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Article

Safety in the Laboratory—An Exit Game Lab Rally in Chemistry Education

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Abstract: The topic of safety in chemistry laboratories in schools is crucial, as severe accidents in labs occur worldwide, primarily due to poorly trained individuals and improper behavior. One reason for this could be that the topic is often dry and boring for students. One solution to this problem is engaging students more actively in the lesson using a game format. In this publication, we present an augmented-reality-supported exit game in the form of a laboratory rally and the results of a pilot study that examined the use of the rally in terms of technology acceptance and intrinsic motivation. The study involved 22 students from a general high school. The study results show a high level of technology acceptance for the augmented reality used, as well as good results in terms of the intrinsic motivation triggered by the lesson.

Keywords: augmented reality; laboratories safety; gamification; exit game; lab rally

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1. Introduction

The topic of safety in the laboratory is of particular relevance in both academic and economic contexts, as demonstrated by the presence of various regulations for the education and business sectors [1–3]. Nevertheless, laboratory accidents occur worldwide, leading to serious injuries or even deaths [4].

According to Marin and Muñoz-Osuna [5] one cause for such accidents is the lack of proper safety perception and culture, which may be attributed to deficiencies in education.

Reasons for this deficient training may consist, on the one hand, in that safety in the laboratory is generally regarded as boring and monotonous, and safety briefings are therefore considered as annoying, recurring obligations, whose value is primarily not recognized by students [6]. On the other hand, the reduced laboratory practice during the pandemic and the resulting lack of experience with laboratory safety and safety briefings may also have contributed to the problem [7].

However, laboratory safety is particularly relevant in schools, as students often lack the necessary skills or understanding for safe laboratory work. It is therefore essential for teachers to focus on safety consistently and preventatively, and to adequately educate students about possible hazards. In addition, students must be informed about the safety procedures and equipment used in the laboratory to prevent accidents and enable proper behavior in case of emergencies [6].

One way to achieve this and motivate students is to actively involve them in the learning process [6]. For this purpose, an augmented-reality-supported exit game in the form of a laboratory rally was developed, which includes all safety-relevant information for working securely in school chemistry laboratories, and conveys this information in a playful and motivating way. In this publication, we present the mentioned laboratory rally and the results of a pilot study in which we investigated the impact of the learning environment on technology acceptance and the students' intrinsic motivation.

1.1. Augmented Reality in Sciences Education

Augmented Reality (AR) is a technology that merges real-world and virtual content. The real and virtual environments are fundamentally different and can be blended and superimposed into a "mixed reality", which lies between the two [8]. To achieve this, digital data like images, videos, and 3D models are frequently projected onto (as a digital overlay) the physical world through a smartphone, tablet, or AR/VR glasses [9]. This overlay takes place interactively and in real-time, with the digital content anchored to a fixed position within the physical three-dimensional space [10].

The educational sector has recognized the significance of AR due to the positive outcomes reported by numerous studies [9,11,12], which suggest that AR can increase student motivation, attention, and independence [12,13].

Despite this, few teachers use this "new" learning tool in their teaching, meaning that very few students benefit from the positive effects [14]. One possible reason for this is that teachers already have a high workload and may be hesitant to experiment with new tools [15]. To address this problem, it is essential that AR-supported teaching and learning scenarios (AR-TLS), developed at academic institutions, can make their way into schools, allowing teachers to use the technology without having to spend time developing their own AR-TLS.

Another step towards solving this issue is that the digital infrastructure in schools is improving, and programs are coming to the market that allows for the development of AR-TLS without any experience in coding. These authoring tools usually allow for the creation of simple AR-TLS with minimal time expenditure and effort using drag-and-drop functions.

Other significant questions that teachers may ask themselves include in which areas AR applications can be used effectively and how these AR-TLS can be evaluated and differentiated based on specific parameters.

1.1.1. Application Areas for AR in Science Education

For the meaningful use of AR, Krug [16] identified three application areas, which are shown in Figure 1. These are:

- Visualization of the invisible: This area refers to the visualization of non-visible processes and can be roughly divided into three subcategories:
    - The visualization of smallest non-visually perceptible things such as chemical reactions, sub-microscopic structures or radiation (e.g., ref. [17]);
    - The representation of massive objects such as solar systems, stars, or planets;
    - The representation of black-box processes, i.e., processes that are difficult or impossible to observe from the outside, such as blast furnaces, expensive electrical appliances, or nuclear reactors.
- Support of paper-based learning: This area deals with enriching mostly analogue media such as books or worksheets with additional digital content to provide additional assistance in the form of texts, images, etc. (e.g., ref. [18]);
- Enrichment of experiments: This area refers to the addition or even replacement of experiments by digital content, whereby the use of AR in this area can vary greatly. Examples of this can therefore be of various kinds and range from digital labeling to the substitution of individual components of the experiment (such as certain chemicals), or even the complete digitization of the entire experiment [16].

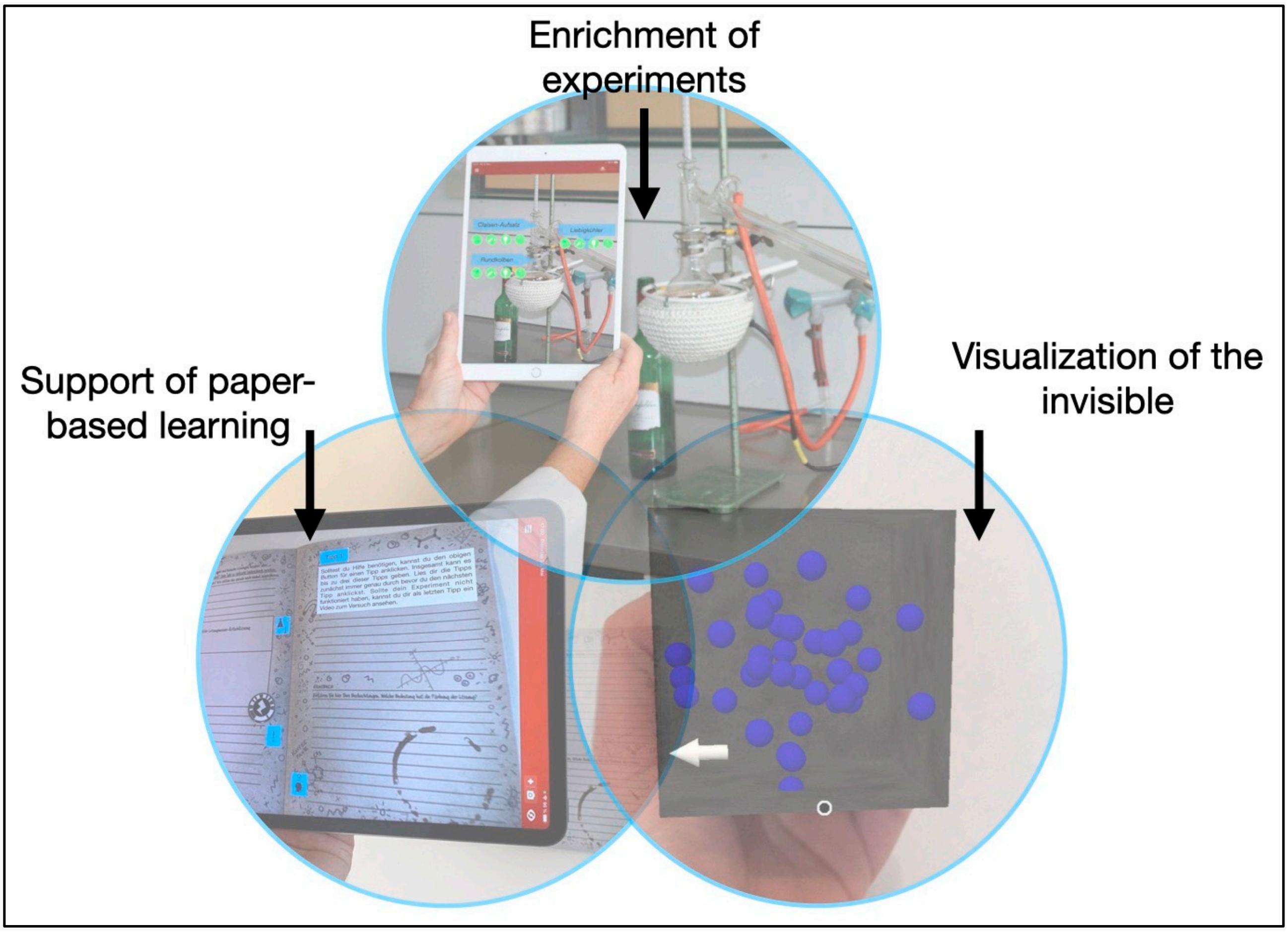

Figure 1. Application areas for AR in science education (Source: in accordance with [10]).

1.1.2. Assessment Parameters for AR-TLS

Parameters for evaluating AR-TLS were first described by Krug et al. [10] and supplemented in the publication by Tschiersch et al. [19]. The described parameters are immersion, interactivity, congruence with reality, content-related proximity to reality, adaptivity, game elements, and complexity. For the development of the laboratory rally, special attention was paid to the game element's parameter, as it can significantly motivate students [20].

The game elements parameter follows the approach that "gamifying" teaching and learning scenarios can increase student motivation through increased interactivity [21]. The degree to which this parameter is present is determined by the presence or absence of eight so-called indicators. These indicators are:

1. Rules/Goals: Does a clear set of rules exist, or does the AR-TLS have a clear goal?
2. Conflict/Challenge: Are students confronted with specific challenges in the AR-TLS?
3. Control: Can students manipulate the AR-TLS themselves, for example, by selecting a certain strategy or approach?
4. Assessment: Is progress measured in the AR-TLS, for example through levels, points, or other feedback?
5. Action Language: Does interaction exist between the AR-TLS and the students, using joysticks, cards, etc.?
6. Human interaction: Does the AR-TLS have a social aspect in which students interact with each other?
7. Environment: Is the AR-TLS freely usable and thus not bound to a specific location or environment?
8. Game Fiction: Does the AR-TLS have a story?

1.2. Gamification in Science Education

Over the past decade, gamification has become increasingly important in various fields, including science education, where numerous instances of game mechanics being employed can be found. The concept of gamification originated from the digital media industry [22]. The term is now used in many fields, including education, and refers to the use of game design elements for non-game applications [22,23], to promote user engagement, motivation, and enjoyment [24]. Elements such as narrative, teamwork, purposeful design, rules, technology, aesthetics, action, and game thinking are often employed [23,25,26], but there are no fixed rules for which elements must be used or that the use of many gamification elements increases the chances of success [27]. The challenge for teachers is to independently recognize and use suitable elements for their students to facilitate teaching and learning [25].

"Serious games" is a significant concept that is closely related to "gamification" as it utilizes game features to enhance educational outcomes. In contrast to gamification, serious games have a distinct objective that goes beyond just amusement and inspiration, and they have a direct impact on learning by conveying vital content within the game [28].

Although serious games can also influence and even increase motivation or engagement, this is not their primary purpose. In contrast, gamification specifically aims to change context-specific behavior and attitudes of learners to improve the teaching–learning process [29].

Through the concepts of gamification and serious games, students can be more deeply engaged in specific subject areas, leading to increased participation and motivation [30]. This is particularly useful in the natural sciences and thus also in the subject of chemistry, where teachers and students are often confronted with content that is abstract, difficult to convey and learn [31], as the contents of the chemistry curriculum are usually difficult to reconcile with the students' everyday world [29].

1.2.1. Escape Rooms in Science Education

Escape rooms (ERs) are a form of collaborative live-action adventure game in which players work together to uncover clues, complete assignments, and solve puzzles in one or more rooms within a set timeframe to accomplish a particular objective. These objectives may include escaping from the room, uncovering a mystery, or discovering a concealed treasure [32]. The game master usually starts the ER by outlining the rules, safety guidelines, and introducing the players to the backstory through a diary entry or similar means. Once the introduction is complete, the players must solve assigned tasks, locate objects, and decode clues within a designated time limit [33]. Educational Escape Rooms (EERs) are a unique type of ERs that offer an imaginative learning setting by combining formal and informal learning techniques. Their objective is to facilitate playful learning and strengthen new skills and content while transferring previously acquired knowledge to novel tasks. By fostering students' awareness of the consequences of their actions on themselves and others, promoting social interaction, and building self-confidence, EERs can have an impact on students' behavior [33].

The concept of using puzzles to convey technical concepts is also prevalent in the domain of chemistry, where such riddles are used to achieve a specific learning objective. In the context of EERs, the puzzles often incorporate custom-designed game components, such as the laboratory notes of a missing scientist [34], a customized "Escape Box" [35], or a fictional intelligence agency's operational order that requires players to defuse bombs [36].

1.2.2. Exit Games as a Special Case

The concept of ERs has undergone recent advancements, with the inclusion of a digital component becoming increasingly common. Besides the traditional physical ERs, new formats such as escape books, escape boxes, and AR escape games have also emerged. [37]. In these formats, there is no physical room that needs to be escaped from; instead, participants must solve riddles to advance in the game. These formats can be summarized under the term "exit games". An example of this kind of games in an educational environment is the project "ZuKon 2030", in which interdisciplinary learning opportunities are presented in the form of workshops and also offered for use in schools or student laboratories. Here, digitally enriched researcher diaries are used, which deal thematically with the 17 global sustainability goals (SDGs) of the Agenda 2030 [38].

1.2.3. Laboratory Rally

A laboratory rally is a type of interactive, competition-oriented game that can be used in laboratories or specialized classrooms, in which participants must complete certain tasks or experiments to collect points or achieve a goal. Laboratory rallies allow students or learners to explore and understand scientific principles and technologies in an exciting and interactive way, while also improving their collaboration and problem-solving skills.

2. Structure of the Exit Game Lab Rally

The design of the Exit Game Lab Rally, as the name suggests, follows a combination of the three approaches of escape rooms, exit games, and lab rallies, with the approach of lab rallies mainly differing from the other approaches in its competitive character. Therefore, the materials presented here include aspects of all three approaches and consist of a mixture of analog and digital elements, planned for a lesson unit of 90 min.

2.1. Goals of the Teaching Unit

For the development of the instructional unit, goals were first defined, with the overarching goal of the lesson being for the students to learn safe behavior in the laboratory. The following are additional specific goals of the teaching unit.

2.1.1. Subject-Specific Goals

The students will:

- Learn behavioral rules in the laboratory, safety equipment, and laboratory devices;
- Be able to name the pictograms of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), derive the potential hazards for human health and the environment from them, and associate them with the respective substances;
- Be able to name the most important command, prohibition, and warning signs that occur in the laboratory and derive the appropriate behavior from them.

2.1.2. Personal and Social Goals

The students will:

- Be able to work in groups;
- Be able to ask for help if necessary;
- Be able to analyze mistakes and consider alternative solutions;
- Be able to actively and in dialogue participate in collaboration with others.

2.1.3. Methodological Competencies

The students will:

- Be able to respect the rules of group work;
- Be able to compare information and establish connections.

2.2. Materials Used

The materials provided in this context were designed to meet the previously mentioned goals, with a specific focus on GHS pictograms, conduct within the chemical laboratory, and laboratory safety equipment. To implement the Exit Game approach of the laboratory rally, various riddles were developed and provided to the students in the form of worksheets. In addition to these riddles, corresponding information materials were created that contain all the information necessary for the course of the rally and the solution of the riddles.

These information materials consist of a letter explaining the story of the rally, a puzzle that must be solved to obtain information, and a collection of stickers that address the topics of safety equipment in the laboratory and GHS pictograms, which can be placed in proximity to the respective facilities in the laboratory. Figure 2 provides an overview of the materials used during the rally.

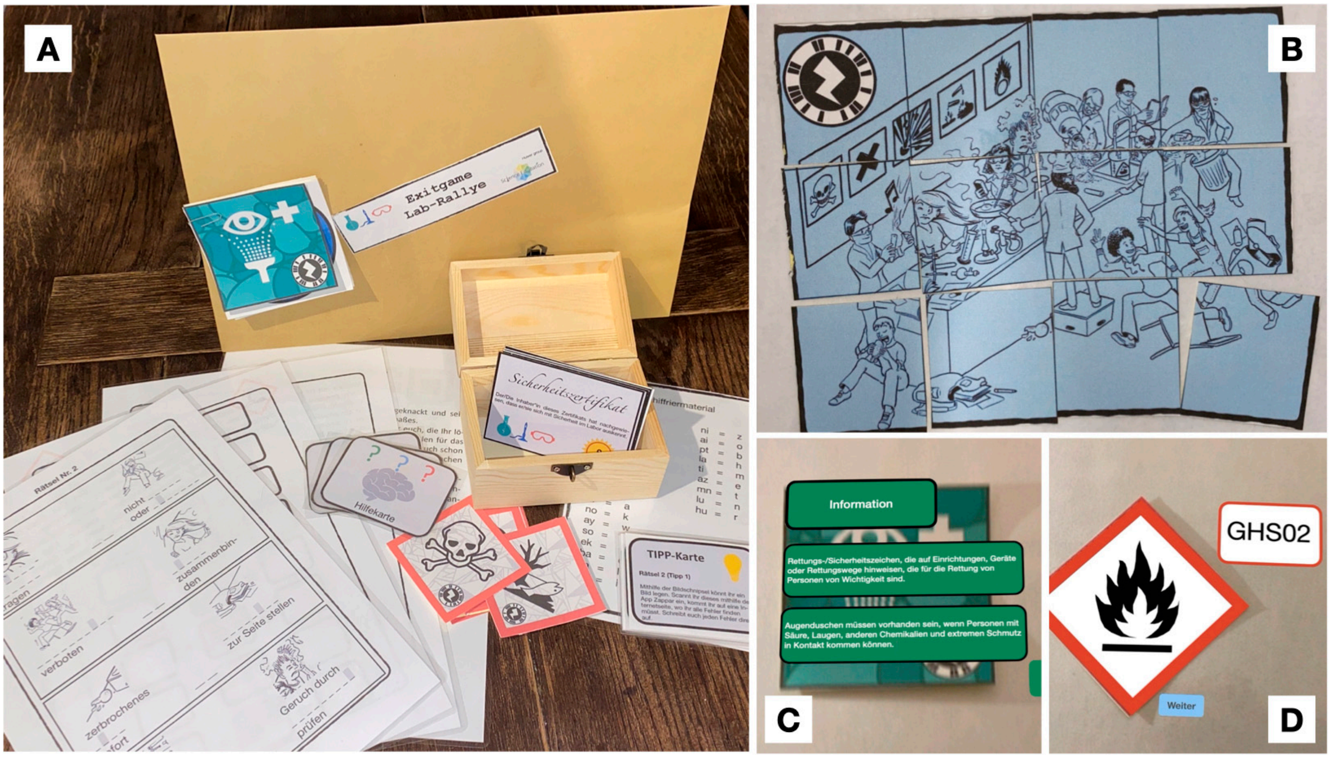

Figure 2. Materials of the Exit Game Lab Rally. (**A**) Overview of materials (**B**) Puzzle picture (**C**) Example of sticker on the topic of safety equipment in the lab. (**D**) Example of sticker for the GHS pictograms.

All information materials were digitally enhanced with AR and can be accessed using a smartphone or tablet, as well as the free Zappar app, which can be found in all popular app stores. The development of the AR components was based on the marker-based method, which works similarly to QR codes and uses a predetermined image as a trigger. When this image is scanned using the app, the additional digital information such as images, texts, videos, etc., are displayed and located at the predetermined location dependent on the position of the sticker. The AR applications were created using the program Zapworks Designer, which is an authoring tool that allows the creation of AR applications without any programming knowledge. In the case of the stickers for laboratory safety equipment, the AR provides a brief description of the corresponding safety equipment, a video on its use, and a knowledge check. In the case of the GHS pictograms, a description of the symbol is also provided, along with information on handling hazardous substances, an example substance, and an overview of the consequences of incorrect handling. Figure 3 shows two examples of stickers enhanced with AR.

In addition to the materials already mentioned, each group will receive a locked chest containing safety certificates that signify the completion of the story and a way to escape the lab. To obtain the code for the lock, the first three riddles must be solved, which will provide the students with three numbers. Thanks to these numbers and a final fourth riddle, the code for the lock will be generated, and the chest can be opened. It is up to each teacher to decide whether additional rewards such as candy or similar should be added or whether a special prize exists for the fastest group, which can further emphasize the rally character of the lesson.

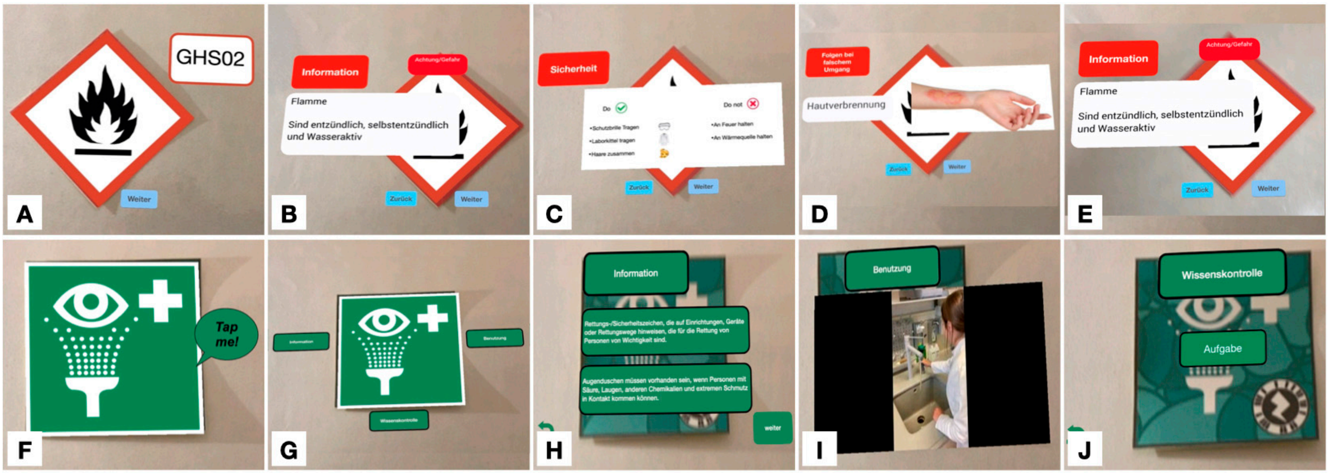

Figure 3. AR-enhanced stickers. (**A**–**E**) AR contents of the GHS02 sticker, (**F**–**J**) AR contents of the eyewash station sticker.

In addition, the teacher will provide each group with three help cards that they can use to obtain clues related to their respective riddles.

Additional information materials will be provided for the teachers to plan and supervise the rally. This information package includes a lesson plan, solutions to all riddles, a completed QR code for riddle 4, and a detailed explanation of the rally. All worksheets, as well as the puzzle picture, stickers, and further information materials for the teacher described in this publication, can be downloaded for free from our website and are freely available. Therefore, only the appropriate chests and locks need to be organized by the teacher for the rally to take place.

2.3. Procedure of the Lab Rally

At the beginning of the lesson, the teacher provides an overview of the lesson's objectives and divides the students into groups of 2–3 individuals, attempting to maintain equality among the groups. Each group is then given the necessary materials to begin the laboratory rally. The students are encouraged to start the rally independently by first reading the information text about the story. They will learn that it is an exit game whose goal is to solve specific riddles related to safety in the lab. The students can then start solving the various riddles by using the worksheets shown in Figure 4.

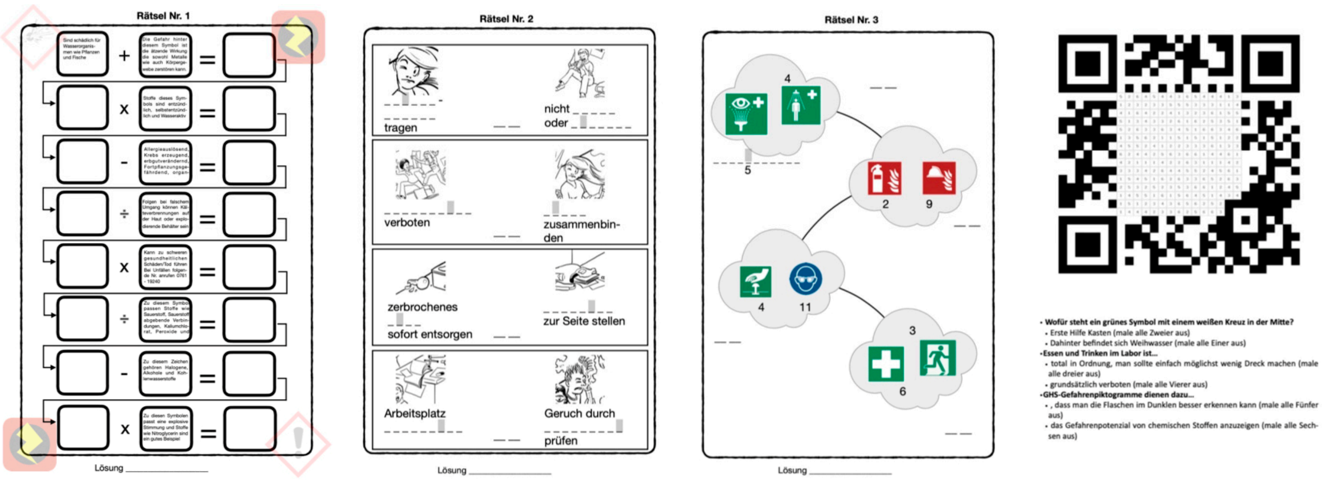

Figure 4. Worksheets for riddles 1–4.

At the back of each worksheet there are texts that advance the story of the rally and provide a hint on how to solve the respective riddles. For example, to solve the first riddle, the stickers with the GHS pictograms distributed around the classroom need to be found and read. Text excerpts can be seen on the worksheet arranged in a type of math problem. When the numbers are replaced with the corresponding pictogram numbers (e.g., GHS09 + GHS05 = 14), a sequence of calculations is formed. At the end of all the tasks, a number is obtained, which is the solution to the riddle. Once the first three riddles have been solved, worksheet 4 must be completed, which generates a QR code leading to a website with further questions. If all questions are answered correctly, the instruction for generating the combination for the lock, using the three numbers from the first riddles, is given. This unlocks the chest and successfully completes the laboratory rally.

3. Study Design

The pilot study presented here represents the first phase of action research aimed at solving the problem of laboratory safety. To this end, an initial basic concept for a teaching unit was designed to make the topic of safety in the laboratory more interesting and motivating. For the investigation of this teaching unit, students in the 8th grade of a general high school were surveyed via a questionnaire study on both technology acceptance and intrinsic motivation regarding the teaching unit. To this end, a measurement instrument was created that is based on the already tested questionnaires of the Technology Acceptance Model (TAM) [39] and the Short Scale of Intrinsic Motivation (KIM) [40].

The questionnaire study aims to answer the following hypotheses:

Hypothesis 1 (H1). *The used questionnaire shows a high degree of reliability.*

Hypothesis 2 (H2). *The AR used in the teaching unit achieves high values in technology acceptance, at least without any negative effects due to very-likely novelty effects.*

Hypothesis 3 (H3). *The teaching unit generates a high level of intrinsic motivation.*

Hypothesis 4 (H4). *The factors interest/enjoyment and pressure/tension have a strong negative correlation with each other.*

In addition to conducting the questionnaire study, the conducting teacher was involved in the research process through consulting sessions. Through these conversations, important ideas, suggestions, and possibilities for improvement for the teaching unit were gained from classroom practice.

3.1. Measuring Instruments

3.1.1. Technology Acceptance Model (TAM)

The Technology Acceptance Model measures technology acceptance through the evaluation of the factors Perceived Ease of Use (PEU), Perceived Ease of Use + Usability (PEUU), Perceived Usefulness (PU), and Attitude toward Using (AT). For the factors PEU, PEUU, and PU, this is done using 15 items and a standardized 7-point Likert scale, with 0 representing "strongly disagree" and 6 representing "strongly agree". The factor AT is assessed using 5 additional items and a 7-point semantic differential scale. The factors PEU and PEUU are measured using a common item package, while the factors PU and AT are measured using separate item packages [39].

3.1.2. Short Scale of Intrinsic Motivation ("Kurzskala Intrinsischer Motivation" KIM)

The short scale for intrinsic motivation (KIM) measures the factors of interest/enjoyment, perceived competence, perceived choice, and pressure/tension using 12 items and a 5-point Likert scale. The scale ranges from 0 for not at all true, 1 for agrees little, 2 for partly true, 3 for pretty true, and 4 for completely true.

Although the entire questionnaire is understood as an assessment of intrinsic motivation, the factor of interest/enjoyment is considered a self-report value and therefore represents the actual evaluation factor for intrinsic motivation. The factors of perceived competence and perceived choice serve as positive predictors for both self-assessment and behavioral measurement of intrinsic motivation. The factor of pressure/tension can be understood as a negative predictor of intrinsic motivation and is therefore in contrast to the factor of interest/enjoyment [40].

3.1.3. Feedback Discussions with the Teacher

As part of the project, two feedback discussions were conducted, one before and one after the instructional unit. This was intended to include the teacher's experience with the class and the topic. The materials for the instructional unit were adapted based on the information gained through these conversations. This was intended to solve potential problems in advance and to address problems that arose during the instructional unit. Additional materials, such as a worksheet for the teacher to collect and secure the results, were added on the advice of the teacher.

4. Results

The study was conducted with 22 students following the instructional unit under investigation. To first examine the internal consistency of the created questionnaire, a reliability analysis of the individual factors of the questionnaire was conducted by calculating the respective Cronbach's alpha. It was found (see Table 1) that all three factors of the TAM (PEU + PEUU = 0.848, PU = 0.904, AT = 0.661) exhibit excellent to acceptable reliability. The measurement of the KIM revealed an excellent reliability for the factors of interest/enjoyment (0.918) and perceived competence (0.825). The factor perceived choice (0.563) proved to be unreliable, while the factor pressure/tension (0.749) is in good range.

Table 1. Cronbach's alpha values of the individual factors of the questionnaire.

	Cronbachs Alpha	Number of Items
PEU + PEUU	0.848	9
PU	0.904	6
AT	0.661	5
interest/enjoyment	0.918	3
perceived competence	0.825	3
perceived choice	0.563	3
pressure/tension	0.749	3

To determine the degree of intrinsic motivation and technology acceptance, average values were first calculated from the results of the individual students on the respective factors of the TAM and KIM, using only complete data sets. This results in values for each student and factor that serve as indicators of the degree of technology acceptance and intrinsic motivation. For clarity, these values were rounded and included in a scoring grid. The following rating was used for the factors of the TAM questionnaire: 6 = strongly agree, 5 = moderately agree, 4 = somewhat agree, 3 = neutral, 2 = somewhat disagree, 1 = moderately disagree, 0 = strongly disagree.

For the factors of the KIM questionnaire, a 5-point Likert scale and the following evaluation were used: 4 = completely true, 3 = pretty true, 2 = partly true, 1 = agrees little, 0 = not at all true.

As can be seen from Figure 5, mainly positive results could be found for the factors PEU+PEUU, PU and AT, of the TAM questionnaire. Thus, 2 students strongly agreed with the statements of the factor PEU+PEUU, 12 moderately agreed, 4 somewhat agreed, 2 were neutral towards the statements and only one student somewhat disagreed with the statements. The AT factor also shows that 6 students strongly agreed, 11 moderately agreed, and four somewhat agreed with the statements. No student was neutral or negative towards the statements. The PU factor was rated less clearly by the students. Thus, 2 students strongly agreed with the statements, 6 moderately agreed, 6 somewhat agreed, 4 were neutral towards the statements, 2 somewhat disagreed and 1 student moderately disagreed.

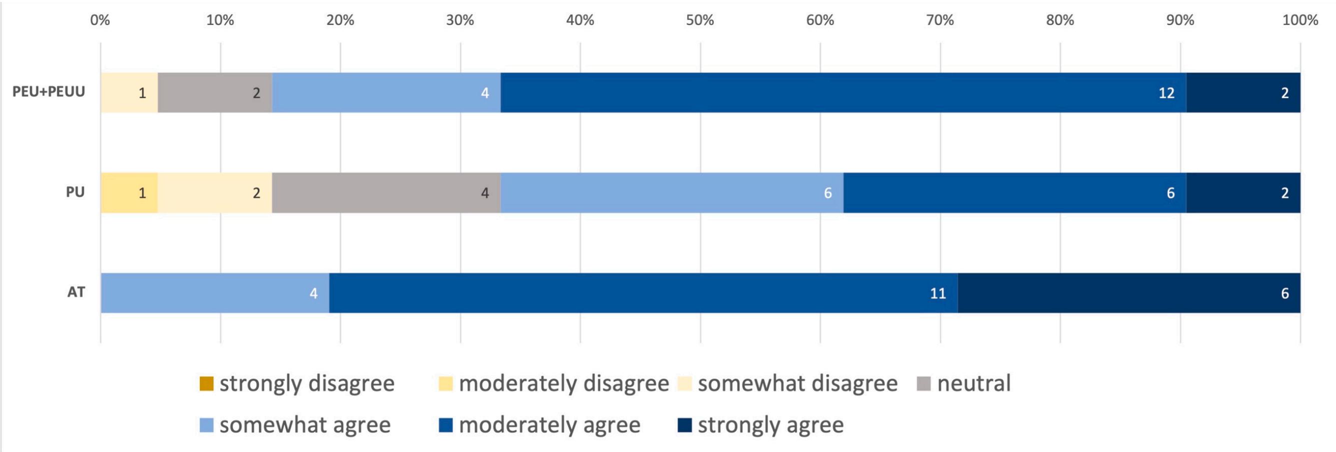

Figure 5. Evaluation results of the TAM questionnaire (numbers are answering students).

The results of the questionnaire, which can be seen in Figure 6, indicate that the investigated teaching unit has evoked a high degree of intrinsic motivation among the students. Thus, the factor interest/enjoyment shows That 12 out of 22 students believed the corresponding statements to be completely true and another 5 out of 22 students believed the statements to be pretty true. Only 3 students thought that the statements were only partially true, and one student agreed little with the statements. Similar results, though not quite as strong, were seen in the evaluation of the perceived competence factor, where 7 students believed the statements to be completely true, 11 believed the statements to be pretty true, 3 students believed that the statements were only partially true, and one student agreed little with the statements.

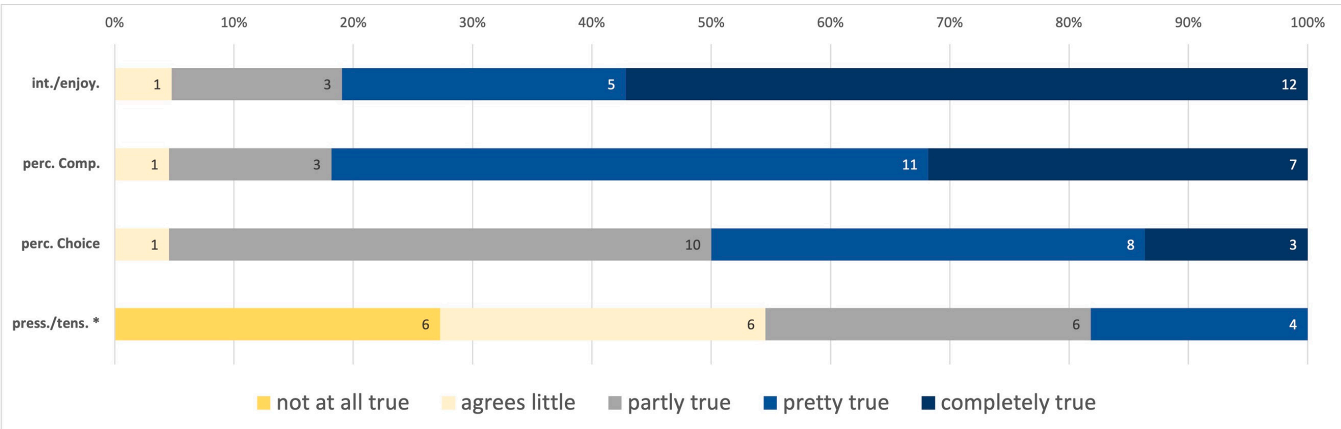

Figure 6. Evaluation results of the KIM questionnaire. * The press./tens. factor contrasts with the int./enjoy factor. This means that the less support this item receives, the more a high intrinsic motivation can be assumed. (numbers are answering students).

The evaluation of the factor perceived choice showed that 3 students believed the corresponding statements to be completely true, 8 students believed the statements to be pretty true, 10 students thought that the statements were only partially true, and one student agreed little with the statements.

A further indication for a high intrinsic motivation could be determined by the evaluation of the factor pressure/tension, which contrasts with the factor interest/enjoyment.

Here it was found that no student believed the statements to be completely true, 4 students believed the statements to be pretty true, 6 thought that the statements were only partially true, 6 students agreed little with the statements, and 6 assumed that the statements were not at all true.

To determine if H3 (The factors interest/enjoyment and pressure/tension have a strong negative correlation) was true, the two factors were examined using the Spearman correlation. A negative but non-significant correlation ($r = -0.375$, $p = 0.94$) was found between the two factors (see Table 2).

Table 2. Correlation of the factor's interest/enjoyment and pressure/tension.

interest/enjoyment	correlation coefficient	1.000	−0.375
	Sig. (2-sided)		0.094
	N	21	21
pressure/tension	correlation coefficient	−0.375	1.000
	Sig. (2-sided)	0.094	
	N	21	22

5. Discussion

This pilot study aimed to evaluate a teaching unit on the topic of safety in the laboratory as part of an action research project, which should make the topic more interesting and motivating. This teaching unit represents an exit game laboratory rally and is based on the concept of gamification, with additional digital content in the form of AR. For the study, a questionnaire was designed based on the Technology Acceptance Model (TAM) and the Short Scale of Intrinsic Motivation, and feedback interviews were conducted with the implementing teacher. This publication presents the results of 22 general secondary school students who participated in the teaching unit and evaluated it directly afterward with the questionnaire.

The study results show that the questionnaire used as a measuring instrument is largely reliable and that the students had an above-average positive attitude towards the statements in all questionnaire factors, except for the factor of pressure/tension. The low result achieved for this factor is nevertheless a good sign, since it contrasts with the interest/enjoyment factor and a high degree of this factor would speak against intrinsic motivation, although investigations into a possible correlation between the two factors revealed a negative correlation, which, however, did not prove to be significant.

Overall, due to the excellent results in technology acceptance and despite a very likely novelty effect, it can be assumed that the AR used in the teaching unit has no negative effect on the students. Further, primarily the high value of the factor interest/enjoyment speaks for the fact that the exit game laboratory rally has a strong motivating effect on the students and thus represents a possibility to communicate the topic of safety in the lab sustainably. We are aware that a novelty effect, which is very likely to occur, also influences the intrinsic motivation of the students, but this cannot be prevented due to the curricular location of the teaching unit since the topic of safety in the chemistry laboratory, and thus the teaching unit presented here, is located at the very beginning of chemistry teaching. In this respect, we have also refrained from measuring the novelty effect as such, since this will occur with all students who carry out this laboratory rally since it can be assumed that the students will neither come into contact with AR nor with the method of the laboratory rally in the chemistry curriculum beforehand.

Limitation

As mentioned above, this study is a pilot study. Although the results so far initially indicate that the evaluated teaching unit could be an approach for solving the problem on the topic of safety in the laboratory at schools, a generalization is not possible due to the study design. Furthermore, only two latent constructs (intrinsic motivation and technology acceptance) were studied, which is why a prediction of the effect on other areas is not possible with our results. Furthermore, it must be assumed with a very high probability that any novelty effects will influence this study's results. However, we assume that the novelty effect will occur in all students who perform this lab rally.

6. Summary

Safety in the chemistry lab at schools represents an important topic, which, however, is often regarded as dry and boring and its relevance is underestimated, especially by students. The results of a pilot study presented here show that an exit game lab rally supported by AR is a way to increase the intrinsic motivation of students in this topic and at the same time, there is a high acceptance towards the AR used by the students concerned.

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Institutional Review Board Statement: All participants were students at German schools. They took part voluntarily and were told that they can quit participating at any time. Pseudonymization of participants was guaranteed during the study. Due to all these measures in the implementation of the study, an audit by an ethics committee was waived.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

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