Automating Academic Advising through Course Recommendations

(Technical Paper)

Smarter Calculators in the Modern Classroom

(STS Paper)

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Navigating the Technological Education System

How do students, educators, and corporations utilize and invent computer-based programs to make for a more intelligent society?

In the current academic climate, there has been a slew of technological innovation that has increased the accessibility of information. With the development of the internet, the last few decades have seen a boom in the number of tutorials, guides, and help videos that allow individuals to learn topics without having to physically seek out an expert (Fahmy, 2004). Furthermore, computer-based computational engines such as Wolfram Alpha are gaining the ability to answer a range of questions that may reduce the need for certain skills. These engines can also present information inquired in a format mimicking a human's solution, further increasing these programs capability. One review summarizes Alpha as: a knowledge engine to answer free-form user queries that does computations from its own internal knowledge, rather than searching the web and trying to match a result (Hindin, 2010). Despite the growing use of these programs, the questions remain: Do students, teachers, and corporations possess a shared understanding of how these fit into the education system? Are educators incorporating these technologies into their lesson plans and/or adapting to their student's technological behavior trends?

Automating Academic Advising through Course Recommendations

Currently, most colleges and higher education universities have department of faculty dedicated to helping students navigate their academic experience. People are deployed as academic advisors because the systems they are advising (majors, courses, topics, careers) are typically complex and advising can vary from student to student. Differences in student traits such as skill sets, career goals, and academic interests lead to variety for their best move. While the current system has its benefits, it is inefficient when students repeatedly ask similar questions thus wasting valuable resources. Furthermore, a study from the Texas A&M discovered that "No significant relationship was found among advisor availability, advisor time with student, advisor focus on student as an individual, … and advisor assistance of educational planning and the criterion variable of perceived value of the advisor among students" (Vasquez, 2017, p. 1). Their research concluded that the frequency of advisee-advisor interactions was the more significant factor in value received by the student (Vasquez, 2017). Utilizing these findings, it is possible that an online technological academic advising solution would allow uninterrupted access and increase the frequency of advisee-advisor interaction while maintaining the utility previously provided by faculty.

My technical capstone research project seeks to create a web application personal assistant to provide concrete guidance in topics such as course recommendations, degree requirements, course workload, and time management. Students will input information about themselves such as desired major, course load, timings, and grade history and this tool will output a potential course schedules they can sign up for. These course schedules will be generated utilizing a constraint algorithm that attempts to maximize student's inputted desires. The goal of this project is to provide advice for commonly asked academic career questions based on student's individual profiles. This will require determining which student qualities most effect given advice, and quantifying these metrics. Specifically, students course history, grades, academic goals, and major requirements will be investigated and analyzed to identify trends in order to provide recommendations for similar students who create a profile and utilize this tool. A survey with a gift card raffle incentive will be utilized to ask UVA students what are other key factors in their decision-making process for course selection. A follow up focus group session will be used to determine further insights. The results from this survey and session will be condensed and added to the list of key factors that affect student decisions. Now, when a user logs into the application for the first time, they will have an option to edit their profile information such as course history, grades, academic goals, and other key factors in order to receive more relevant academic advising per semester.

In order to provide a recommend course schedule(s), this personal assistant will need to access a database of the courses offered at UVA; this will be done through existing web-scraping libraries and the public UVA Student Information System API. Furthermore, there is also a need to quantify the requirements for a variety of majors into a singular format that works efficiently with other aspects of this app. This will most likely be done manually by team members due to the complex nature and non-standardization in the format this data is currently present. There will also be metadata for each course in the database which will be collected and updated every semester through a CSV scraping tool that iterates over the publicly accessible grade data. The user will not be able to directly access this information as there are other mediums better suited for those needs; Rather, grade and course metadata will be utilized by the constraint algorithm to provide optimal schedule recommendations. Some examples of course metadata utility includes: course timings for students who prefer morning or afternoon courses, unwise course pairings so students do not take an excess of difficult courses, and prerequisite status so students can prioritize courses that open future course opportunities.

The ideal results of this project will be a personal assistant that can provide a recommended course scheduled for a variety of computer science majors at UVA. This is a feasible amount of functionality that will highlight the strengths and weaknesses of our design before further utility is expanded. The goal is also to provide a basis through which this personal assistant can be expanded such that multiple majors and a variety of student profiles can be given recommendations.

The Different Uses of Computational Knowledge Engines in Education

How are K-12 students and teachers incorporating computational knowledge engines into their learning and lesson plans and how is this modifying the modern classroom dynamic?

Introduction

Wolfram Alpha, Symbolab, and Mathway are all computational knowledge engines created in the last decade. The goal of these tools is to solve a range of queries such as simple fact-checking or complex multivariable calculus equations. These technological innovations have the potential to significantly alter how knowledge is transferred from teachers to students; my research seeks to analyze how students and teachers view the abilities of these engines and how, if it all, the engines affect their behavior. I want to determine whether there is a disconnect in students and teachers' beliefs on the role of computational knowledge engines in K-12 education. Targeting this ideological dissonance can produce a rippling effect in the multitrillion-dollar education industry and help reduce technological inefficiency and excess monetary costs. In turn this may lead to a more intelligent society of which an increasing number of students can be successful, functioning members.

Background and Theoretical Framework

Technology such as personal computers and smartphones have been rapidly transitioning into the classroom over the past few decades. Accompanied with these devices is an endless stream of online information indexed by search engines and analyzed by computational engines. However, research is divided as to whether these devices, and the access they provide, has resulted in a net positive effect on education. In a survey by the University of Phoenix in 2017, 71% of teachers felt that personal devices distracted students more than the aid provided. Still, the study also showed that over 50% of teachers used games and simulations to aid learning and allowed students to research subjects through the internet (*Majority of U.S. K-12 Teachers are Assinging less Homework Than Americans May Think*, 2017). As technology will continue progress and enter the classroom, it is important that students and teachers use it effectively.

On the educator's perspective of computational knowledge engines, there exists some foundational research into how to incorporate these engines into lesson plans and teaching methods. Furthermore, there has been some analysis on whether these engines have a net positive or negative result on student's success. One study by a group of researchers in Mexico had educators and Wolfram Alpha developers implement specific widgets for the course content so that the students could input physics problems into a smaller version of Alpha tailored for those problems. The findings showed that these widgets resulted in a "better understanding of abstract concepts" through visualization and revelation of hidden connections among related ideas (Cepeda & Acosta, 2014, p. 269). However, another study suggested that the use of engines such as Alpha to learn probability, required a "deep understanding of mathematics" and the advantage of them was the minimal programming skills required rather than utility towards teaching (Abramovich & Nikitin, 2017). It is possible that these deviation views on knowledge engines are a result of variance in subject matter they were used with, differences in the overall curriculum structure, or numerous other situational factors. In my research, I will attempt to better discern educator's perspective and experiences with computational knowledge engines.

From a student's perspective, step-by-step calculators, search engines, and computational knowledge engines are generally an aid towards completing assignments and better understanding concepts in school. However, there is not extensive research on how students use these tools and again, whether there is a net positive or negative effect on their overall learning. As described in a study by the National Council of Teachers of Mathematics, the benefit of computational knowledge engines is the amount of raw, accurate data available and the ability to represent data in various forms. Furthermore, queries can be structured and combined in a variety of formats further allowing students to recognize nuances in concepts (Thrasher & Perry, 2015). To understand student's perspective on computational engines, I plan to examine primary sources that document when and how these engines are used.

Data Collection

The goal of this STS research is to determine the similarities and differences among students and teacher's perspective and utility of online computational knowledge engines. More specifically, the purpose is to determine where there is ideological dissonance among these two groups and whether this leads to adverse effects towards learning in K-12 education. To gather information on teachers, I will collect and analyze their discourse through online lesson plans, blog posts, reddit posts, news articles, educational journals, survey data. From this data I hope to discover whether teachers create their own lessons plans or use resources available to them. Furthermore, whether there is a distinction in utility through personalized teaching material vs out of the box resources. I will also look through comments on message boards, blogs, and other online discussion forums to pinpoint comment sentiments and shared feelings towards the role of computational engines in classrooms. To understand confounding variables that may impact how these engines are being brought into the education system, I will analyze and determine if there are any relevant trends in conferences and workshops being hosted for teachers. Specifically looking at keynote topics chose, expert panels brought in, hosted workshops, and sponsor content. I hope this information will also answer questions such as if a change in the adoption of computational engines can be tied to an increase in scholarships dealing with technology. Lastly, I will interview some professors in the Curry School of Education at UVA to determine whether my findings are consistent with their experience and knowledge of the subject.

In order to collect data and form an understanding of student's behavior towards computational knowledge engines, I will look at the marketing material provided by the corporations that create computational knowledge engines. This information will be used to determine if the engines are advertised towards students and whether students are aware of these utilities. Furthermore, I hope to determine whether there are any barriers to entry for these tools, including but not limited to monetary costs, technological knowledge, and corporate approval. Since many of these knowledge engines contain application programming interfaces (APIs) and widget builders, the next step of data collection will consist of looking through GitHub and widget repositories to determine if and how students and or teachers have used these tools to customize engines to their needs. I will also analyze articles on tech channels of Medium and other locations where individuals can share write ups for the work they have done with APIs and widgets.

Methods

In order to analyze the data and draw any possible conclusions, I will determine a list of key themes among information collected about teachers and students. These key themes will be important to keep a count of what perceptions and behaviors are shared among teachers and students in regard to computational knowledge engines. I will also sort the extent APIs and widgets were utilized among both groups and use this information to determine whether any specific group(s) of actors possessed a deeper understanding and utility of these engines. My hope is that teachers, students, and corporations can all find utility from these findings. On the teachers end, knowledge of these differences may enable them to modify their teaching style and plan to better suit their students. From the student's perspectives and behaviors, information on barriers to entry and common use cases can be used by corporations to tailor their projects to a wider audience.

The STS research as described above hopefully provides a step forward in the understanding and utility of computational engines in K-12 classrooms. It also should provide a foundation upon which further research can expand and assist in providing resources for teachers to improve overall pedagogy.

Conclusion

In the United States, the education market is expected to reach 2.04 trillion dollars by 2026, up from 1.35 trillion in 2017. In such a large industry it the impact of technology can be huge and small optimizations derived from research have paved how education has improved over the past hundreds of years. In performing research on students' college planning decision process and impact of computational engines K-12 education, I will be able to provide insight on one aspect of how the modern education system is integrated with technological innovation.

References

Abramovich, S., & Nikitin, Y. Y. (2017). Teaching Classic Probability Problems with Modern Digital Tools. *Computers in the Schools, 34*(4), 318–336. https://doi.org/10.1080/07380569.2017.1384687

Cepeda, F. J. D., & Acosta, R. D. S. (2014). Designing a Site to Embed and to Interact with Wolfram Alpha Widgets in Math and Sciences Courses. In I. Arnedillo Sánchez and P. Isaías (Eds.), *Proceedings of the 10th International Conference on Mobile Learning (pp. 266-270)*. Retrieved from http://www.iadisportal.org/digital-library/designing-a-site-to-embed-and-to-interact-with-wolfram-alpha-widgets-in-math-and-sciences-courses

Delgado-Cepeda, F. J. (2016). Widget Based Learning in Math and Physics Undergraduate Courses as Blended Learning Approach. *Athens Journal of Education*, *3*(3), 241–260. https://doi.org/10.30958/aje.3-3-3

Eyyam, R., & Yaratan, H. S. (2014). Impact of use of technology in mathematics lessons on student achievement and attitudes. *Social Behavior & Personality: An International Journal*, *42*, 31–42. https://doi.org/10.2224/sbp.2014.42.0.S31

Fahmy, M. F. (2004). Thinking about Technology Effects on Higher Education. *Journal of Technology Studies*, *30*(1), 53–58. Retrieved from https://eric.ed.gov/?id=EJ905124

Hindin, H. J. (2010). Wolfram Alpha. *Mathematics & Computer Education*, *44*(1), 77–81. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=48082068&site=ehost-live&scope=site

- Kim, J., & Choi, K. (2008). Closing the Gap: Modeling Within-School Variance Heterogeneity in School Effect Studies. *Asia Pacific Education Review*, *9*(2), 206–220. https://doi.org/10.1007/BF03026500

Loewus, L. (2017). *Will Online Tools Make Texas Instruments' Graphing Calculators Obsolete?* Retrieved from https://www.edweek.org/ew/articles/2017/06/14/will-online-tools-make-texas-instruments-graphing.html

Majority of U.S. K-12 Teachers are Assinging less Homework Than Americans May Think. (2017). Retrieved from https://edtechmagazine.com/k12/article/2017/09/classroom-tech-use-rise-infographic

McGill, C. M. (2019). The Professionalization of Academic Advising: A Structured Literature Review. *NACADA Journal*, *39*(1), 89–100. https://doi.org/10.12930/NACADA-18-015

Moore, R., Sanchez, E., San Pedro, M. O., & ACT, Inc. (2018). *Investigating Test Prep Impact on Score Gains Using Quasi-Experimental Propensity Score Matching. ACT Working Paper 2018-6*. Retrieved from ACT, Inc. website: http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED593130&site=ehost-live

Pomerantz, H. (1997). *The Role of Calculators in Math Education*. Retrieved from https://education.ti.com/sites/US/downloads/pdf/therole.pdf

(2014). Potential Negative Effects of Mobile Learning on Students' Learning Achievement and Cognitive Load--A Format Assessment Perspective. *Journal of Educational Technology & Society*, *17*(1), 332–344. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=94937822&site=ehost-live&scope=site

Schacter, J. (1999). *The Impact of Education Technology on Student Achievement: What the Most Curent Research Has To Say.* Retrieved from https://files.eric.ed.gov/fulltext/ED430537.pdf

Schiller, K. (2009). Wolfram Alpha: Focusing on Education With "Homework Day." *Information Today*, *26*(11), 36. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=45576692&site=ehost-live&scope=site

Simpson, C. (2016, May). *Effects of Standardized Testing on Students' Well-Being*. Retrieved from https://projects.iq.harvard.edu/files/eap/files/c._simpson_effects_of_testing_on_well_being_5_16.pdf

The 2011 CDWG Campus Report. (2011). Retrieved from https://edtechmagazine.com/higher/sites/default/files/102442-wp_21st_century_campus_df.pdf

Thrasher, E. P., & Perry, A. D. (2015). High-Leverage Apps for the Mathematics Classroom: WolframAlpha. *Mathematics Teacher*, *109*(1), 66–70. https://doi.org/10.5951/mathteacher.109.1.0066

Vasquez, S. (2017, January 1). *Student Perceptions of the Value of Academic Advising at a Hispanic Serving Institution of Higher Education in South Texas*. *ProQuest LLC*. ProQuest LLC. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED581970&site=ehost-live&scope=site