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Searching for Answers: The Impact of Student Access to Wikipedia

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Abstract

Young people across the developing world are gaining access to the internet. Can schools introduce the internet in a way that promotes reading and learning? We provide Wikipedia access to a random subset of secondary school students in Malawian boarding schools. This setting is unique: students otherwise have limited study resources and no internet access. Students used Wikipedia intensively, and found it accessible and trustworthy. They developed a preference for Wikipedia over other online sources, including for information about news events and safe sex. We find a large impact on English final exam scores (.11 standard deviations), especially for low achievers (.21 standard deviations). Students also used Wikipedia to study for Biology, and exam scores increased for low achievers (.17 standard deviations). Our results imply that Wikipedia is a source of simple and engaging reading material, and can improve English language skills. It is also a source of accessible study material that increases study time productivity for low achievers.

JEL Codes: I21, I28, O15

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1 Introduction

Internet access is expanding worldwide, and young people are early adopters. In the developing world, internet access increased dramatically in the last decade, from 8 percent in 2005 to 42 percent in 2017. In Africa, young people aged 15 to 24 use the internet at twice the rate of the general population.[1] The internet brings about all-encompassing change in our daily lives. It changes the way societies interact, how we acquire information, and how we learn. It informs and misinforms, it entertains and it distracts.

Does the internet have a place in school, and can it be introduced to young people in a way that promotes reading and learning? By showing students how to find accurate information online, schools have an opportunity to produce better learners and informed citizens. Yet, internet in schools presents new challenges. While information on the internet is plentiful, it varies in its accuracy, trustworthiness and complexity.[2] Moreover, students often prefer games, videos and social media to learning. Indeed, there is evidence that full internet access does not improve academic performance (Goolsbee and Guryan, 2006; Vigdor *et al.*, 2014; Faber *et al.*, 2015; Malamud *et al.*, 2019). To learn about, and from the internet, students might benefit from an initial online experience restricted to informational content.

We provide Malawian secondary school students with access to Wikipedia, an online encyclopedia, to answer three research questions.[3] First, how does an introduction to Wikipedia affect a student's ability to find accurate information online, and do students perceive Wikipedia to be more trustworthy than the broader internet?[4] Second, Wikipedia gives students access to reading material on a vast range of topics. How much time do students spend reading, and how does this affect English language ability?[5]

[1] Source: International Telecommunications Unit `https://www.itu.int/en/ITU-D/Statistics/Pages/stat/`, accessed on May 13, 2019.

[2] For new users, trustworthy information is often hard to find or understand (Wang *et al.*, 2006; MacMillan and MacKenzie, 2012). Many websites harbor false or misleading claims, and social media is rife with misinformation (Allcott and Gentzkow, 2017; Lazer *et al.*, 2018).

[3] Rather than restricting to a single information source, existing work measured the impact of full scale internet access on education (Bulman and Fairlie, 2016; Yanguas, 2018; Malamud, 2019), political and economic behavior (Goyal, 2010; Bailard, 2012; Miner, 2015; Campante *et al.*, 2018; Chen and Yang, 2019) and development (Galperin and Viecens, 2017; Hjort and Poulsen, 2019). Randomized experiments specifically involving Wikipedia focused primarily on the decision to contribute to a public good (Chen *et al.*, 2018; Hinnosaar, 2019).

[4] There is evidence that Wikipedia is mostly accurate, though incomplete. Giles (2005) shows that Wikipedia is relatively accurate compared to the Encyclopedia Britannica and Rosenzweig (2006) shows that for history knowledge, Wikipedia is more accurate than the encyclopedia Encarta. For the quality and accuracy of health-related information, see Clauson *et al.* (2008) and Heilman *et al.* (2011). Mesgari *et al.* (2015) provides a complete assessment of Wikipedia's comprehensiveness, currency, readability and reliability.

[5] English is an official language of Malawi, and most courses are taught in English.

Third, what is the impact on academic performance in Biology, an important subject for which study materials are crucial? Biology is the most popular subject, and is important for career aspirations, as many students go on to a career in health care.[6]

We conducted a randomized experiment in government boarding schools in Malawi, a country with rapidly improving internet infrastructure, but where students have limited internet experience, no internet access, and few study resources. This setting allows us to isolate both treatment and control students from the broader internet. Students were allowed to use Wikipedia inside a digital library. It was open evenings and weekends during one school year, and access was restricted to treated students. This design limits potential spillovers on English language skills and Biology exam scores.[7] Students did not have any other internet access during term time.

Students found the online material engaging, as evidenced by their frequent and broad use of Wikipedia. They spent, on average, one hour and twenty minutes per week online. Unlike studies that rely on aggregate usage statistics,[8] we observe browsing histories, which allows us to characterize demand for specific topics at the level of an individual. Each student browsed, on average, more than 800 different pages across a range of topics.

We find that students came to use and trust Wikipedia, particularly for topics which are important and prone to misinformation, such as world news and safe sex. We find spikes in activity in the week surrounding world news events that occurred during the experiment, such as the arrest of Robert Mugabe, the Zimbabwean dictator, in November 2017. We also show that students with access to Wikipedia are able to find news information that control group students cannot. Information about safe sex in particular is crucial for young people (Dupas, 2011; Derksen and van Oosterhout, 2018; Kerwin, 2018). We find that students spent 5 percent of their browsing time on topics related to sex and sexuality. Students sought information on both news and sex and sexuality independently, without prompts or incentives.[9] At endline, treatment students were more likely than control students to report a preference for Wikipedia over other internet sources for both online news and information on safe sex, and were more likely to view it as easier to use and more trustworthy. Indeed, a majority of treatment students

[6]We pre-registered final (term 3) English and Biology scores as our two primary outcomes (AEA RCT Registry number AEARCTR-0003824). English and Biology are core courses and are most often named as a favorite subject at baseline, and these subjects have the highest rate of exam completion.

[7]We include a specification that estimates such spillovers in the appendix.

[8]See Okoli *et al.* (2014) for a review of the literature.

[9]In fact, Chen and Yang (2019) show that even when provided with an internet VPN, university students in China do not search for international news unless incentivized. Our results suggest that interest in world news may be different outside of a censored regime.

preferred Wikipedia along these dimensions.

Students also used Wikipedia for general interest reading, and our strongest impacts are on English final exam scores. We find a significant improvement on average (.11 standard deviations) and for low achievers in particular (.21 standard deviations) in their final exams.[10,11] Students in the treatment group spent more than one hour every week reading articles in English, primarily on topics that were not directly related to the school syllabus. This should not be viewed as a harmful distraction, as we can rule out even small negative effects across most subjects. Instead, we find a positive treatment effect on English exam scores that grows over time.

The fact that Wikipedia alone improves English language skills is remarkable, because interventions that simply provide reading material are usually ineffective (Glewwe *et al.*, 2009; Borkum *et al.*, 2012; Sabarwal *et al.*, 2014).[12] To work well, reading interventions typically require intensive teacher involvement (Machin and McNally, 2008; Abeberese *et al.*, 2014; Lucas *et al.*, 2014; Kerwin and Thornton, 2018).[13] We suggest that a simple reading intervention can be successful with a base level of student literacy, and a supply of engaging, wide ranging and accessible material.

By linking search terms to the school syllabus, we show that students find Wikipedia to be a useful study resource, especially for Biology. In other contexts, survey data suggests that students see value in Wikipedia as a study tool (Lim, 2009; Head and Eisenberg, 2010; Colón-Aguirre and Fleming-May, 2012). Here we observe student browsing choices directly. We did not incentivize or pressure students to use Wikipedia for school, yet the average student did spend 22 percent of their time on pages related to the school syllabus. They spent more than twice as much time on Biology-related pages as on any other school subject.

This translates to an improvement in study time productivity and Biology exam scores for low achievers. We find a small positive impact on Biology exam scores (.06 standard deviations in final exam scores), but a much larger and significant impact for low achievers (.17 standard deviations). Low achievers did not spend more time on syllabus-related pages than high achievers, and neither low nor high achievers changed

[10]Throughout the paper, we define a low achiever to be a student whose exam score at baseline is below the median. This is calculated based on an average of English and Biology scores.

[11]In our setting, English exam scores measure English language ability. We include a sample English exam in Supplementary Materials in the appendix.

[12]Knauer *et al.* (2020) also find that providing story books to young children at home does not increase their vocabulary overall.

[13]Other interventions that improve language skills involve machine or computer-aided learning in combination with extra instruction (He *et al.*, 2008; Muralidharan *et al.*, 2019).

their total study time in response to the intervention.[14] This implies an increase in study time productivity for low achievers. Indeed, we find that most treatment students preferred Wikipedia to their Biology textbooks, and were able to find academic information that their control group peers could not. Students perceived Wikipedia to be easy to use and understand; this would explain larger gains for students who were struggling at baseline. We do not, however, find any treatment effect on student education or career goals, which suggests that the effect on Biology exam scores is driven by study inputs and not by a change in aspirations.

We find no impact on other subjects, which is not surprising for subjects such as Mathematics and Physics which rely more heavily on skills and problem solving and less on reading material. However, we cannot rule out small positive impacts for low achievers. For Mathematics, science subjects, and humanities subjects we find average effect sizes between -.03 and .04 standard deviations. The final term impact on Chichewa, a core school subject and local language which is largely absent from Wikipedia, is -.06 standard deviations, and insignificant. It is suggestive of mild substitution effects, as students shift their attention towards subjects taught in English.

Most education interventions to date target primary school students, and learning gaps in secondary school merit attention. While secondary school attendance is rising, completion rates are low in Malawi and across sub-Saharan Africa.[15] Yet, returns to secondary school are high (Ozier, 2015), and some graduates go on to play important and impactful roles in society. Indeed, secondary school is a necessary step towards postsecondary education, and a career in policy, education or health care.

Moreover, the effect of providing study material to secondary schools is likely to be different from the effect observed in primary schools, due to the advanced subject matter, and the fact that students are not illiterate. Evaluations of programs that provide resources, such as textbooks or libraries, to primary schools in low resource settings typically find little to no effect on academic performance.[16] Glewwe *et al.* (2009) finds that providing textbooks to primary schools improves performance only for high ability students in the higher grades. Information technology resources such as computer

[14]Study time is based on detailed time use data. Study time includes time spent studying in the digital library according to student self reports, but should not include time spent browsing general interest pages.

[15]In Malawi, 26 percent of women and 36 percent of men have at least some secondary education, however, less than half of those who start go on to graduate, see Malawi DHS 2015-16 (National Statistical Office/Malawi and ICF, 2017). According to Barro and Lee (2013), in 2010, 27 percent of individuals in sub-Saharan Africa aged 15 and over had completed some secondary education.

[16]See Glewwe and Muralidharan (2016) for a review of the literature and Borkum *et al.* (2012) and Sabarwal *et al.* (2014).

hardware and internet access also appear ineffective, and students often use the internet for entertainment as opposed to learning (Malamud and Pop-Eleches, 2011; Beuermann *et al.*, 2015; Malamud *et al.*, 2019).[17] On the other hand, several randomized controlled trials have shown that carefully designed computer-aided learning programs can narrow the gap in learning and grade levels.[18] We might expect different gains among secondary school students, though evidence so far is limited (Barrera-Osorio and Linden, 2009; Banerjee *et al.*, 2013).

Wikipedia appears to be a useful substitute for English books and Biology textbooks, and is an accessible, cost-effective and up-to-date alternative for schools operating in low resource settings. Books are expensive to ship, necessarily limited in scope, and become out of date. Internet-enabled tablets and phones are available locally, and internet infrastructure is in place. We estimate that our intervention, as implemented, costs $4 USD per student per month. This is clearly more cost-effective than programs that provide reading material to primary schools, with no impact. It is also more cost-effective than many computer-aided learning programs. Internet and technology costs are decreasing over time, and if implemented in entire schools, the intervention might benefit from additional economies of scale.

The paper proceeds as follows. Section 2 describes the setting, the experimental design, the intervention, and our data sources. In Section 3, we explore student use of Wikipedia and the digital library. In Section 4, we investigate outcomes related to student beliefs, abilities and preferences in the context of Wikipedia and other online information sources. Section 5 presents our results on student academic performance. We conclude in Section 6 by discussing mechanisms, policy implications, and future research.

2 The Intervention: Wikipedia in Schools

2.1 Wikipedia

Wikipedia is an online encyclopedia. It is a large source of collaborative, accurate, non-biased, and open source information.[19] It is the largest and most visited reference site

[17] Other evidence suggesting that computers and internet access have a negative or no effect on school performance includes Fairlie and Robinson (2013), Faber *et al.* (2015) and Cristia *et al.* (2017).

[18] For the effects of computer-aided learning programs, see Banerjee *et al.* (2007), Linden (2008), Carrillo *et al.* (2011), Mo *et al.* (2013) and Muralidharan *et al.* (2019).

[19] The Wikipedia page about itself (`https://en.wikipedia.org/wiki/Wikipedia`, accessed on June 17, 2019 states that "Wikipedia is a multilingual online encyclopedia, based on open collaboration through a wiki-based content editing system. It is the largest and most popular general reference work on the World

on the internet.[20] Wikipedia is free and owned by Wikimedia, a non-profit organization with no advertising. Content is created through open collaboration, and its accuracy on scientific topics is comparable to offline encyclopedias (Giles, 2005).

Wikipedia is a high quality and accessible resource for young people, and especially for students. It provides interesting, accurate and up-to-date reading material on a wide range of topics. Information is easy to find and understand. Articles can be read in English or Simple English[21] (among many other languages), and Wiktionary serves as a companion dictionary. Wikipedia has many well developed pages related to the typical secondary school syllabus, and often provides more detail than a standard textbook. For example, consider the page for photosynthesis, a topic from secondary school Biology. The English page for photosynthesis has over 7000 words and several diagrams, and students can easily click links to similarly detailed pages on related concepts. There is also a Wikipedia page for photosynthesis in Simple English, with less detail, but with very simple explanations, such as "Photosynthesis is the process by which plants and other things make food."

2.2 Setting and Sample

Malawi is a country in southern Africa with a GDP of less than $400 USD per capita, yet internet infrastructure is present throughout the country.[22] 2G networks are largely accessible in rural areas, and 3G and 4G networks are available in towns and cities. Buys *et al.* (2009) find that in 2006, 93 percent of the Malawian population lived in an area with access to a mobile network.[23] This surpasses the network coverage in neighboring Zambia and Mozambique (both at around 40 percent), and is comparable to the much richer South Africa (see Table 1).

Though internet infrastructure exists, access to the internet is unaffordable for most Malawians. 54 percent of Malawian households have a mobile phone,[24] but most of these phones are not internet enabled. In addition to an expensive phone, to purchase

Wide Web (...). Overall, Wikipedia comprises more than 40 million articles in 301 different languages." Regarding the accuracy, the same page reports that "In 2005, Nature published a peer review comparing 42 hard science articles from Encyclopaedia Britannica and Wikipedia and found that Wikipedia's level of accuracy approached that of Britannica."

[20] Source: Wikipedia, https://en.wikipedia.org/wiki/Wikipedia, accessed on May 23rd 2019.

[21] Simple English is a language defined by Wikipedia, which uses simpler words and shorter sentences than English Wikipedia. As of 2019, Simple English Wikipedia has more than 150,000 pages.

[22] According to the World Bank, GDP per capita in 2017 was $339 USD. This is well below the Sub-Saharan Africa and world average of $1,575 and $10,749, respectively. Current USD values.

[23] See Batzilis *et al.* (2010) for a detailed description and analysis of the mobile network in Malawi.

[24] See Malawi DHS 2015-16 (National Statistical Office/Malawi and ICF, 2017).

a 1GB internet bundle the average Malawian would have to spend 45 percent of their monthly income in 2007 (see Table 1). This income share was three times larger than in Mozambique or Zambia, where incomes are relatively higher. By 2017, the internet bundle price in Malawi fell (18 percent of monthly income), but remains higher than neighboring countries. It is not surprising then that internet use in Malawi has lagged behind other countries. As of 2007, less than 1 percent of Malawians had regular access to the internet (see Table 1). This is changing. In 2015, approximately 6 percent of women and 17 of men had used the internet in the past year.[24]

Malawi is on the verge of internet adoption, yet Malawian schools have limited resources and no internet access, making this a unique and appropriate setting for our study. The presence of internet infrastructure makes internet provision in schools feasible. Yet, most of the population, including youth, have limited internet experience. School libraries are small and contain textbooks in limited quantities. Most students do not have access to online resources. Personal devices such as mobile phones are usually prohibited. While some schools do have computer labs, they are typically offline.

At the same time, secondary school is challenging and completion is rare. Only 10 percent of women and 17 percent of men complete secondary school.[24] Courses are taught in English, and require adequate literacy and language skills. The courses are difficult, and study and reading materials are likely to be important.[25] In the fourth and final year, students take a national examination which determines university admission. Among those who sit their final exams, more than one third fail.[26]

Our experiment took place in four government boarding schools which serve high achieving students of mixed socioeconomic status. Each school has approximately five hundred students spread over four forms (grade levels).[27] Government boarding schools are common in Malawi, and are more academically competitive than government day schools and most private schools. Admission is based on a national primary school exam (de Hoop, 2010). While government boarding schools attract top students, fees are not exorbitant.[28] Indeed, many students at our sample schools are of lower socioeconomic status: 42 percent do not have electricity at home, and 45 percent do not have running water. One third of students have at least one parent who did not complete primary

[25]The core subjects are English, Biology, Chichewa (the local language) and Mathematics. Other subjects including Chemistry, Geography, History, Life Skills, Physics, and Social Studies are offered depending on the school, form (grade level) and interests.

[26]The 2018 pass rate for the Malawi Secondary Certificate of Education (MSCE) was 63 percent (https://maneb.edu.mw).

[27]Two are district boarding schools and two are national boarding schools.

[28]The school fees in our schools ranges from 75 and 165 USD per term, with many students on bursaries or scholarships.

school.[29]

Boarding schools provide a controlled environment; students have no access to the internet outside of our intervention, allowing us to cleanly limit internet use to Wikipedia. At the time of the intervention, the school grounds had consistent 3G or 4G network coverage. However, students were not allowed to access the internet or use phones, even outside of class time. Students sleep in dormitories. They are not permitted to leave the school grounds. In particular, they do not go home during the term, so even those who do have home internet access cannot use it.[30]

2.3 Experimental Design

In each boarding school, we set up a digital library where students could access Wikipedia outside of class time. The digital library was open most of one school year: from November 2017 to June 2018. It was open for four hours after school and eight hours on Saturday and Sunday. Each digital library was equipped with 12 internet-enabled Android devices. The 12 devices were shared among 69 to 82 students in each school. We used password-protected software to restrict the devices to Wikipedia and Wiktionary.[31] We put links to English Wikipedia, Simple English Wikipedia and Wiktionary on the main login page.

Inside the digital library, students could browse Wikipedia privately and anonymously. The digital library was supervised by our research staff, referred to as digital librarians. To log into a device, each student used a personal, unique and anonymous username and password.[32] Students could ask the digital librarian for technical help, but were not permitted to talk among themselves. While the librarian supervised the room, they did not monitor the content browsed by students. Students used the devices on their own (not in pairs or groups), and were not permitted to leave the digital library with a device. Students were allowed to take notes, and many did.

Digital librarians held a presentation at each school to introduce the project to students.[33] This introduction was conducted one form at a time. All students received the same information.[34]

[29] These statistics are taken from our baseline survey of students in Forms 2, 3 and 4

[30] Students are sent home for two to four weeks between terms.

[31] We used the software *Kioware* to prevent students from accessing other webpages or applications. Students did not manage to exit the software or access other applications on the devices.

[32] No one, including the research team, would be able to link a specific student to their browsing history.

[33] The teachers also received a short introduction to the project. In this information session, we introduced our digital librarians, informed the teachers about the opening hours of the digital library, the software used to prevent students from having a full access to Internet, and answered their questions.

[34] See Supplementary Materials in the appendix for a detailed description of the classroom introduction.

We conducted a baseline survey in October 2017, and collected baseline exam scores. Our team of eight enumerators surveyed every student in Forms 2, 3 and 4.[35] In total, we interviewed 1,508 students to collect information on their background, past internet use, time use, career and life aspirations, interests, and social networks.

After completing the baseline survey, we randomly assigned students to a treatment group or to a larger control group. The randomization assigned one fifth of students, a total of 301, to the treatment group. The remaining 1,207 students formed the control group. A sparse treatment ratio was chosen to limit spillovers.[36] We also hoped this might reduce feelings of unfairness or disappointment, as a large majority of students found themselves in the control group.[37] A subset of students in the control group (299 students out of 1,207) was randomly assigned to a supplementary survey sample. This sample would be surveyed more extensively than other control group students for the construction of secondary outcomes. We collected baseline exam scores in all subjects from the school administration.

We randomized at the student level, and stratified on four key variables: school, form, exam scores and internet experience.[38] The bin for exam scores is defined as above or below the median score (within the school and form). We used the average of English and Biology exam scores. These are our two primary outcomes; we have data for both English and Biology scores for 95 percent of students at baseline. We constructed a separate bin for students with missing exam score data. Internet experience is defined as whether the student has ever used the internet. There are 51 stratification bins. Tables 2 and 3 show that our randomization is balanced across stratification variables and many other baseline variables.

After the randomization took place, we publicly announced the names of the students in the treatment group, and held a mandatory induction session in the digital library. The digital librarians met with small groups of treatment students to explain the digital library and its rules. They also showed students how to access Wikipedia on the devices, and allowed the students to practice for fifteen minutes. Students were told that breaking the rules would result in suspension or removal of access.[39]

[35] To our knowledge, we surveyed every student who was enrolled and attending school at the time of the survey. We excluded students in Form 1 from the project. We could not get pre-intervention exam scores for Form 1 students. Furthermore, Form 1 students often arrive late in the first term, and including them would have delayed our experiment.

[36] We estimate the spillovers in the appendix and show that our results are robust to such specification.

[37] At endline, 79 percent of control students and 91 percent of treatment students felt the program was fair.

[38] We used a computer to randomize using the Stata command *randtreat*, seeded with the date of the randomization (2910).

[39] See Supplementary Materials in the appendix for a detailed description of the induction and digital

During the induction, the students obtained an anonymous username that they would use to log in to the browsing application, which would be linked to their browsing history. The first letter of the username identifies coarsened student characteristics. Students with similar characteristics attended the same induction, and drew their usernames from the same envelope. This made it clear that browsing data obtained by the researchers would not be linked to a particular student. Students also chose a private password. The students were told to remember their username and password and to keep them private.

Treatment students were invited to visit the digital library during opening hours, and sign in with the digital librarian to use a device within the digital library. If all devices were in use, they would join the waitlist or come back later. If there were students waiting, usage was restricted to approximately 30 minutes.[40] A digital librarian recorded arrival time and device usage for each student in a waitlist book. Only students in the treatment group used the digital library, and the librarians used student photos to verify a student's identity.[41] This restriction limits the scope for any spillovers to the control group that would rely on direct access to devices, Wikipedia or the internet.

2.4 Data Sources

We use a diverse set of data sources to measure outcomes and describe student behavior. We explore student browsing patterns by accessing the complete and detailed browsing history from our Wikipedia-enabled devices. In addition to the baseline survey, we conducted two endline surveys. These surveys capture students' beliefs, preferences and abilities with respect to online information. We also use these surveys to document student time use, class participation and aspirations. We measure academic performance using a panel of administrative data containing student exam scores. We will explain each data source in detail in Sections 3, 4 and 5.

3 How Students Used Wikipedia

In this section, we describe in detail how students in the treatment group used Wikipedia. We explore how students use a new online information source, what types of infor-

library rules.

[40] Digital librarians allowed for extra minutes due to poor network signal.

[41] Every week, a field team leader would visit each digital library to spot check the identities of the students and verify that no student in the control group was given access to the digital library. We also conducted spot checks, comparing student signatures to the baseline survey. We did not encounter a case where a control student gained access to the digital library.

mation they value, and the tradeoff they face between general interests and academic subjects. Browsing behavior gives us a window into student interests and demand for information, which we will explore further in Section 4 using survey data. Understanding browsing behavior will also be key to interpreting results on academic performance in Section 5.

Our browsing data is rich and granular, which allows us to provide a detailed analysis of browsing behavior, beyond a description of basic usage statistics. We begin by documenting the number of browsing hours and pages visited. We then categorize pages according to subject matter, and characterize student interest within and across broad topics. We examine whether students use Wikipedia to learn about certain topics which are important for young people and subject to misinformation: world news and sex and sexuality. Finally, we map the school syllabus to Wikipedia pages, and discuss the extent to which students use Wikipedia directly as a study tool.

3.1 Browsing Data

Browsing data was recorded by software on our Wikipedia devices, and contains the complete sequence of pages visited by a particular student (linked to an anonymous username), a timestamp, and the time spent on each page. Although the browsing data does not identify any individual student, each username is linked to coarsened student characteristics.[42]

Students made regular use of the digital library, and every student in the treatment group visited at least once. Most students made frequent visits. On average, students visited the digital library 33 days during the school year and each visit lasted 52 minutes.[43] This adds up to approximately one hour and twenty minutes per week for each student, or 29 hours over the course of the year.

The students spread their browsing time over a large number of different Wikipedia pages. The 301 students in the treatment group visited 101,808 unique Wikipedia pages.[44] Each student visited an average of 878 unique pages, and spent about two and a half minutes per page. 99.9 percent of pages visited were in English, and nearly 7 percent were in Simple English.

In Panel A of Figure 1 we present the distribution of browsing hours across students.

[42]More specifically, we are able to retrieve indicators for: school, gender, whether the student had used the internet in the past, and exam scores above median at the baseline.

[43]The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations. We consider any browsing time within the same day to constitute one visit.

[44]We define a Wikipedia page to include URLs corresponding to the same particular search term. This means that, for example, pictures within a page are not counted as separate pages.

The distribution is skewed to the right. While the average student spends 29 hours in the digital library, some students spent more than 150 hours browsing Wikipedia, over more than 100 visits. The time spent in the digital library is similarly distributed across those with and without past internet experience (Panel B of Figure 1), and across low and high achievers (Panel C of Figure 1). This suggests that the intervention was accessible even to students with weaker digital or language skills. Girls and boys both made frequent use of the library, with boys using it slightly more than girls (Panel D of Figure 1).[45]

3.2 Topic Classifications

We next classify Wikipedia pages according to topics. We use this classification to shed light on specific student interests. We also use it to describe broadly how students search across different topics.

We use the Wikipedia category tree to classify Wikipedia pages into broad yet meaningful topics. Wikipedia has a user-generated and user-maintained category tree. The tree has 39 top-level categories which correspond to broad areas of knowledge. We adopt the top-level categories as topic classifications.[46] Each top-level category branches into one or more subcategories which, in turn, may contain both pages and narrower subcategories.[47] A Wikipedia page typically belongs to more than one narrow subcategory. For example, the page on Barack Obama is associated to over 40 subcategories such as "Presidents of the United States", "University of Chicago Law School faculty" and "Grammy Award winners". By following different paths through the Wikipedia category tree, we might categorize it under more than one top-level category. In order to generate a unique topic classification, we proceed as follows. We consider every path in the Wikipedia category tree that reaches the top of the tree in at most six steps. We then select the top-level category that appears most often at the top of these paths. For example, the topic we assign to Barack Obama's Wikipedia page is "People".

Panel A in Figure 2 presents the 24 most common Wikipedia Browsing topics accord-

[45] We note that girls logged 9 fewer hours in the digital library. This is partly driven by occasional electricity black-outs in the schools during the intervention period, as schools sometimes prevented girls from leaving their dormitories.

[46] The full list can be found at https://en.wikipedia.org/wiki/Category:Main_topic_classifications and is reproduced here for convenience: Academic Disciplines, Arts, Business, Concepts, Crime, Culture, Economy, Education, Energy, Entertainment, Events, Food and drink, Geography, Government, Health, History, Human behavior, Humanities, Knowledge, Language, Law, Life, Mathematics, Military, Mind, Music, Nature, Objects, Organizations, People, Philosophy, Politics, Religion, Science, Society, Sports, Technology, Universe, and World.

[47] For more information on the tree structure, see https://en.wikipedia.org/wiki/Wikipedia:Categorization#Topic_categories.

ing to time spent. The most visited topic, with an average of four hours per student, is "People". The pages within the topic might be about musicians, athletes, politicians, or other individuals of interest. The second most popular topic is "Entertainment", with two hours on average per student. Many popular topics including "Life", "Academic disciplines", "Arts", and "Nature" are likely to overlap with school subjects. We will identify school-related pages using a narrow classification in Section 3.5.

The students browsed a multitude of pages spread across different topics. This could indicate variation in browsing interests across students, or that individual students have broad interests. To shed more light on this distinction, we generate a measure of within-student topic concentration. We calculate the share s_{ij} of time that student i spent in topic $j = 1, \ldots, 39$ across all visits to the digital library. We then compute the following diversity index:

$$d_i = \frac{1}{\sum_j^{39} s_{ij}^2}.$$

This is a modification of the Herfindahl index. It is simple and intuitive: if a given student splits time equally between N topics, then $d_i = N$. If the student's time is split unevenly, the measure reflects this. For example, if the student spends 99 percent of their time on one topic, $d_i \approx 1.02$. Thus d_i is roughly the number of topics that student i spends time on. In Panel B of Figure 2, we plot the distribution of d_i across students. We see that, on average, the diversity index is $d_i = 8.6$ topics. This illustrates that the variation in topics shown in Panel A is driven both by different interests across students, as well as by the fact that individual students spend time on a wide variety of topics.

3.3 News and World Events

In this section, we investigate whether students use Wikipedia to learn about the news. We focus on the news for two reasons. First, other popular news sources, such as social media and online news sites, are often biased and sometimes inaccurate.[48] By comparison, news articles on Wikipedia are often impartial and accurate. If provided with this type of fact-based resource, will young people use it to read about world events? Do they still find news stories compelling when delivered in a dispassionate format? Second, while the previous section provided a broad overview of the topics browsed by students, a focus on world events allows us to describe student browsing behavior with

[48]There is variation in the credibility of news across different sources of information (Chung *et al.*, 2012).

some additional clarity and depth, at least along one dimension. For example, the popularity of "People" pages may be partially explained by an interest in important figures at the center of a news story.

We ask whether students read about a news event in the time leading up to or immediately following the event.[49] We associate a particular news event to specific pages in Wikipedia.[50] We record the number of hours per week spent browsing associated pages.

Let us first focus on some specific examples. Consider two major news stories from Africa: the arrest of Robert Mugabe, the Zimbabwean dictator, on November 15th, 2017; and the resignation of Jacob Zuma on February 12th, 2018 (Panels A and B of Figure 3). These news stories generated significant interest from students. The week of Robert Mugabe's arrest, the average student spent nearly one minute reading about it. On the other hand, some events that generated international interest did not catch the attention of students. In Panels C and D of Figure 3, it seems that students were not interested in the US government shutdown (January 20th, 2018), nor the poisoning of the Skripals in the UK (March 3rd, 2018).

In order to gauge interest in world news more generally, we use Wikipedia's comprehensive list of 54 major world events that happened after the start of the intervention and prior to the start of the endline surveys (November 2nd, 2017 to May 9th, 2018).[51] We classify these events according to whether they occurred in Africa or elsewhere, and whether or not they were geopolitical events. To aggregate across events, we normalize the time-of-event to $t = 0$.

We observe a clear spike in student browsing activity during the week the event occurred (Panel A of Figure 4). The average student spent 1.7 minutes browsing these news stories, aggregated over the 54 events. While few students read about any particular event, most students searched for at least one. The spike emerges for both African and non-African events (Panels B and C of Figure 4). Events occurring in Africa are much more popular, with students spending 15 times longer on news events taking place in Africa (Panel B of Figure 4). This underestimates total interest in the news, as many African and Malawian news events are not included among Wikipedia's top 54 stories.

[49] Students might learn about news events from Wikipedia itself (as Wikipedia's main page has a section on news), from teachers, or during term breaks.

[50] For a particular event, we generate a list of narrow keywords associated with that event. We include all Wikipedia pages that contain any of those keywords in the title. The full list of keywords is available in Supplementary Materials in the appendix.

[51] Source: https://en.wikipedia.org/wiki/2017 and https://en.wikipedia.org/wiki/2018. We removed ten events that we could not link to a specific Wikipedia page.

3.4 Sex and Sexuality

Next, we examine the extent to which students use Wikipedia to learn about sex and sexuality. These are important topics for young people, and while teenagers are often curious, the information they obtain is not always accurate. Misinformation has serious consequences. It can lead to unwanted pregnancy, inappropriate behavior, and health issues. In particular, HIV infection is a significant concern for many young Malawians. Wikipedia contains extraordinarily detailed, accurate, and up-to-date information on many aspects of sex and sexuality including human reproduction, sexuality and sexual health.

We again use Wikipedia's category tree to quantify the time students spend on pages related to sex and sexuality. None of the top-level Wikipedia categories correspond to this topic, and it is therefore not captured in Figure 2. However, the category "Human Reproduction" is two levels below the top, and includes subcategories for "Human Sexuality" and "Sexual Health". As in Section 3.2, for each page visited, we examine every path in the Wikipedia category tree that reaches the top in at most six steps. If the category for "Human Reproduction" appears in any of these paths, we categorize the page as related to sex and sexuality.

The average student spent 1.5 hours, or approximately five percent of their time on pages related to sex and sexuality. They visited 48 different pages on this topic. Comparing this to Figure 2, we see that sex and sexuality would rank among the top ten general interest topics. The page for "Sexual Intercourse" is the most popular page within this topic and across all Wikipedia pages. The average student spent 8 minutes on that page.

3.5 The School Syllabus

Wikipedia has the potential to impact student learning in various direct and indirect ways. Here we focus on whether students use Wikipedia to study their school subjects directly, and if so, for which subjects. Wikipedia has content on every academic subject, and might replace or complement a textbook. In secondary school, textbooks are widely used and likely very useful for some subjects, but are often in short supply. The findings of this section will inform our later discussion of results on academic performance and student time use.

We manually map the Malawian secondary school syllabus to specific Wikipedia pages and narrow Wikipedia subcategories from the category tree described in 3.2. For example, the subcategory for "Circulatory System" matches a topic in the Biology syl-

labus, and we include it in our list of syllabus subcategories. We do not include broad categories such as "Biology" or "History". If a Wikipedia page matches a topic for a particular school subject, or belongs to a syllabus subcategory, we classify it as directly related to that subject syllabus.[52]

We find that students do use Wikipedia as a study tool. The average student spent 6.3 hours on pages related to the school syllabus, with some students spending as many as 20 hours on school subjects (Panel A of Figure 5). Comparing this to Figure 2, we see that students spent more time on school subjects than on any general interest topic. High achievers spend more time on the syllabus than low achievers (7.5 versus 5.3 hours), despite similar total browsing hours (see Figure 6). We will discuss these patterns further in relation to the intervention's impact on academic performance in Section 5.

We saw in Section 3.2 that students have wide ranging interests, and we expect students to face a tradeoff between browsing general interest pages and syllabus pages. On average, students allocate 22 percent of their browsing time to pages directly related to the syllabus. There is also heterogeneity along this dimension: some students spent up to 60 percent of their time on syllabus-related pages (Panel B of Figure 5).

The tradeoff between general interest and syllabus-related browsing might shift over time. For example, students might focus on their studies right before exams, or lose willpower towards the end of a term. In Figure 7 we plot the use of the digital library over the school year. While overall browsing was slightly higher at the introduction of the intervention, the digital library was used consistently over all three terms, and the share of syllabus-related browsing was roughly constant. In all three terms there is a decline in digital library use immediately before the exam period. It is not clear whether this indicates a fall in student demand, or an effort by teachers to limit access.

We might expect syllabus-related browsing to drop sharply within a single browsing session, as students are tempted towards general interest topics. In Panel A of Figure 8, we show the fraction of students that are browsing for syllabus-related material at a given second counted from the start of the browsing session. In this figure, we average across all users and sessions. We do not see a sharp drop in syllabus-related browsing. The share of students browsing syllabus-related pages is relatively stable though slightly declining over time. The peak is achieved at around 10 minutes of browsing time, when roughly one fourth of students are browsing pages related to the syllabus.[53] The share

[52] We include pages that are several layers below the category, as long as the overall path length of the tree is at most 6 steps from the top of the tree.

[53] The initial minutes are spent on the log in page, Wikipedia main page, or searching for the page of interest.

declines to one fifth of students after 50 minutes of browsing.[54]

Wikipedia is likely to be more useful for some subjects than others, and we find that students browsed Biology pages more than any other subject. We examine syllabus-related browsing for each school subject (Panel A of Figure 9). By far, the most frequently browsed subject was Biology (2.7 hours on average). This was followed by other science subjects (Physics and Chemistry, one hour each), humanities (Social Science, Geography, History, Life Skills and Agriculture, thirty minutes to an hour), and, finally, English and Mathematics (below thirty minutes each).[55]

3.6 Discussion of Student Browsing Patterns

As we examine student browsing patterns, the following stylized facts emerge. First, students made extensive and heterogeneous use of Wikipedia, with some students spending much more time than others. Second, individual students had broad interests: they visited a multitude of pages on a variety of topics. Third, students showed an interest in using Wikipedia to learn about important topics such as world events and sex and sexuality. Finally, by matching the Wikipedia pages to the school syllabus, we find that approximately a fifth of their time was spent on pages directly related to their school subjects. Students appear to find Wikipedia useful as a study tool, especially for Biology, but other interests compete for their time.

Wikipedia is a source of information, but it is also a source of reading material. The reading material available on Wikipedia is broader, more compelling, and easier to understand than the books typically found in a school library. Indeed, we find that students in the treatment group spent more than one hour per week reading articles on Wikipedia, and spread their time across many different topics and pages. The intervention could easily be re-characterized as a very well-received literacy program.

[54] In Figure A1 we compute transition matrices between different topics and school subjects across visits to the digital library (Panels A and C) and 10-minute windows of browsing time (Panels B and D). We find that the transition matrices are close to diagonal, suggesting that students, on average, more often remain on the same topics or subjects for the duration of the browsing session and across different visits to the digital library.

[55] In Panel B of Figure 9 we recompute the Herfindahl-based diversity index for syllabus subjects. Students spread their time among approximately five subjects (out of ten). This indicates that each student acquires information on a relatively broad set of subjects beyond Biology.

4 Information and the Internet

Online information is unregulated, and sometimes spurious, biased, or contentious (Allcott and Gentzkow, 2017; Lazer *et al.*, 2018). In contrast, Wikipedia serves as an accessible and usually accurate source of information. By giving students an intensive introduction to Wikipedia, we might affect how students engage with online information. First, students might become more comfortable with information technology, and learn to use it to quickly find accurate information. Second, students might learn that Wikipedia is an easy to use and reliable source of information, and develop a preference for it over other online sources.

In this section, we measure the impact of the intervention on student information seeking. Our outcomes include student beliefs, abilities and preferences. We first assess whether students learned what Wikipedia is and how it can be used. We next test their ability find information, directly on an internet-enabled device, and more generally with the resources available to them at school, including the digital library. Finally, we ask students to compare Wikipedia to other online information sources for various types of information, and along several dimensions.

4.1 Data and Empirical Strategy

We conducted two endline surveys. Endline Survey A took place between May and June, 2018. It had two versions: a short version that was administered to all students in Forms 2, 3, and 4, and a longer version that was administered to students in the treatment group and to the subsample of control students who were randomly selected for supplementary surveys. Endline Survey B was a longer survey administered to treatment students and to the subsample of control students. Endline B took place after Endline A, in June and July, 2018.

We have a low rate of attrition for both Endline Surveys A and B (Table 4). The attrition rate for Endline A is 5 percent in both the treatment group and the supplementary sample control group. There is significantly higher attrition in the full control group (8 percent), and this should be noted when interpreting the results on time use and participation in Section 5.3. The attrition rate for Endline B is 8 percent, with no differential attrition between the treatment and control groups.

To investigate the impact of the intervention on survey outcomes, we estimate the following regression equation:

$$y_i = \beta \text{Treatment}_i + \sigma_s + \varepsilon_i. \quad (1)$$

Here, y_i is a survey outcome measure for student i at endline. Treatment_i is a indicator for treatment status. ε_i is a mean-zero error term. To estimate our standard errors consistently, we also include a fixed effect for the stratification bin, σ_s, where s is the stratification bin for student i.[56] We report heteroskedasticity-robust standard errors.[57]

We use ordinary least squares to estimate the treatment effect β. Because treatment status Treatment_i is randomly assigned, we expect the error term to be mean-independent of treatment status, $\mathbb{E}(\varepsilon_i|\text{Treatment}_i) = 0$. Therefore, in the absence of spillovers, the OLS estimate $\hat{\beta}$ is unbiased.

Some of our outcomes are surely subject to spillovers. For the outcomes examined in this section, spillovers are likely to be positive, from treatment students to other treatment students or from treatment students to control students. Then, for all specifications, $\hat{\beta}$ is an underestimate of the true effect of a school-level intervention.

For some outcomes, we investigate heterogeneous treatment effects with respect to past internet use, as past use may shape students' comparisons of Wikipedia to the broader internet.

$$y_i = \beta\left(\text{Treatment}_i \times \text{NoPastInternet}_i\right) + \gamma\left(\text{Treatment}_i \times \text{PastInternet}_i\right) + \sigma_s + \varepsilon_i \quad (2)$$

Here, PastInternet_i and NoPastInternet_i are indicators for whether or not student i reported past internet use at baseline. PastInternet_i is one of our stratification variables, and its intercept is absorbed by the stratification fixed effects σ_s.

4.2 Ability to Find Information

First, we show that treatment students are more likely than control students to understand what Wikipedia is and how it can be used. In Endline A, we ask students whether they believe it is possible to find information about world events on Wikipedia, to find student exam scores, to watch movies, and to communicate with friends. We also ask students to identify several logos for internet applications, and note whether they correctly name the Wikipedia logo. We construct a summary index[58] based on correct answers to these five questions. Column 1 of Table 5 shows that relative to the control group, treatment students have a significantly better understanding of Wikipedia (.9 standard deviations of the index score).

[56] This is necessary to produce consistent standard errors (Bruhn and McKenzie, 2009).

[57] We randomize at the individual level, and therefore do not report cluster-robust standard errors (Abadie *et al.*, 2017).

[58] We are guided by Anderson (2008) in our construction of a summary index.

The intervention helped students learn how to use an internet-enabled device to find information quickly and easily. During the Endline B survey, the enumerator handed the student an internet-enabled device equipped with several internet applications including both Wikipedia and Google. The student was asked to find the number of stars in the Milky Way. Most treatment students (58 percent) are able find the correct answer within 2 minutes (Column 2 of Table 5). Only 39 percent of control students succeed at this task.

Finally, we show that students with access to the digital library have better access to information about the news and about academic subjects. We used a small experiment to capture a student's ability to find information at school. In Endline A, each student was given two quiz questions: a news question and an academic question.[59] These questions were different for every student. We incentivized students to find the correct answer in time for the next endline survey: students were told that two weeks later, during Endline B, they would be given a prize for each correct answer. The digital library was open between the two endline surveys. Students in the treatment group are 9 percentage points more likely to find the answer to the news question (Column 3 of Table 5). They are also 11 percentage points more likely to correctly answer the academic question (Column 4 of Table 5). This is perhaps more surprising, as all students had access to the school library, their notes and their teachers. This suggests that the digital library may be useful as a study resource, over and above the resources provided by the school.

4.3 Preference for Wikipedia over the Internet

Early access to Wikipedia might affect the way that young people search for online information and trust its accuracy. Here, we ask whether students prefer Wikipedia to the wider internet, for which types of information, and why.

Using survey results from Endline B, we show that students in the treatment group are more likely to prefer Wikipedia for information about safe sex and the news (Columns 1 and 2 of Table 6). A majority of treatment group students prefer Wikipedia to the internet for these two topics. Indeed, we saw in Section 3 that students did often search for both of these topics. This preference for Wikipedia appears for both students with and without past internet experience. However, when we consider news information, the Wikipedia preference is smaller and insignificant for students with past internet experience (Column 4 of Table 6). This suggests that the intervention may not shift students

[59] The student drew each question from a hat, and kept the slip of paper. See Supplementary Materials in the appendix for a list of sample questions.

away from online news sources altogether.

We also show that treatment students are more likely to actually choose Wikipedia over other internet information sources. As previously mentioned, during Endline B we asked students to find the number of stars in the Milky Way, using a device equipped with both Wikipedia and Google Chrome, as well as other applications. Treatment group students were twice as likely to use Wikipedia for this task (Column 3 of Table 6).

We find that treatment group students are more likely to find information on Wikipedia trustworthy, easy to understand and easy to find as compared to information on the internet (Table 7). Again, these effects appear for both students with and without past internet experience. Within the treatment group, a large majority prefer Wikipedia to the internet along each of the three dimensions.

It appears as though intensive exposure to Wikipedia generated a strong preference for Wikipedia over other online information sources. This is true for sensitive and controversial topics such as world news and safe sex, where misinformation is common and has serious consequences. In addition to finding it easy to use, treatment group students are keenly aware that Wikipedia is a relatively accurate and trustworthy information source.

5 Academic Performance

Wikipedia has the potential to impact academic performance. It might be used directly as a study tool in place of, or in support of, textbooks, notes and teachers. We saw in Section 3 that many students use Wikipedia as a study tool, especially for Biology. It might also affect performance indirectly. For example, it might build knowledge that is foundational or loosely related to school subjects. It might also improve English language skills by offering compelling and wide-ranging reading material. This would likely impact performance in English class, and possibly other subjects, as most are taught in English. Wikipedia content might inspire students to higher aspirations, or shape student interests. There is also the potential for a negative impact, if Wikipedia acts primarily as a form of entertainment or distraction. Given the share of browsing time devoted to non-syllabus topics (Section 3.5), this is a potential concern.

In this section we estimate the impact of Wikipedia access on academic performance. We estimate the impact of the intervention over time and focus on the final exam scores for our main analysis. We also shed light on potential mechanisms by exploring student time use, class participation, and aspirations, as well as stated preferences for Wikipedia as a study tool.

5.1 Data and Outcomes

To measure academic performance, we use administrative data on school exam scores. We collected exam scores for all subjects in all three terms, as well as end-of-year scores for the year before the intervention began.

Our primary outcomes are English and Biology exam scores in the final term.[60] We focus on these two subjects for several reasons. If Wikipedia serves as a literacy intervention, English language skills should improve over time and impact English exam scores. Biology exams require students to learn a large quantity of information, and Biology students are likely to benefit from additional study materials. English and Biology are the most popular subjects in our sample, as measured by enrollment and stated preference. Biology is especially important for students' career prospects. At baseline, a majority of students aspired to become doctors, nurses, or other health care professionals. Many of the students who pass their final exams do go on to college programs in nursing, medicine, or other health specialties.

For each core subject (English, Biology, Math and Chichewa), we construct a separate outcome variable y_{it} representing the normalized exam score in that subject, for student i in term t.[61] These values are normalized within term, form and school by subtracting the mean and dividing by the control group standard deviation. We then subtract the overall control group mean.

Other subjects are offered as electives, or are offered only in certain schools and forms. We combine similar subjects using an index measure that assigns weight to non-missing values at the student level (following Anderson, 2008). We construct an outcome for science subjects (Physics and Chemistry) and a separate outcome for subjects which we loosely define as humanities (Social Science, Geography, History, Life Skills and Agriculture). We again normalize each subject within term, form and school before constructing the summary index measure y_{it}.

Administrative data is missing for some exam scores. We are missing data for between 3 percent and 9 percent of students depending on the term and subject (Table 8). An exam score is missing either because the school lost the record, or because the student did not sit the exam. Across all terms, control students are slightly more likely to have a missing score. This is because they are less likely to sit their English and Biology exams. This difference is only significant in term 2 for Biology.

[60] We pre-registered term 3 English and Biology scores as our two primary outcomes (AEA RCT Registry number AEARCTR-0003824).

[61] Form 4 students do not receive school exam scores at the end of term 3, and for these students we instead collected data on national exam scores.

5.2 Empirical Strategy and Main Results

We estimate the effects of the intervention on exam scores for each subject in each term.[62] We do so to observe the evolution in achievement throughout the year-long experimental period. We then estimate the following equations.

$$y_{it} = \sum_{t=1}^{3} \beta_t \left(\text{Treatment}_i \times 1[\text{Term} = t]\right) + \delta \left(y_{i0} \times \text{Data}_{i0}\right) + \delta_0 \text{MissingData}_{i0} + \sigma_s + \tau_t + \varepsilon_{it} \tag{3}$$

Here, y_{it} is the measure of academic performance for student i in term $t \in \{1, 2, 3\}$. Treatment_i is an indicator for treatment status and $1[\text{Term} = t]$ is the term-t indicator. ε_i is a mean-zero error term. To improve precision, we control for the baseline measure of the outcome, y_{i0}, taken from term 3 of the previous school year. We dummy out missing baseline scores: Data_{i0} and MissingData_{i0} are indicators for whether or not we have baseline data y_{i0} for student i.[63] We include a fixed effect for the stratification bin and a term fixed effect τ_t. We report robust standard errors, clustered at the student level (the level of randomization). Our parameter of interest is the average treatment effect in term t, β_t.

We also implement the heterogenous treatment effect version of the equation above,

$$\begin{aligned} y_{it} = & \sum_{t=1}^{3} (\gamma_t^L \, \text{Treatment}_i \times \text{LowAchiever}_i + \gamma_t^H \, \text{Treatment}_i \times \text{HighAchiever}_i) \times 1[\text{Term} = t] \\ & + \delta \left(y_{i0} \times \text{Data}_{i0}\right) + \delta_0 \text{MissingData}_{i0} + \sigma_s + \tau_t + \varepsilon_{it} \end{aligned} \tag{4}$$

where γ_t^L and γ_t^H capture term-t treatment effects for low achievers and high achievers, respectively.

Because treatment status Treatment_i is randomly assigned at the student level, we expect the error term to be mean-independent of treatment status, $\mathbb{E}(\varepsilon_{it} | \text{Treatment}_i) = 0$. Therefore, in the absence of spillovers, the OLS estimates $\hat{\beta}_t$, γ_t^L and γ_t^H are unbiased.

Spillovers are possible in our setting, from treatment students to other treatment students or from treatment students to control students. They are mitigated by the fact that the digital library is restricted to treated students. In the previous section, we examined outcomes involving awareness, attitudes, and the ability to find a simple piece of information, and all of these are naturally susceptible to spillovers. For academic outcomes, spillovers are likely to be smaller. Any impact on English language skills or

[62] In Appendix, we present the results pooled across terms 1, 2 and 3.

[63] We are missing baseline exam score data for 4 percent of students.

Biology exam scores is likely to be small without direct access to the reading material. We hypothesize small, positive spillovers, which would imply that our estimates are a slight underestimate of the impact of a school-level intervention. In the appendix (Table A2), we provide some evidence that this is indeed the case, using a specification that controls for treated study friends.[64] This implies that $\hat{\beta}$ will underestimate the true effect of a school-level intervention.

We find a significant impact on term 3 English scores, overall and for low achievers, and a significant impact on Biology scores for low achievers. We plot the term-by-term results in Figure 10 (see Table 9 for the point estimates). In the left column, we see average treatment effects, which roughly increase over time for English and Biology scores. This increase is clearer in the right column, where we examine low achievers separately. We see a strong increase over time for English scores, with a treatment effect size of .21 standard deviations in term 3 (Column 1 of Table 10). For low achievers, the impact on Biology scores also increases over time, reaching a .17 standard deviation effect size in term 3 (Column 2 of Table 10).

5.3 Time Use, Class Participation and Aspirations

We now turn our attention to survey data on student time use, class participation, and aspirations. These outcomes will help us understand how Wikipedia affected student behaviour, and potential mechanisms behind the effect on academic performance.

Treatment students who visited the digital library had to reallocate time away from other activities. By examining time use across different activities, we are able to determine whether treatment students substituted away from study time to spend time in the digital library.

We collected time use and class participation data from all students in Endline A, while the digital library was still in operation. We asked students to recall their time spent on specific activities, day by day, for the three days preceding the survey. We then classify time use as studying, recreation or sleep.[65] Study time includes time the students

[64]The spillover effect specification in Table A2 in the appendix contains controls for the number of named study friends at baseline, treated study friends and treated study friends interacted with being a control student. It is difficult to fully capture spillovers using a baseline networks, and doing so in our case introduces noise. In fact, our friendship networks are endogenous to the treatment itself, a finding which will be explored in depth in future research. We choose to rely on study friend networks because Malawian schools assign students to "study circles" at the beginning of the school year, and so such friendship networks are less responsive to the intervention.

[65]We compute average daily study time by summing time spent studying alone and time spent studying with others. To construct a measure of time spent on recreational activities, we sum the time spent hanging out with friends, in school clubs, religious activities, sports activities and any other activities. Finally, we

spent studying in the digital library, but not other browsing time. Indeed, our research staff observed many students actively studying in the digital library, and making notes while browsing. We use equation (1) to estimate the impact of the intervention on study time, recreation time, and sleep.

It appears that students did not take significant time away from their studies to visit the digital library, and did not cut back on sleep either (Columns 1 and 4 of Table 11).[66] Rather, the digital library crowded out time spent hanging out with friends, playing sports, and attending religious activities. On average, treatment students spent 17 fewer minutes per day on recreational activities (Column 3 of Table 11). Low achievers and high achievers reallocated their time in a similar way (Column 2 of Table 11).

In addition to behavior outside of class, access to Wikipedia might affect student participation in class. For example, access to additional information might increase student confidence, motivation, or interest. Class participation might directly affect a student's academic performance, or otherwise indicate a change in student engagement.

To assess the level of participation, we use survey measures of class participation. In Endline A, we asked each student to report the number of times they raised their hand in each class, day by day, over three days. We then take the average number of times they raised their hand over the three days. We use equation (1) to estimate the impact of the intervention on class participation.

We do not find evidence for a change in class participation. On average, a student raises their hand three times per school day. There is no significant difference between treatment and control students (Column 5 of Table 11).

Finally, we investigate the impact of Wikipedia access on student aspirations. Information on Wikipedia might help students choose and plan for a career. It might also introduce new role models. We examine aspirations as an outcome of interest in its own right, and for its potential to explain the effects on academic performance.

We ask students, at baseline and in Endline Survey B, which career they hope to have in the future. In Endline B, we also ask students to name the college they will most likely attend, as well as their dream college.

We first note that our pool of students has high aspirations. At baseline, one third of students hoped to become a doctor, specialist doctor or surgeon. Fully half of student sought a career in health care, including nursing, physiotherapy and other health spe-

asked students the time at which they woke up and went to bed, and compute average awake time over the previous three days.

[66] Note that time spent on general browsing (but not studying) in the digital library is an omitted category.

cialties. Beyond reflecting current health challenges in Malawi,[67] these baseline levels suggest there is limited scope for Wikipedia to increase self-reported aspirations.

We define an indicator variable for a change in career choice between baseline and endline.[68] We use equation (1) to estimate the impact of the intervention on the likelihood of a change in career aspirations.

The intervention does not appear to cause students to change their career aspirations (Column 6 of Table 11). At endline, treatment students and control students choose similar types of careers, with most aspiring to health care positions. In Figure 11 we present the career aspirations of treatment and control students at endline. There are no clear systematic differences. In Panels A and B of Figure 12, we present most likely and dream colleges reported by treatment and control students, and again see no systematic differences.

6 Discussion and Conclusion

We find that providing students with access to Wikipedia affects students along three key dimensions. First, it affects their perceptions of online information. Students are more likely to prefer Wikipedia to the broader internet for its usability and trustworthiness, even for important controversial topics like world news and safe sex. Second, students use Wikipedia intensively, and read articles, in English, on a broad range of topics of general interest. This access to wide ranging reading material, during a full school year, leads to large gains in English exam scores, especially for low-achieving students. Finally, students use Wikipedia as a study tool for Biology, and prefer it to their textbooks. This has a large impact on exam scores for low-achieving students, whose study time becomes more productive with access to Wikipedia.

6.1 Mechanisms

In Section 3, we saw that students spent more than an hour per week in the digital library, and spent most of that time on topics unrelated to the school syllabus. Nonetheless, Wikipedia access did not have a negative impact on academic performance. Using 95

[67] In 2015-16, HIV prevalence in Malawi was 8.8 percent among the 15-49 year-old population (National Statistical Office/Malawi and ICF, 2017).

[68] The outcome variable is coded as equal to one if the individual reported any career choice change between baseline and endline surveys. This can arise due to change in career as well as a change in precision (for example, "doctor" in the baseline to "neurologist" in the endline)

percent confidence intervals, we can rule out negative effects for English scores, and effects below -.03 standard deviations for Biology.

Rather, we find positive average effects on English and Biology scores, and our effect sizes are meaningful when compared to other education interventions. The average treatment effect in term 3 is .11 and .06 standard deviations for English and Biology respectively. These effects are much larger for low achievers. In the final term, low achievers with access to Wikipedia score .17 to .21 standard deviations higher than their counterparts without Wikipedia access. Our estimated effect size are relatively large compared to primary school interventions that provide instructional or reading materials, but smaller compared to intensive teacher training, computer-aided learning programs (Muralidharan *et al.*, 2019), or supplying basic aids such as eyeglasses or lamps (Glewwe *et al.*, 2016; Hassan and Lucchino, 2016).[69] Indeed, some of these programs generate very large effects,[70] but the distribution is skewed by the many students who are near illiterate at baseline. We might expect smaller gains among secondary school students, though evidence is limited.

Our largest effects are on English exam scores. English exams are a good test of English language ability; they include multiple choice questions that test student understanding of words, sentences, and grammar, and essay questions.[71] The effects are concentrated among low achievers, nearly half of whom had a failing exam score in English at baseline. The positive effect grows over time, as language ability develops (Figure 10). In the final term, the gap between low and high achievers is closed by one fifth due to Wikipedia access.

Recall that students spent most of their time in the digital library on general interest topics, unrelated to the school syllabus. The impact on English skills leads us to view student browsing behavior in a different light. If Wikipedia serves as a literacy intervention, it matters less whether students choose to read about academic topics. In fact, we posit that Wikipedia is effective as a literacy tool precisely because it gives students access to reading material on any topic they choose.

Neither low nor high achievers increased their study time in response to the inter-

[69] See McEwan (2015) for a meta analysis of the effects of different school interventions on students achievement in developing countries.

[70] For example, Kerwin and Thornton (2018) finds that a literacy program for primary school students improved reading and writing skills by .45-.64 standard deviations. In primary schools, many of the most effective interventions target math scores (Banerjee *et al.*, 2007), and few studies have outcomes in specialized subjects such as Biology. An exception includes Beg *et al.* (2019) who study the effect of a computer-aided learning program on student performance in science.

[71] We include a sample of questions from an English exam in the Supplementary Materials in the appendix.

vention, yet Biology scores improved rapidly for low achievers. We see a large and significant effect in both terms 2 and 3 (Figure 10). Study time must have become more productive, in particular for low achievers. If Wikipedia is easier to use and understand than standard textbooks, this would explain a rapid increase in study time productivity, especially among students who are struggling. Another possibility is that students substituted time away from other subjects, Chichewa for example, towards Biology, because of Wikipedia access. This is a subtle difference, as it would still suggest that students find Wikipedia to be a superior resource for Biology. In Endline B, we asked students to rank Wikipedia against their textbooks for each subject. We find that 56 percent of treatment students preferred Wikipedia for Biology. This is consistent with the focus on Biology we saw in the browsing data. Students spent at least twice as much time on Biology as on any other subject (Figure 5). This is also consistent with the small experiment we conducted in Section 4.2, showing that students with Wikipedia access were able to find academic information that control students were not (Column 4 of Table 5). Finally, in Section 4.3, we saw that students find and understand information on Wikipedia easily. Taken together, these results indicate that Wikipedia serves as a useful and accessible study tool for Biology.

Chichewa exam scores serve as both a placebo test and a test for substitution effects. Chichewa is a local language spoken by most Malawians, and a core school subject. There is a fledgling Chichewa presence on Wikipedia, but in 2018 there were fewer than 600 pages in Chichewa, and the students did not visit any of them. It is reassuring therefore that we do not find a positive impact on Chichewa exam scores (Table 9). We find some limited evidence for a substitution effect: Wikipedia access might cause students to spend less time on Chichewa and more time on subjects taught in English. The treatment effect on Chichewa exam scores is negative, but insignificant, for both low and high achievers in every term (Figure 10).

We do not find meaningful impacts on Mathematics or science subjects, perhaps because these subjects require tools for problem solving and skill building as opposed to additional reading material. We also do not find any impact on high achievers. It appears that for highly literate students, access to Wikipedia serves as equal part distraction and input to academic performance, with a net effect of zero. We are not able to rule out small substitution effects from Chichewa, as students shift their attention away from that subject towards subjects for which Wikipedia is useful.

It is plausible that Biology exam scores are subject to positive spillovers from treatment students to both treatment and control students, if students shared the information they learned on Wikipedia. In this case, the effect sizes we estimate understate the true

effect of an intervention at scale. English exam scores are less likely to be subject to spillovers. If these gains represent an improvement in English language ability, they are likely due to direct exposure to reading material. Any spillovers appear to be small and positive for both Biology and English exam scores. Controlling for baseline study friends increases the average treatment effect and effect for low achievers (see the appendix).

6.2 Cost-Effectiveness, Policy Implications and Future Research

Providing access to Wikipedia is cost-effective as a substitute for other types of reading materials, and as a literacy intervention in general. We estimate that our intervention, as implemented, costs $4 USD per student per month, including the cost of project management, digital library staff, internet-enabled devices and internet data packages. This is more cost-effective than programs that provide reading material to primary schools, as most have no impact. It is also more cost-effective than many computer-aided learning programs.[72] Our cost-effectiveness is similar to many primary school interventions that increase the teacher-student ratio or provide remedial lessons, but smaller than programs that provide performance incentives to teachers (McEwan, 2015). There are some reasons to expect smaller returns in secondary school, as subject matter increases in difficulty, and students are starting from a higher level of baseline literacy.

This study has important policy implications for educators. Where textbooks are in short supply, Wikipedia might serve as a useful and inexpensive substitute. Wikipedia may in fact be easier to use and understand than classic textbooks, especially for students who are struggling. For students with lower literacy levels, Wikipedia, with both English and Simple English options, is a low-cost and effective literacy intervention. Not only is the reading material simple and informative, it engages student interest. Students are excited to use Wikipedia, and choose to spend a great deal of time reading. This translates to real gains in English language ability.

Providing Wikipedia to students serves as an appropriate introduction to online information, and might affect the way young people use the internet more broadly. We find that students introduced to Wikipedia find it more trustworthy and easier to use than other sites on the internet, including for topics like world news and safe sex. After graduation, many of the students in this study will have access to the internet on a regular basis. In future research, it will be important to measure the long run effects of this

[72] For example, Muralidharan *et al.* (2019) show that Mindspark, a computer-aided learning platform for primary school students, generates a language score impact of 0.23 standard deviations, at a cost of $15 USD per student per month. They find that this is more cost effective than default public spending in India.

intervention on internet use and the ability to find accurate and trustworthy information online.

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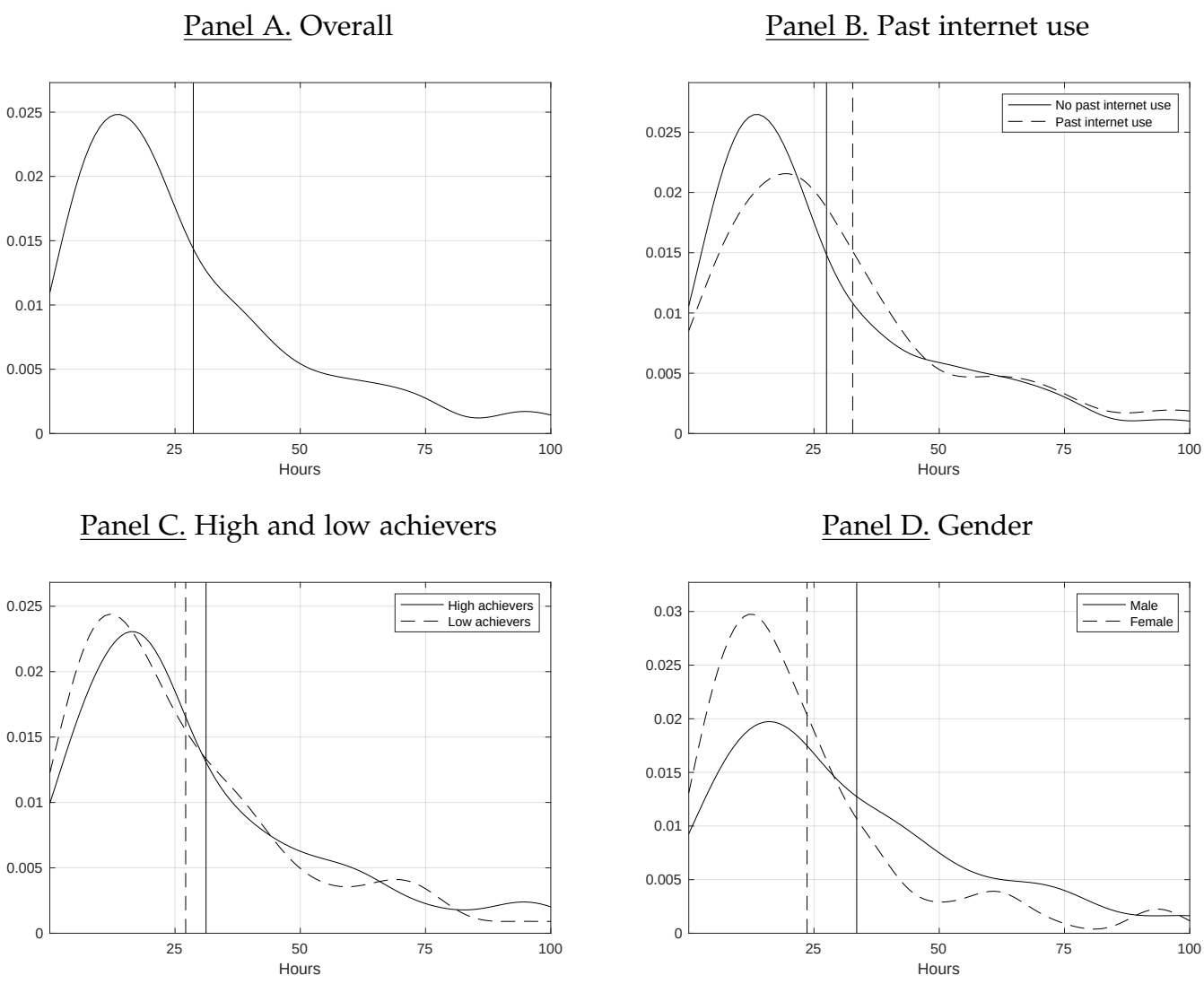
Figures

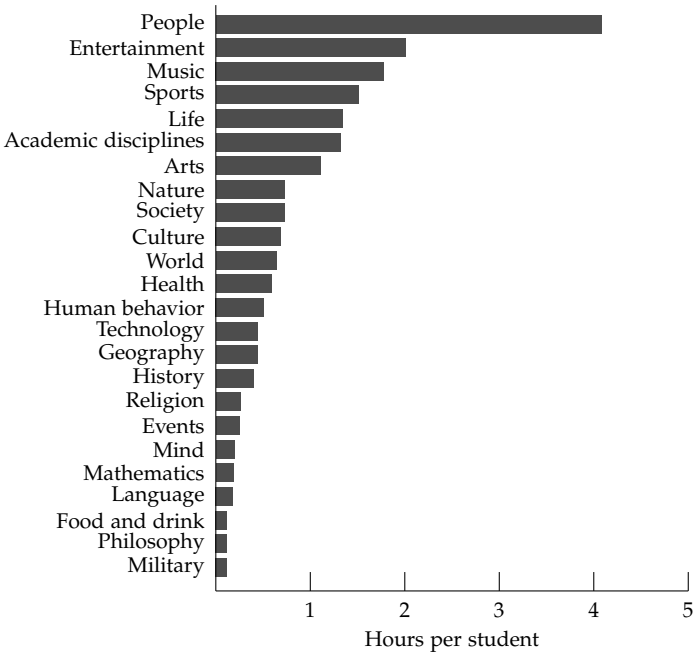
Figure 1: Browsing hours



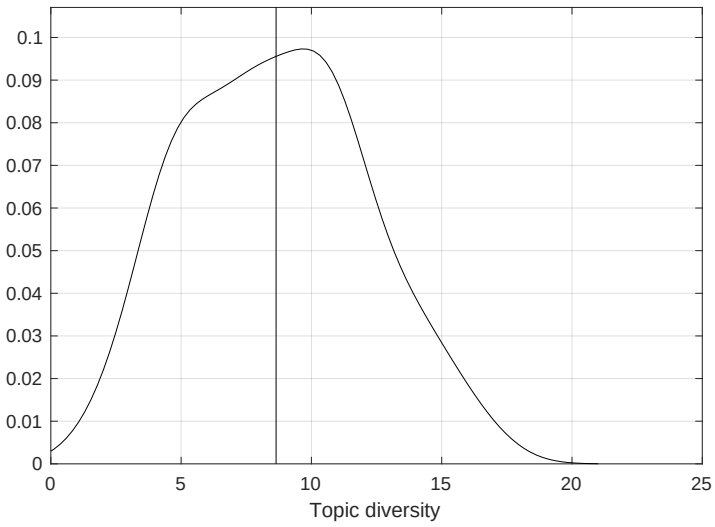
Notes: Density of browsing hours, across treatment individuals only, aggregated over the course of one academic year, for the 108 students who reported internet use prior to the experiment and 97 who reported no prior internet use. We have no information for 96 students. Panel A: Vertical line is the average hours spent browsing of 28.6 hours. Panel B: 27.5 for no past internet use and 32.7 for past internet use. Panel C: 31.2 for high achievers and 27.1 for low achievers. Panel D: 33.5 for male and 23.6 for female. The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

Figure 2: Wikipedia Topics

Panel A. Topic popularity

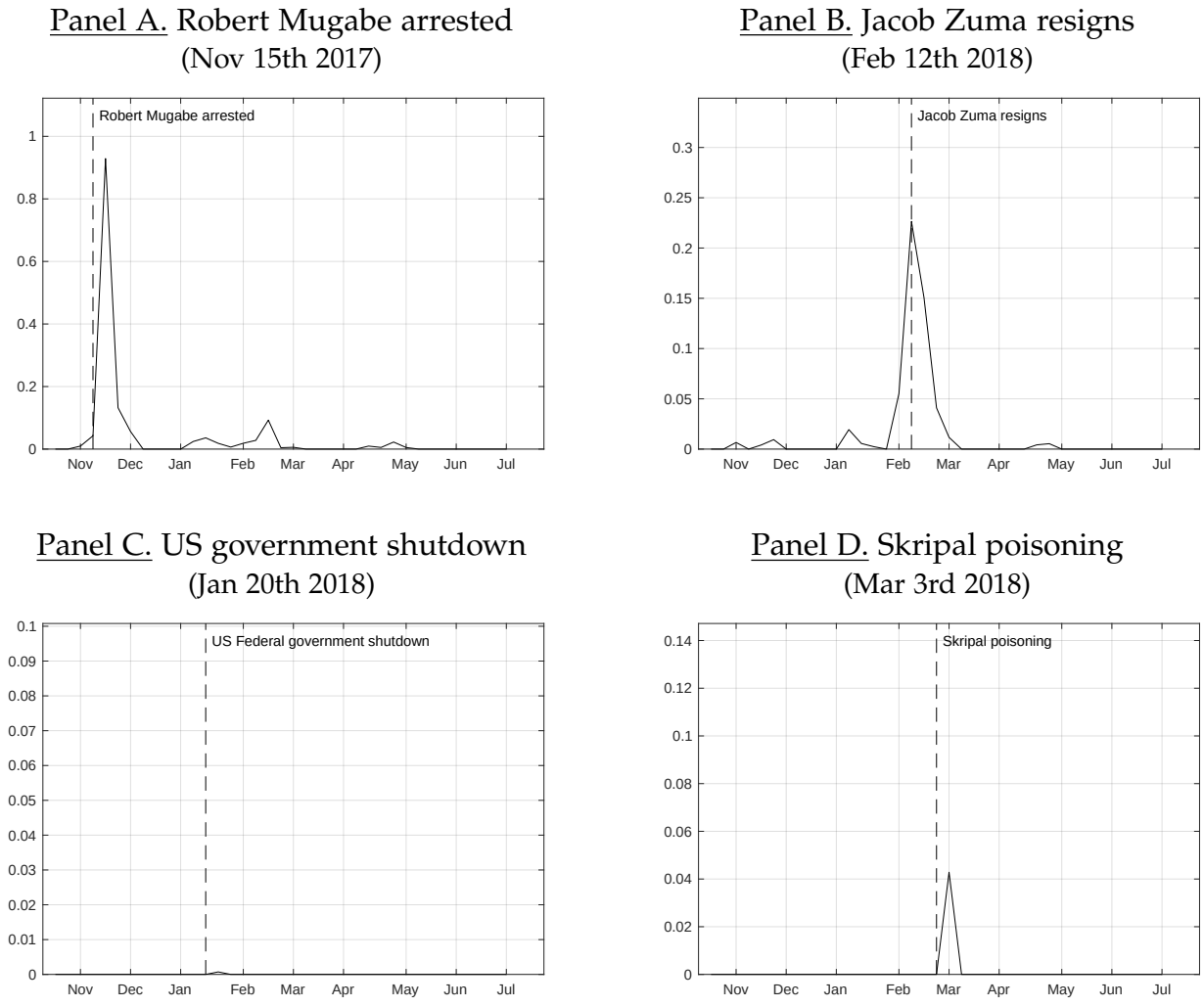


Panel B. Diversity of topics across students



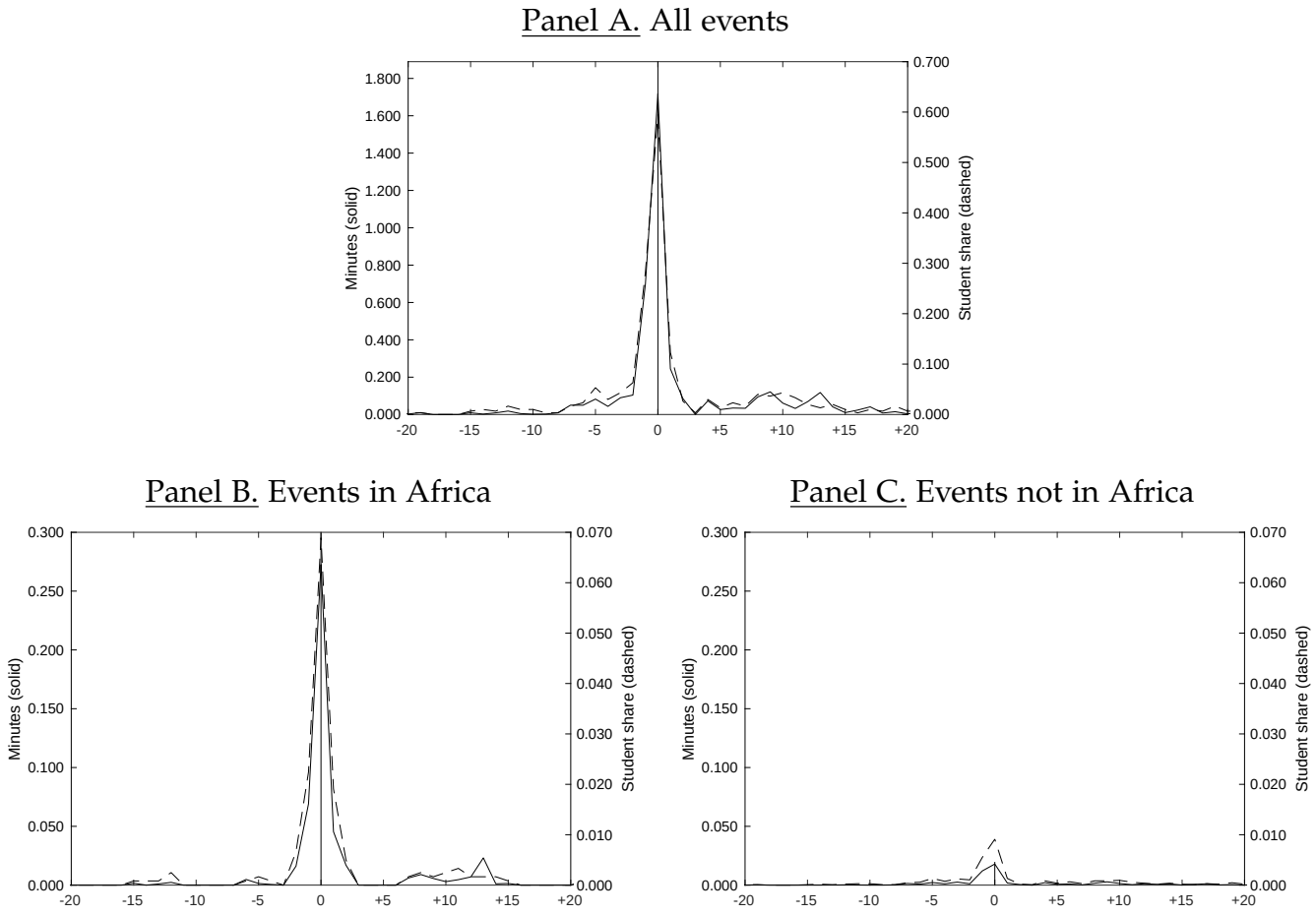
Notes: Panel A: Browsing hours per topic classified under the Wikipedia Category tree, per student, aggregated over the course of one academic year. The topics Business, Concepts, Crime, Economy, Education, Energy, Government, Humanities, Knowledge, Law, Objects, Organizations, Politics, Science, and Universe are excluded from the figure. Panel B: diversity of browsing topics across students. Adaptation of the Herfindahl index, computed as $d_i = 1/\sum_j s_{ij}^2$ where s_{ij} is the share of time that student i spends in topic j, throughout the duration of the experiment. Larger numbers represent broader diversity of topics. Dashed line is the average (8.64 topics). The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

Figure 3: Wikipedia Browsing for Events in 2017-18



Notes: Average amount of browsing minutes by week spent on specific Wikipedia pages related to worldwide events by week of experiment.

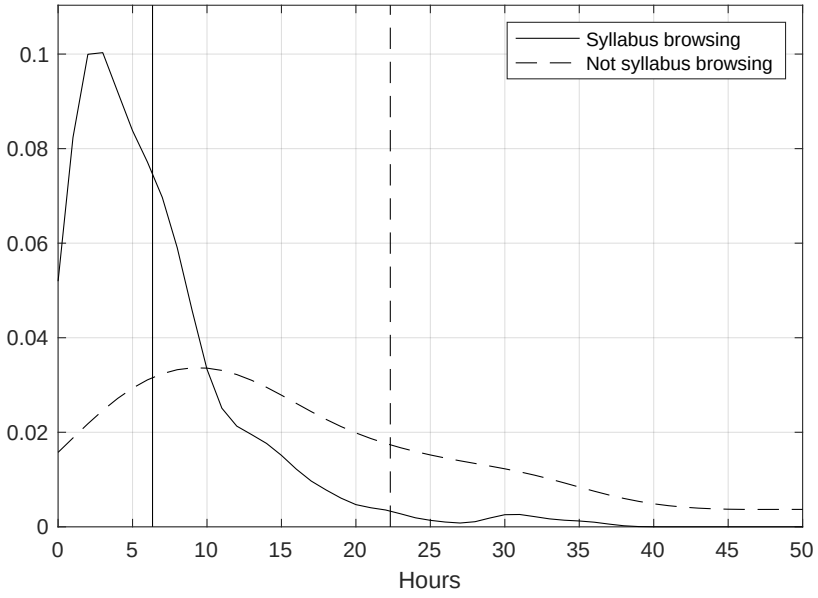
Figure 4: Wikipedia Browsing for Events in 2017-18



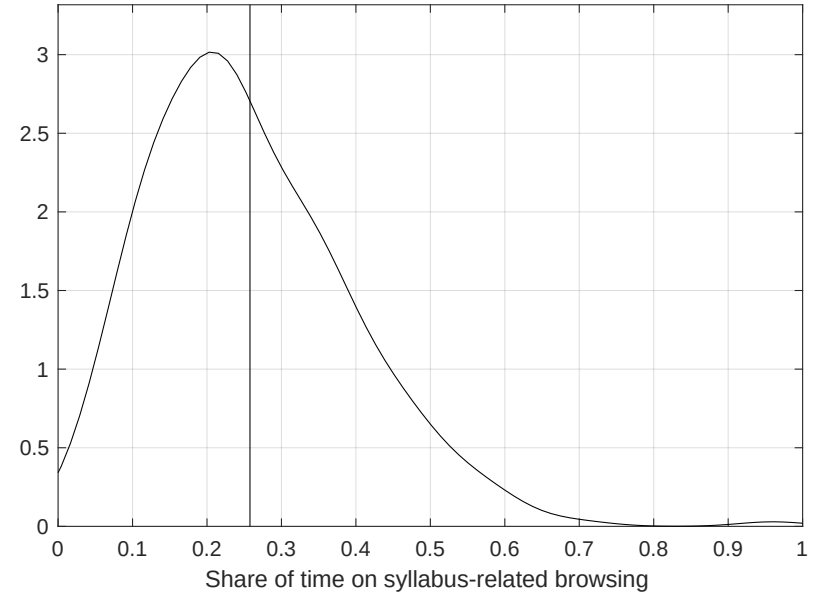
Notes: Panel A: Average amount of browsing minutes by student on Wikipedia pages related to all worldwide events on the left hand side axis. Share of students that visited the pages associated to at least one event on the right hand axis. Panels B and C: Average amount of browsing minutes by student and event on Wikipedia pages related to all worldwide events on the left hand side axis. Share of students that visited the pages associated to a given event on the right hand axis. All events from November 2nd 2017 to May 9th 2018 as reported in https://en.wikipedia.org/wiki/2017 and https://en.wikipedia.org/wiki/2018 were considered, for the 20 weeks before and after they occurred. Total of 64 events, out of which 10 did not have a specific Wikipedia page associated to them and were eliminated from the analysis. Week of the event is set at zero. Negative (positive) numbers on the x-axis are the browsing hours by weeks before (after) the event.

Figure 5: Hours Spent on School Subjects

Panel A. Hours spent on syllabus

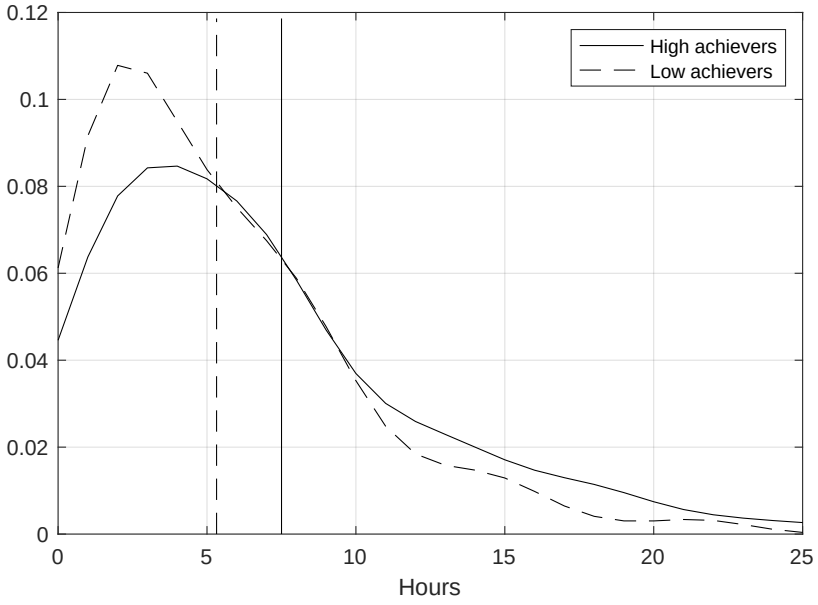


Panel B. Share of time spent on syllabus



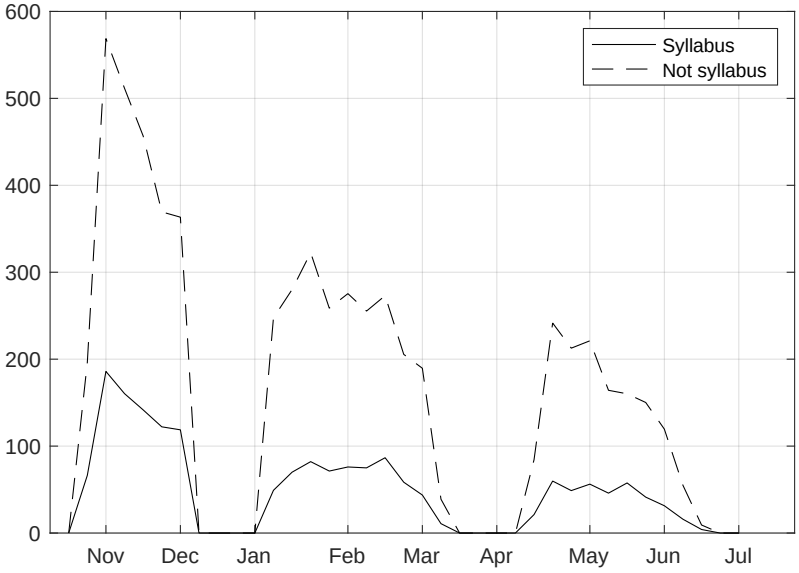
Notes: Panel A: Density of browsing hours, across treatment individuals only, aggregated over the course of one academic year, for syllabus and non syllabus-related Wikipedia pages. Vertical lines are the average hours spent browsing (6.3 on syllabus and 22.3 on non syllabus-related). Panel B: Distribution of the share of time spent on syllabus materials across students. The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

Figure 6: Hours Spent on School Subjects, High and Low Achievers



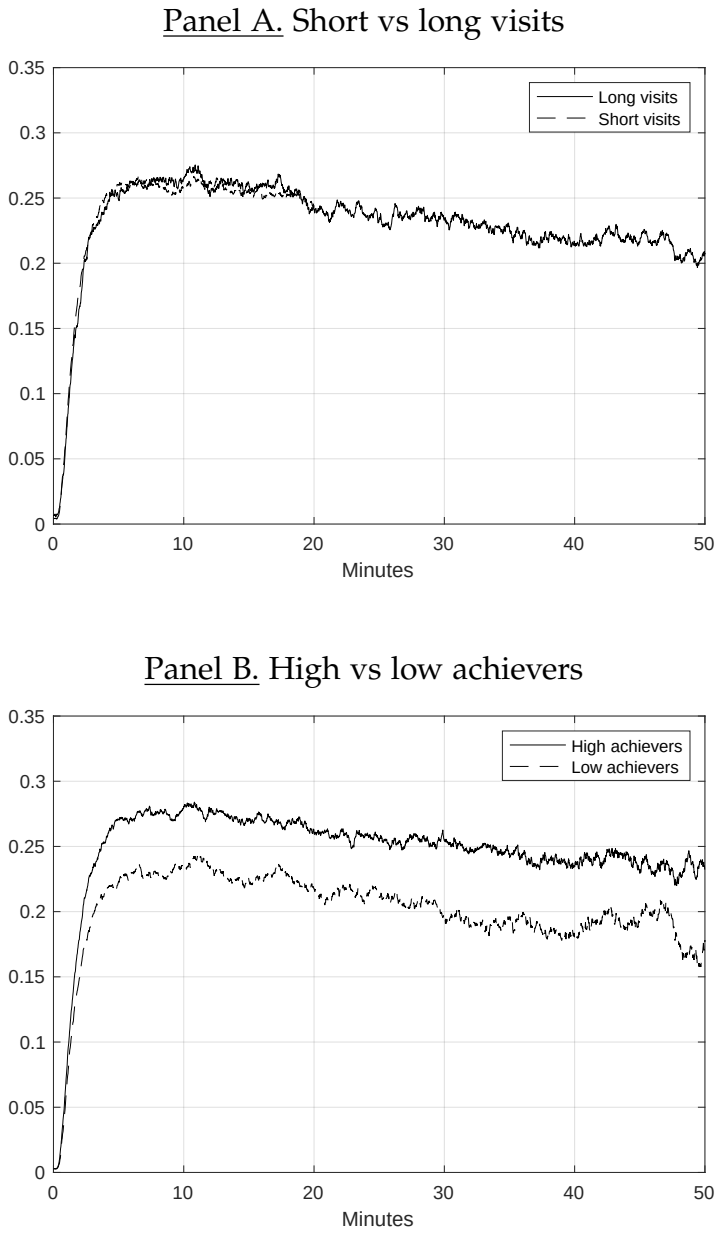
Notes: Density of browsing hours, across treatment individuals only, aggregated over the course of one academic year for syllabus-related pages. High (low) achievers defined as above (below) median exam scores at the baseline. Vertical lines are the average hours spent browsing (7.5 for high achievers and 5.3 for low achievers). The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

Figure 7: Hours Spent on School Subjects Over Time



Notes: Weekly browsing hours on syllabus- and non syllabus-related Wikipedia pages. The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

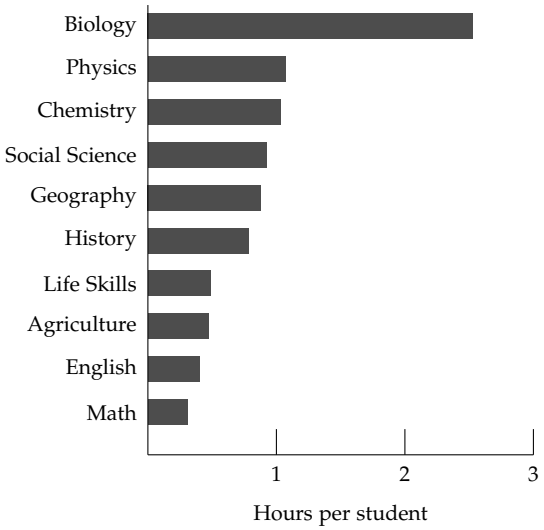
Figure 8: Hours Spent on School Subjects Within Browsing Streams



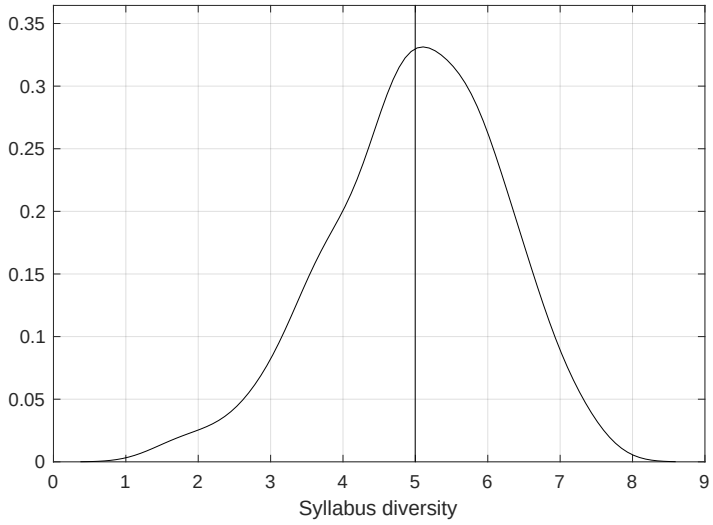
Notes: Share of students at a given time browsing syllabus-related Wikipedia pages, for the first 50 minutes of browsing. Zero represents the start of the browsing session. We define "short visits" as those that lasted between 20 and 50 minutes. Long visits are defined as those that for 50 minutes or longer. High (low) achievers defined as above (below) median exam scores at the baseline.

Figure 9: Hours Spent by Subject

Panel A. Subject popularity

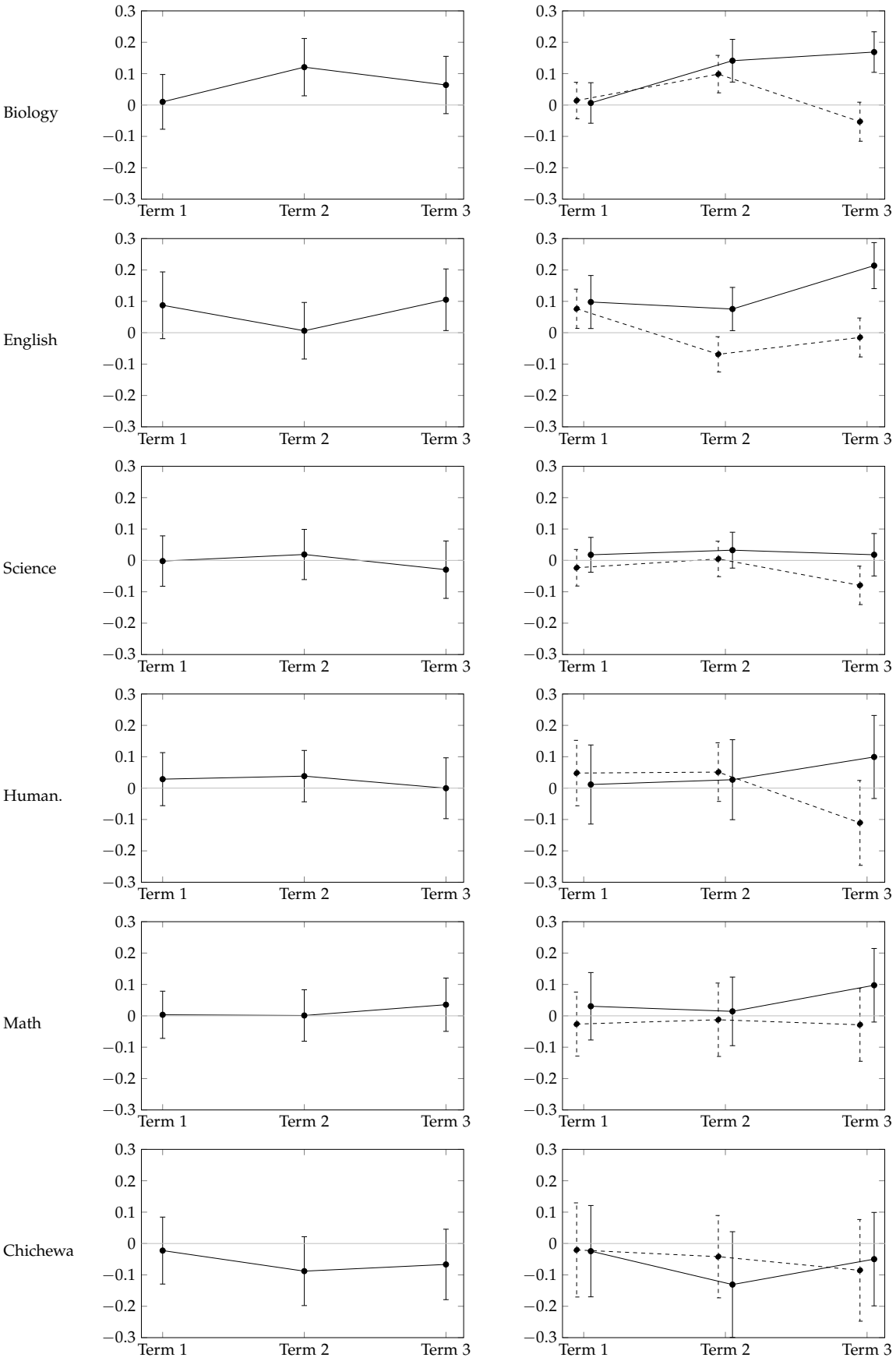


Panel B. Diversity of topics across students



Notes: Browsing hours per school subject, per student, aggregated over the course of one academic year. Diversity of Wikipedia-related subjects across students. Adaptation of the Herfindahl index, computed as $d_i = 1/\sum_j s_{ij}^2$ where s_{ij} is the share of time that student i spends in subject j, throughout the duration of the experiment. Larger numbers represent broader diversity of subjects. Dashed line is the average (5.00 subjects). The digital library was open for 20-22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations.

Figure 10: Treatment Effect on Exam Scores by Term



Notes: Regression results of pooled test scores from terms 1, 2 and 3. Robust confidence interval in brackets. Treatment effects across students on the left-hand side, and for low achievers (solid line) and high achievers (dashed line). See Table 10 for details.

Figure 11: Career Plans

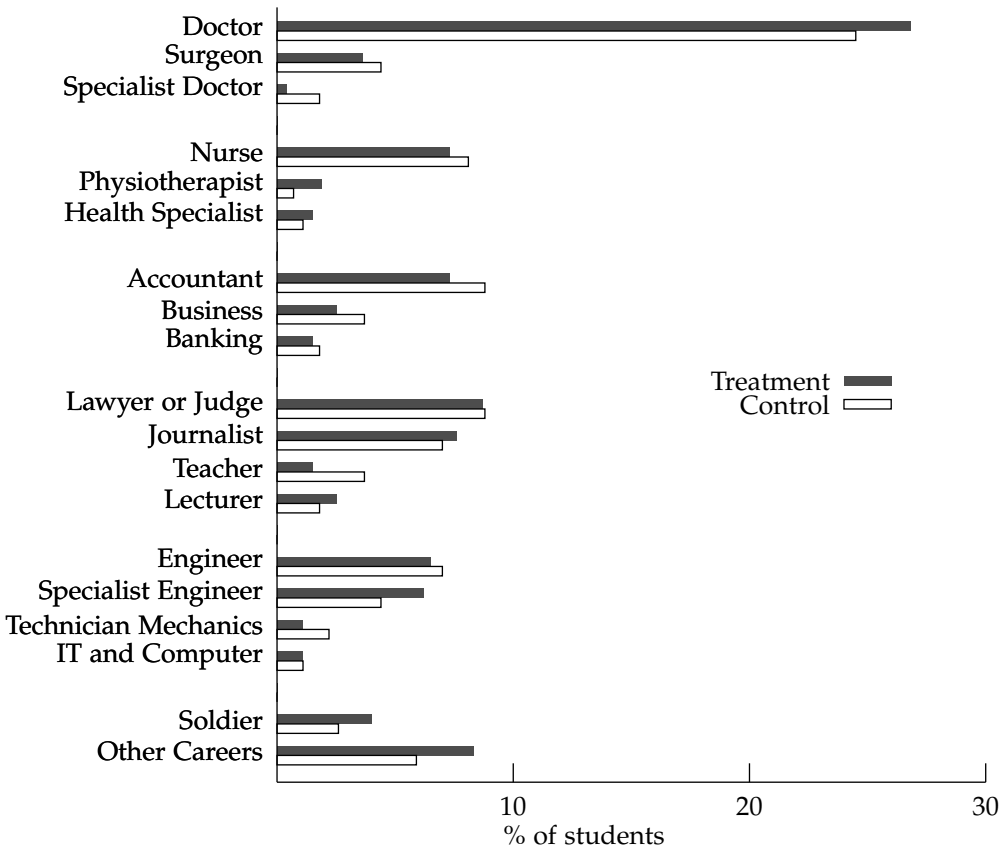
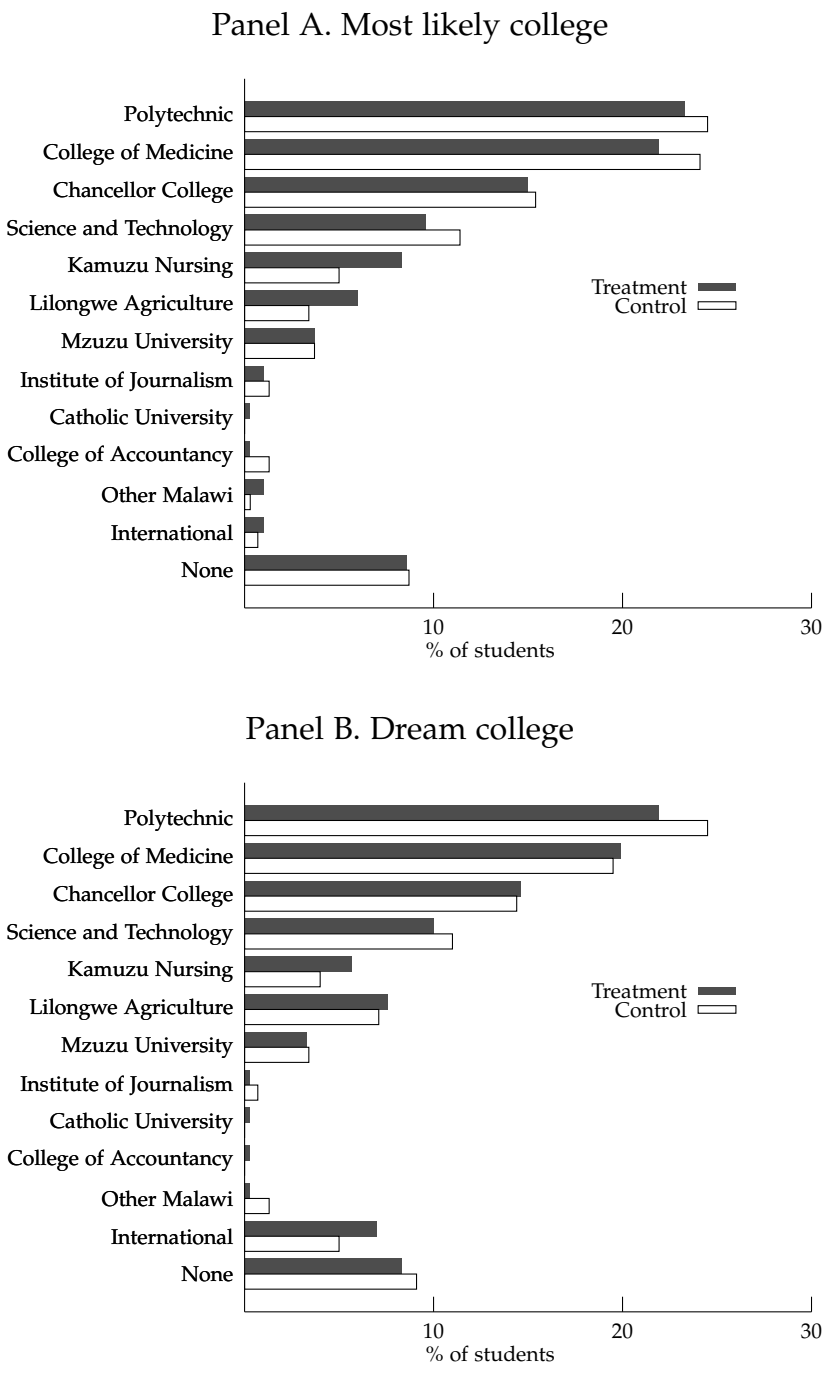


Figure 12: College Choice



Notes: Frequency of career choices and dream college in Panels A and B, respectively, as registered in the endline survey, across 301 treated and 298 control students.

Tables

Table 1: Mobile Phone and Internet Use

	% population within network coverage	Mobile subscriptions per 100 inh.		Internet bundle price as % of income		% population with internet use		GDP per capita
	2006	2014	2017	2007	2017	2007	2017	2017
Malawi	93.1	7.6	41.7	45.2	18.0	1.0	13.8	$338.5
Zambia	44.9	20.7	78.6	15.2	12.6	4.9	27.9	$1,332.2
Mozambique	42.1	13.9	40.0	13.3	7.2	.9	20.77	$441.6
South Africa	99.8	84.8	156.0	1.3	1.2	8.1	56.2	$6,339.6
LDC	–	15.1	68.6	21.4	14.8	1.9	17.8	$1,092.6
Developing	–	39.1	99.0	9.0	6.3	11.8	42.3	$5,229.0
Developed	–	102.0	127.0	.9	.8	59.1	79.5	$42,346.2
World	–	50.6	103.6	6.5	4.6	20.5	48.6	$10,748.7

Sources: "% population with GMS coverage" from Buys *et al.* (2009). Remaining data, excluding GDP per capita, from the International Telecommunications Unit. Classification of "Least Developed Country" (LDC), "developing" and "developed countries" also drawn from the International Telecommunications Unit. "Internet bundle price as % of income" is the proportion of the average national income to purchase 1GB of a data bundle, monthly. GDP per capita obtained from the World Bank. Definition of LDC in the last column uses the United Nations' classification. Average GDP per capita of developing (developed) countries approximated by the average GDP per capita of middle (upper) income countries. Income in current US$.

Table 2: Balance Tables: Stratification variables

	(1) Treatment	(2) Control (long survey)	(3) p-value	(4) Control (all)	(5) p-value
School 1	.272	.262	.768	.261	.689
	(.446)	(.440)		(.439)	
School 2	.262	.289	.475	.280	.537
	(.441)	(.454)		(.449)	
School 3	.236	.232	.900	.229	.792
	(.425)	(.423)		(.420)	
School 4	.229	.218	.745	.230	.968
	(.421)	(.414)		(.421)	
Form 2	.342	.346	.929	.342	.999
	(.475)	(.476)		(.475)	
Form 3	.332	.329	.930	.328	.892
	(.472)	(.471)		(.470)	
Form 4	.326	.326	.998	.330	.891
	(.469)	(.469)		(.470)	
Above median Bio. and Eng. exam scores	.468	.473	.908	.472	.906
	(.500)	(.500)		(.499)	
Past internet use	.502	.500	.968	.505	.908
	(.501)	(.501)		(.500)	
Number of students	301	298		1,207	

Notes: Balance table across the treated (N=301), control with expanded survey (N=298) and control with short survey (N=1,207) populations. Columns (3) and (5) shows the p-value of the difference between treated and surveyed controls, and treated and all controls, respectively. "Above median Biology and English exam scores" computed on the previous school year. "Past internet use" is a dummy variable which indicates if the student had any exposure to internet prior to the experiment. Standard errors in parenthesis.

Table 3: Balance Tables: Non-stratification variables

	(1) Treatment	(2) Control (long survey)	(3) p-value	(4) Control (all)	(5) p-value
Average exam score in Biology and English	55.530	55.491	.973	55.555	.977
	(13.427)	(13.844)		(13.746)	
Age	15.973	16.060	.577	16.033	.635
	(1.971)	(1.845)		(1.869)	
Female	.452	.433	.641	.423	.361
	(.499)	(.496)		(.494)	
District of origin	.605	.574	.444	.575	.348
	(.490)	(.495)		(.495)	
Mother's education	.746	.698	.224	.718	.258
	(.436)	(.460)		(.450)	
Father's education	.849	.852	.918	.856	.775
	(.359)	(.356)		(.351)	
Household has electricity	.611	.557	.179	.576	.262
	(.488)	(.498)		(.494)	
Household has mobile phone	.870	.849	.451	.866	.852
	(.336)	(.359)		(.340)	
Number of students	301	298		1,207	

Notes: Balance table across the treated (N=301), control with expanded survey (N=298) and control with short survey (N=1,207) populations. Columns (3) and (5) shows the p-value of the difference between treated and surveyed controls, and treated and all controls, respectively. District of origin equals 1 if the district where the student is from is the same district as the school district. Mother's and father's education is equal to one if she or he has completed primary education. Standard errors in parenthesis.

Table 4: Attrition in Endline Surveys

	(1)	(2)	(3)
	Endline A	Endline A	Endline B
Control	.030**	–	–
	(.014)	–	–
	p = [.066]	–	–
Control (supplementary sample only)	–	.007	.002
	–	(.016)	(.021)
	–	p = [.681]	p = [1.000]
Mean of dependent variable in treatment	.047	.047	.083
Strata FE	yes	yes	yes
Number of students	1,508	599	599

Notes: Differential attrition between treatment and control groups. Regression of attrition indicator in endline surveys A and B on the treatment status with strata bins fixed effects. Randomization stratified by school, form, above median achievement and past internet use. Column (1) compares treated with all control students. Columns (2) and (3) compare treatment with the subsample of control students that received the supplementary survey. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 5: Understanding of Wikipedia and Ability to Find Information

	(1)	(2)	(3)	(4)
		Ability to find information		
	Understands what Wikipedia is (index)	Milky way phone test	News quiz	Academic quiz
Treatment	.877***	.183***	.089**	.108**
	(.074)	(.039)	(.042)	(.041)
	p = [.000]	p = [.000]	p = [.032]	p = [.010]
Units	s.d. of controls	Binary	Binary	Binary
Mean of dependent variable in control	.000	.392	.513	.567
Strata FE	yes	yes	yes	yes
Number of students	549	548	535	538

Notes: Effects on the student understanding about Wikipedia. "Understands what Wikipedia is" refers to the index calculated over correct answers to the following questions: "Can you find information about world news events on Wikipedia?", "Can you find the MSCE results for students from your school on Wikipedia?", "Can you watch movies on Wikipedia?", "Can you communicate with friends on Wikipedia?" and if the Wikipedia app was recognized among seven other apps (not prompted). "Milky way phone test" refers to the test whereby students were asked "How many stars are there in the Milky Way?" and were allowed to consult internet during the survey to find the answer. Registered as a binary outcome if the student was correct within two minutes of search. "News" and "academic quiz" records if the student correctly answers to each quiz question. Questions were student-specific and correct answers were incentivized. Stratification by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 6: Is Wikipedia Information Better than the Internet?

	(1)	(2)	(3)	(4)	(5)	(6)
	Safe sex		News		Milky way phone test (opened Wikipedia)	
Treatment	.185***		.155***		.253***	
	(.043)		(.043)		(.038)	
	p = [.000]		p = [.000]		p = [.000]	
Treatment x No past internet use		.213***		.242***		.394***
		(.059)		(.059)		(.050)
		p = [.000]		p = [.000]		p = [.000]
Treatment x Past internet use		.160***		.071		.117***
		(.060)		(.059)		(.053)
		p = [.000]		p = [.223]		p = [.032]
Mean of dependent variable in control	.457	.457	.377	.377	.212	.212
Strata FE	yes	yes	yes	yes	yes	yes
Number of students	536	536	548	548	549	549

Notes: "Safe sex" refers to the question "What is the best place to find information about safe sex?" Students were asked to rank the following six options: a teacher, books in the school, Wikipedia, internet (other sites), another student, a family member. Coded as one if Wikipedia was ranked higher than internet (other sites). "News"refers to the question "What is the best place to find information about news events?" where, again, students ranked options. "Milky way phone test (opened Wikipedia)"is a binary variable equal to one if student opened the Wikipedia app during the Milky Way phone test. "No past internet use" if student did not relate having used internet at the baseline. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 7: How is Wikipedia Better than Other Sites on the Internet?

	(1)	(2)	(3)	(4)	(5)	(6)
	Trustworthy		Easy to understand		Easy to find	
Treatment	.262***		.333***		.247***	
	(.039)		(.038)		(.038)	
	p = [.000]		p = [.000]		p = [.000]	
Treatment x No past internet use		.309***		.391***		.380***
		(.057)		(.055)		(.054)
		p = [.000]		p = [.000]		p = [.000]
Treatment x Past internet use		.218***		.277***		.118**
		(.054)		(.050)		(.051)
		p = [.000]		p = [.000]		p = [.032]
Mean of dependent variable in control	.436	.436	.495	.495	.542	.542
Strata FE	yes	yes	yes	yes	yes	yes
Number of students	549	549	549	549	549	549

Notes: Multiple choice answers to the question "How is Wikipedia better than other sites on the internet?" Outcomes in columns (1) and (2) is equal to one if option "Information on Wikipedia is more trustworthy" was chosen. Columns (3) and (4) if "It is easier to understand information on Wikipedia"was chosen. Columns (5) and (6) if "It is easier to find information on Wikipedia"was chosen. Other alternatives were "There is more information on Wikipedia", "There are more things to do on Wikipedia", and "Don't know". "No past internet use" if student did not relate having used internet at the baseline. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 8: Attrition in Exam Scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Biology				English			
	Term 1	Term 2	Term 3	All	Term 1	Term 2	Term 3	All
Control	-.000	.029**	.006	.012	.007	.019	.005	.010
	(.014)	(.015)	(.015)	(.009)	(.013)	(.012)	(.015)	(.008)
	p = [.991]	p = [.458]	p = [.853]	p = [.568]	p = [.808]	p = [.533]	p = [.863]	p = [.566]
Mean of dependent variable in treatment	.053	.086	.063	.068	.043	.033	.060	.045
Strata FE	yes	yes	yes	yes	yes	yes	yes	yes
Number of students	1,508	1,508	1,508	4,524	1,508	1,508	1,508	4,524

Notes: Differential attrition between treatment and control groups. Regression of attrition indicator in Biology and English grades for terms 1, 2 and 3 and pooled across all terms. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 9: Exam Scores Post-Intervention by Term

	(1) Biology	(2) English	(3) Science	(4) Human.	(5) Math	(6) Chichewa
Treatment x term 1	.010	.087	-.002	.029	.003	-.023
	(.045)	(.054)	(.041)	(.043)	(.038)	(.054)
	p = [.827]	p = [.086]	p = [.962]	p = [.519]	p = [.930]	p = [.677]
Treatment x term 2	.121***	.006	.019	.038	.001	-.088
	(.047)	(.046)	(.041)	(.042)	(.042)	(.056)
	p = [.012]	p = [.900]	p = [.634]	p = [.374]	p = [.978]	p = [.098]
Treatment x term 3	.064	.105**	-.029	-.000	.035	-.067
	(.047)	(.050)	(.047)	(.049)	(.043)	(.058)
	p = [.189]	p = [.044]	p = [.506]	p = [.994]	p = [.416]	p = [.233]
Mean of dependent variable in control	.000	.000	.000	.000	.000	.000
Strata FE	yes	yes	yes	yes	yes	yes
Term FE	yes	yes	yes	yes	yes	yes
Number of students	4,177	4,281	4,158	4,184	4,048	4,143

Notes: Regression results of test scores from terms 1, 2 and 3. We include a control for baseline test score with an indicator for missing baseline score. Science is a summary index of Chemistry and Physics. Humanities is a summary index of Agriculture, Geography, History, Life Skills and Social Science. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 10: Exam Scores Post-Intervention by Term

	(1) Biology	(2) English	(3) Science	(4) Human.	(5) Math	(6) Chichewa
Treatment x low achiever x term 1	.007	.098	.018	.011	.030	-.024
	(.065)	(.084)	(.055)	(.064)	(.055)	(.074)
	p = [.927]	p = [.215]	p = [.758]	p = [.866]	p = [.584]	p = [.734]
Treatment x low achiever x term 2	.141**	.075	.033	.027	.014	-.131
	(.068)	(.069)	(.057)	(.065)	(.056)	(.086)
	p = [.048]	p = [.288]	p = [.574]	p = [.669]	p = [.805]	p = [.097]
Treatment x low achiever x term 3	.169***	.214***	.018	.099	.097	-.050
	(.065)	(.073)	(.068)	(.068)	(.060)	(.076)
	p = [.026]	p = [.008]	p = [.781]	p = [.151]	p = [.102]	p = [.545]
Treatment x high achiever x term 1	.014	.076	-.023	.048	-.026	-.020
	(.058)	(.062)	(.058)	(.053)	(.052)	(.077)
	p = [.829]	p = [.247]	p = [.679]	p = [.395]	p = [.615]	p = [.775]
Treatment x high achiever x term 2	.098*	-.069	.005	.051	-.013	-.042
	(.060)	(.056)	(.056)	(.048)	(.060)	(.067)
	p = [.103]	p = [.257]	p = [.936]	p = [.323]	p = [.837]	p = [.544]
Treatment x high achiever x term 3	-.053	-.015	-.080	-.111	-.029	-.086
	(.062)	(.062)	(.061)	(.069)	(.059)	(.083)
	p = [.482]	p = [.819]	p = [.179]	p = [.065]	p = [.648]	p = [.275]
Mean of dependent variable in control	.000	.000	.000	.000	.000	.000
Strata FE	yes	yes	yes	yes	yes	yes
Term FE	yes	yes	yes	yes	yes	yes
Number of students	4,177	4,281	4,158	4,184	4,048	4,143

Notes: Regression results of test scores from terms 1, 2 and 3. We include a control for baseline test score with an indicator for missing baseline score. Science is a summary index of Chemistry and Physics. Humanities is a summary index of Agriculture, Geography, History, Life Skills and Social Science. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table 11: Time Use and Participation in Class

	(1)	(2)	(3)	(4)	(5)	(6)
	Time Use (hours per day)				Participation in class (per day)	Career change
	Study	Study	Recreational	Awake		
Treatment	-.029		-.286***	.007	-.025	.031
	(.071)		(.078)	(.086)	(.159)	(.042)
	p = [.718]		p = [.005]	p = [.931]	p =[.874]	p=[.564]
Treatment x low achiever		-.038				
		(.098)				
		p = [.744]				
Treatment x high achiever		-.019				
		(.104)				
		p = [.867]				
Mean of dependent variable in control	1.937	1.937	.967	17.032	2.891	.549
Strata FE	yes	yes	yes	yes	yes	yes
Day-of-the-week FE	yes	yes	yes	yes	yes	no
Number of students	1,402	1,402	1,396	1,398	1,402	549

Notes: Treatment effects on time use and participation in class. "Study", "Recreational" and "Awake" refers to the time spent on study, recreational activities and not sleeping, respectively, and averaged over the three days prior to the interview. Study time is the sum of the answers to the questions "How much time did you study alone?" and "How much time did you study with others?". Recreational time is the sum of the answers to the questions "How much time did you hang out with friends?", "(...) in a school club?", "(...) in religious activities?", "(...) sports activities?" and "(...) other activities?". Awake time is the duration between waking up and going to sleep at night. Time Use specifications (1)-(4) include baseline controls. Participation in class counts the number of times that students responded that they raised their hands in class to ask a question, also averaged over the three days prior to the survey. Change in career between baseline and endline surveys. Outcome variable considers both changes in career category and precision in the career choice, e.g. "doctor" to "surgeon" is considered a change. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as “p = [ ]”.

Appendix: Pooled Results

We estimate the effect of the intervention on exam scores for each subject, pooling across terms 1, 2 and 3

$$y_{it} = \beta \text{Treatment}_i + \delta \left(y_{i0} \times \text{Data}_{i0} \right) + \delta_0 \text{MissingData}_{i0} + \sigma_s + \tau_t + \varepsilon_{it}. \quad (5)$$

Here, y_{it} is the measure of academic performance for student i in term $t \in \{1, 2, 3\}$. Treatment_i is an indicator for treatment status. ε_i is a mean-zero error term. To improve precision, we control for the baseline measure of the outcome, y_{i0}, taken from term 3 of the previous school year. We dummy out missing baseline scores: Data_{i0} and MissingData_{i0} are indicators for whether or not we have baseline data y_{i0} for student i.[73] We include a fixed effect for the stratification bin and a term fixed effect τ_t. We report robust standard errors, clustered at the student level (the level of randomization).

Our parameter of interest is the average treatment effect β. Because treatment status Treatment_i is randomly assigned at the student level, we expect the error term to be mean-independent of treatment status, $\mathbb{E}(\varepsilon_{it} | \text{Treatment}_i) = 0$. Therefore, in the absence of spillovers, the OLS estimate $\hat{\beta}$ is unbiased.

Across all terms, the intervention had a small average treatment effect on Biology and English exam scores (Panel A, Table A1). Biology scores improved by .06 standard deviations, and English by .07 standard deviations. Both coefficients are significant at the 10 percent level. The effects on science subjects, humanities subjects and Mathematics are all close to zero and precisely estimated. We find a negative impact on scores in Chichewa, the local language. This effect is equal and opposite to the effects on Biology and English (.06 standard deviations), but is not significant.

We also estimate heterogeneous effects of the intervention on the academic performance of students who were low or high achievers at baseline.

$$\begin{aligned} y_{it} = {} & \beta \left(\text{Treatment}_i \times \text{LowAchiever}_i \right) + \gamma \left(\text{Treatment}_i \times \text{HighAchiever}_i \right) \\ & + \delta \left(y_{i0} \times \text{Data}_{i0} \right) + \delta_0 \text{MissingData}_{i0} + \sigma_s + \tau_t + \varepsilon_{it} \end{aligned} \quad (6)$$

Here, HighAchiever_i and LowAchiever_i are indicators for whether or not student i was a high achiever at baseline. We construct the HighAchiever_i measure by taking an average of the students' English and Biology exam scores in term of the previous year, and comparing this average to the median within the school and form.[74]

We find small average treatment effects, and much higher treatment effects for the low achievers. For this subsample, the effect size is .11 standard deviations for Biology scores and .13 standard deviations for English scores, and both estimates are significant at the 5 percent level (Table A1).

[73] We are missing baseline exam score data for 4 percent of students.

[74] Students with missing baseline data are assigned $\text{HighAchiever}_i = 0$. HighAchiever_i is one of our stratification variables, and its intercept is absorbed by the stratification fixed effects σ_s.

Appendix: Spillovers

While control students did not gain direct access to Wikipedia or the internet during the experiment, our primary outcomes may still be subject to spillovers. For example, a student's language skills or Biology knowledge may improve if they study with students who have benefited from Wikipedia access.

To test for spillovers on academic performance, we use baseline social network data. At baseline, we ask every student to name the friends they study with. We say there is a study link between two students if both students name each other. While social networks change over the course of a school year, study friends are in part determined by school-level decisions such as classroom, dormitory, and formal study groups. These formal study groups are assigned by teachers at the start of the school year, and meet regularly. Therefore, study friends are more likely to remain constant over the school year. Study friends are also most likely to benefit from spillovers that impact academic performance.

We estimate equations 3 and 4 from Section 5, adding controls for the number of study friends total and the number of study friends in the treatment group. We also interact own treatment status with the number of treated study friends, as spillovers may exist only between treatment and control group students.

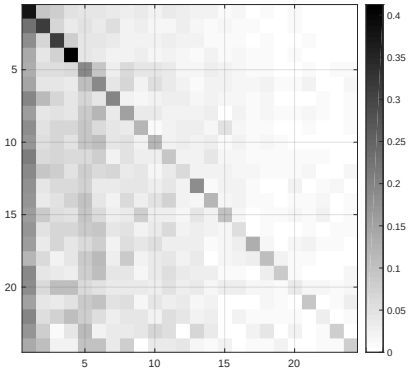
We find positive, insignificant spillovers from the treatment group to the control group (see Table A2, which reports results for term 3 English and Biology). In this specification, our estimated effect sizes are slightly larger (.19 and .14 standard deviations for English and Biology, respectively), but have larger standard errors. Effects for low achievers are also larger, and remain significant (.28 and .23 standard deviations for English and Biology, respectively).

This specification may not capture all spillovers, as spillovers may exist beyond study friends at baseline. However, it suggests that spillovers are likely to be positive from treatment to control students, and that our estimates slightly underestimate the true impact of the intervention.

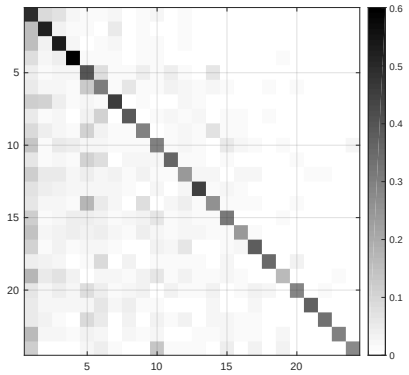
Appendix: Figures and Tables

Figure A1: Transitions between topics and school subjects

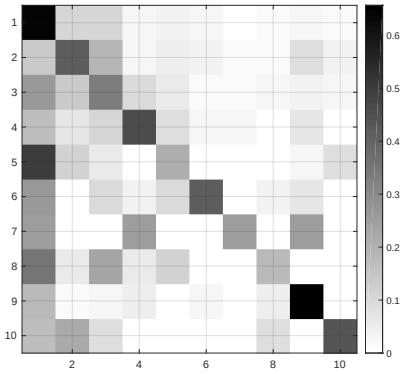
Panel A. Transition of topics across sessions



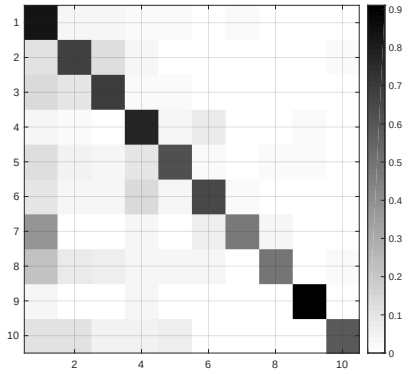
Panel B. Transition of topics 10-min browsing period



Panel C. Transition of subjects across sessions



Panel D. Transition of subjects 10-min browsing period



Notes: Panels A and C: transition between topics (subjects) across sessions. Element (j,k) is the frequency that topic (subject) k is the most visited in the session after a session in which topic (subject) j was the most visited. Panels B and D: transition of topics (subjects) across 10-minutes of browsing, within a browsing session. Element (j,k) is the frequency that topic (subject) k is the most visited in a 10-minute block after a block of equal length in which topic (subject) j was the most visited. Rows are normalized to one, and sorted from most to least popular topics (subjects), as in Panel A of Figure 2 and Panel A of Figure 9, respectively.

Table A1: Exam Scores Post-Intervention

	(1) Biology	(2) English	(3) Science	(4) Human.	(5) Math	(6) Chichewa
Panel A. Overall effects						
Treatment	.064*	.066*	-.004	.022	.013	-.060
	(.036)	(.039)	(.034)	(.035)	(.033)	(.040)
	p = [.083]	p = [.090]	p = [.903]	p = [.520]	p = [.687]	p = [.134]
Panel B. Heterogenous effects						
Treatment x low achiever	.105**	.129**	.023	.046	.047	-.069
	(.053)	(.061)	(.050)	(.054)	(.047)	(.058)
	p = [.061]	p = [.032]	p = [.631]	p = [.386]	p = [.314]	p = [.238]
Treatment x high achiever	.019	-.003	-.032	-.004	-.023	-.049
	(.046)	(.045)	(.046)	(.043)	(.046)	(.054)
	p = [.687]	p = [.951]	p = [.482]	p = [.928]	p = [.637]	p = [.362]
Mean of dependent variable in control	.000	.000	.000	.000	.000	.000
Strata FE	yes	yes	yes	yes	yes	yes
Term FE	yes	yes	yes	yes	yes	yes
Number of students	4,177	4,281	4,158	4,184	4,048	4,143

Notes: Regression results of pooled test scores from terms 1, 2 and 3. We include a control for baseline test score with an indicator for missing baseline score. Science is a summary index of Chemistry and Physics. Humanities is a summary index of Agriculture, Geography, History, Life Skills and Social Science. Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01. Randomization inference p-values based on 10,000 replications in brackets and denoted as "p = [ ]".

Table A2: Exam Scores Post-Intervention, Term 3, with Spillover Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Biology				English			
Treatment	.063	.141			.103**	.190		
	(.046)	(.090)			(.050)	(.098)		
Treatment x low achiever			.177***	.230**			.213***	.276***
			(.064)	(.098)			(.073)	(.107)
Treatment x high achiever			-.065	-.005			-.018	.052
			(.062)	(.101)			(.062)	(.110)
Treated Study Friends	-.011	-.028	-.011	-.023	-.004	-.023	-.004	-.018
	(.012)	(.021)	(.012)	(.021)	(.013)	(.022)	(.013)	(.023)
Study Friends	.014***	.014***	.015***	.015***	.007	.007	.008	.008
	(.004)	(.004)	(.004)	(.004)	(.005)	(.005)	(.005)	(.005)
Control x Treated Study Friends		.015		.015		.018		.018
		(.021)		(.021)		(.023)		(.023)
Mean of dependent variable in control	.000	.000	.000	.000	.000	.000	.000	.000
Strata FE	yes	yes	yes	yes	yes	yes	yes	yes
Number of students	4,117	4,117	4,117	4,117	4,281	4,281	4,281	4,281

Notes: Regression results of test scores for all terms. Columns (1) and (4) are the spillover specifications corresponding to Equation (5). Explanatory variables are the treatment indicator, number of treated study friends and number of study friends, all interacted with the term dummy, in addition to an indicator for missing baseline score. Columns (2) and (6) add control for the number of treated study friends interacted with control student indicator. Columns (3) and (7) are the spillover specification corresponding to Equation (6). Explanatory variables are the treatment indicator interacted with high and low achiever indicator, number of treated study friends and number of study friends, all interacted with the term dummy, in addition to an indicator for missing baseline score. Columns (4) and (8) add control for the number of treated study friends interacted with control student indicator. Study friend network collected at the baseline. A link is considered to be present if students nominate each other during the three-day recall based on the question "With whom did you study with [yesterday]?" Only term 3 results are presented for conciseness. In Column (1), term 1 and 2 effects are .008(.044) and .120***(.046) respectively. Column (2), -.058(.085) and .120(.099). Column (3), term 1 effects for low and high achievers are .006(.064) and .009(.058); term 2 effects for low and high achievers are .145**(.068) and .092(.059). Column (4), -.055(.095), -.060(.092), .141(.107) and .089(.110) for low and high achievers in terms 1 and 2. Column (5), term 1 and 2 effects are .087(.054) and .008(.046). Column (6), 058(.116) and -.013(.094). Column (7), term 1 effects for low and high achievers are .107(.083) and .064(.063); term 2 effects for low and high achievers are .082(.068) and -.073(.056). Column (8), .077(.133), .030(.113), .046(.106) and -.114(.098). Randomization stratified by school, form, above median achievement and past internet use. Robust standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

Searching for Answers: The Impact of Student Access to Wikipedia

Laura Derksen, Catherine Michaud Leclerc and Pedro CL Souza

Supplementary Materials

Examples from English Examinations

In this section, we provide examples of the multiple choice questions and composition questions that students have to take for their English classes. The questions were provided by the school administration.

Figure 1: Sample of Multiple Choice Questions: English Examinations

4. We travelled_____train from Salima to Lilongwe
   A. on
   B. in
   C. through
   D. by
5. Everyone was surprised_____the bad weather.
   A. with
   B. by
   C. at
   D. for
6. The storm had_____when we started our journey.
   A. died away
   B. died out
   C. died off
   D. died down

Sample of Composition Question: English Examinations

" – Answer one question only
– Spend the first 10 minutes reading the questions and planning your answers to the question chosen. Planning may include writing rough notes. Cross out your rough notes before you hand in your Answer Book.
– Marks will be awarded for layout, language, content and creativity. Candidates will be penalized for committing mechanical errors and writing answers that are short and /or off-point.
– You are expected to write between 350 and 500 words for the question you have chosen.

EITHER
1. Write an original short story entitled 'The Imposter' (40 marks)

2. Imagine that the area where you live was flooded. The floods destroyed homes and property. Write a report to the District Commissioner informing him or her of the disaster. (40 marks)"

Classroom Introduction to the Project

- We are working for the University of Toronto in Canada for a research project
- The research project will take place in this school for the entire school year in which some students in Forms 2-4 will have access to a digital library with phones with access to an online encyclopedia.
- First, we would like to survey every student in Forms 2-4.
- The survey is not too long – about 10-20 minutes
- After the survey is finished, we are going to select some students for the mobile phone program
- The students are going to be selected RANDOMLY – it is not the best students. Every student in Forms 2-4 has the chance to be selected. [Make sure this is extremely clear]
- We cannot select every student, only a few students will be selected
- During the year, those selected students will be able to take part in a digital library program
- A digital library will be set up in [classroom]
- There will be a number of mobile phones with access to an online encyclopedia
- Students taking part in the program will be able to search online for information about their studies and other information [see examples below]

- If you are not selected for the program, you are free to ask selected students to search for something or to explain what they have learned
- If you are selected, you are free to take part or to refuse, you are not obligated to use the digital library
- We will continue to ask some students to answer short surveys throughout the year – these will include some selected students and other students
- Any questions?
- Looking forward to seeing you again when we will be conducting the survey

About Wikipedia

A lot of information can be accessed on Wikipedia. This includes information about academics, health, politics, world news, sports and entertainment.

For example, suppose your Biology teacher says that next week you will start the topic of photosynthesis. If you search Wikipedia, you will find a detailed explanation of the process of photosynthesis, with equations and illustrations.

I will give you another example. Suppose you did not understand the different types of soil you discussed in agriculture class. You can use Wikipedia to find out more about the topic, including the definition of soil and the various types of soil. Wikipedia includes information about soil fertility, soil formation and the different functions of the soil.

In Wikipedia, you can find information about almost any topic from your studies. For example, you can find information about chemical reactions and the periodic table in chemistry, matter in physics and volcanos in geography. You can even review different rules you learn in mathematics such as the rules for exponents. You can find information about local and international authors.

If you are thinking about what you want to do after secondary school, you can search Universities in Malawi and you will find a list of all colleges, public and private universities in Malawi. You can even look into the careers you may be interested in pursuing.

As we said, there is information just about everything on Wikipedia. If you want to know more about menstruation, birth control or pregnancy, you will find it in Wikipedia. Wikipedia talks also about different diseases such as malaria, Ebola and HIV. You can find information about the causes, symptoms and prevention.

You can find information about local politics and international news. You can find information about sports stars like Lionel Messi, and celebrities like Jay-Z or Nicki Minaj.

We think this project will help you a lot with your studies. Even if you are not selected for the program, you can ask your friends to search for information on a topic from class. If you are selected, you can share what you learn with your classmates.

Digital library Induction

Instructions for Digital Librarians

- The induction should be done in small groups – enough so that each student can use one phone. Only for selected students
- Explain the digital library itself; Opening hours
- Explain Wikipedia. What it is, what kind of information you can find
- Explain privacy. Anonymous, you are free to search anything.
- You can only use Wikipedia. Everything else is blocked
- Practice together. Give several examples of things to search for (e.g. photosynthesis and Malawi).
- Show how to solve common problems. How to get back to search page (home three dots OR icon). Show what happens if they try to click on external links or restart the phone

How to Use the Digital Library

- There are 12 phones in the digital library
- Sign in with the librarian
- If all phones are in use, join the waiting list or come back later
- If there is a waiting list, students are restricted to 30 minutes (35-40 minutes when the network is not good)
- Use the phone within the library
- Do no try to tamper with the phones
- There are no backup phones so if one breaks or goes missing there will be fewer phones to use
- Privacy. Your searches are anonymous – no one can see what you personally searched for (not the researchers, not the field team, not the teachers). This is a very important point – make sure they students can explain it back.

Digital Library Rules

1. Only selected students can use the digital library
2. When you arrive, sign in with the digital librarian.
3. The phones should be used one by one (not in pairs)
4. Take care not to damage or tamper with the phone
5. Do not try to access other websites than Wikipedia
6. When you are done, return the phone to the digital librarian
7. Do not hand the phone to any other student

If you break the rules you will be suspended or removed from the program

Table 1: Classification of News Events in 2017-18 (I/II)

Date	Description	Eliminated	Not specific	No Searches	Africa	Geopolitics	Keywords
11/2/17	New species of Orangutan	no			no	no	Orangutan
11/3/17	ISIL defeated in Syria	no			no	yes	Islamic State
11/5/17	Appleby scandal	yes	no	yes	no	no	
11/5/17	Sutherland Springs shooting	no			no	no	Sutherland Springs
11/12/17	Earthquake in Iran and Iraq	no			no	no	2017 Iran-Iraq earthquake
11/15/17	Robert Mugabe arrested	no			yes	yes	Robert Mugabe
11/15/17	da Vinci auction	no			no	no	Leonardo da Vinci
11/15/17	ARA San Juan missing	no			no	no	ARA San Juan
11/20/17	Oumuamua asteroid detected	no			no	no	Oumuamua
11/22/17	Mladic found guilty	no			no	yes	Mladic
11/24/17	Mosque attack in Egypt	no			yes	no	2017 Sinai Mosque Attack
12/5/17	Russia banned from Winter Olympics	no			no	no	Doping in Russia, Russia at the Olympics
12/6/17	US recognizes Jerusalem as Israeli capital	no			no	yes	Consulate General of the United States Jerusalem, United States recognition of Jerusalem as Israeli capital, Status of Jerusalem
12/9/17	Iraq liberated from ISIS	no			no	yes	ISIS
12/14/17	Disney acquires 21st Century Fox	no			no	no	Proposed acquisition of 21st Century Fox by Disney, The Walt Disney Company
12/22/17	UN imposes sanctions to North Korea	no			no	yes	North Korea
12/24/17	Guatemala recognizes Jerusalem as Israeli capital	yes	yes		no	yes	
1/13/18	Killing of Mehsud in Pakistan	yes	no	yes	no	yes	
1/20/18	Turkey invades northern Syria	yes	no	yes	no	yes	
1/20/18	US Federal government shutdown	no			no	yes	US government shutdown
1/24/18	China announces cloning of monkeys	no			no	no	Zhong Zhong and Hua Hua
1/31/18	Total lunar eclipse	no			no	no	January 2018 lunar eclipse, Lunar eclipse
2/6/18	Falcon Heavy launch	no			no	no	Falcon Heavy, SpaceX
2/9/18	Winter Olympics starts	no			no	no	Winter Olympics
2/10/18	First female archbishop nominated	yes	yes		no	no	
2/11/18	Saratov Airlines crash in Russia	no			no	no	Saratov
2/14/18	Jacob Zuma resigns	no			yes	yes	Jacob Zuma
2/14/18	Majory school shooting	no			no	no	Stoneman Douglas
2/18/18	Iran Aseman Airlines crash	no			no	no	Iran Aseman
3/4/18	Skripal poisoning	no			no	yes	Skripal
3/6/18	Russian Air Force crash	yes	yes		no	no	
3/9/18	Winter paralympics start	no			no	no	Winter Paralympics
3/9/18	Trump accepts meeting with Kim Jong-un	yes	yes		no	yes	
3/11/18	Jinping named President for Life in China	no			no	yes	President for Life, Xi Jinping

Notes: All major newsworthy events as reported in `https://en.wikipedia.org/wiki/2017` and `https://en.wikipedia.org/wiki/2018` during the experiment. "Eliminated" marks the events that were not considered either because no specific Wikipedia page could be associated (column "not specific") or because we found no evidence of browsing (column "no searches"). "Africa"and "Geopolitics" refer to whether the events were considered to be African or of geopolitical nature. Elements in column "keywords" are used to match the Wikipedia pages with terms associated to them.

Table 2: Classification of News Events in 2017-18 (II/II)

Date	Description	Eliminated	Not specific	No Searches	Africa	Geopolitics	Keywords
3/12/18	US-Bangla Airlines crash in Nepal	yes	no	yes	no	no	
3/14/18	School walkout in response to shootings in the US	yes	yes		no	yes	
3/18/18	Putin re-elected president	no			no	yes	Vladimir Putin, Russian Elections 2018
3/19/18	White rhino declared extinct	no			no	no	White rhinoceros
3/23/18	Carcassone terrorist attack	yes	no	yes	no	no	
3/24/18	Demonstrations against gun violence	yes	no	yes	no	yes	
3/25/18	Quantas launches Perth-London flight	yes	yes		no	no	
3/25/18	Kemerovo fire	yes	no	yes	no	no	
3/26/18	Russian diplomats expelled in the wake of Skripal poisoning	yes	yes		no	yes	
3/28/18	Kim Jong-un meets Xi Jinping	no			no	yes	Kim-Xi meetings
3/28/18	Fire in Valencia, Venezuela	yes	no	yes	no	no	
4/4/18	Commonwealth games start	no			no	no	Commonwealth games
4/5/18	Lula arrested	yes	yes		no	yes	
4/6/18	Humboldt Broncos crash	yes	no	yes	no	no	
4/8/18	Sarin attack in Douma, Syria	no			no	yes	Douma, Use of chemical weapons in the Syrian Civil War
4/11/18	Algerian Air Force crash	no			yes	no	2018 Algerian Air Force Il-76 crash
4/14/18	Syrian bases bombed by US	no			no	yes	American-led intervention in the Syrian Civil War
4/18/18	Nicaragua protests	no			no	yes	2018 Nicaraguan protests
4/18/18	Movie theathers open in Saudi Arabia	yes	yes		no	no	
4/18/18	NASA TESS satellite launched	yes	no	yes	no	no	
4/19/18	Diaz-Canel sworn President of Cuba	yes	no	yes	no	yes	
4/19/18	Swaziland changes name to Eswatini	yes	no	yes	yes	yes	
4/23/18	Toronto van attack	no			no	no	Toronto Attack, Toronto van attack
4/27/18	Kim Jong-un meets Moon Jae-in in the DMZ	yes	yes		no	yes	
5/3/18	ETA announces dissolution	yes	no	yes	no	yes	
5/3/18	Volcano Puna erupts	yes	no	yes	no	no	
5/5/18	Insight probe launched	no			no	no	InSight
5/8/18	Trump withdrawals from Iranian nuclear agreement	no			no	yes	Joint Comprehensive Plan of Action, Negotiations leading to the Joint Comprehensive Plan of Action
5/8/18	Eurovision contest starts	no			no	no	Eurovision
5/9/18	Pakaran Harapan coallition wins majority in Malaysia	yes	no	yes	no	yes	
5/16/18	Agong pardons Ibrahim in Malaysia	yes	yes		no	yes	
5/18/18	Cubana airline crash	no			no	no	Cubana de Aviacion Flight 972
5/19/18	Prince Harry and Meghan Markle wedding	no			no	no	Prince Harry, Meghan Markle
5/20/18	Venezuelan elections	yes	no	yes	no	yes	
5/24/18	Punggye-ri nuclear test site destroyed in North Korea	yes	no	yes	no	yes	
5/25/18	EU data protection regulation goes into effect	no			no	no	General Data Protection Regulation
5/25/18	Abortion referendum in Ireland	no			no	yes	Abortion in the Republic of Ireland

Notes: as above.

Academic Questions – Sample

Biology Questions
A spirochaete is a type of...
Which of the following bacteria is gram-negative?
Which of the following bacteria is gram-positive?
How do fungi acquire their food?
Penicillin is derived from penicillum, a type of
Cholera is a
Which of the following is an example of an endocrine gland?
Which of the following is both an endocrine and an exocrine gland?
Where is insulin produced?
History Questions
World War I began in which year?
Adolf Hitler was born in which country?
John F. Kennedy was assassinated in
Who fought in the war of 1812?
Which general famously stated "I shall return"?
American involvement in the Korean War took place in which decade?
The Battle of Hastings in 1066 was fought in which country?
The Magna Carta was published by the King of which country?
Who first successfully developed the printing press?
Geography Questions
Which of the following cities is the capital of Argentina?
Which ocean lies on the east coast of the United States?
How many Great Lakes are there in the United States/Canada?
Which is the world's highest mountain?
Which is the longest river in the World?
Which is the biggest desert in the World?
Which of this cities is not in Europe?
Which of the following cities is the capital of Netherlands?
Which of this is the largest city in Africa?
What is the capital of Turkey?