Research on the language barrier of students who use Khan Academy as a mathematics homework platform

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Homework is a routine practice in math classes, and research has shown that the immediate feedback and acknowledgement of effort is important for students. Unfortunately, the traditional classroom setting does not allow for this degree of feedback. Khan Academy, on the other hand, offers a free tool that allows teachers to monitor students’ activity and provide them with feedback and guidance. In this study, we investigated one high school’s use of Khan Academy as a homework platform, focusing specifically on language barrier and their impact on students’ ability to benefit from Khan Academy. We found that students who faced a lower language barrier were able to make better use of Khan Academy’s educational resources. Surprisingly, we also found that a reported language barrier does not significantly correlate with students’ English grades.

Keywords: Homework, online assessment, language barrier, electronic resources.

Introduction

Everyone did much math homework during his/her high school studies. I remember doing most of it on the way to school or before math classes during break. At the beginning of math class teacher would walk around the class checking some notebooks randomly to see if there is anything that looks like homework. Since I really enjoyed math, I did most of math homework by myself and then lend it to others to copy. We didn’t receive almost any feedback on our homework, so that it is no wonder that many students were not very motivated to do their homework on their own. Unfortunately math teacher in large class didn’t have much of a choice back then. But new online technologies today (Khan Academy, 2016) offer individualization, guidance and immediate feedback for students and great amount of data about students’ activity for teachers.

The Khan Academy (KA) is the non-profit organisation that runs the website www.khanacademy.org. Since 2008, it has undergone a great deal of development. What started as a list of instructional math videos has developed into a network of vast educational resources including interactive exercises covering mathematics, natural sciences, and more, from the elementary to the undergraduate level. Thanks to generous donors, KA is able to provide all of its content for free, and it probably will not be cancelled or priced any time soon. On the other hand, KA exercises and most of the educational videos are offered in English only, as it is with many other online resources. We therefore decided to investigate the effects of language barrier on preferences and attitudes towards KA of students who practice math using KA exercises.

Theory

Homework and feedback

Homework assignments are routine in most mathematics classes, including those in high schools in the Czech Republic. There is a great deal of evidence suggesting that monitoring students’ work and
acknowledging their efforts are very important for students as it increases the effort students put into the homework (Strandberg, 2013). If teachers do not grade the homework assignments and return them promptly, students report feeling like they have wasted their time on that activity (Strandberg, 2013; Wilson & Rhodes, 2010). Students need to believe that their homework is meaningful and that teachers value their endeavour (Bempechat et al., 2011).

When it comes to feedback, there are still important gaps in our understanding (Shue, 2008). There is some evidence suggesting that when a task requires material or procedural understanding and analytical problem-solving (such as mathematics), providing hints and allowing multiple attempts may lead to higher increase in students’ performance than simply revealing correct solutions (Clarina & Koul, 2003; Attali, 2015).

Students would benefit greatly from timely and meaningful homework feedback. Unfortunately, it is beyond teachers’ capacity to provide this to every single student in the traditional classroom setting. However, technology might be able to help teachers with this. More than that, technology can prevent misunderstanding between students, teachers, and parents about the amount of time students spend on homework, as accurately estimating this can be difficult for teachers in the traditional classroom setting (Strandberg, 2013).

**Language barrier**

We didn’t find many recent studies investigating the English language barrier when learning mathematics, nor for learning in general. There have been some studies that have investigated non-native English-speaking students in an English-speaking environment, at both the high school (Adams et al., 2015) and university levels (Variawa & McCahan, 2012), but those are not very relevant to our setting as they study foreign students in English speaking communities and in different subjects (chemistry and engineering).

For the purposes of this study, we define a language barrier as English language difficulties as perceived by students when interacting with the Khan Academy website.

**Khan Academy**

KA has provided interactive exercises for only a few years, so it has not yet been heavily researched. On the other hand, videos have been used for educational purposes for decades. Two recent studies investigated data from several Massie Open Online Courses to determine the attributes of more engaging videos (Guo, Kim, & Rubin, 2014; Kim et al., 2014). In our previous study, we concluded that KA’s videos align well with most of the aforementioned recommendations (Vančura, in press). Our investigation into the possible impact of KA as a homework platform on student attitudes towards mathematics demonstrated that negative impacts are very unlikely (ibid).

A large study was also conducted concerning the implementation of KA into U.S. classrooms (Murphy et al., 2014). The results revealed that only 45% of American students reported being able to learn new skills from using KA without teacher assistance. We found similar results (46%) in our previous study (Vančura, in press).
Context

In this study, students were assigned homework on a weekly basis through KA’s interactive exercises (see Figure 1).

Every exercise consists of a series of problems related to very specific topics. In the exercise shown in Figure 1, students are asked to practice estimating equation solutions using graphs. Students are required to select the shape of a graph of function $g$ [1], graph the function $g$ using the interactive graphing tool [2], and then estimate the lower solution of equation $f(x) = g(x)$, where function $f$ is given by its graph. Students cannot move on to the next problem until they solve the exercise correctly. If they cannot solve the problem, there are hints [4] that demonstrate step-by-step solutions. Even after revealing the whole solution, students are required to graph the function $g$ and estimate the solution correctly. They can then continue on to the next problem. Students can also watch instructional videos that explain the solutions to a sample problem in detail [5]. The student’s progress is captured and displayed at the bottom of the screen [6]. Students receive a check-mark for solving problems correctly on the first try without hints. They get a cross-mark for entering wrong solutions and a light bulb icon for solving problems correctly on the first try with some hints. In order for students to successfully finish an exercise, they must get five (or sometimes three) check-marks in a row, i.e. solve five problems on the first try without hints. This multiple-try mechanism
aligns well with the findings on feedback (Attali, 2015). On the other hand, this feedback does not tell the students where they have made a mistake and usually provides only one way to solve the problem. Some exercises consist of multiple-choice problems, and students might be tempted to guess the answer. However, the requirement of solving five problems in a row makes guessing time-consuming. For example, even if students are able to narrow the choices down to two, they still need to answer 62 questions on average in order to get five in a row correct. If the students guess blindly from four choices, they will need to answer 458 questions on average.

The second important tool KA offers is the teacher’s dashboard, which allows teachers to monitor student activity. Teachers can see when students work on exercises, which exercises they work on, and how well they solved the problems. Teachers can even see the amount of time spent on each problem, as well as the total time spent on KA. These data allow teachers to monitor, acknowledge, and assess the homework objectively and meaningfully. These attributes allowed the teachers in our study to grade homework on a weekly basis.

Based on the results of the SRI study (Murphy et al., 2014), our students were not required to learn new skills on KA, but they had to practice skills that they had already acquired.

**Methodology**

**Research questions**

1. Does a student’s language barrier influence whether they prefer KA homework to homework from traditional textbooks?
2. How does the language barrier influence students’ attitudes towards KA and their ability to learn while using it?

During the research, we have already seen that the language barrier plays an important role, which made us add a third question of interest.

3. Can the language barrier of individual students be easily and reliably estimated (i.e. by asking an English teacher)?

**Data collection**

We developed two surveys based on the surveys used by the SRI study (SRI, 2015), though we added questions about English language usage and omitted some questions that were irrelevant to our setting. The first survey was administered in December 2015, and the second was administered in June 2016. Both surveys contained several pairs of verification questions that detected inconsistently or carelessly filled out surveys. To measure the language barrier, we used Likert-scale questions, such as, “my limited English knowledge prevents me from using Khan Academy effectively”. To measure the preference of homework platform, we used Likert-scale questions, such as, “I prefer to solve examples from common textbook than from Khan Academy”. Surveys were administered during an ordinary math class so that the students had no reason to hurry.

We also collected students’ midterm and final grades in mathematics and English for the 2015–2016 school year.
At the beginning of September 2016, we asked English teachers to estimate the reading and listening abilities of the participating students, as well as the effects of their language barrier when using mathematical software in English. Teachers were asked to use the Common European Framework of Reference for Languages (A1–C2) (Council of Europe, 2016), which was then recoded on a scale of 1–6.

**Participants and criteria of analysis**

The first survey was administered to 141 students aged from 15 to 20 across 7 classes in two Prague high schools. In the second survey, the participants included 83 students from 5 out of the 7 classes that participated in the first survey. All of our students learn English as their second or third language. A total of 64 students participated in both surveys. The students in our study were taught by six different English teachers, who were asked to estimate the students’ language barrier. The author of this paper is a math teacher in two of the seven classes. Therefore, we looked for relative patterns (i.e. connection between language barrier and learning independence), rather than absolute results. When investigating absolute results, such as student preference of KA over traditional textbooks, we also investigate the differences between students that are taught by the researcher and those that were not.

To measure the language barrier, we required Cronbach’s alpha to be greater than 0.7, which is generally considered to be an acceptable level of consistency. When it came to correlations and hypothesis-testing, we used the 5% significance level, which means that the probability that our results were random is less than 5%.

**Results**

In the first survey, students reported a strong preference for KA over the traditional textbooks (Vančura, in press). This preference decreased significantly in the second survey, but KA was still preferred. In both surveys, students taught by the researcher did not report a stronger preference for KA than other students. Preference for KA significantly correlated with reported language barriers (see Figure 2). Students with greater language barriers tended to prefer KA less. However, even students that reported significant difficulties with English preferred KA over traditional textbooks.

Both surveys revealed a significant connection between the students’ reported language barrier and several other factors. In both surveys, students with lower language barriers:

- Found KA videos and exercises more helpful (correlations 0.18–0.45).
- Reported higher autonomy when learning new skills using KA (correlations 0.17–0.28).
- Reported a more adequate understanding of their skills when working in KA (correlations 0.22–0.29).

The reported levels of language barriers decreased slightly between the two surveys, but this decrease was not statistically significant. Surprisingly, the reported language barriers did not significantly correlate (~0.02, 0.14) with English grades. We assumed that different teachers would have different grading strategies and standards, so we normalised the English grades within groups of students taught by one teacher, and the resulting correlation increased slightly to 0.16, which is
still insignificant in our case. We also calculated the correlation between English grades and the decrease of language barriers between the two surveys and, again, the correlation was insignificant (0.02).

Driven by these results, we asked English teachers to evaluate the students’ English listening and reading skills, which correlated moderately (0.45; 0.48) with the language barriers reported by students.

**Conclusion and discussion**

Homework remains an important part of mathematics education in the Czech Republic. KA can provide students with guidance and immediate feedback, which we believe is the main factor that leads students to prefer KA to traditional textbooks. The decrease in KA preference over time may be attributed to the novelty of this new system wearing off, but it is worth noting that even six months and many working hours later, KA remained the preferred choice by the majority of students.

We found language barrier to play an important role in both preference and reported utilisation of KA. Students with greater English-language capabilities reported higher ability to use KA learning resources, which we believe is a strong factor behind their higher preferences of KA to traditional textbook. We can assume that similar patterns will appear with other online educational resources, the number and quality of which continues to grow rapidly and would take a great deal of time to translate into Czech. In fact, KA is one of the most-translated educational resources in the Czech Republic. However, despite great effort from the non-profit organisation (Khanova škola, o.s., 2016), only about 35% of KA’s videos have subtitles and less than 1% has Czech dubbing. If we want our students to benefit from these growing resources, we need to prepare them for learning in English.

Another result of our study is that students’ English grades did not significantly correlate with the reported language barriers, i.e. the ‘best’ English students did not typically feel better able to overcome the language barrier than the struggling students. This pattern holds even after six months.
of using KA. We assumed that students will learn to overcome this barrier over time by using more English resources. Our study did indeed show that the reported language barriers decreased slightly, albeit insignificantly, over the course of six months. The teachers’ evaluation of reading and listening skills correlates significantly (0.45, 0.48) with the language barriers reported by students, so such evaluation could provide a very rough estimate of the language barrier of a group of students. However, the correlation is not strong enough to provide a reliable estimate of the barrier faced by individual students, as it only explains about 23% of it ($0.48^2 = 0.23$). In the end, we were ultimately unable to find a quick and reliable way to estimate individual students’ language barriers that they reported.

**Limitations and future research**

The size of our sample made it impossible for us to find small correlations or inconspicuous patterns. Larger samples would have also allowed us to verify our results at a higher confidence level. The disconnection between the reported language barriers and English grades could also be a local phenomenon, since every school in the Czech Republic has its own curriculum.

In this study, we relied mostly on student’s opinion, which might not be completely accurate, i.e. when students report that they can make a good use of KA resources does not necessarily mean that they really do.

The results also show that the English courses that are currently offered to students might not be enough to prepare them to learn mathematics in English using tools like KA. How to help students learn in English might be an interesting question for researchers and a challenge for both math and English teachers.

KA offers a great variety of exercises, but its narrow focus (i.e. graphing quadratic function in vertex form) and repetitive nature might produce very formal knowledge that cannot be transferred. In future studies, we would like to investigate what students actually learn using KA and how it might be affected by their language barrier.

As with every other digital source, KA sometimes experiences technical problems. Exercises can fail to load properly, and some data might not show up in the teacher’s dashboard, so it is a good idea to consider possible technical problems before judging students too quickly.

**References**


