states that learning is influenced by external factors: Feedback or reinforcement from the environment informs about the correctness and incorrectness of an issue and leads to learning. The third component *construction* describes that simple processes in the environment can be learned by trial and error. Through experiences, pushing boundaries, and reflecting on processes, not only are predefined contents learned, but rather new horizons are discovered.

Essentially, the three components presented can be attributed to the three competence dimensions (see Subsection III-D). Reception is mainly concerned with the transfer of knowledge, communication is related to attitudes, and construction contributes to the acquisition of skills.

The largest part of the planned learning activity is devoted to learning through construction. This is due to the game mechanics of *Access to Escape*, which involves solving puzzles through independent interaction within the given space. The remaining components of the learning process involve learning through reception and learning through communication. Prior to the game, players receive information that is relevant to their understanding of the game; in a concluding debriefing, a series of information is presented for learners to absorb and process (learning through reception). Through hints and encouragement before and during the game, as well as feedback on insights during the debriefing, information is conveyed in an interpersonal manner (learning through communication).

H. Learning Processes

The introduced components of reception, communication and construction (see Subsection III-G) will be used to break down how learning processes can be initiated by the learning offer, according to Kerres [13].

Reception: Asking the question of how learning processes can be supported by the presentation of information, Kerres focuses on the so-called *didactisation of the presentation*. Here, various approaches are introduced, which support the learning process through a curtain presentation of information. One approach being the *use of questions* to initiate independent thinking processes. Instead of just naming facts and results, the learners develop a solution to given questions. The VR-Escape Room goes one step further: Learners figure out the questions on their own as they are confronted with barriers. Only by eliminating the barriers, they can go on within the game. This inevitably raises the question of how accessibility can be implemented in the respective area. If the learners cannot define the questions on their own or cannot find an answer, hints can be received at any time. Further, Kerres mentions the *use of examples* to vividly present complex content and by that, support the learning process. All puzzles are examples of a barrier. One of the puzzles shows that conveying information only through color is a barrier. The learners have to figure out another way to convey information and can thus remove the barrier.

Communication: Kerres claims that communication always includes a *content level* and a *relationship level*. On the content level, knowledge regarding accessibility is conveyed through the learning offer. On the relationship level, power and appropriate behavior on the side of the teachers are essential aspects to consider. The aim is to create an environment conducive to learning. In the case of the VR-Escape Room, a power imbalance can almost completely be ruled out. Knowledge is conveyed in a playfully without an evaluation of performance. Throughout the game, the learners can ask for hints and are supported by teachers.

Construction: Here, the question arises as to which learning activity can best initiate cognitive activation. Kerres describes that especially the active engagement with the learning content leads to learning success. Learning activities, like summarizing or drawing, are said to promote learning. The VR-Escape Room is no suitable learning offer to apply these learning activities. However, another type of activity can be reached in the game: Through the practical examination of the content in a virtual environment, cognitive activation is stimulated to subsequently build up competences. This is intended to enable learners to apply the learning content in future situations.

I. Learning Spaces and Learning Media

The learning spaces and learning media play an important role concerning the learning process and finally the learning success. According to Kerres, learning spaces have the potential to influence the learning experience [13]. The learning offer can convey information through different learning media, also influencing the learning experience. Every learning room features a didactic design and therefore has the potential to influence the learning experience. The resources available, but also the furniture in the room, are factors that influence learning and teaching. In addition, learning spaces have a so-called affordance, which means they suggest certain behaviors: While some rooms may encourage focused individual work, others encourage creative group work. There are also differences in the digital world: Some digital learning spaces may be particularly helpful for flexible, self-determined learning, while others have a positive effect on group dynamics and thus promote collaborative learning. Here, it should be noted that the extent of the influence that a learning space has on learning behavior is a subjective perception varying from person to person.

Access to Escape is a learning offer, which uses playful elements and tension to achieve learning success. Since the aim is to make barriers tangible, the use of VR as a learning medium is ideal as it can recreate a realistic experience. In addition, the immersion associated with VR can encourage learners to stick with it. The individual rooms in *Access to Escape* should not appear cramped, but should not be too spacious either so that the learner does not lose their orientation. By using appropriate light sources and unobtrusive sounds, the focus should be entirely on learning and not be wasted on disruptive factors.

J. Learning Organization

Based on Kerres' definition, learning organization describes how the learning offer is organized in terms of time, whether and when synchronous or asynchronous elements are planned, and which social forms should be used [13]. However, due to its current short-term and isolated use, the VR-Escape Room does not fit the concept of learning organization. For now, there is no plan for recurring use of the learning offer; rather, the Escape Room only needs to be completed once. Since the learners will use the learning offer alone, the social form can clearly be defined as individual work (with supervision).

K. Evaluation

Evaluating a learning offer provides insights into the positive as well as negative aspects of an implemented concept. Based on the identified characteristics, future teaching can be made more efficient and effective. Four key evaluation areas include:

- Acceptance: Learner perspectives and invested resources (time).
- Engagement: Cognitive, emotional, and behavioral involvement.
- Learning Outcomes: Competences acquired.
- Consequences: Effects on individuals, organizations, and society.

The VR-Escape Room is evaluated using the method of observation, open-ended feedback as well as two questionnaires: the User Experience Questionnaire (UEQ) and the Goethe University Frankfurt's Course Evaluation Questionnaire (CEQ). The UEQ provides insights into the acceptance and learning engagement parameters of the learning offer. The CEQ also assesses learning engagement in the learning process, evaluates the scope of learning outcomes, and hints at the prospects of learning consequences. Further details on the questionnaires, their application, and results can be found in Section V.

L. Examination

Examinations play a crucial role in assessing developed competences in both formal and non-formal educational offers. It is the responsibility of educators to design an examination format that aligns with the instructional methods employed. For instance, if the primary focus for achieving teaching and learning objectives was on pure knowledge transfer, the examination format should not include complex application tasks to avoid a discrepancy between the learning and testing situations.

Competence assessment through an examination is not planned in the first phase of this project. Several reasons underlie this decision: Firstly, the VR-Escape Room constitutes a learning activity that is conducted only once. Consequently, the amount of content that can be covered through the learning offering is limited. The plan is to introduce learners to five barriers in a playful manner, which does not allow for the creation of a comprehensive examination. It is only during the debriefing, following the completion of the game that participants are explicitly informed about the learning content. Assessing the learning content immediately in a subsequent examination would only reflect whether learners have temporarily memorized the information from the debriefing. However, assessing competence acquisition in the case of *Access to Escape* is more about whether learners are sensitized to the barriers in the long term and can recognize them and provide solutions even after a significant amount of time has passed. Furthermore, the developed learning offer was evaluated during a pandemic. The presence of an examination and the associated effort could have had a discouraging effect on the already reduced number of participants. Due to these reasons, competence assessment was not initially planned. To still be able to make a statement about the added value of the learning offer and its consequences, the focus shifts to evaluation (see Section V).

IV. Implementation

The implementation is divided into different sections: First, we introduce the VR-Escape Room *Access to Escape* and its learning objectives. They specify what skills and knowledge the learners are supposed to gain. Next, the application of the GAG workflow is presented, which exemplifies how the workflow can be integrated into the development process. Finally, the implemented accessibility features are presented and categories for clustering them are proposed.

A. Access to Escape

At the beginning of the game, the player is in a university building and has to find a certain auditorium. Initially, the person playing is on the first floor where a training room is located. As soon as the player is ready, they can use an elevator to go to the desired location but because of a defect, the elevator crashes shortly after. Finally, the player lands on the basement floor where five puzzles, each representing a barrier, need to be solved to get the elevator running again.

- Puzzle 1: Once the elevator crashes onto the basement floor, a security box opens. In it, a numerical code - the so-called security code - can be seen. There are also three symbols: the London Eye, the Eiffel Tower and the Brandenburg Gate. Under each of the landmarks is a slot. Initially, the card is in the Eiffel Tower slot. To open the elevator doors, the security code must be figured out. Just as in real life, they are supposed to press the emergency button, recognizable by the yellow bell (see

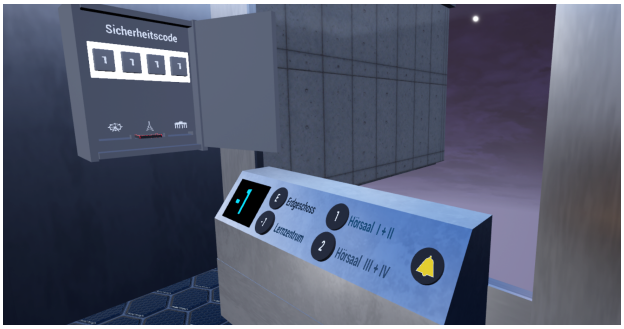

Fig. 1. Puzzle 1: Interior view of the elevator after the crash.

Fig. 2. Access card and scanner to enter a room.

Figure 1). However, the following announcement is not understandable, as it sounds like the French sound image but does not contain any French text. Only when the mentioned card is inserted into the Brandenburg Gate slot the originally German text can be understood. After entering the correct code, which was hinted at by the announcement, the elevator doors open.

The incomprehensible speaker announcement is caused by an incorrect language setting, which introduces the learning objective of the first puzzle: *WCAG success criterion 3.1.1 Language of Page (Level A)*. This success criterion requires the ability to programmatically determine the language of the content at hand. People who use a screen reader will encounter this barrier, for example, when a web page has no or an incorrect language tag. If the screen reader pronounces text in a different sound than the language in which the text is written, the read-out

Fig. 3. Puzzle 2: Overview of the room.

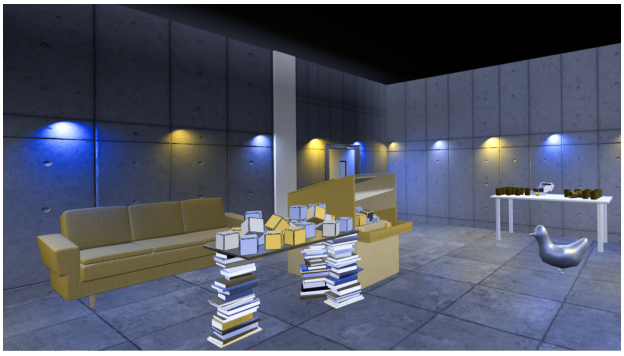

Fig. 4. Puzzle 3: Using a color filter, the player experiences the perception of a person with a color vision deficiency (deuteranopia).

text is very difficult or even impossible to understand.

As soon as the player leaves the elevator, they find themselves in the foyer of the former computer science learning center. Various objects can be seen there, some of which resemble the atmosphere of an abandoned building. One object, however, is relevant for the further game: On a shelf is an access card on which the outline of Goethe's head is depicted in reference to the Goethe University Frankfurt (see Figure 2). The scanners on the doors leading from the foyer to other rooms also show a Goethe head. The players should recognize that the access card must be placed on the scanner to open a door. Only one of the doors can be opened with the first access card. Once the correct door is opened, the player can start puzzle 2 (see Figure 3).

- Puzzle 2: Within the entered room, a multitude of blocks are distributed, which are labeled with different letters. An important code, which is needed to move on within the game is projected onto a wall as an extremely blurry image. On another wall, there is a hint: "bei uns können Alle Leute Teilnehmen" (engl. "with us all people can participate", see Figure 3). The incorrect capitalization indicates the solution word: "A", "L", "T". By placing the correct cubes in the designated trays, an alternative text appears on the monitor. In addition, the image on the projector screen becomes sharp. Both provide information about the code that is needed to open the door lock in the room, which hides another access card. In case the player does not find the solution through the clue on the wall alone, there is a Guiding Character, which appears here for the first time and accompanies the player with clues throughout the game. This Guiding Character is a robot chicken that is supposed to represent a project from a university module and claims to have been left behind in this place.

  Puzzle 2 introduces the player to the difficulties caused by inaccessible graphics, which are mentioned in the *WCAG success criterion 1.1.1 Non-text Content (Level A)*. Here, it is described that non-text content needs an alternative textual access point.
- Puzzle 3: After solving the previous puzzle, the player receives another card that allows them to enter a room

Fig. 5. Puzzle 4: Three button options next to the magic carpet, each representing a different heading level.

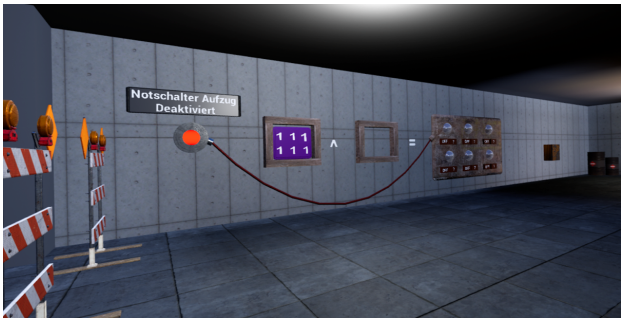

Fig. 6. Puzzle 5: Overview of the room.

containing a color-dependent puzzle. However, just a few seconds after entering the room, they can only see a limited amount of colors due to a color filter, which imitates the color vision deficiency deuteranopia (see Figure 4). As they cannot perceive all colors, the player must consider other ways to convey information, in this case through patterns: To solve the puzzle, the player needs to arrange some blocks on the shelf. But currently, the colors of these blocks look quite similar, making it impossible to get the correct order. The player needs to find a so-called color-scanner, which can add patterns to the blocks. After that, the puzzle can easily be solved.
Here, the player is introduced to the content of *WCAG success criterion 1.4.1 Use of Color (Level A)*, which states that color should not be the only way to convey information. If content is conveyed through color alone, people with limited color perception may not be able to assimilate this information.

- Puzzle 4: In the next room, a cliff has to be crossed by choosing the correct order of labeled buttons, which represent heading levels (see Figure 5) and by that, the player becomes familiar with the content of *WCAG success criterion 1.3.1 Info and Relationships (Level A)*. This success criterion requires that the structure of (web) content must be programmatically determinable. If the correctness of the heading order is not given, the comprehensibility of the digital content is limited.
With a hint from the Guiding Character, the player can cross the cliff, using a so-called magic carpet. The challenge is to understand that the correct heading order is given whenever the current heading level is followed by a level that is either lower, equivalent, or only one level above the existing level. The player can choose between three different buttons each representing a heading level. If the player selects the wrong button they will travel down to that level but immediately get back to the previous position. Only by selecting the correct level, they will advance to a position further ahead and can then choose the next button. Due to simulator sickness, which can occur within a virtual environment [16], we implemented another game mode to solve this puzzle: The player is standing in front of a panel divided into three pieces each representing a heading level equivalent to the buttons of the first game mode. Through teleportation to the piece representing the correct heading level, a new panel appears and the player can again try to select the correct level. Using one of these game modes, the player can finally reach the other side of the room where they find a board with six bits on it that is necessary to solve the last puzzle.
- Puzzle 5: The board discovered in the previous puzzle can now be combined with the existing board in the foyer (see Figure 6). This allows the solution of the resulting propositional logic equation. To operate the lights, three buttons below them can be used: the “OFF” button, which deactivates the respective light; the “ON” button, which activates it; and a “?” button, randomly toggling each of the six lights. The challenge arises from the “ON” button’s small size (see Figure 7), often leading to inadvertent contact with surrounding buttons. After several wrong attempts, the puzzle gets blocked by a wall sliding over the light panel. Simultaneously, an audible signal sounds, and a fuse box opens. Among those is the “Lamp Function” fuse, enabling interaction with the light panel. There is also a lever related to button size, initially set to “small”. Switching it enlarges the “ON” button to match the others. Consequently, the puzzle can be effortlessly solved following the logical equation and by that, the elevator can be reactivated.
This puzzle is based on *WCAG success criterion 2.5.5 Target Size (Level AAA)*, which states the necessity to maintain a minimum size for buttons (and other interactive elements) in order to guarantee their operability for all users.

B. Implementation of GAG Workflow

The development process of the VR-Escape Room follows the phases of the IGDA workflow for an accessible implementation:

Phase 1 - Familiarization: The structure and content of the GAG and the presented Oculus manual were considered.

Phase 2 - Evaluate & Plan: The GAG are provided in the form of an Excel spreadsheet in which each row represents a success criterion whereas the Oculus manual contains var-

Fig. 7. Puzzle 5: Inaccessible target size of the "ON" Button making it impossible to select the element.

Guideline	Importance	Ease
Hearing		
Basic		
Provide subtitles for all important speech	1	1,5
Provide separate volume controls or mutes for effects, speech and background / music	1	2
Ensure no essential information is conveyed by sounds alone	1	1

Fig. 8. Excel spreadsheet with a rating of guidelines.

ious texts, which are spread over several pages. To allow a structured evaluation, we converted the content of the Oculus manual into an organized Excel spreadsheet. The further evaluation of the now prepared guidelines was approached together with the following phase.

Phase 3 - Prioritizing & Scheduling: The prioritization of the guidelines has been carried out in several steps. First, it was decided that, in addition to the Oculus manual, only the basic GAG guidelines would be considered. These do not require a complex implementation and yet help a large number of gamers, making them a suitable basis for the first prototypical implementation. In the next step, the Excel spreadsheet from phase 2 was extended by two additional columns, "Importance" and "Ease", which take a value between 1 (important resp. easy) and 3 (rather unimportant resp. difficult) for each guideline (see Figure 8). "Importance" is used to indicate how necessary a guideline is for the concrete game experience of *Access to Escape*. Thus, the guideline to use a readable text size is associated with the importance of "1", whereas the guideline to inform about accessibility features during the game is rated with the importance of "2". The latter policy aims to improve the game experience by providing information; the former policy aims to provide a basic perceptible game experience, which is why it is considered more important. "Ease" describes how complex and time-consuming a potential implementation of the policy is estimated. After determining whether a policy applies to the game (see Phase 2), the values of "Importance" and "Ease" were discussed and recorded. By looking at the final scores, a prioritization of the guidelines or features could be performed.

Phase 4 - Implementation: Throughout the development process, the game was evaluated by usability and accessibility experts. Because of these evaluations, an implemented puzzle could be identified as a trigger for simulator sickness and thus as non-accessible. Therefore, an alternative path to the game was developed, which avoids the sickness-indicating factors.

Phase 5 - Informing: Game-internal informing was not considered in the context of the prototypical VR-Escape Room. *Access to Escape* does not have any settings that can be accessed by the players but the implemented policies represent features that are inevitably encountered in the game anyways.

Phase 6 - Assessing & Learning: The testing phase of *Access to Escape* included 11 participants with connections to the study field of computer science [17]. We were present throughout the testing, which made it easy to observe how the participants reacted to the accessibility features. Here, it became apparent that the implemented features were also able to provide a better gaming experience for players without impairments or disabilities. They showed positive reactions to multiple access possibilities. Examples are the textual content conveyance through subtitles, the auditory signaling of events via sound effects, and the haptic feedback in the form of different vibration patterns of the controllers.

C. Implementation of Accessibility Features

This section sketches the implemented and discarded guidelines and presents different categories in which these guidelines can be clustered. The respective categories are not to be considered disjunctively; thus, a guideline that is assigned to one category may also be part of another. In the following, the categories and exemplary associated guidelines are presented in ascending order of effort.

1. Implementation by the game engine: Besides guidelines, which have to be implemented manually, there are also accessibility features, which can be implemented by pre-developed templates of the chosen game engine (in our case Unreal Engine), such as: "Representation of the controllers in the virtual environment" [12]. In order for the players to have a reference to the real controllers during the game and to simplify their use, a virtual copy of the controllers should be displayed (see Figure 7). This not only shows the position of the buttons on the controllers, so that the players do not have to remember them, but also marks the position of the controllers in the real space, and thus simplifies their findability [12]. The game engine Unreal also provides this feature in the engine's own VR-template.

2. Implementation based on prior knowledge of accessibility: Further, there are such guidelines that can be implemented simply and with small expenditure, if there is knowledge of their necessity. One of these guidelines being: "Ensure no essential information is conveyed by a color alone" [8]. Since not everyone can perceive information through color, an alternative form of communication must be implemented [8]. This can be in the form of patterns, icons, or text.

In *Access to Escape*, a combination of these approaches is used. At one point, color signals the activation of a button,

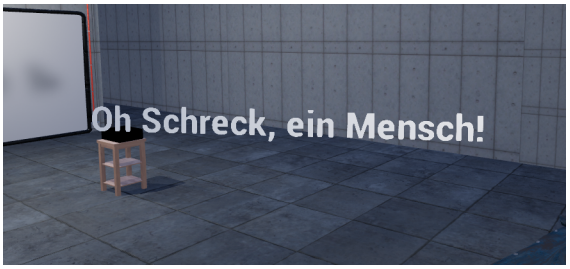

Fig. 9. Visualization of captions of spoken dialogue of the Guiding Character.

which is additionally symbolized by sound and changing text. Another example are color-coded blocks that are equipped with patterns, so that they can be clearly differentiated without the visibility of color.

3. Implementation through elementary game design: A subset of the guidelines can be grouped under features that every common game design includes to make the application fundamentally playable, for example: "Placing UI elements in a user-friendly way" [12]. For an unrestricted gaming experience, the elements of the user interface must be easily accessible and visibly positioned, otherwise the game flow suffers [12]. The chosen position should indicate the relation of the element to the rest of the room.

In our VR-Escape Room, the guideline was planned into the visual conception of the games. The previous considerations about the positioning of individual UI elements have greatly simplified the fulfillment of this guideline.

4. Implementation through high effort: The guidelines sets also include policies that require costly implementation, such as "Provide subtitles for all important speech" [8]. Purely auditory instructions and narrations exclude persons with hearing impairments or persons who are more likely to take in written information from a full game experience [8]. To counteract this, the use of subtitles can be considered.

However, the implementation of these is not possible without further effort using Unreal Engine. The option to add subtitles to audio tracks is offered, but these are displayed in a font size that is too small and in an unsuitable position in the game. During our research, no option could be found to change font size and position, so another approach had to be taken: The subtitles are currently displayed as a separate text field based on predefined time frames (see Figure 9). Due to the complexity of this approach, the subtitles in the prototype were only implemented as an exemplary feature in one scene of the game.

5. Implementation not possible: Lastly, there are policies that have not been implemented. In our case this had several reasons; for one, the guidelines may not be in accordance with the game rules or the game form: "Provide details of accessibility features on packaging and / or website" [8]. To benefit from the implemented accessibility features, players must first be made aware of them [8]. If these are implemented but not advertised, players may overlook them and, therefore, assume that the game is not playable for them. In addition, advertising the features can increase search engine traffic and distinguish the application from other games of the same kind.

However, since *Access to Escape* is only a prototype and currently no public deployment is planned, this policy was not implemented for the current application.

For another, the reason for the lack of implementation may be resource constraints, as some implementations of policies may require additional expertise or time:

"Personalization of Controller-Based Movements" [12]. For example, players who have difficulty holding a game-required arm position for an extended period of time should have the opportunity to personalize controller-based movements [12]. If a position, such as an outstretched arm, cannot be achieved in the real world, it should nevertheless be possible to personalize the parameters of size, rotation or distance, so the virtual arm can be fully extended or moved to a different position. Due to different mobility abilities, these "hand profiles" should be implemented individually for the left and right hand. This guideline was not implemented within *Access to Escape* due to its extensive implementation work and project time restrictions.

V. Evaluation

The evaluation study was conducted with the support of eleven participants from the field of computer science, as they are the primary target audience for the planned learning concept. Among the participants, there were two former students and nine individuals currently pursuing their studies. Over a period of three weeks, they were invited to play the VR-Escape Room in person. After completing the game, the participants were asked to take part in an online survey on-site. This survey was created using the survey and examination software *evasys*, which is used at the Goethe University Frankfurt, among other places, for quality management purposes. The survey primarily consists of two questionnaires: the User Experience Questionnaire (UEQ) [18] and the Course Evaluation Questionnaire (CEQ) [19]. In addition, open feedback was collected, and observations were documented. A comprehensive elaboration of the evaluation results can be found in [17]. Following, the results concerning Accessibility Education collected by the CEQ will be presented.

For the establishment of the VR-Escape Room as a learning offer, it is necessary to evaluate it as such. The CEQ is employed to gather feedback from learners, enabling the identification of positive aspects of the learning offering as well as the investigation and improvement of negative aspects. The CEQ is structured into three sections: *General*, *Educational Objectives* and *Learning Format*. Out of a total of 17 items, 15 are assessed using a 6-point Likert scale (1: strongly agree - 6: strongly disagree). The remaining two items consist of open questions.

As Table I shows, the implemented learning format has the potential to increase knowledge regarding accessibility by understandably conveying content. A somewhat diverse

TABLE I. CEQ - General: Mean values (1: strongly agree - 6: strongly disagree).

Statement (translated from German)	Mean	Standard deviation
The completion of the Escape Room leads to an increase in knowledge.	1.5	0.5
The content is presented in an understandable manner.	1.5	0.7
The relevance of the topics covered is evident.	1.8	1.0

TABLE II. CEQ - Educational Claim: Mean values (1: strongly agree - 6: strongly disagree).

Statement (translated from German)	Mean	Standard deviation
The learning experience makes me see things differently and makes me recognize new connections.	1.5	0.7
The covered topic is comprehensively explored and reflected upon.	1.5	0.5
The learning offer helps me develop my own perspective.	1.5	0.7

range of opinions follows the statement "The relevance of the topics covered is evident." The majority fully agrees with this statement, but one person each chose the options "somewhat agree" and "somewhat disagree". This feedback is significant as a primary focus of the learning offer is to convey the importance of the topic of accessibility and exhibits a matter for further inspection.

The items "The learning experience makes me see things differently and makes me recognize new connections." and "The learning offer helps me develop my own perspective." both receive identical and mostly positive ratings, suggesting that this goal has been achieved (see Table II). The positive agreement with the statement "The covered topic is comprehensively explored and reflected upon" supports the hypothesis that initial steps towards addressing the educational objective of teaching about accessibility and initiating a sense of sensitization have been taken.

The results of the last section of the CEQ show the advantage of an innovative learning format. The participants stated interest in the learning offer due to the use of VR and the Escape Room format even though it was a voluntary learning session about a rather unknown topic (see Table III).

Additional free-text feedback, analyzed using the Summative Qualitative Content Analysis according to Mayring [20], particularly emphasizes awareness of the topic of accessibility.

TABLE III. CEQ - Learning Format: Mean values (1: strongly agree - 6: strongly disagree).

Statement (translated from German)	Mean	Standard deviation
VR has sparked my interest to take part in this offer.	1.5	0.7
I participated because I am interested in Escape Rooms.	1.2	0.4

In five free-text responses, it is highlighted that the VR-Escape Room, for example, "creates attention for a topic that often seems intangible to outsiders" (translated from German) and that "the feeling of having a disadvantage in everyday life becomes practical" (translated from German). Additional benefits of the VR-Escape Room for teaching Accessibility Education can be summarized under the advantages of playful learning, originality, appealing aesthetics, and simplified learning.

VI. Discussion & Limitations

Access to Escape covers accessibility in two kinds of ways: The VR-Escape Room was implemented following the GAG workflow to achieve a low-barrier application (Game Accessibility). Further, *Access to Escape* is supposed to educate about accessibility, so the players experience sensitization for the topic and develop an understanding of different kinds of barriers and how to avoid them (Accessibility Education).

Focusing on the first goal of *Access to Escape*, creating a low-barrier application, challenges need to be addressed. The discipline of Game Accessibility deals with eliminating avoidable barriers for people with disabilities or impairments within the framework of game rules [7]. This creates a dilemma between adhering to the game rules and making the game as accessible as possible. Game rules typically require overcoming intended barriers that are presented in the form of game challenges.

For example, a digital chess game where each move is timed cannot fulfill the guideline of variable game speed without violating the game rules [11]. Furthermore, not every guideline is relevant to every game. For example, the guideline that requires the use of subtitles cannot be applied to a game that does not have audio. Therefore, developers must be aware that a game may not be entirely accessible due to the game rules but also that a game can still be accessible even if not every single guideline is met. Thus, developers are faced with the challenge of recognizing which guidelines are feasible and relevant for the game.

Within the scope of this work, the GAG workflow has proven to be a suitable approach, especially for the needed structured exploration of the guidelines. Furthermore, the transfer of this workflow to other guidelines has also been successful and can be recommended. However, developers must consider that a resource-based prioritization, as suggested in phase 3 of the GAG workflow, cannot produce an accessible application. This goal can only be achieved by implementing all applicable guidelines. The EU Directive 2016/2102 (39) also emphasizes this fact: "Only legitimate reasons should be taken into account in any assessment of the extent to which the accessibility requirements cannot be met because they would impose a disproportionate burden. Lack of priority, time, or knowledge should not be considered as legitimate reasons." Therefore, while the GAG workflow provides a structured approach to developing a low-barrier application, it is only suitable for implementing an accessible application if prioritization within the workflow does not lead

to the exclusion of other applicable policies. This is crucial as each guideline ensures the access to the presented content for a specific target group and further, as confirmed by our results, they can improve the game experience for everybody. To comply with all applicable guidelines, it is necessary to schedule enough time to implement accessibility features that were not achieved to the desired extent in the discussed implementation. In retrospect, it could be recognized that a classification of guidelines into categories is possible, which could support better time management during the development process. Another aspect that must be addressed early on during the development process is the cooperation with people affected by impairments or disabilities. Since no test person stated that they are affected, the question of inclusion can only be answered theoretically, not practically.

Having addressed Game Accessibility, we shift our focus to the objectives regarding Accessibility Education.

To clearly define the scope and objectives of the learning offer, Kerres' guide provided a supporting framework [13]. Contexts, stakeholder, teaching objectives and many more components could be specified on a common understanding of the terms and their attributes. Considerations and challenges regarding the learning format and the learning content could be identified.

As defined in Subsection III-D, learners are supposed to acquire competences to remember and understand encountered barriers as well as apply that knowledge by identifying and removing similar ones. The attainment of this goal cannot be answered definitely as there was no examination conducted. This poses a gap that needs to be closed. To do that, the challenges regarding the format of a potential examination need to be addressed (see Subsection III-L), e.g., with the help of long-term participants who could be examined after a longer period of time.

However, tendencies regarding the teaching objective concerning the attitudes of the learners could be identified. The majority of learners stated that they recognized the importance of digital accessibility (see Section V). They experienced a newfound perspective on everyday barriers and felt more aware of otherwise intangible challenges [17], which emphasizes the suitability of the format for this competence dimension.

Another advantage a novel learning format [17] like a VR-Escape Room holds, can be defined by the intrinsic motivation it is able to evoke (see Section V). Students voluntarily registered to participate in the learning session, even though it covered a rather theoretical topic like accessibility. Their motives can be defined by the use of VR and the interest in Escape Rooms.

In conclusion, the development of an accessible VR game requires enough resources and a well-defined time schedule. To plan these factors, the GAG workflow offers a supporting guide but is not sufficient on its own, which is why thorough research and more tangible implementation templates are needed. Moreover, Kerres' guide provided a common foundation for the definition of the learning offer. Expanding on this, the considerations taken in the conception phase simplified the merge of the didactic and technical design. They reported a sense of sensitization and understanding of barriers. A research gap left open states the examination for learning success regarding the competence dimensions of knowledge and cognitive skills. Overall, *Access to Escape* represents a learning format that has the potential to effectively raise awareness among students, and its development process can be replicated through the proper utilization of support resources such as those provided by GAG or Kerres.

VII. Conclusion and Future Work

As a result of the development of *Access to Escape*, approaches to create accessible and innovative learning offers in fields like Accessibility Education could be identified. While *Access to Escape* provides a foundation for tackling the challenge of delivering learning content in an engaging manner, numerous opportunities for further enhancement and expansion were formulated.

A. Conclusion

Summarizing, the research question "What does the design process for creating an accessible VR game entail and what implementation steps are necessary to achieve this goal?" can be answered supported by Kerres' guide and the GAG workflow.

The former offers guidance throughout the development process of a didactic design for a learning offer. It highlighted various aspects that need to be taken into account to create a game that can be used in educational settings.

Based on the results of the developed didactic concept, the game can then be designed accessible using the GAG. The GAG workflow provides a suitable starting point for developing accessible games and a structured approach to working with large sets of accessibility guidelines like the GAG and the Oculus manual. The workflow is especially useful for identifying and prioritizing policies that can be implemented in a first implementation cycle. But here, the examination of the guidelines alone is not sufficient for a sustainable assessment of which prioritization these features should take. A retrospective view of the implemented features shows that preceding steps are needed, like the consideration of the features that the chosen game engine already offers, as well as the documentation of existing implementations. Here, the classification into the categories presented in this paper could benefit the development process. They offer the possibility of assessing the workload that would be needed to meet each guideline. However, since many guidelines fall under the category of "Implementation through high effort" or "Implementation not possible", our VR-Escape Room *Access to Escape* cannot meet the requirements of an accessible VR game. Our research phase indicated that there is a need for low-level solutions for accessible games and VR applications so that accessibility features that were classified under the

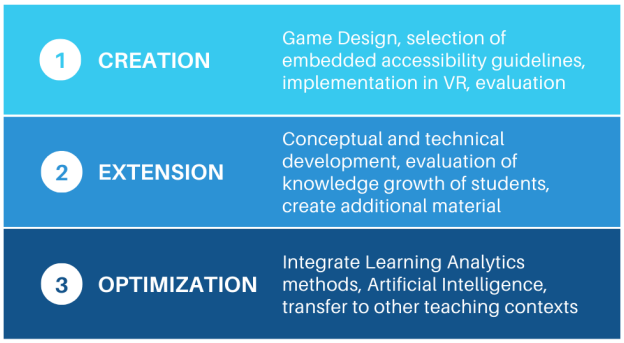

Fig. 10. Three phases of development and research: creation, extension, and optimization.

mentioned categories can ideally be classified into "Implementation by game engine". Since this is not the case yet, the guidelines were implemented in an exemplary manner at various points in our VR-Escape Room, but not consistently, which is unsatisfactory and needs to be addressed in future design iterations. Another aspect that needs to be included in future work is the evaluation of *Access to Escape* by people with impairments or disabilities to get reliable insights into the accessibility of the VR game.

B. Future Work

The evaluation of *Access to Escape* in the first development phase shows that the selected format of a VR-Escape Room is suitable for sensitizing students to digital barriers that may arise (see Section V). This subsection gives an overview of the further development, the related research questions, and discusses different approaches for future work. Figure 10 shows three phases, being creation, extension and optimization of development and research.

With a focus on accessibility [1] and the implementation in VR [17] the first phase has been completed and the results have been published. The initial work is about the game design of the VR-Escape Room, the definition of the topics covered, a state-of-the-art analysis, the implementation of *Access to Escape*, and a first evaluation.

The next steps of development and research are divided into two further phases (see Figure 10), which may overlap in time. In the second phase, the VR-Escape Room will be further developed and improved, and in the third phase, an expansion and integration of learning analytics approaches and AI will be considered.

Following, the conceptual and technical development, game accessibility, possible integration into teaching, and the examination of the learning success are described in detail.

1) Further technical development:

Development environment: After the first development cycle, the question is whether to migrate the VR-Escape Room from Unreal to Unity. A main argument is that it can then be integrated into an overall concept of new learning and teaching spaces as part of other ongoing projects such as *fuels* [21]. However, this step would involve considerable effort.

Improvements based on evaluation results and user feedback The evaluation has shown that the current state of development still needs adjustments and improvement (see Section V). Besides bugfixing, one improvement would be that the Guiding Character provide more assistance, e.g., through time-independent hints.

Multiplayer mode: The current single-player game could be enhanced by a multiplayer mode, increasing the players' motivation. This would also be in line with the typical game mechanics of an Escape Room, which includes team play to encourage the discussion of different approaches.

Learning Analytics & Artificial Intelligence: By integrating learning analytics methods into the VR-Escape Room, learning data can be analyzed. The identification of the relevant data and appropriate collection methods are subject to future projects. Further research will address the elaboration of different scenarios for the application of Artificial Intelligence (AI) such as interactive and adaptive assistance.

Transfer to other topics: Access to Escape was implemented for Accessibility Education. The transfer of the designed learning format to other topics will be approached. This includes the development of an easy replication process and the evaluation of learning success in different fields. Here, projects like UEmbed [22] could allow users without programming knowledge to create a game using the Unreal Engine. Since the tool is modifiable, it could be integrated into the VR-Escape Room project and expanded with new features. For example, options for the type of in-game navigation can be enabled or disabled in advance.

2) Conceptual development:

Cooperation with accessibility stakeholders In further development, increased cooperation with accessibility experts and organizations is sought, and people with disabilities or impairments should be involved in the development process.

Addition of in-depth learning content Access to Escape currently covers the content of five WCAG success criteria. Approaches to the integration of more information on these criteria need to be discussed. However, the presentation of information within the game should not disturb the game flow. Therefore, one strategy would be to create additional material, including explanations of the barriers encountered within *Access to Escape*.

Addition of new learning content In the first version of *Access to Escape*, success criteria were selected from the WCAG and conveyed through puzzles. The goal of future iterations is to include additional success criteria.

3) Game Accessibility:

Using the GAG workflow, a clear prioritization of the guidelines was made, making it possible to identify a first set of guidelines that were implemented within the project scope of *Access to Escape*. However, this can only be a starting point as an accessible application requires the implementation of all applicable guidelines. In future development, the integration of remaining guidelines is a main goal.

4) Integration into educational context:

Currently, *Access to Escape* is not integrated into any university courses. Following the optimization of the VR-Escape Room during phases two and three, it should be considered how to integrate it into courses and curricular planning. One possibility is to develop a module as an addition to an existing course or to create a new, stand-alone course focused on accessibility, e.g., as part of Open Educational Resources (OER).

5) Evaluation:

User testing and feedback User testing with people from different backgrounds, including people with disabilities or impairments is planned to gather feedback on the accessibility of *Access to Escape*. This feedback can be used to iterate and improve accessibility features and the overall user experience. *Evaluation of impact* Further, studies are planned on how to assess the effect of the learning offer on the awareness and knowledge of digital accessibility among participants.

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