Math Trainer as a Chatbot Via System (Push) Messages for Android

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Abstract—In the recent years, as technology grew, so did the chatbot technology. More and more companies and people are using and reaping the benefits from them. This paper shows how a chatbot for mathematical tasks, named mathbot, was developed. The chatbot uses mathematical exercises from the "Schulapps" of the LearningLab of Graz, University of Technology and combines them with textual questions to provide a useful utility for practicing. It is shown that such a chatbot could be useful for pupils and teachers by evaluating a test run in an elementary school.

Keywords—chatbot, learning analytics, mathematics, children, education

1 Introduction

Nowadays, almost every person has their own digital device, be it a mobile phone, tablet or a laptop [1]. Times have changed, and so has technology. The digital world is more accessible than ever to both the youth and the mature population of the world. With the knowledge of that fact, software developers can create many helpful tools, such as a variety of applications that can teach a new skill or a language, improve existing ones and many other things. When talking about skills, school subjects are included as well. Mainly, mathematics, as it was the primary focus of the application that was developed.

One key feature of mobile phones, specifically of applications, is the concept of push notifications. Push notifications are messages that sort of pop up to the mobile phone screen and notify the user. It can notify her/him of anything, ranging from a reminder to asking him a question. Because chatbots are becoming more and more popular [2] it is possible to communicate with the user in a human-like way, such a concept could be used for push notifications too. It can be observed in Figure 1 how a conversation with a chatbot looks like.

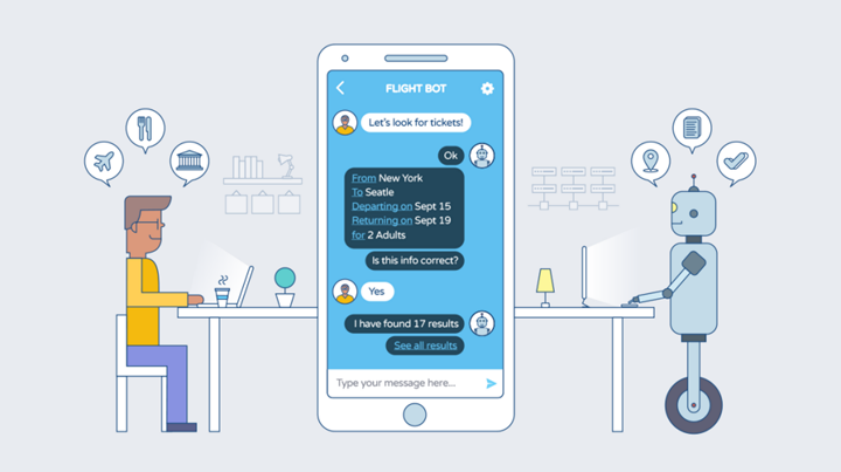

Fig. 1. Conversation with a chatbot [3]

Students tend to have problems with their studies early on that can create a problem that persists throughout their adult life too, mostly because they do not find the way of learning interesting or the subject itself [4].

One solution to that problem was presented in a study [5] where young children (age span of 4 to 5 years) used math applications instead of the standardized learning. With the combined help of the teachers and the app, in the end, the experiment has shown a positive learning effect. Such positive effects were also confirmed by a further study [6].

Another benefit of mobile applications is the use of the haptic features, which can be very intuitive and suitable for the children. For example, clicking or dragging items can be a very fun way to learn. This can be achieved using UI (user interface) elements on the screen or physical elements [7].

The main purpose of this work is to demonstrate if and in what way(s) a chatbot can be beneficial for pupils and teachers. Specifically, with arithmetic operations combined with the phone's system notifications where the children would, depending on the set time interval, be asked an interesting mathematical question and the answer would require solving a mathematical exercise.

At first this publication presents some related work and after that, the chatbot app is shown in a very detailed way. This is followed by an evaluation of the app in a real-world setting and the results are discussed.

2 Related work

2.1 Learning analytics

Learning Analytics, or short LA, can be described as the collection and acquirement of information related to the area and the person requesting the information. It

gained a huge rise in popularity due to the rise of technology and data collection, which provides more accurate and detailed results. Its focus lies in the promotion of learning and popularization of data [8]. The "Schulapps"[1] of the LearningLab of Graz, University of Technology are collecting the data of the performance of the pupils and presenting them to the teachers in different ways.

2.2 Chatbots

It has been shown [9, 10] that the advantages of using chatbots positively increased. Still, that depends on the area and topic of usage, as the broad pool of responses that a chatbot can produce can often be deceiving and or misleading.

Some companies are already benefiting from them where some have the desire and are planning to use them. Different usages of chatbot technology can also be seen as a technology to make websites more interactive and/or interesting.

Using chatbots in education is best combined with teaching methods which are mentioned by [11], namely teaching with communication, because with this method it is possible to use the chatbot in a way to fulfill a teacher role with the help of assistance tools such as diagrams, digital drawing boards and so on.

It was shown [12] that the scholars who used digital tutors performed better than the other scholars who did not have the assistance of the chatbots, mainly due to the better communication offered. If any questions or problems appeared, they could have been solved quicker and more efficiently by the chatbot.

Due to the rise of students and online courses, e-learning is slowly becoming the new standard of learning. Therefore, it is hard for the teachers to provide enough care for their students [13]. Considering that chatbots are in a way automated computers, their response time is instant, which makes them even more efficient.

Because most students are afraid to ask the teacher a question directly because of the fear of embarrassing themself, a solution to that could be the usage of chatbots [14] in a way that they can act as a tool to ask any type of question, anonymously, where the students do not have to be afraid of the response.

There are many more benefits which include increased sales, faster and advanced customer support, availability and so on.

3 Implementation

This section presents the chatbot app in detail. At first it is shown how the app was designed using mockups. After that, the app is explained in both, in a functional and in a technical way.

[1] https://schule.learninglab.tugraz.at, accessed May 31, 2022

3.1 Mockups

At the start of the whole development project, it is recommended to use mockups in order to demonstrate the design of the application. Mockups are a useful tool which act as a sketch of the applications interface.

Figure 2 shows two mockups. At the left side the mockup for the login screen is presented. On the right side the mockup of the chat is shown when a math problem is asked to the pupils. It can be seen that there is a field to answer the question and a button to submit the answer.

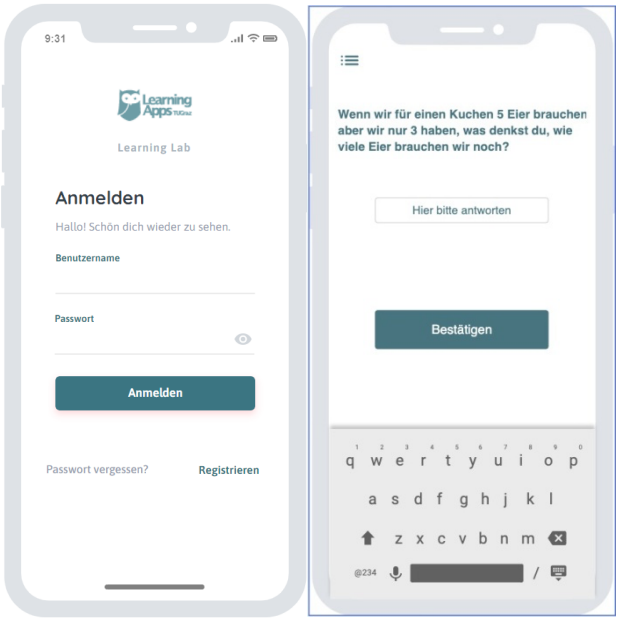

Fig. 2. Chatbot app mockups. Login screen (left) and question (right)

3.2 The chatbot app

The chosen mobile operating system in which the application was developed is Android. Android is an open-source operating system that is owned by Google and mainly used on mobile phones and tablets. The main concept of Android is that it is mainly open source software, which means endless ways of modification are available to every developer.

The first screen the user is greeted with is the login screen (see Figure 3, right) where it is possible to either proceed with the authorization or if the user does not have an account, to create one. The main part of the application is in the home screen where the user can set up the time intervals and select the trainers (see Figure 3, left). It can be seen that the current two implemented trainers are *1x1 (Einmaleins) Trainer* and *PlusMinus Trainer*. Figure 4 demonstrates the timepicker and trainer selection.

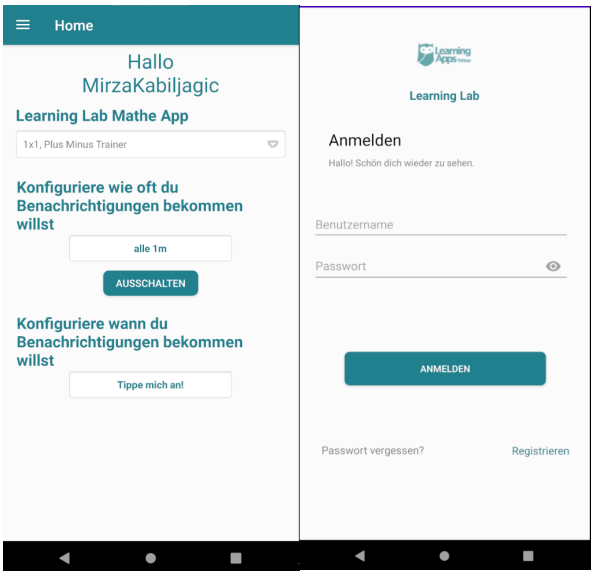

Fig. 3. Home (left) and login (right) screen

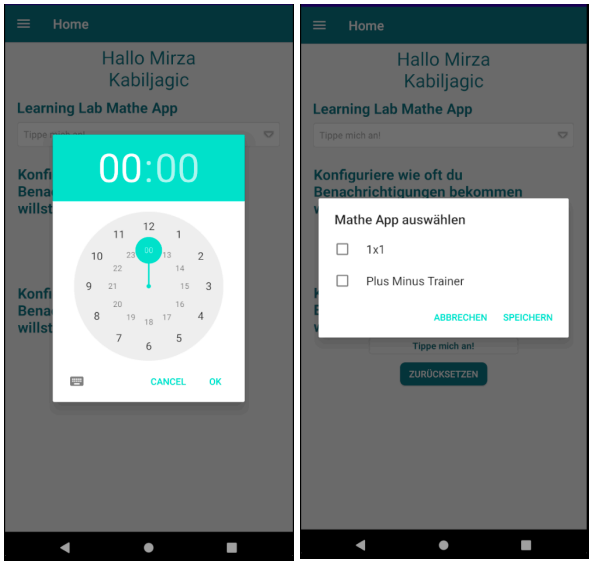

Fig. 4. Timepicker (left) and trainer selection (right)

After configuring the app at the home screen, the chatbot will send out push notification if a new math problem ready to solve. With the help of *Java Threads* and *AlarmManager*, it is possible to send out these scheduled notifications.

Now a notification is present in the corresponding area of the phone. When the user clicks on this notification, she/he is directed to the app to solve the math problem.

This is done by reading the question of the chatbot and answering it by entering the number in the offered box. After submitting the answer it is shown whether is correct or wrong (see Figure 5).

Fig. 5. The question and a feedback are shown

As the application itself does not require many things saved, a database is not needed. The things that need to be saved are the time interval settings and selected trainers and therefore, *Shared Preferences* are used. The arithmetic operations and numbers used for the calculations as well as the answers were provided by the "Schulapps" LearningLab backend.

In order to retrieve data from the backend, some sort of communication protocol is required and for the communication with the "Schulapps" LearningLab backend API, *simple object access protocol* (SOAP) is used. It is a communication protocol that enables the developer to request and send data.

4 Evaluation and discussion

A user study consisting of 18 children, was conducted to see the performance and usefulness of the mathbot and if the children will benefit from it. The tests were performed at the "VS Judendorf-Straßengel" elementary school. In order to acquire more accurate results, the duration of the study was one week in school, from the 15th till the 19th of November.

The testing was set up on eighteen tablets, where each child was given one device for testing. The children used the app in this week during their time in school. This

means that they had to answer a question with a math problem from the chatbot from time to time.

The idea was to see the reactions and feedback from both the children and their teacher and that is why two questionnaires were handed out. Both were short and concise with four questions for each questionnaire. Figure 6 demonstrates the children questionnaire and Figure 7 the teacher questionnaire.

The questionnaire for the children used four thump fingers to collect the answers and it asked the following questions:

- How satisfied are you in general with the app?
- Was the app helpful?
- Was it easy to use the app?
- Was the app interesting?

Fig. 6. Children questionnaire

In contrast to that, the questionnaire for the teacher used check boxes to collect the answers for the following questions:

- Was the app helpful for learning?
- Could such a digital way of learning become a standard in teaching one day?
- Could the app help to improve the mathematical skills of the children with continued usage?
- Was it interesting for the children to use such an app with push notifications?

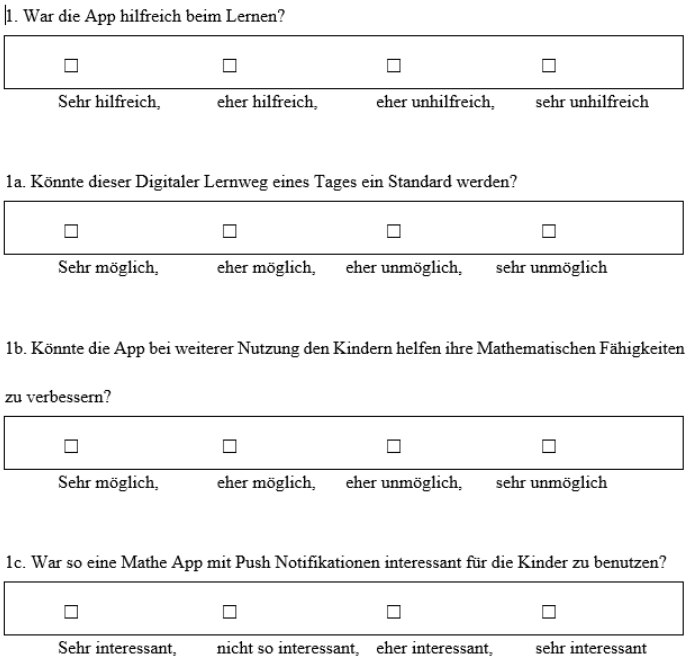

Fig. 7. Teacher questionnaire

Regarding the first question from the children's questionnaire (see Figure 6, first question), most of them were satisfied with the application overall, with the teacher's feedback supporting this. The exact results can be seen in Table 1.

Table 1. Feedback from the first question

Very satisfied	Satisfied	Not so satisfied	unsatisfied
12	5	1	0

The next question (see Figure 6, second question) was asked to see exactly how much helpful the application was to the children and looking at the feedback in Table 2, it can be observed that the feedback is somewhere in the middle, neither on the positive nor on the negative side. The reason for that might be the way how the questions are constructed. After a couple of days testing, the children figured out that they could simply look at the numbers presented in the question and perform the arithmetic operation immediately instead of reading the whole text of the question. For example, if the selected trainer was the *1x1 (Einmaleins) Trainer*, it would mean that the children would need to look for the two numbers in the question and perform the mathematical operation which in that case is multiplication.

Table 2. Feedback from the second question

Very helpful	Helpful	Not so helpful	unhelpful
4	2	6	6

Regarding the results (see Table 3) of the next question (see Figure 6, third question) about the interface, it was almost expected that the outcome will be positive because the goal was to keep the functionality as well as the design as simple as possible. It can often happen that young children tend to lose interest when dealing with more complex user interfaces.

Table 3. Feedback from the third question

Very easy	easy	Not so easy	Not easy at all
18	0	0	0

Concerning the feedback from the teacher, it was confirmed that the pupils did not experience any trouble with the usage. The results (see Table 4) from the last question (see Figure 7, fourth question) could be explained with the same reasoning as in Table 2. That is because after a while of using the app more frequently, it gets to a point of performing mathematical operations on numbers only.

Table 4. Feedback from the fourth question

Very interesting	interesting	Not so interesting	Not interesting at all
3	2	6	7

In general, the feedback from the teacher's questionnaire was positive as well as her statement concerning the application. This means that the teacher always selected the second best answer as visible in Figure 8. The teacher reported that the children had no problem using the app. However they soon realized how to filter out the math problem without really reading the question text (see above).

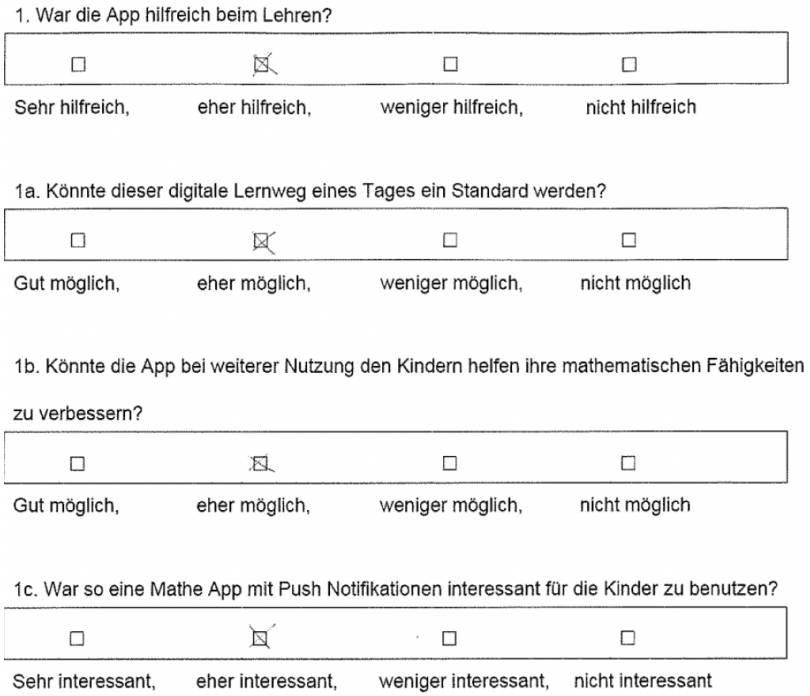

Fig. 8. Feedback from the teacher

In addition to the questionnaires, the statistics of the performance of the pupils at the math problems was evaluated. Concerning the statistics given by "Schulapps" of the LearningLab, most of the questions were answered correctly with a small number of wrongly answered ones. To be specific, around 55% of the answers were rated with "very correct/good", 43% of the answers were rated with "correct/good" and around 3% of the answers were wrong. Although there is a high number of questions that had no answer (1181), reason being a timeout of the API due to the high frequency of requests sent. For this problem the app has to be updated. Figure 9 depicts the statistics mentioned. Because the statistics state that a very high number of (very) good knowledge was reached by the pupils using the app it can be assumed that the app is helpful in terms of learning success.

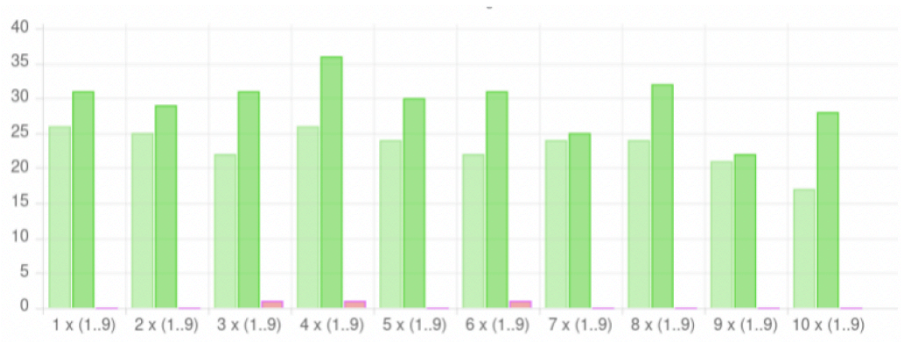

Fig. 9. Answered questions statistics. Light green: very good, dark green: good, red: wrong

5 Outlook and conclusion

This work presents a chatbot app where mathematical problems are asked to pupils using the push notifications of the phone.

Overall results of this study point to the possibility of improvement in mathematical areas of young children. Distributed practice, according to [10], is an optimal way to get the most out of studying. It means creating a study schedule, which consists of multiple study sessions throughout a period, and each session is kept short. The goal and idea of this publication were established around this concept, because by using the time scheduling in the app, exactly that can be achieved. This means that the chatbot provides multiple short study sessions, spread throughout the day. It is shown by this study that such an app is considered helpful by the pupils as well as by the teacher. This is confirmed by the results to the math problems as pointed out by a statistic of the answers in a test run in an elementary school.

Improvements, such as adding new trainers with different arithmetic operations would be an optimal idea. Adding to that, more complex questions containing the math problems should be implemented to avoid that the pupils only have to look at the two numbers in the text to know what to do.

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