The Usability Engineering Lifecycle in Developing a Ludic Application about Scorpions for Children

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Abstract. Introduction: *Given the increasing number of scorpion-related accidents, especially involving children, it is essential to develop educational strategies that promote awareness and prevention of such incidents.* ***Objective:*** *In this context, this article presents the practical application of the Usability Engineering Lifecycle in developing an educational ludic application aimed at children aged 5 to 10. The main goal is to create a playful and accessible tool that helps disseminate information about the risks and safety measures related to scorpions.* ***Methodology:*** *The methodology followed the classic stages of the Usability Engineering Lifecycle - Requirements Analysis, Design, Evaluation, and Development - carried out with the collaboration of experts in health, education, and technology, ensuring that the content and interface were appropriate for the target audience.* ***Results:*** *The results indicate that the developed ludic application has significant potential to promote children's awareness, contributing to the prevention of scorpion accidents. The study also highlights the importance of integrating usability principles from the early stages of development. It emphasizes the relevance of participatory, user-centered approaches in the context of public health solutions.*

1. Introduction

The state of São Paulo has experienced a worrying increase in scorpion-related incidents, particularly involving children, as documented by the State Health Department [Henriques et al. 2022, Silva 2023]. This situation underscores the urgent need for accessible and effective educational strategies to raise awareness and promote accident prevention.

In the context of game and interactive application development, a persistent challenge lies in optimizing processes to reduce costs, minimize rework, and improve efficiency. A common pitfall is postponing usability and quality evaluations until the final stages of development, often resulting in systems that are difficult to use, demotivating users, and delaying delivery [Norman 2013, Asuncion et al. 2011]. The Usability Engineering Lifecycle (UEL) [Mayhew 1999] offers a structured, user-centered approach that integrates continuous evaluation throughout development.

This study addresses both the public health concern and the challenges of playful application development by presenting the design and evaluation of an educational game about scorpions, aimed at children aged 5 to 10. The Usability Engineering Lifecycle was employed to guide the process, aiming to create an engaging and effective tool that promotes safety and awareness among children.

2. Theoretical background

Scorpion accidents have increased significantly in recent years, especially involving children, who are often more vulnerable in such situations [Henriques et al. 2022]. These circumstances call for effective educational tools. Playful applications offer a promising approach, combining engagement and knowledge in a child-friendly format.

The integration of the Usability Engineering Lifecycle into the development of these applications helps ensure that usability is not an afterthought but a continuous concern. Evaluation can occur iteratively during the development process, preventing issues from accumulating and improving the application's overall quality and impact.

This study hypothesizes that systematically applying the Usability Engineering Lifecycle to develop a playful educational application on scorpions can result in an engaging, informative tool that supports awareness and prevention efforts.

2.1. Usability Engineering Life Cycle

Initially proposed by [Nielsen 1992], the Usability Engineering Lifecycle aims to integrate usability practices into the development of interactive systems. The model emphasizes continuous evaluation and a user-centered design process, aligning with key principles of interaction design and user experience.

Nielsen's approach combines elements from the waterfall and spiral models, adopting a structured sequence of development steps while allowing flexibility through iterative evaluation. This enables teams to refine or revisit stages as needed based on user feedback.

In the study by [Mayhew 1999], this model was later expanded (Figure 1), emphasising iterative cycles in which each stage—requirements, design, and development — is evaluated before advancing. This ensures the final product better meets user needs. Her framework reinforces the importance of intuitive interfaces and a positive user experience in software development.

Our literature review [Halker et al. 2024], guided by Mayhew's studies [Mayhew 1998, Mayhew 1999], confirmed that usability is a central concern in software design. Scholars such as [Seffah et al. 2005] and [Marcilly and Peute 2017] highlight the ongoing need to integrate Human-Centered Design (HCD) into development lifecycles effectively. These insights support the relevance of applying usability models in educational game design.

3. Methodology

This study adopts an iterative, user-centered approach based on the Usability Engineering Lifecycle proposed by [Mayhew 1999]. The process includes three stages (Figure 1):

1. Requirements Analysis – understanding user needs and context;
2. Design, Evaluation, and Development – building and refining the application;
3. Installation – deploying and adapting the final version (not included in this study's scope).

For the practical implementation, we collaborated with a public health expert specializing in scorpion-related incidents. Together, we applied the first two stages of the

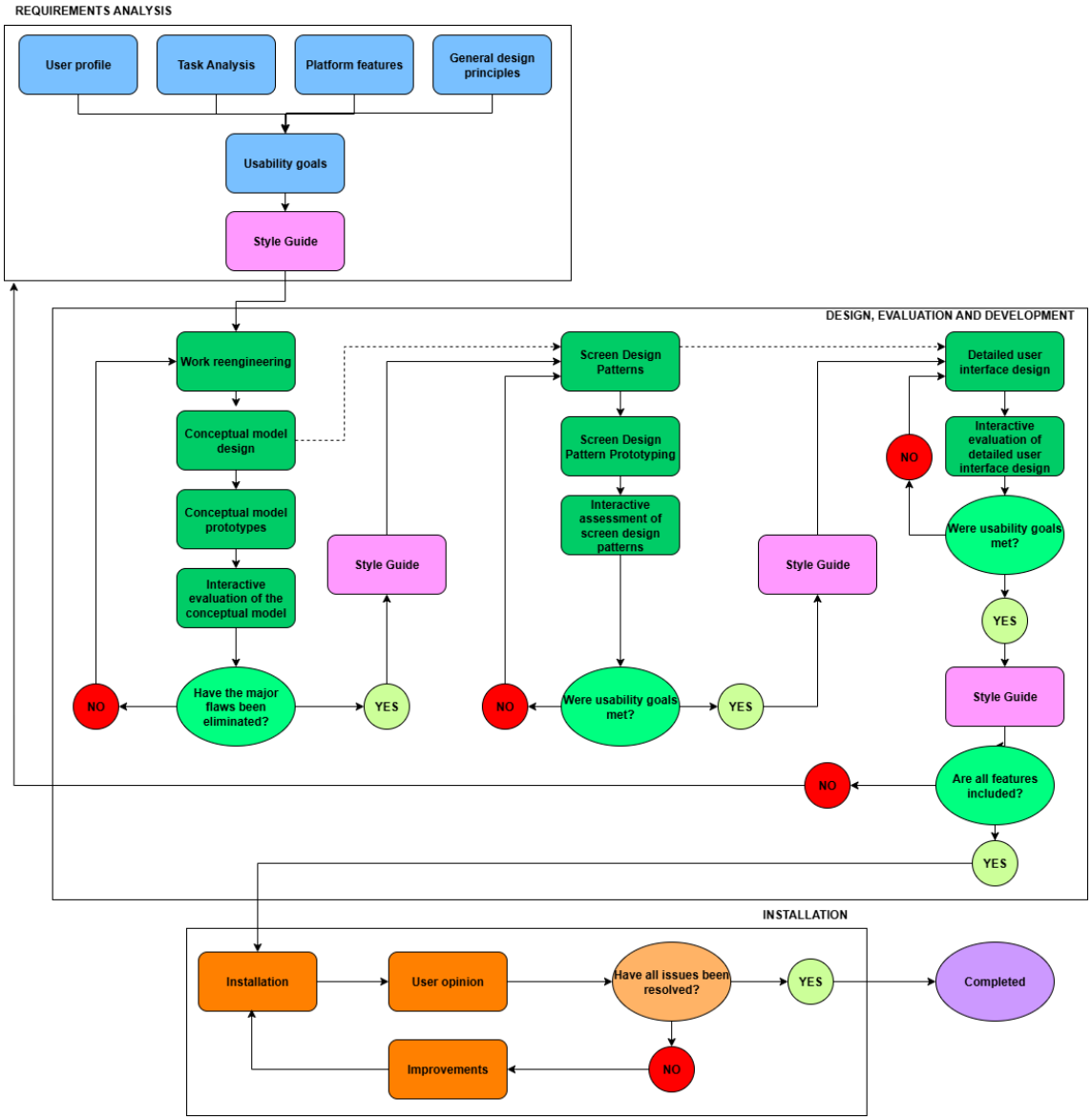

Figure 1. Usability Engineering Life Cycle Diagram [Mayhew 1999]

lifecycle to build a proof of concept that integrates usability principles into the development of a playful application.

3.1. Requirements analysis

In collaboration with the domain expert, we identified key problems faced by communities with high scorpion infestation rates. Based on these insights, we gathered functional requirements, analyzed the target audience (children aged 5–10), and defined the platform's characteristics. Two main usability goals were established [Mayhew 1999]:

1. Guide designers and developers with concrete, focused objectives;
2. Enable ongoing evaluation of design ideas during development.

We created a preliminary style to ensure visual consistency and alignment among team members. This served as a reference for interface elements and supported the transition to the next stage: design, evaluation, and development.

3.2. Design, evaluation and development

This stage was structured into three iterative levels:

Level I (Low-Fidelity Prototypes): Initial sketches were created using paper and pencil. These prototypes facilitated quick feedback and early discussions. Storyboards and wireframes helped shape the narrative and interface structure.

Level II (High-Fidelity Prototypes): Using digital tools like Figma [Figma Inc. 2012] and Unity [Unity Technologies 2005], the visual design and interactivity were refined. The style guide was updated based on feedback, and usability goals were revisited to ensure alignment with user needs. This level consolidated design elements and included interactive components for evaluation.

Level III (Interactive Evaluation): A final round of checks was performed using the updated style guide. All core functionalities were reviewed against the initial requirements. If any were missing, previous stages were revisited for corrections before completion.

4. Results

The application was developed iteratively, following the Usability Engineering Lifecycle. This section summarizes the outcomes from prototyping to evaluation.

4.1. Level I - Low Fidelity

The conceptual model was based on content provided by the domain expert and requirements analysis. Initial sketches (Figure 4) illustrated the application's structure and scenarios. These drawings were validated by the expert and refined based on feedback, particularly regarding accuracy and clarity of information.

Figure 2. *
(a) Storyboard 1

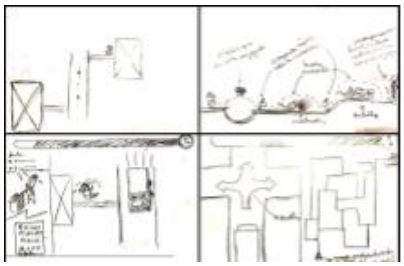

Figure 3. *
(b) Storyboard 2

Figure 4. First low-fidelity prototype [Own manual authorship].

The final story was structured into five phases: (1) Introduction to the environment and first contact with a scorpion; (2) Cleaning the backyard to prevent scorpion appearance; (3) A sting event followed by calling an adult for help; (4) Reporting the case to health authorities; and (5) A classroom quiz to reinforce the knowledge acquired.

Once the first version of the story had been developed, the low-fidelity prototype and the modifications suggested by the work team, the material was presented for validation by the domain expert, undergoing the first interactive evaluation of the conceptual model. The result of this validation was suggestions for changes to information

that was incorrect or not very clear. To help with the modifications and other possible doubts, the domain expert provided more material from the São Paulo State Health Department [Freitas 2023, Silva 2023].

4.2. Level II - High Fidelity Prototypes

Using Figma and Unity, we developed high-fidelity prototypes (Figure 7) with increasing complexity. These were evaluated through usability and entertainment heuristics [Cuperschmid, 2008], focusing on visual consistency, interaction quality, and engagement.

Figure 5. *
(a) In-game dialogue

Figure 6. *
(b) Reward collection

Figure 7. In-game Screens [Own authorship]

The design process was divided into four development iterations. In each, specific features were implemented and evaluated. A summary of planned activities and associated heuristics follows:

- Iteration 1: Basic interactions such as object manipulation, camera control, character dialogue, and scene navigation were implemented.
- Iteration 2: New mechanics like inventory use, invisible barriers, and directional indicators were introduced, along with additional dialogues and missions.
- Iteration 3: Alert dynamics were added (e.g., countdown timer, danger signals), as well as interactions with health professionals and environmental feedback.
- Iteration 4: Polish and refinement included transitions, background music, sound effects, and AI-generated voices for dialogue.

At times, low-fidelity sketches were reused to support the visualization of more complex scenes not addressed earlier. Each iteration ended with interactive evaluations and adjustments based on the findings.

A final review session with the domain expert provided validation for both the conceptual narrative and the interface. The expert reinforced the importance of language accessibility - both written and auditory - for effectively reaching the child audience, and highlighted the value of digital media in public health education.

For each cycle of execution of activities followed by the application of heuristics, observations were made, and some points of attention were raised to be taken to the next interaction. In some of the iterations carried out at level 2, low-fidelity prototypes were developed that should have been carried out at level 1, but as it was perceived that it was difficult to visualize some parts of the story that had not been thought of initially,

the prototype step of the conceptual model, which belongs to level 1, was carried out concurrently with level 2 to help with the prototyping of screen design patterns.

A total of three iterations were carried out, followed by an interactive evaluation of the conceptual model and the screen design patterns, i.e. since several modifications had been made since the start of level 2, both at the low and high fidelity prototype level, it was decided to hold a new meeting with the domain expert to validate topics pertinent to the conceptual model and the screen design patterns.

After presenting the material, some of the domain experts' positive feedback was collected. This feedback confirms the need to build educational materials that focus on raising awareness of safety and prevention issues among children and, in addition, the association with digital tools that facilitate the dissemination of the material. In addition, the point about the language of communication used, which must be accessible and easy for children to understand, and the form of communication, both written and auditory, was reinforced.

5. Discussion

Based on the work carried out, it is possible to verify the use of the Usability Engineering Life Cycle, more specifically Mayhew's model [Mayhew 1999]. The sequence of stages carried out during the development of the project had a well-established direction, while at the same time not limiting the process, making it possible to return to previous stages when necessary. This allowed the development of prototypes to be made and revised whenever necessary to suit the needs and requirements raised.

Although the development of the playful application has achieved promising results, some limitations must be considered. The lack of usability tests with the target audience prevents a more accurate assessment of the effectiveness of the playful application in terms of usability and user experience. In addition, the absence of pre- and post-interaction tests does not allow the educational impact of the playful application to be measured in terms of awareness and prevention of scorpion accidents.

For future research, we suggest carrying out usability tests with children aged between 5 and 10 to identify possible usability problems and improve the user experience. In addition, it is essential to carry out pre- and post-interaction tests to assess the educational impact of the playful application in raising awareness and preventing accidents with scorpions.

6. Conclusions

The main objective of this study was to deepen studies and validate a procedure in which evaluation is requested regularly during the development lifecycle of entertaining and interactive applications. Through the application of the Usability Engineering Life Cycle, it was possible to develop a playful educational application about scorpions, aimed at children aged 5 to 10, which seeks to raise awareness and educate about preventing accidents with these animals.

With the conclusion of the project's development stages, which involve the development of the high-fidelity prototype and the application of usability tests, it is recommended that the playful application be distributed to schools and communities in risk

areas, following the guidelines of the relevant departments, to promote awareness and education about scorpions to a broader audience. The creation of complementary materials, such as booklets and educational videos, can be an effective strategy to reinforce the messages conveyed by the application.

This work shows the potential of the Usability Engineering Life Cycle for developing effective and engaging educational game applications. Through collaboration with experts, the application of evaluation methods, and a focus on the user, it was possible to create a playful application that seeks to raise awareness and educate about the prevention of scorpion accidents, contributing to the reduction of cases and the promotion of public health.

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