KARLI: Kid-friendly Augmented Reality for Primary School Health Education

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Abstract

Acquiring health knowledge is essential and starts already in primary school. Augmented Reality (AR) helps to convey complex topics in a more understandable way. In this paper, we present the prototype of *KARLI*, the *"Kid-friendly Augmented Reality Learning Interface"*. This AR smartphone app for in-school use is designed for age level 8 to 10, enabling pupils to explore a 3D model of the human body based on the primary school curriculum. Underlining the importance of kid-friendly app development and testing, our evaluation results of 38 pupils and 3 teachers indicate that *KARLI* is suitable and helpful for health education in primary schools.

Index Terms: Human-centered computing—Mixed / augmented reality Human-centered computing—Usability testing Applied computing—Education—Collaborative learning Social and professional topics—User characteristics—Age—Children

1 Introduction

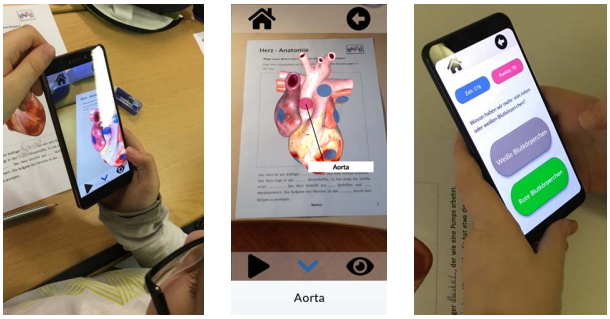
Health knowledge comprises factual knowledge, theoretical understanding of information and practical skills related to health topics, closely entwined with *health literacy* [7]. Health education has been integrated into the Austrian primary school curriculum to promote health knowledge and literacy early on. However, due to the complexity of content, learning about organs and body functions might be challenging for children. Here, Augmented Reality (AR) can help present complex topics more comprehensibly [4].

To cover the need of performing understandable health education for children based on the Austrian primary school curriculum, we developed *KARLI*, the *"Kidfriendly Augmented Reality Learning Interface"*. It is the prototype of an Android AR learning app for in-school use, based on a country-specific primary school curriculum (Austria for the prototype), and designed for the age level of third and fourth grade pupils (8 to 10 years). We evaluated usability, perceived learning experience, and task appropriateness of our prototype with 38 pupils and three teachers, examining two research questions:

- RQ1: *"What is the perception of primary school pupils in terms of usability and perceived learning experience using KARLI?"* – usability, perceived learning experience
- RQ2: *"What is the perception of primary school teachers in terms of task appropriateness regarding the in-school use of KARLI"* – task appropriateness

2 Background

AR provides users with an interactive environment, enriching the real world with "virtual objects or superimposed information" [4]. It supports learning and active thinking, and results in higher learning motivation and better contributions, increased collaboration, increased interest and curiosity, better understanding of content and improved task achievements [4, 9]. AR is usually used in science subjects for showing abstract connections that are difficult to understand, with a focus on children's education in recent research [1, 5]. Especially the increased spatial aspect due to AR is highly promising in learning about human organs and their location and functions in the human body [4]. According to the learning theory *Constructivism*, learners should take an active role in their learning processes and content should be provided using different media (video, audio, images, and text) for multi-channeled learning. Also, *collaborative learning* (CL) settings seem beneficial for AR-based education [6].



(a) Pupil using AR mode (b) Screenshot (c) Using Quiz mode

Figure 1: Pupils using the AR mode (triggered from the *KARLI worksheet*) and the Quiz mode.

3 *KARLI* Prototype Development

According to *Piaget's Stage Theory of Cognitive Development*, cognitive development differs considerably throughout the childhood stages. Children aged 8 to 10 years (*stage of concrete operations*) develop abstract and logical thinking abilities, and develop their speaking and reading skills. When developing an AR app for them, complexity of content and the children's reliance on trial and error need to be considered, e.g., by providing post-failure instructions [8]. We searched for comparable Android apps, collecting user comments and online reviews in Google Play Store and on educational websites. We identified five educational AR apps covering human anatomy, which are also used in Austrian schools. A detailed table is presented in the *Supplemental Materials*. Those marker-based AR apps use worksheets and / or t-shirts to provide 3D models of e.g., a beating heart. However, they are either designed without aiming at a specific age level or at the appropriate school level (third and fourth grade of primary school in Austria).

The *KARLI* prototype (see Figure 1) comprises two modes (see *Supplemental Material*): an *AR mode* for exploring the human heart and a *Quiz mode* for revision and checking the acquired knowledge. Both modes can be used separately, but we recommend exploring the human heart before taking the quiz. The app's live AR camera view captures the printed markers on the *KARLI worksheet*. The holographic 3D learning contents are superimposed on the paper. The worksheet also contains a cloze text that pupils can solve with a

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pen. When exploring the human body in AR, the children collaborate in pairs or small groups, sharing a device. Afterwards, the pupils can either complete the cloze text independently, e.g., for assessing learning outcomes, or again in a group setting by discussing what they had just experienced in the app.

4 Methodology

In our in-school sessions, we examined usability, perceived learning experience, and task appropriateness using two custom questionnaires and the *KARLI worksheet*. To ensure a child-appropriate usability testing approach, we created the *KARLI feedback questionnaire* (see *Supplemental Materials* and [11]) for examining RQ1. It is based on the *Fun Toolkit* [10], using the *Smileyometer, Again-Again-Table* and a *Fun Sorter*. We focused on how children succeeded in operating the app, what they thought of it, whether they enjoyed working with it and if they would want to integrate it into traditional classes. Before using the *KARLI feedback questionnaire*, we pre-tested its usability and comprehensibility with five additional nine-year-old children not involved in the school testing sessions. *Task appropriateness* was assessed from both the pupils' and the teachers' perspectives. We checked whether pupils could use the app for completing the gap text about the heart on the *KARLI worksheet*. For the teachers (RQ2), we created a questionnaire [3] for general usability, kid-friendliness, and in-class use, based on Nielsen's Usability Heuristics and the Child Usability Heuristics [2].

5 User Study

We evaluated the use of *KARLI* at our partner school *Neuhofen / Krems Primary School* in Upper Austria in December 2019 with three teachers and 38 third-grade primary school pupils. A short application for an ethics vote was approved by the ethics committee of the Lower Austria Federal State. Informed consent was obtained by parents / legal guardians, and all participants.

In two 30-minutes testing sessions in the partner school, the pupils ($n_1 = 21$, $n_2 = 17$) explored the AR contents and the Quiz mode and filled in the cloze text on the *KARLI worksheet*. The children gathered into groups of four to five people, sitting at tables arranged in small learning spaces throughout the classroom. We handed out the smartphones and worksheets: one smartphone per group, one worksheet per pupil. We asked the pupils to explore the AR content together as a team, but to fill in the worksheet on their own. Teachers observed the collaborative work and app handling. Project group members were available for clarifying the task or handling problems. Afterwards, pupils and teachers filled in the feedback forms.

6 Results

The most important results are presented here, for detailed results see [3, 11]. No child wished to interrupt or drop out of the testing session, therefore $n_{1,2} = 38$.

Concerning *usability*, 97 % of the pupils liked *KARLI* "(very) much". For *perceived learning experience*, 97 % wished to use the app in class, and 92 % indicated it would help them for learning new content. Only individual children did not see benefits in using the app, disliked it as a learning material and did not wish to have it integrated into the regular lessons. Also, the majority enjoyed AR / Quiz mode (see Figure 2) and would like to use it again. In terms of *task appropriateness*, 94 % of the total 228 blanks were filled in correctly. All three teachers "(totally) agree" on the statements concerning general usability, kid-friendliness, and in-class use of the prototype, and approved its future use.

7 Discussion

Health education is fundamental for future health decision making. *KARLI* can be used as additional teaching and learning material for providing pupils with a comprehensible experience of the human body using AR. Overall, the children were satisfied with using the app for completing the cloze text on the worksheet, and our app proved to be a sufficient tool for doing so.

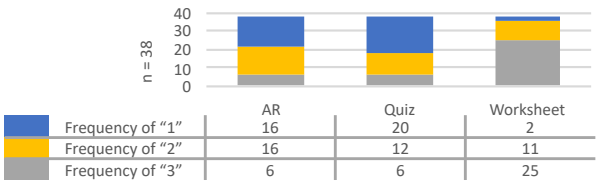

Figure 2: Results of *Fun Ranking*: "Please rank AR, Quiz and Worksheet according to what you enjoyed the most." (1 = most, 3 = least)

To fulfill user needs, a major aspect when designing for children is the strong dependency of the design on the target group's age and cognitive development. Compared with *KARLI*, this seems to lack in previous comparable applications. Child-appropriateness should also be ensured during evaluation, e.g., by using kid-friendly usability testing tools. Further research might use pre-/post-test designs to evaluate learning outcomes and comprehension compared to traditional teaching / learning materials or other educational apps.

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