Kid Query: Co-designing an Application to Scaffold Query Formulation

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ABSTRACT

In this work, we discuss the findings emerging from co-design sessions between children ages 6 to 11 and adults, which were conducted to advance knowledge on how to best support children using well-known search tools for online information discovery. Specifically, we argue that by leveraging scaffolding, gamification techniques, and design choices via an application, it is possible to enhance children's habits related to query formulation. Outcomes from this preliminary exploration reveal that gameplay incentives (e.g. levels, points, and other incentives like customization) are needed and effective in motivating further interaction with the application, which in turn leads to further utilization of the scaffolding needed to positively impact query formulation.

CCS CONCEPTS

• **Human-centered computing** → **Participatory design**; **User centered design**; • **Social and professional topics** → **Children**.

KEYWORDS

Web search, children, design

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1 INTRODUCTION

With the widespread adoption of the Internet and mobile devices among children (up to 18 years of age), it is unsurprising that they often turn to the web for information [3, 7]. Children generally opt for popular search engines, such as Google, for both educational and everyday inquiries [2, 5]. Although familiar to this user group, these search tools were not designed with them in mind, leading children to frequently struggles with successfully completing inquiry tasks when using them [2, 5, 30]. These difficulties, however, are not limited to mainstream search tools, as similar concerns have been noted with respect to child-friendly tools [2, 14].

In-development reading and writing skills, along with limited search literacy exposure also pose a barrier, preventing children from best taking advantage of digital resources [26]. This is evident in children's known challenges to formulate effective search queries, navigate search engine result pages, and identify relevant resources among those retrieved by search tools in response to their search queries [6, 13, 21, 32]. This prompts us to question how we can support children so that they can best take advantage of existing search tools. We posit that this can be accomplished by leveraging the concept of *scaffolding* aided by *gamification*. The goal of scaffolding is to provide support to the user as they learn and develop a new skill [18, 23, 34]. An example of a common use of scaffolding is training wheels for a bicycle to assist the user in remaining upright while they learn to balance, peddle, steer, etc. Gamification refers to utilizing game-design techniques in traditionally non-game contexts [8, 9, 19, 20, 27, 29].

As the type of scaffolding needed depends on the skill to be acquired along with the abilities of the individual, to control the scope of this work, we turn to the four pillars defined in [22] to guide the design and assessment of Information Retrieval tools for children: user group, task, context, and strategy. In our case, we study children ages 6 to 11, looking for online information related to the school curriculum, using strategies meant to foster best practices for query formulation. In particular, we examine whether, via an application utilizing scaffolding and gamification, it is possible to modify how children formulate search queries. Our focus on query formulation is inspired by the fact that query variability can directly impact the search process and that not all queries lead searchers to useful information [1, 25].

To contribute towards better supporting children as they search for information online we conducted three co-design sessions with a group of users in our target age group (ages 6-11). These co-design sessions utilized the "Cooperative Inquiry" techniques outlined and refined by Druin and Guha et al. [10, 17]. The techniques outline the steps necessary for a team that includes children to "...conceive, develop, and produce a technology..." [17]. In our case, the team participating in these sessions is an inter-generational group that

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includes children in our target age group as well as adults, this team is outlined in further detail in Section 3.

Outcomes from our preliminary exploration reveal that child participants in this study had trouble spelling, typing, and identifying relevant results which is inline with prior research [13]. Further, concerning design choices, the consensus from these sessions was that game incentives – primarily points and personalization of the user's avatar – were paramount in driving engagement with the potential application. Lastly, but critically important, was that the co-designed application was able to successfully convey query formulation practices to the participants.

2 RELATED WORK

In this section, we briefly discuss how children interact with search engines, and how query formulation strategies differ between child and adult searchers. Further, we review different tasks that have been addressed using gamification.

Children and Search Engines. When children formulate the queries meant to initiate the search process, Fails et al. [13] noted that Search Engines (**SE**s) provided these children with limited assistance and that search tools for children lacked functionality that facilitates the construction of queries. Gossen et al. [16] observed that children tend to have limited vocabulary and cognitive abilities that lead to issues when forming queries, children tend to submit shorter and more misspelled queries compared to adults, children tend to have difficulties typing, and children tend to use natural language searches more often than older searchers. In another study, Gossen et al. [15] mentioned that, throughout their searching, child searchers needed emotional support and a feeling of success as ~ 25% of children (ages 6-11) self-reported that they had little to no confidence in finding what they are searching for online. Further, success in a task has been shown to have an impact on children's development which aligns with Expectancy-Value Theory (**EVT**) [33]. EVT effectively states that if someone does not believe they can be successful at a task, they will be less motivated to engage in said task. Other studies revealed that children tended to struggle with typing and spelling (aligning with the findings from Gossen et al.), and that child searchers rarely went past the first page of search results and that the first result was typically the result the searcher clicked on [4, 11].

Gamification. Gamification has been utilized in some different educational and learning contexts. For example, Câmara Olim et al. [8] created a virtual reality adventure game to teach young learners (ages 11-13) about the periodic table. This approach utilized virtual reality and presented users with a linear story-driven experience to "...facilitate better learning acquisition through gaming and storytelling." Their findings indicate that when tackling an abstract process, like the bonding of chemical elements, using real world references that the children were familiar with (e.g., using water and diamonds instead of Di-hydrogen Monoxide and Carbon) seemed to help them understand the processes better. Furthermore, they found that emotional empathy with the characters improved engagement and the players' desire to reach the end of the game. Plecher et al. [27] utilized an exploration game to teach Adults (ages 21-29) about the Middle Egyptian language by presenting the users with puzzles that were specially designed to incorporate and teach Middle Egyptian Hieroglyphs. This study found that increasing the autonomy of players, in the form of only giving hints when the player asked for one, had a significant positive impact on the learning outcomes of the game. Although this particular study did not include children, the findings offered interesting insights on gamification.

Building on Prior Work. When it comes to children using mainstream SEs, their needs seem to be somewhat overlooked. This is evident in the noted lack of functionality to assist them with their known struggles with query formulation including the need for emotional support and feelings of success [13, 15, 16]. A common game-design technique is providing that feeling of success and progression (e.g. leveling up, winning, experience points). Regarding the utilization of gamification, it was found that having an emotional connection with a character can help drive engagement [8]. This leads us to believe that adding a character that the players can interact with is an important aspect to consider when designing a gamified application.

3 METHOD

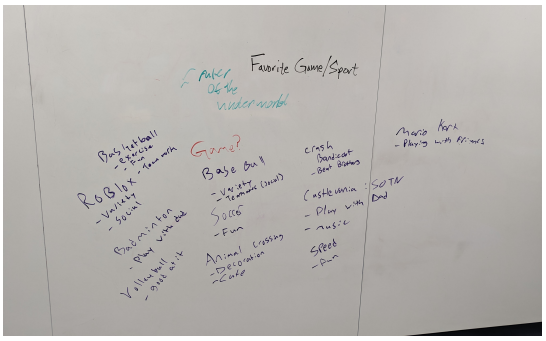
Our exploratory study consists of three co-design sessions with nine children (ages 6-11) and six adults. Each session took place in Boise, Idaho in the United States of America. The sessions are described below, and the findings of each session are presented in the next section.

Kidsteam. The children involved in our study are members of an inter-generational co-design team consisting of adults and children working together as design partners [10, 12, 17]. Meeting twice a week after school, this team, dubbed Kidsteam, works collaboratively to design new and improved current technologies for children. The parents of these children signed consent forms to allow participation and the children themselves assented to participating on the team. Demographics of the team during this study consisted of five boys and four girls (ages 6-11) each having varied computer skills and knowledge, as well as six adults all of whom are involved in the Computer Science field.

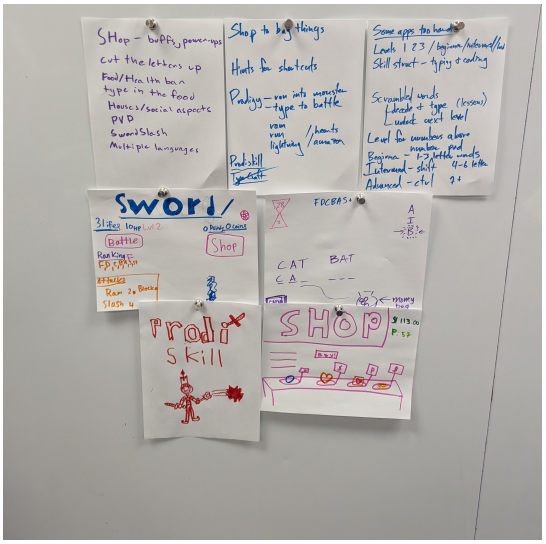
Session 1: Exploring Search Techniques and Favorite Games. In the first session, we asked the group about their favorite games and why they were their favorites. The games were not limited to video games, as they could be any type of game. We posed these questions to gauge the team's preferences for which game-design techniques should be prioritized in the potential application. The study of game-design techniques is abundant [28, 31] and, as such, it is sometimes pertinent to narrow down what techniques to focus on. After eliciting game favorite games, the team was asked to seek information to answer school-appropriate questions, grouped into two different "lessons", using a search engine designed for children[1]. The questions in these lessons pertained to the original thirteen colonies of America as well as questions about beavers. These lessons were chosen to simulate the day-to-day studies that the children in the group may experience at school. For the thirteen original colonies lesson, the questions ranged from the definition of

[1] https://cast.boisestate.edu/lessons/

(a) Session One: Query Formulation



(b) Session One: Favorite Games and Why



(c) Session Two: Gamified Scaffold for Typing

Figure 1: Kidsteam During Co-Design Sessions 1 and 2.

a colony to what Native American tribe lived where the participants now live. In regard to the beaver lesson, the questions ranged from what some of the characteristics of a beaver are to how beavers affect their ecosystems. We logged the interactions with the search engine including the queries they formulated for later analysis.

Session 2: Co-designing a Gamified Scaffold. In the second session, we first introduced the concept of scaffolding and gamification to the Kidsteam group. We then asked the team to brainstorm what they found difficult about using a computer with the intention of co-designing an application that uses gamification and scaffolding to address the difficulties the group identified. This prompt was kept broad as we were interested in the team's chosen gamification design strategies for this session, i.e., what aspects of a game meant to teach a computer skill would interest them. The team was split into smaller groups, each group was provided with paper and colored markers, and asked to draw their gamified scaffold ideas. Each group then presented their ideas to the full team and big ideas were identified from each group. Commonalities and salient outlier ideas were identified and confirmed as a team. These commonalities as well as outcomes from Session 1 were then used to create a prototype of an application that utilized gamification and scaffolding to assist in query formulation.

Development of a Prototype Application. Utilizing the outcomes observed from Sessions 1 and 2 (see Section 4) as well as the lessons revealed from the related work, we set out to develop a prototype application with the purpose of promoting better query formulation practices. The core gameplay involved helping the main character answer school-appropriate questions by having the player formulate queries that the character could use on a search engine. The game scored submitted queries from 0-500, with 500 being a perfect score. Queries were evaluated based on whether the answer to the given question was present in the returned results as well as the positioning of the results with the correct answer (i.e., a "correct" result that is higher on the search engine result page was given

Figure 2: Prototype Application Screenshot

more points than a "correct" result that was lower). Further, queries that were deemed too long or too short, or that had misspelled words or lots of stop words (e.g. to, for, be, but, etc.) were also scored lower. The crafted prototype also included a character that the user could customize with cosmetics (e.g., a hat, glasses, nose, ears) at an in-game shop using the points they earned from playing. A screenshot from the query formulation part of the prototype, including the character with an example customization, can be seen in Figure 2.

Session 3: Testing and Critiquing a Prototype Application. During the third session, we showcased the prototype application to the Kidsteam group and asked them to critique it. The team was provided with basic note-taking equipment, sticky-notes and pens, and asked to write down their likes and dislikes about the prototype as they played, as well as further design ideas that they might have. The participants were instructed to write only one idea per note to ease the grouping of notes. After testing and note-taking were completed, the individual notes were clustered into 3 main categories; *Likes*, *Dislikes*, and *Design Ideas*. These 3 categories were further divided into smaller sub-categories based on the theme of the note (see Figure 3b for full note groupings).

4 RESULTS AND DISCUSSION

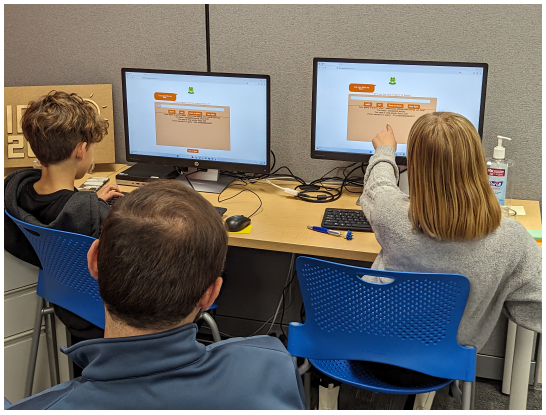
In this section, we discuss the outcomes and implications from each of the co-design sessions described in Section 3.

Session 1. In a meeting of adult team members after the initial session, an informal, formative analysis was conducted based on the data and observations collected during that session. This analysis, which was conducted by the primary author and confirmed by the adult team members, revealed that the most common aspect of each favorite game was some kind of social interaction, whether that be with a team or a family member. The next most prevalent commonality was being good at the game. The last two commonalities were for the game to be fun and have some variety (See Figure 1b for the full list). During the second portion of Session 1, the query formulation part (Figure 1a shows Kidsteam taking part in this activity), the observed outcomes were that there were a lot of misspelled words used, whereas the spellchecker was dismissed quite often. Furthermore, the participants had trouble identifying relevant results while some even struggled using a mouse and keyboard. These observations align with struggles identified by prior studies [2, 5, 13, 14, 24]. With these outcomes, we as researchers, were able to observe and identify certain aspects of query formulation that appeared to be problematic to searchers ages 6-11, mainly spelling errors and dismissal of query assistance. However, moving into Session 2, we wanted to know the difficulties these child-searchers perceived personally as well as how they might go about creating a gamified scaffold to address these issues.

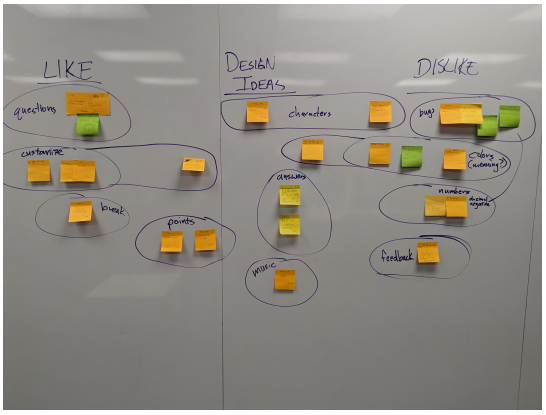
Session 2. The initial brainstorming portion of this session, in which we asked the participants to identify difficulties in using a computer, identified two main issues : difficulty typing and difficulty using a mouse. Three teams were established and asked to design a gamified scaffold to address one of these issues. Two groups decided to create a design meant to help teach typing (See Figure 1c for one of the co-designed ideas) while the other group chose to confront the typing issue. Application commonalities that emerged from all three co-design groups were: (i) shops, (ii) player/difficulty levels, (iii) cosmetics (pets, hats, etc.), (iv) points/coins, (v) rewards, and (vi) characters and customization of those characters.

The main connection from these commonalities seems to be a desire for character customization. All of the shops that were designed included items that could be used to enhance and/or customize a character, whether with new clothing options or giving the player character some kind of pet. Further, for every shop that was designed there was some kind of currency designed as well, whether that be points or coins, that could be utilized at the shops in order to unlock options for the player character.

Session 3. The observations that emerged from Session 3 revealed mostly that: (i) there were some bugs present, (ii) the team enjoyed



(a) Session Three: Testing the Prototype Application



(b) Session Three: Note Groupings

Figure 3: Kidsteam During Co-Design Session 3.

playing the game so that they could earn points and unlock customization options for their character, (iii) the instructions were inefficient, and (iv) the scoring was confusing. However, when asked what they learned from the game, the general consensus was that (i) queries should not be too long, nor too short, (ii) the spellchecker should be utilized more, and (iii) the stop words are not always necessary in query formulation. Furthermore, the most prevalent 'dislike' was there were not enough questions in the game and that the game itself was too short (see Figure 3b for notes and groupings). The second most prevalent 'dislike' was there were not enough customization options to choose from.

We can see from this session that individuals can be made aware of better query formulation habits through an application utilizing gamification and scaffolding. The participants correctly identified how they could earn more points in the application: fewer misspelled words, queries that were neither too long nor too short, and minimizing the use of stop words. Character interaction and customization with cosmetics drove engagement with the gamified scaffold. The two main 'dislikes' that were noted by the group, the game being too short and there not being enough character customization options, feed into the importance of having a customizable character. The notion of the game being too short (there not being enough questions) was born from the teams wanting to earn more points to be used to unlock more customization options for their characters, which, according to the teams' other main dislike, there were not enough query prompts that allowed them to practice more and earn points.

5 CONCLUSION & NEXT STEPS

In this work, we presented the outcomes of a preliminary exploration that leveraged co-design sessions to guide the design choices of an emerging application that utilizes scaffolding and gamification to ease child query formulation by promoting better formulation practices. Findings that emerged from this exploratory study show that such an application shows potential in conveying and modifying query formulation practices. The prototype application utilized scoring guidelines meant to promote the aforementioned better formulation practices: fewer misspelled words, not too long or too short of a query, and not too many stop words. Even though the child participants noted the seemingly ambiguous nature of the scoring, they were still able to pick up on what led to a better score. Additionally, when designing such an application, gameplay incentives play an important role in driving engagement and seem to be specifically desired by our target group. The most common ideas that emerged from Session 2 included character customization and aspects that could be used in conjunction with this customization, namely shops and some kind of currency (points, coins, or something similar) to spend at said shop. Furthermore, the biggest critiques that we saw from Session 3 were that there were not enough questions, which led to not enough points, that the players wanted to use to unlock more customization options for their characters, which the players also wanted more of. Our initial findings illustrate how scaffolding and gamification can support children's creation of better queries, and we believe further research that utilizes these mechanisms will lead to better supporting children's search literacy skills.

6 SELECTION AND PARTICIPATION OF CHILDREN

Child participants were members of an ongoing inter-generational design team. Children were recruited via paper posters posted in the local area, localized social network platforms, and information shared by current and past participants on the team. All research protocols were approved by an Institutional Review Board and consent and assent were attained before conducting the research.

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