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Restricted access: How the internet can be used to promote reading and learning

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ABSTRACT

Can schools use the internet to promote reading and learning? We provided Wikipedia access to randomly-selected students in Malawian boarding secondary schools. Students used the online resource broadly and intensively, and found it trustworthy, including for information about news and safe sex. We find a 0.10σ impact on English exam scores, and a higher impact among low achievers (0.20σ). Students used Wikipedia to study Biology, and exam scores increased for low achievers (0.14σ). Our results show that by restricting internet access to a source of engaging and accessible reading material, it is possible to encourage independent reading and affect educational outcomes.

1. Introduction

In the developing world, school books are often in short supply, yet programs that simply provide reading material often have no impact on literacy or academic performance.[1] If reading material is not at the right level or does not cater to student interests, students are unlikely to read it or learn from it. Effective reading interventions usually require teacher training and engagement.[2] In order to be compelling, useful and accessible on its own, reading material must satisfy the demands of heterogeneous students, and be relevant across contexts.

As the internet expands worldwide, information technology offers a potential solution. The internet hosts reading material on almost every topic, at every level of difficulty. Young people in particular are enthusiastic internet users; in Africa, young people aged 15 to 24 use the internet at twice the rate of the general population.[3] Yet, internet in schools presents challenges of its own. While information on the internet is plentiful, it varies in its accuracy, trustworthiness and complexity (MacMillan and MacKenzie, 2012; Allcott and Gentzkow, 2017; Lazer et al., 2018). Moreover, students often prefer games, videos and social media to learning. In fact there is evidence that full internet access does not improve academic performance.[4]

In this paper, we show that the internet has a place in schools, and can be introduced in a way that promotes reading and learning. We provide students with an online experience restricted to Wikipedia, a vast yet accessible open source of accurate reading material.[5,6] This preserves one of the most exciting aspects of the internet: detailed and

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[1] See for example Glewwe et al. (2009), Borkum et al. (2012), Sabarwal et al. (2014), and Knauer et al. (2020).

[2] Examples include He et al. (2008), Machin and McNally (2008), Abeberese et al. (2014), Lucas et al. (2014), Bai et al. (2016), Piper et al. (2018), Brunette et al. (2019) and Kerwin and Thornton (2021).

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

[4] See Goolsbee and Guryan (2006), Vigdor et al. (2014), Faber et al. (2015), and Malamud et al. (2019).

[5] Rather than restricting to a single information source, existing work measured the impact of full scale internet access on education (Bulman and Fairlie, 2016; Malamud, 2019; Yanguas, 2020), political and economic behavior (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 (Hinnosaar, 2019; Chen et al., 2020).

[6] There is evidence that Wikipedia is mostly accurate, though incomplete. See Giles (2005), Rosenzweig (2006), Heilman et al. (2011), and Mesgari et al. (2015).

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up-to-date information on almost any topic. Restricted access to online information might compel students to spend time reading, while avoiding other online distractions that do not involve reading. Wikipedia is simple to use and understand, even for students of heterogeneous ability. Many articles have versions written in both standard and simple English. While restricted, this intervention still allows students to easily search for information they need online, and click to learn more about concepts they do not understand, including concepts related to their studies. In this sense, the internet allows students to effectively customize the contents of their learning as well as the difficulty level.

We provide Malawian secondary school students with access to online information, restricted to Wikipedia, and use novel data on student browsing behavior, as well as survey and administrative data, to answer three research questions. First, how do students use this new online resource? Do they find it engaging and accessible? Second, this intervention gives students access to reading material on a vast range of topics. Are students compelled to spend time reading, and how does this affect English language ability? 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 secondary students in Malawi go on to a career in healthcare.[7]

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 and no internet access at school. This setting allows us to isolate both treatment and control students from the broader internet. Students were allowed to use Wikipedia inside a classroom referred to as a digital library, using anonymous usernames. Students were aware that their browsing behavior was private, and that browsing histories could not be linked to individual students. The digital library 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. Students did not have any other internet access during term time.

The design of this study took into account several ethical considerations. First, Wikipedia contains information on topics that some educators might view as inappropriate. We discussed the breadth of information provided with administrators, who were supportive.[8] Second, schools and workplaces often monitor internet browsing behavior. Because browsing was restricted only to Wikipedia, we rather decided to protect privacy by anonymizing browser histories. Finally, the randomization may have been seen by students as unfair. From our perspective, randomization was justified by the fact that, at the outset, we were uncertain whether the intervention would support or undermine student learning.

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. Rather than relying on aggregate usage statistics, we observe individual 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.

Students came to use and trust Wikipedia, particularly for topics which are important, prone to misinformation and often absent from school books, such as world news and safe sex. We find spikes in activity in the week surrounding world news events that occurred during the experiment. We also show that students with access to Wikipedia are able to find news information that control group students cannot. Young people are generally curious about sex, and we find that students spent 7 percent of their browsing time on topics related to sex and sexuality. While Wikipedia pages are informative, and access to accurate information about sex can be important (Dupas, 2011; Kerwin, 2018; Derksen et al., 2021), students may have browsed these pages not only for information but also as a form of entertainment. One third of the time spent browsing these topics overlapped with topics from the school syllabus, such as pregnancy and reproductive health. Students sought information on both news and sex and sexuality independently, without prompts or incentives.[9]

Students used the internet-enabled devices intensively for general interest reading, and we find a positive impact on English final exam scores. We find a significant improvement on average (0.10σ) and for low achievers in particular (0.20σ).[10] We do not find any impact on high achievers. Students in the treatment group spent more than one hour per 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. In fact, we find a positive treatment effect on English exam scores for low achievers. This heterogeneity does not appear to be driven by differences in usage. On average, low and high achievers are similarly able to find information online, and low achievers in fact spend slightly fewer hours in the digital library. We conclude that an additional hour spent reading must have a greater impact for low achievers than for high achievers, perhaps because high achievers are already proficient in English at baseline.

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). Here we observe student browsing choices directly. We did not incentivize or pressure students to use the internet 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 positive but insignificant impact on Biology exam scores (0.06σ), and a significant impact for low achievers (0.14σ). We again find no impact on high achievers. Low achievers did not spend more time on syllabus-related pages than high achievers, and neither low nor high achievers changed their total study time in response to the intervention. This implies an increase in study time productivity for low achievers. Indeed, we find that most treatment students, and especially low achievers, preferred Wikipedia to their Biology textbooks and teachers, and were able to find academic information that their control group peers could not. The fact that information on Wikipedia is particularly easy to find and understand could explain larger gains for students who were struggling at baseline. We do not 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.

This paper shows that by providing suitably restricted internet access, it is possible to engage students in independent reading, and improve academic outcomes. The fact that access to Wikipedia can impact exam scores is remarkable, because interventions that provide full internet access are usually ineffective (Goolsbee and Guryan, 2006;

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

[8] In particular, access to broad and accurate information on sex and sexuality is mentioned explicitly the Malawian secondary school syllabus.

[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.

[10] Here, we define a low achiever to be a student whose average exam score (English and Biology) at baseline is below the median.

Vigdor et al., 2014; Faber et al., 2015; Malamud et al., 2019), unless it is integrated formally into the classroom (Kho et al., 2020).[11] The internet provides students with a compelling and ever expanding set of reading material, but Malamud et al. (2019) find that students primarily use the unrestricted internet for videos, social media, and games.[12] One possible solution is to restrict resources to reading material. Yet, interventions that provide books to schools are also typically ineffective (Glewwe et al., 2009; Borkum et al., 2012; Sabarwal et al., 2014). This highlights the importance of not only supplying reading materials, but finding a way to encourage students to use them (Falisse et al., 2019). There is a vast literature in the theory of education that emphasizes the importance of stimulating self-led, inquiry-based learning; students are more likely to engage with material they find interesting and relevant.[13] In this paper, we demonstrate the empirical importance of this type of student engagement. By providing access to a wide-ranging and up-to-date source of online reading material, it is possible to engage student interest without teacher involvement or incentives.

Second, we contribute to an expanding literature on interventions that can close the achievement gap, especially involving computer programs that "teach at the right level". Such programs have shown promise, particularly for low achievers (Banerjee et al., 2007; Linden, 2008; Barrow et al., 2009; Muralidharan et al., 2019; Beg et al., 2022). Muralidharan et al. (2019) highlight a potential mechanism: even in heterogeneous classrooms, a computer program can adapt to a student's ability. However, these programs are context specific, rely on proprietary software, and often involve teachers and administrators.[14] Wikipedia offers a free, open source alternative to this tailored approach which is still appropriate for students of heterogeneous ability. It allows each student to search for the specific information they need, written in accessible language. Some other self-led reading interventions have also been shown to disproportionately impact low achievers, as they allow students to set their own level and pace (Falisse et al., 2019). On the other hand, if materials are too advanced for some students, they might in fact widen the achievement gap (Glewwe et al., 2009). Baseline literacy is key; in secondary school, even low achievers are proficient enough to engage with new material, while high achievers may be too proficient to improve further.

Finally, this paper contributes to an emerging literature on education interventions in secondary school. Most education interventions to date target primary or middle school students,[15] 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.[16] Yet, returns to secondary school are high (Ozier, 2018). Secondary school is a necessary step towards postsecondary education, and a career in policy, education or healthcare. Finally, 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. In this paper we show that reading material can in fact be useful to secondary students with a base level of literacy, for an advanced subject such as Biology.

The internet can serve as 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.[17] 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. Internet and technology costs are decreasing over time, and if implemented in entire schools, the intervention might benefit from additional economies of scale. This is clearly more cost-effective than programs that provide reading material to primary schools to promote reading, with no impact. It is also more cost-effective than many computer-aided learning programs. It is, however, less cost-effective than some of the most impactful primary school interventions, especially those that improve the quality of instruction. It is difficult to compare our intervention to other potential impacts in secondary school, as evidence is limited (Banerjee et al., 2013), but we might expect smaller returns in secondary school due to higher baseline ability levels.

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 whether students were able to use the digital library to find information. Section 5 presents our results on student academic performance. We conclude in Section 6 by discussing mechanisms, policy implications and external validity.

2. The intervention: Restricted internet in schools

2.1. Wikipedia

Wikipedia is an online encyclopedia, providing up-to-date reading material on a wide range of topics. It is the largest and most visited reference site on the internet. It is a source of collaborative, accurate, open source information.[18] Content is created through open collaboration, and its accuracy on scientific topics is comparable to an offline encyclopedia (Giles, 2005). However, Wikipedia is frequently updated, and offers far more informational content than an offline encyclopedia, in terms of breadth, depth, and relevance.

Wikipedia is a high quality resource for secondary school, and is accessible to students of heterogeneous ability. Information is easy to find and understand, and it is easy for students to search directly for concepts they find difficult. Articles exist in English and Simple English[19]

[11] Providing computers is also typically ineffective (Malamud and Pop-Eleches, 2011; Fairlie and Robinson, 2013; Beuermann et al., 2015; Cristia et al., 2017), though some programs (which include educational software) find improvements in computer skills and math (Carrillo et al., 2011; Mo et al., 2013). See Bulman and Fairlie (2016) for a broad review of the literature on information technology and education, and Rodriguez-Segura (2021) for a review of educational technology in developing countries.

[12] Parents may attempt to limit internet access for this reason, rather than install appropriate parental controls (Gallego et al., 2020).

[13] Dewey (1938), Bruner (1961), Freire (1970), and Rancière (1991) have promoted self-led and inquiry-based learning as a pedagogical method in which teachers guide students to learn independently. More recently, this topic has been studied by Biesta (2007), hooks (2010), McLaren (2015), and Giroux (2020).

[14] Remedial lessons (without computers) also improve scores for low achievers (Banerjee et al., 2007).

[15] See Banerjee et al. (2013) for a review of studies which focus on post-primary school students. Furthermore, Evans and Mendez Acosta (2020) review recent empirical education research in Africa, and find that one quarter of articles discuss secondary education. The majority of these articles focus on girls specifically or the impact of cash transfers or subsidies. Barrera-Osorio and Linden (2009) study an ICT intervention which did include secondary schools.

[16] 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.

[17] Bando et al. (2017) show that digital content can be used as a cost-effective substitute for primary school textbooks.

[18] Source: Wikipedia, https://en.wikipedia.org/wiki/Wikipedia, accessed on May 23rd 2019. Wikipedia is free and owned by Wikimedia, a non-profit organization with no advertising.

[19] 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.

(among many other languages), and Wiktionary serves as a companion dictionary. Wikipedia has a page for every topic on the typical secondary school syllabus, and often provides more detail than a textbook. For example, the English page for photosynthesis (a topic from secondary school Biology) 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 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.[20] In 2006, 93 percent of the Malawian population lived in an area with access to a mobile network.[21] 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 A1).

Though internet infrastructure exists, access to the internet is unaffordable for most Malawians. 54 percent of Malawian households have a mobile phone (DHS, 2015–16),[22] but most of these phones do not have internet capabilities. Moreover, 1 GB of internet costs the average Malawian 18 percent of their monthly income (see Table A1). This income share is larger than in Mozambique or Zambia, where incomes are higher. However, prices are dropping rapidly, and internet use in Malawi is on the rise. In 2007, less than 1 percent of Malawians had regular internet access (see Table A1). In 2015, this rose to approximately 12 percent (DHS, 2015–16).

Malawi is on the verge of internet adoption, yet Malawian schools do not have internet access, making this a unique and appropriate setting for our study. The presence of internet infrastructure makes internet in schools feasible. Yet, most of the population, including youth, have limited internet experience. At school, 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 (DHS, 2015–16). Courses are taught in English, and require adequate language skills. The courses are difficult, and study materials are likely to be important.[23] 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.[24]

Our experiment took place in four government boarding schools which serve students of mixed socioeconomic status. Each school has approximately five hundred students spread over four forms (grade levels). Government boarding schools are common in Malawi and across sub-Saharan Africa. They are more academically competitive than government day schools and most private schools (de Hoop, 2010). However, even in these schools, many students do struggle academically. In particular, one quarter of students had an English exam score below 50/100 in the year before the intervention. While government boarding schools attract good students, fees are not exorbitant.[25] Indeed, according to our baseline survey, 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 school.

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, and being caught with a phone at school was grounds for suspension. Students sleep in dormitories, and are not permitted to leave the school grounds. In particular, they do not go home during the term, so those who do have home internet access cannot use it.[26]

2.3. Experimental design

In each boarding school, we set up a digital library where students could access the restricted internet 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. These devices were battery powered, and the internet was typically accessible even during power outages. The devices were shared among 69 to 82 students in each school. We used password-protected software to restrict the devices to Wikipedia and Wiktionary.[27] We put links to English Wikipedia, Simple English Wikipedia and Wiktionary on the main login page.

Inside the digital library, students could browse online information 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.[28] The librarian 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, but students were not allowed to study in the digital library unless they were actively using a device.

In October, 2017, we introduced the project to students, conducted a baseline survey, and collected baseline exam scores.[29] Our team of eight enumerators surveyed every student in Forms 2, 3 and 4. In total, we interviewed 1508 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

[20] 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 $1575 and $10,749, respectively. Current USD values.

[21] See Buys et al. (2009). 2G networks are largely accessible in rural areas, and 3G and 4G networks are available in towns and cities. Data networks are reliable even during electricity outages. See Batzilis et al. (2010) for a detailed description and analysis of the mobile network in Malawi.

[22] See National Statistical Office (Malawi) and ICF (2017) for Malawi DHS, 2015–16.

[23] 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.

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

[25] Admission is based on a national primary school exam. The school fees in our schools range from 75 to 165 USD per term, with many students on bursaries or scholarships.

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

[27] 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.

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

[29] We introduced the project to students and teachers at each school, one form at a time, and all received the same information. See the supplementary materials for a detailed description of the classroom introduction.

sparse treatment ratio was chosen to limit spillovers, and jealousy, between students. We also hoped this might reduce feelings of unfairness or disappointment, as a large majority of students found themselves in the control group. At endline, 79 percent of control students and 91 percent of treatment students felt the program was fair (see Appendix Table A2).[30] This also limits the potential for teachers to adapt their lesson plans in tandem, as most of their students do not have access to the internet. A subset of students in the control group (299 students out of 1,207) was randomly assigned to a supplementary survey sample. This subsample would be surveyed more extensively for the construction of some secondary outcomes.

We randomized at the student level, and stratified on four key variables: school, form, exam scores and internet experience.[31] 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. Panel A of Table 1 shows that our randomization is balanced across baseline variables (Appendix Table A3 shows balance across stratification 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.[32] During the induction, the students obtained an anonymous username 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 could not be linked to a particular student. While ensuring privacy, this does prevent us from linking detailed browsing patterns to other outcomes at the individual level.

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 min. Only students in the treatment group used the digital library, and the librarians used student photos to verify identities.[33] This restriction limits the scope for any spillovers to the control group that would rely on direct access to devices, Wikipedia or the internet. Teachers did not have access to the devices.

3. How students used Wikipedia

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

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.

Most students made frequent use of the digital library, and every student in the treatment group visited at least once. The average student visited the digital library on 33 days during the school year and each visit lasted 52 min.[34] This is approximately one hour and twenty minutes per week for each student, or 29 h over the course of the year. 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 Fig. 1 we present the distribution of browsing hours across students. The distribution is skewed to the right. While the average student spent 29 h in the digital library, some students spent more than 150 h browsing Wikipedia, over more than 100 visits. The time spent in the digital library is similarly distributed across low and high achievers (Panel B of Fig. 1). This suggests that the intervention was accessible even to students with weaker language skills.

3.2. Topic classifications

We use the Wikipedia category tree to classify pages according to broad topics in order to shed light on student interests and search behavior. Wikipedia has a user-generated and user-maintained category tree. The tree has 39 top-level categories which we adopt as topic classifications. Each top-level category branches into one or more subcategories which, in turn, may contain both pages and narrower subcategories. We trace each page visited by a student to one top-level category.[35]

Panel A in Fig. 2 presents the 24 most common Wikipedia Browsing topics according to time spent. The typical student spread their browsing time across several different topics (see Panel A of Appendix Figure A2 for detail on within-student variation in topics). The most popular topic is "People", with an average of four hours per student. This topic includes politicians, musicians, athletes, and other individuals of interest. Many popular topics including "Life", "Academic disciplines", "Arts", and "Nature" overlap with school subjects. We will identify school-related pages using a narrow classification in Section 3.5.

[30] In Section 6, we explore whether this difference can explain the treatment effects we find.

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

[32] The digital librarians explained the digital library and its rules. They also showed students how to access Wikipedia, and allowed the students to practice for fifteen minutes. Students were told that breaking the rules would result in suspension or removal of access. See the supplementary materials for a detailed description of the induction and digital library rules.

[33] 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.

[34] 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. Appendix Figure A1 shows browsing over time.

[35] The full list of top-level categories can be found at https://en.wikipedia.org/wiki/Category:Main_topic_classifications. For more information on the tree structure, see https://en.wikipedia.org/wiki/Wikipedia:Categorization#Topic_categories. 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. We 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". Additional detail is provided in Appendix A.

Table 1
Balance table and attrition in endline surveys and exam scores.

	(1) Treatment	(2) Control (subsample)	(3) *p*-value	(4) Control (full)	(5) *p*-value
Panel A. Balance, non-stratification variables					
Average exam score in English	57.188	57.626	.694	57.429	.780
	(13.187)	(13.533)		(13.005)	
Average exam score in Biology	53.810	53.267	.709	53.544	.816
	(17.196)	(17.640)		(17.985)	
Average exam score in Science	55.300	54.233	.498	54.041	.303
	(18.317)	(19.498)		(19.559)	
Average exam score in Humanities	58.778	57.998	.520	58.369	.676
	(14.964)	(14.128)		(14.582)	
Average exam score in Math	44.892	43.535	.476	43.899	.501
	(21.904)	(23.077)		(22.622)	
Average exam score in Chichewa	61.791	61.712	.947	62.007	.819
	(14.438)	(13.782)		(13.942)	
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	.358
	(.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)	
Panel B. Attrition					
Endline A	.047	.050	.653	.076	.027
	(.211)	(.219)		(.265)	
Endline B	.083	.084	.933	–	–
	(.276)	(.278)			
Exam scores (English)	.060	.050	.680	.065	.736
	(.238)	(.219)		(.246)	
Exam scores (Biology)	.063	.054	.700	.069	.715
	(.244)	(.226)		(.253)	
Number of students	301	298		1,207	

Notes: Panel A: Balance table across the treatment (N=301), subsample of control (N=298) and full sample of control (N=1207) groups. (3) and (5) show the *p*-value of the difference between treatment and subsample of control, and treatment and full sample of control groups, 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. Panel B: Differential attrition between treatment and control groups. Regression of attrition indicator in endline surveys A, B, and Biology and English scores on the treatment status with strata fixed effects.

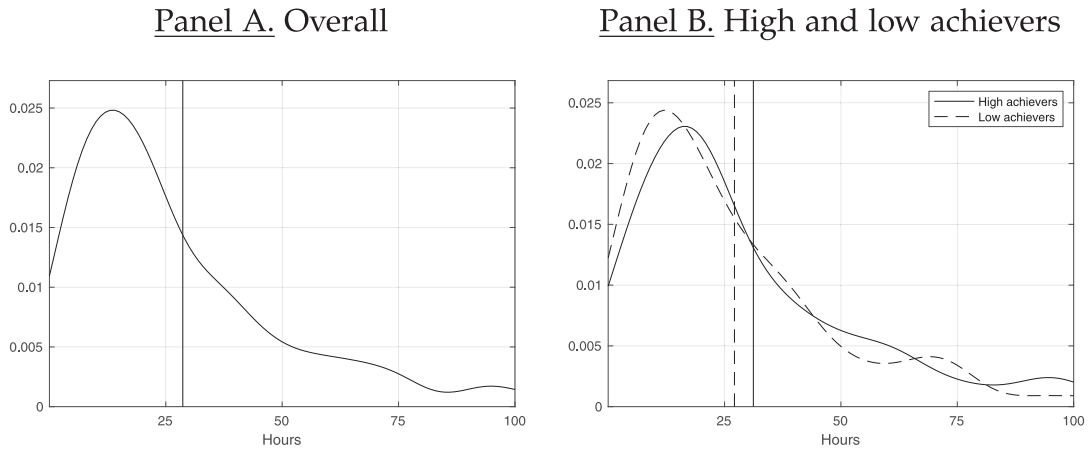

Fig. 1. Histogram of hours spent browsing Wikipedia. *Notes:* Density of browsing hours, treatment students only, aggregated over one academic year. The digital library was open for 20–22 weeks, from November 2017 to June 2018, excluding Christmas and Easter vacations. Vertical lines are the average hours spent browsing. Panel A: Average is 28.6. Panel B: Average is 31.2 for high achievers and 27.1 for low achievers.

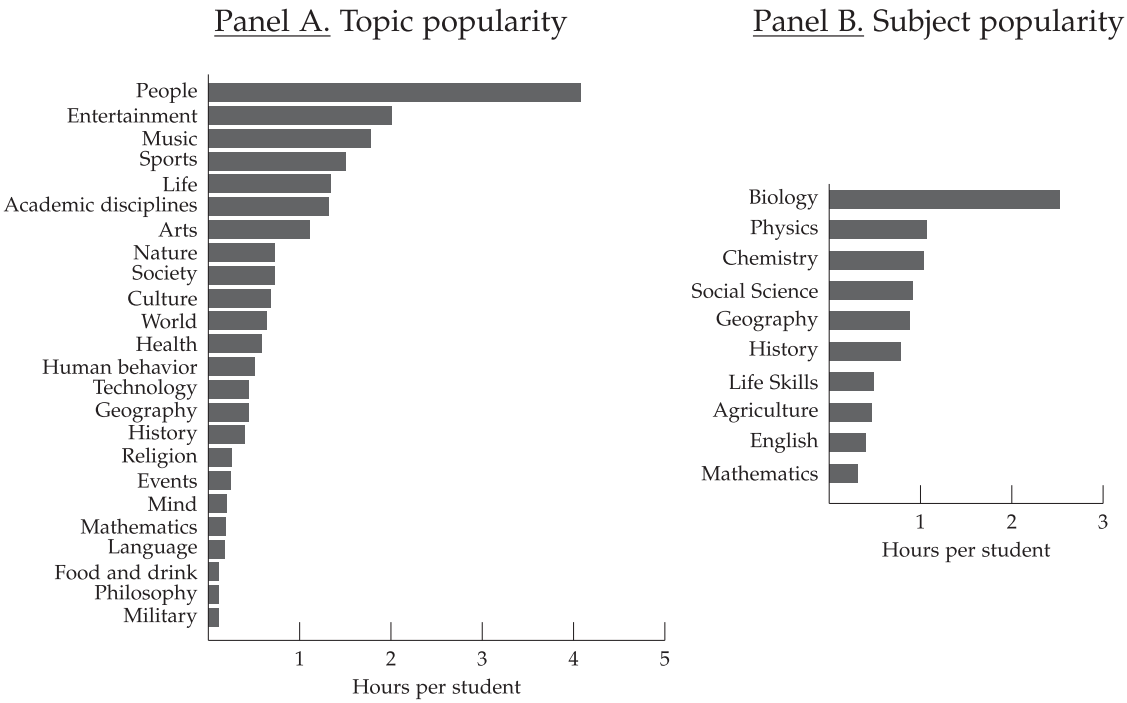

Fig. 2. Hours spent browsing Wikipedia by topic and school subject. *Notes:* Panel A: Browsing hours per topic, per student, aggregated over one academic year. See Appendix A for details on topic classification. The topics Business, Concepts, Crime, Economy, Education, Energy, Government, Humanities, Knowledge, Law, Objects, Organizations, Politics, Science, and Universe are excluded from the figure and are less than 0.12 h. Panel B: Browsing hours per school subject, per student, aggregated over one academic year.

3.3. News and world events

In this section, we ask whether students use Wikipedia to learn about the news. Indeed, the popularity of "People" pages may indicate interest in individuals at the center of a news story. Other popular news sources, such as social media and online news sites, are often biased and sometimes inaccurate (Chung et al., 2012). By comparison, news articles on Wikipedia are often impartial and accurate (Lih, 2004). If provided with this type of fact-based resource, will young people use it to read about world events?

We examine student browsing in the time leading up to or immediately following the event. 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. We use Wikipedia's comprehensive list of 64 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).[36]

When we look at time spent on pages related to a particular news event, we observe a clear spike during the week the event occurred (Panel A of Fig. 3). The average student spent 2.9 min browsing these news stories, aggregated over 64 events. While few students read about any particular event, most students searched for at least one. This greatly underestimates total interest in the news, as most news events, and particularly news stories from Africa and Malawi, are not included among Wikipedia's top 64 stories. The spike in browsing emerges for both African and non-African events (Panels B and C of Fig. 3). Students spent 10 times longer on news events taking place in Africa (Panel B of Fig. 3).

3.4. Sex and sexuality

Sex and sexuality 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 HIV infection. Wikipedia contains detailed, accurate, and up-to-date information on human reproduction, sexuality and sexual health. Yet, while informative, some pages related to sex and sexuality might serve primarily as entertainment for students who otherwise have no internet access. Moreover, policymakers, educators and parents might not view unlimited information access as desirable, if it leads to beliefs, attitudes, and sexual behaviors they wish to discourage. These views likely vary and depend on the cultural context. In 2013, Malawi became a signatory to the *UNESCO Ministerial Commitment on Comprehensive Sexuality Education and Sexual and Reproductive Health Services for Adolescents and Young People in Eastern and Southern Africa* (Likupe et al., 2021), which includes a commitment to provide "comprehensive, life skills-based HIV and sexuality education [...] by providing scientifically accurate, realistic, non-judgmental information". The Malawian secondary school curriculum includes clear objectives to inform and educate students on safe reproductive health, and topics from the Life Skills syllabus include: "differences between sex, sexuality and gender", "structures that support victims of sexual harassment and abuse", "reproductive health problems: teenage pregnancy, fistula, abortion, contracting STIs including HIV", "discussing myths about sexuality", and "analyzing sources of unreliable information about sex and sexuality". In practice, however, teachers might not have the resources, training, or desire to discuss these topics fully. In Section 3.5, we will explore the overlap between the school syllabus and sex and sexuality topics browsed by students.

We find that the average student spent 2.0 h, or 7 percent of their time on pages related to sex and sexuality, broadly defined, as determined by the Wikipedia categories for "Human Reproduction", "Human Sexuality", "Sexual Health", and "Sexuality and Society".[37]

[36] Source: https://en.wikipedia.org/wiki/2017 and https://en.wikipedia.org/wiki/2018. We consider Wikipedia pages that are related to each event prior to May 11th, when Endline A took place. Details of the procedure to associate events to Wikipedia pages can be found in Appendix C. The list of events can be found in the supplementary materials.

[37] Additional details, as well as examples of page classifications and alternative definitions are available in Appendix A.

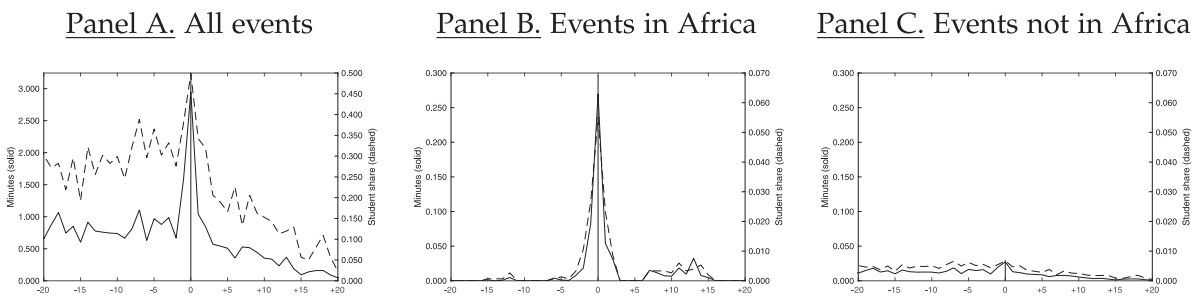

Fig. 3. Wikipedia browsing for news about world events in 2017-18. *Notes:* Panel A: Left axis (solid line) shows total average browsing minutes per student on pages related to full set of worldwide events. Right axis (dashed line) shows share of students that visited pages associated to at least one event. Panels B and C: Left axis (solid line) shows average number of minutes per student and event. Right axis (dashed line) shows average share of students that visited pages associated to a single event. 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 are included, with the 20 weeks before and after they occurred. See Appendix B for details on classification of news events. Week of the event is set at zero. Negative (positive) numbers on the x-axis are weeks before (after) the event.

Comparing this to Fig. 2, we see that sex and sexuality would place third among general interest topics. The page for "Sexual Intercourse" is the most popular page within this topic and across all Wikipedia pages.

3.5. The school syllabus

While 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. Wikipedia has content on every academic subject, and might replace textbooks, which are often in short supply. The findings of this section will inform our later discussion of results on academic performance and student time use.

By manually mapping the Malawian secondary school syllabus to specific Wikipedia pages and narrow subcategories, we can show that students do use Wikipedia as a study tool.[38] We manually map the Malawian secondary school syllabus to specific Wikipedia pages and narrow Wikipedia subcategories from the category tree described in Section 3.2. For example, the subcategory for "Circulatory System" matches a topic in the Biology syllabus, 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 exactly matches a topic for a particular school subject, or belongs to a syllabus subcategory, we classify it as directly related to that subject syllabus. We further discuss this classification, as well as other potential classifications in Appendix A.

Students face a tradeoff between browsing general interest pages and syllabus pages, and on average, students allocate 22 percent of their browsing time to pages directly related to the syllabus. The average student spent 6.3 h on pages related to the school syllabus, with some students spending as many as 20 h on school subjects (Panel A of Fig. 4). Comparing this to Fig. 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 h). We will discuss these patterns further in relation to the intervention's impact on academic performance in Section 5.

We expected Wikipedia to be useful, and used, for Biology, and students indeed browsed Biology pages significantly more than any other subject (2.5 h on average, Panel B of Fig. 2). 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).[39] The average student spread their study time across five different school subjects (see Panel B of Appendix Figure A2).

There is overlap between the school syllabus and topics related to sex and sexuality. One third of the time students spend on sex-related topics involves pages that can be directly linked to the school syllabus. These topics are frequently part of the Biology syllabus (e.g. "Sexual Reproduction") or the Life Skills syllabus (e.g. "Birth Control"). However, sex and sexuality appear to be of particular interest to the students for reasons that are likely unrelated to their studies. If we exclude all sex-related topics, the average time spent on pages related to the school syllabus drops from 6.3 to 5.7 h. However, Biology remains by far the most popular subject, with 2.1 browsing hours on average.

3.6. Discussion of student browsing patterns

As we examine student browsing patterns, the following stylized facts emerge. First, the intervention was effective in encouraging students to read. The average student used the new resource intensively, and spent one hour and twenty minutes per week reading articles on Wikipedia. Second, individual students have broad interests: they visited a multitude of pages on a variety of topics, mostly not related to their studies. 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.

4. Using digital technology to find information

In this section, we show that treatment students became comfortable with information technology, and learned to use it to quickly find accurate information. We show that students prefer Wikipedia to other information sources, and that access to Wikipedia allowed treatment students to find information about news events, as well as information about academic subjects that their peers could not find using school resources.

4.1. Data and empirical strategy

We conducted two endline surveys.[40] 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

[38] The 2017–2018 Malawi secondary school syllabus can be provided by the authors upon request.

[39] Students spent more than twice as much time (a simple t-test generates a 95 percent confidence interval of 1.3 to 1.6 more hours) on Biology pages than on Physics pages (the next most popular subject).

[40] We include the complete list of questions from the endline surveys in the supplementary materials.

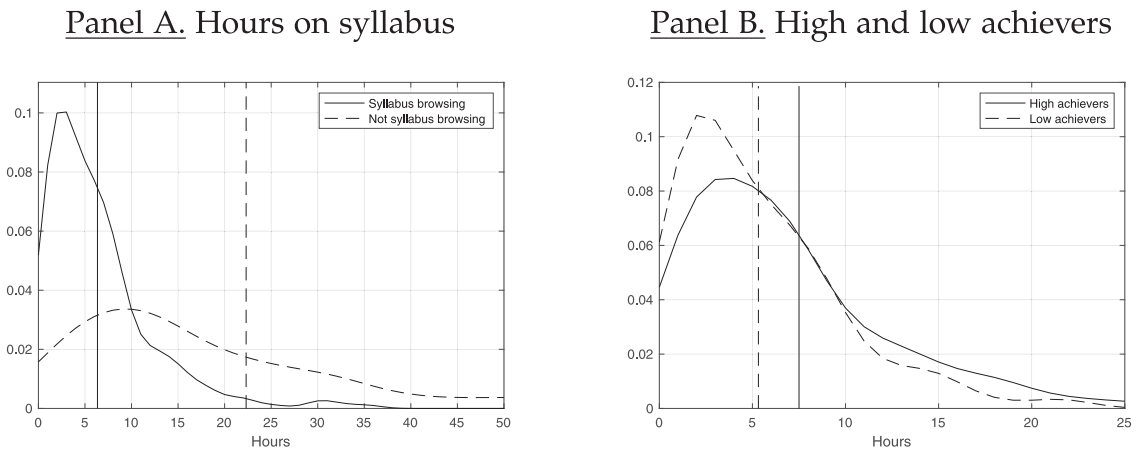

Fig. 4. Hours spent browsing pages related to the school syllabus. *Notes:* Density of browsing hours, across treatment students only, aggregated over one academic year for school syllabus-related pages. Panel A: Hours on syllabus- and non syllabus-related Wikipedia pages. Vertical lines are average hours spent browsing (6.3 on syllabus and 22.3 on non-syllabus). Panel B: High (low) achievers defined as above (below) median exam scores at the baseline. Vertical lines are the average hours spent browsing syllabus pages (7.5 for high achievers and 5.3 for low achievers).

supplementary surveys. Endline Survey B was a 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 (Panel B of Table 1). The attrition rate for Endline A is 5 percent in both the treatment group and the subsample control group. There is significantly higher attrition in the full control group (8 percent), and we therefore include Lee (2009) bounds 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.

Data from Endline Survey B shows that treatment students found Wikipedia accessible and useful. Fig. 5 plots the percentage of treatment students who prefer Wikipedia to their textbooks or teachers, respectively, by topic. Most students prefer Wikipedia to either books or teachers for general interest subjects such as news events and safe sex. They also prefer Wikipedia to their Biology books and teachers, with a slightly higher preference for Wikipedia among low achievers (the difference is not statistically significant). Overall, more than two-thirds of treatment students believe that information on Wikipedia is easier to find, easier to use, and more trustworthy than information on the broader internet (beliefs are similar for low and high achievers, see Appendix C).

We investigate the impact of the intervention by regressing survey outcomes on the treatment variable. We estimate the following 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 an 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.[41] We report heteroskedasticity-robust standard errors, as well as randomization inference p-values.[42]

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. For the outcomes in this section, positive spillovers are likely, especially from treated to control students (see Section 6.1). In this case, $\hat{\beta}$ is an underestimate of the effect of the intervention. The nature of spillovers on academic performance outcomes is likely to be different, and will be examined in Section 5.

4.2. Results

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. Treatment students are more likely to choose Wikipedia over other internet information sources: they were twice as likely to use Wikipedia for this task (Column 1 of Table 2). These results are large and significant for both low and high achievers. Most treatment students (58 percent) are able to find the correct answer within 2 min (Column 2 of Table 2). Only 39 percent of control students succeed.

Next, we show that students with access to the digital library have an advantage over their peers when it comes to finding information about both the news and about academic subjects, which suggests that the digital library may be useful as a study resource, over and above the resources provided by the school. 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.[43] These questions were different for every student. 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 surveys. Students in the treatment group are 9 percentage points more likely to find the answer to the news question (Column 3 of Table 2). They are also 11 percentage points more likely to correctly answer the academic question (Column 4 of Table 2). This is more surprising, as all students had access to the school library, their notes and their teachers. The effect is only statistically significant for high achievers. These outcomes are likely subject to spillovers; indeed we find that control students often asked treatment students to search on their behalf. This is discussed in Section 6.1.

Here and in Appendix C we test multiple closely related hypotheses related to online information. Pooling all outcomes, including heterogeneous treatment effects, we calculate sharpened q-values using

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

[42] We randomize at the individual level, and therefore do not report cluster-robust standard errors (Abadie et al., 2017). Randomization inference p-values are based on 10,000 replications.

[43] The student drew each question from a hat, and kept the slip of paper. See the supplementary materials for a list of sample questions.

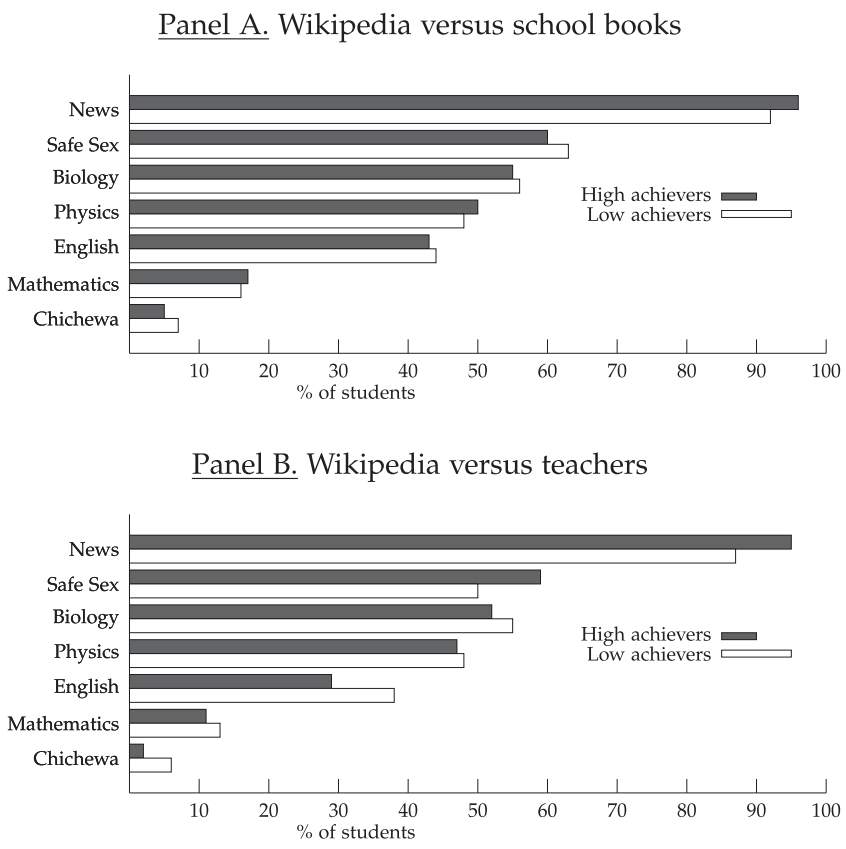

Fig. 5. Student preference for Wikipedia by school subject. *Notes:* Percent of treated students that prefer Wikipedia over school books and teachers respectively. At endline, students are asked to rank sources according to the "best place to find information" for each topic. High (low) achievers defined as above (below) median exam scores at the baseline.

Table 2
Ability to find information.

	(1) Milky way phone test (opened Wikipedia)	(2) Milky way phone test	(3) News quiz	(4) Academic quiz
Panel A. Overall effects				
Treatment	.253***	.186***	.089**	.108***
	(.038)	(.039)	(.042)	(.041)
	p = .000	p = .000	p = .035	p = .009
Panel B. Heterogeneous treatment effects				
Treatment x low achiever	.233***	.183***	.029	.096
	(.052)	(.053)	(.058)	(.060)
	p = .000	p = .001	p = .622	p = .111
Treatment x high achiever	.275***	.190***	.152**	.120**
	(.055)	(.059)	(.060)	(.056)
	p = .000	p = .001	p = .013	p = .034
Units	Binary	Binary	Binary	Binary
Mean of dependent variable in control	.212	.392	.513	.567
Strata FE	yes	yes	yes	yes
Number of students	549	548	535	538

Notes: Treatment effects on student ability to find information. "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 the internet during the survey to find the answer. (1) is an indicator equal to one if the student opened the Wikipedia app during the test. (2) is an indicator equal to one if the student was correct within two minutes of search. (3) and (4) are indicators equal to one if at Endline B, the student correctly answered the quiz question that was provided during Endline A. Questions were student-specific and correct answers were incentivized. High (low) achievers defined as above (below) median exam scores at the baseline. The sample is students in the treatment group and in the subsample of the control group with supplementary surveys. We include strata fixed effects. Randomization was stratified by school, form, above median achievement and past internet use. Robust standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$. Randomization inference p-values based on 10,000 replications denoted as "p =".

the Benjamini et al. (2006) false discovery rate method, following Anderson (2008). All average and heterogeneous treatment effects in Table 2 and Table A4 are robust to this multiple inference method at the five percent level, with the exception of the (insignificant) impact on low achievers' news quiz scores in Table 2, Column 3.

5. Academic performance

In this section we investigate the impact of restricted internet access on academic performance, as well as student time use, class participation, and aspirations. Wikipedia might improve English language skills, and English exam scores, by offering compelling and accessible reading material. 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. 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.

5.1. Data and outcomes

Our primary outcomes are English and Biology exam scores in the final term.[44] We selected these two subjects as primary outcomes for several reasons. If Wikipedia serves as a literacy intervention, English language skills should improve over time and impact English exam scores.[45] Biology exams require students to absorb a large amount of information, and Biology students are likely to benefit from additional study materials. Our browsing and survey data support the view that students find Wikipedia particularly useful for Biology. Recall that students spent more time on pages related to Biology than on any other school subject. Moreover, at endline we elicited student preferences for Wikipedia by school subject, and find that most treated students prefer Wikipedia to their Biology books and teachers respectively (Fig. 5). This preference for Wikipedia does not exist for other subjects. Finally, at baseline, 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 healthcare professionals. Many of the students who pass their final exams do go on to college programs in nursing, medicine, or other health specialties. This interest in Biology reflects career prospects for Malawian secondary school graduates more generally; the schools in our sample do not have any particular focus on Biology or healthcare.

We also measure impacts on other academic subjects including Mathematics, Chichewa (a local language), other science subjects (Physics and Chemistry) and the humanities. We did not expect to see a positive impact on these subjects. Mathematics, Physics and Chemistry are primarily skill based. While Wikipedia does have a version in Chichewa, it hosts only a few hundred pages, none of which were visited by students. The humanities are unpopular with students at baseline, as measured by enrollment and stated preference. We therefore did not include any of these subjects as primary outcomes. However, we might expect a negative impact if students shift time away from those subjects towards English, Biology, or online distraction.

To measure academic performance, we use administrative data on school exam scores, and national exam scores for Form 4 students. 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.

For each core subject (English, Biology, Mathematics and Chichewa), we construct a separate outcome variable y_i representing student i's final exam score in that subject, standardized within the form and school. Other subjects are offered as electives, or only in certain forms or schools. We combine similar subjects using an index measure that assigns weight to non-missing values. We construct an outcome for other 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).[46] Administrative data is missing for a few exam scores, as some students drop out or miss an exam. We are missing data for approximately 7 percent of students (Panel B of Table 1).

We also construct two measures of absolute overall performance, based on the measures used by the Malawi National Examination Board (MANEB). Form 4 students receive a point-score for each subject exam, with points ranging between 1 (top score) and 9 (fail). The total number of points is determined by adding up the score on the English exam and the top 5 other subjects. A student passes secondary school if they pass English and five other subjects, with a "credit" in at least one subject (a score of 6 points or less). We use the MANEB conversion between percentage scores and points to define proxy measures for students in Forms 2 and 3.

5.2. Empirical strategy and main results

We estimate the effects of the intervention on exam scores for each subject in the final term.

$$y_i = \beta \text{Treatment}_i + \delta \left(y_{i0} \times \text{Data}_{i0} \right) + \delta_0 \, \text{MissingData}_{i0} + \sigma_s + \varepsilon_i \qquad (2)$$

Here, y_i is the measure of academic performance for student i in term 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.[47] We use indicators for missing baseline scores: Data_{i0} and MissingData_{i0} are indicators for whether or not we have baseline data y_{i0} for student i. We include a fixed effect for the stratification bin. We report robust standard errors, as well as randomization inference p-values based on 10,000 replications. 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, $\mathbb{E}(\varepsilon_i | \text{Treatment}_i) = 0$. Therefore, in the absence of spillovers, the OLS estimate of β is unbiased.

We also estimate heterogeneous treatment effects by baseline achievement, interacting the treatment variable with an indicator for high achievement at baseline. We define high achievement as above median average score in English and Biology, which corresponds to one of our stratification variables.

Spillovers are possible in our setting, from treatment students to other treatment students or to control students. While information is likely to be shared between treatment and control students, any impact on English language skills or Biology exam scores is likely to be small without direct access to the reading material. In Appendix Table A7 we provide some evidence that this is indeed the case, using a specification

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

[45] In our setting, English exam scores measure English language ability. We include a sample English exam in the supplementary materials.

[46] For Form 4 students we use national exam scores. We standardize scores by subtracting the mean and dividing by the control group standard deviation within each school and form. We then subtract the overall control group mean (across forms and schools). We are guided by Anderson (2008) in our construction of summary indices. Each index variable is a weighted mean of standardized scores. This procedure gives less weight to highly correlated outcomes and outcomes with missing values.

[47] In Appendix Tables A5 and A6 we report results without controlling for baseline exam scores.

Table 3
Treatment effects on exam scores, primary outcomes.

	(1) English	(2) Biology
Panel A. Overall effects		
Treatment	.103**	.063
	(.050)	(.047)
	p = .046	p = .192
Panel B. Heterogeneous treatment effects		
Treatment x low achiever	.195**	.143**
	(.076)	(.067)
	p = .016	p = .043
Treatment x high achiever	.003	−.025
	(.062)	(.064)
	p = .964	p = .707
Mean of dependent variable in control	.000	.000
Strata FE	yes	yes
Number of students	1412	1406

Notes: Treatment effects on final exam scores. High (low) achievers defined as above (below) median exam scores at the baseline. We include a control for baseline exam score, an indicator for missing baseline score, and strata fixed effects. Randomization was stratified by school, form, above median achievement and past internet use. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Randomization inference p-values based on 10,000 replications denoted as "p =".

that controls for spillovers from treated study friends.[48] A different type of spillover may operate through teacher behavior, however, given the sparse treatment, and standardized syllabus and exams, there was little opportunity for teachers to adapt to the intervention. We discuss this further in Section 6.1.

We find a significant impact on English exam scores, overall (0.10σ) and for low achievers (0.20σ), and a significant impact on Biology scores for low achievers (0.14σ, see Table 3). We find no significant impact on high achievers in either subject. We also estimate alternate heterogeneous treatment effect specifications, and find similar results (Appendix Tables A8 and A9).

For our primary outcomes, including heterogeneous treatment effects, we again calculate sharpened q-values using the Benjamini et al. (2006) false discovery rate method. The three significant estimates in Table 3 (the average treatment effect on English scores and heterogeneous treatment effects on English and Biology for low achievers) are robust to this multiple inference method at the ten percent level, with $q < 0.07$ for all three estimates.

We do not find any impact, positive or negative, on other school subjects (see Table 4, Columns 1 to 4). Average treatment effects are between -0.03σ and 0.04σ for Mathematics, and science and humanities subjects. We cannot rule out a small negative impact on Chichewa; while insignificant, the estimate is -0.07σ.

Finally, we see positive, though statistically insignificant impacts on absolute measures of overall performance. In Table 4, Column 5, we report the impact on the total number of points awarded to students, as defined by MANEB. Fewer points represent a higher score, and in Table 4 we have scaled this outcome by -1 for ease of interpretation. Treatment students score 0.2 fewer points on average, an approximate 0.02σ improvement. This effect is larger, though still insignificant for low achievers, whose scores improve by 0.5 points or approximately 0.05σ. The impact on pass rates is also insignificant, though point estimates are positive (Table 4, Column 6). Treatment students are 3 percentage points more likely to pass the year, and low achievers are 6 percentage points more likely to pass (significant at the 10 percent level).

Most exams are marked by the students' teachers, which could bias our results up or down. On the one hand, there could be teacher demand effects; teachers might grade treated students differently from control students. However, each teacher teaches hundreds of students, and it would be difficult for them to keep track of which students took part in the intervention. If teachers did know which students were taking part, and this explained the impact on scores, we would not expect stark differences by subject and baseline achievement. On the other hand, exams might not fully capture the impact of the intervention, if students improve their subject knowledge in ways that exams do not measure. Or, teachers might grade exams based on their own knowledge or outdated learning materials, and might therefore grade correct answers that students learned online as incorrect. This would bias our results towards zero.

5.3. Time use, class participation and aspirations

We next examine student time use across different activities, to determine whether treatment students substituted away from study time to spend time in the digital library. We collected time use 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.[49] Study time includes time the students spent studying in the digital library, but not other browsing time. We use Eq. (1) to estimate the impact of the intervention on study time, recreation time, and sleep. Because Endline A was subject to differential attrition in the full control group, we also report Lee (2009) bounds.

[48] The spillover effect specification in Appendix Table A7 follows Miguel and Kremer (2004) and 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 network, 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.

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

Table 4
Treatment effects on exam scores, other school subjects.

	(1) Science	(2) Human.	(3) Math	(4) Chichewa	(5) Points	(6) Pass
Panel A. Overall effects						
Treatment	−.029	−.001	.042	−.066	.206	.029
	(.047)	(.050)	(.044)	(.057)	(.378)	(.020)
	p = .520	p = .988	p = .331	p = .239	p = .577	p = .139
Panel B. Heterogeneous treatment effects						
Treatment x low achiever	.016	.100	.105*	−.071	.493	.060*
	(.070)	(.070)	(.062)	(.079)	(.585)	(.032)
	p = .803	p = .142	p = .084	p = .386	p = .379	p = .075
Treatment x high achiever	−.076	−.112	−.022	−.060	−.106	−.001
	(.062)	(.070)	(.061)	(.083)	(.467)	(.022)
	p = .213	p = .061	p = .734	p = .438	p = .830	p = .962
Mean of dependent variable in control	.000	.000	.000	.000	−26.448	.867
Strata FE	yes	yes	yes	yes	yes	yes
Number of students	1370	1396	1376	1398	1399	1381

Notes: Treatment effects on final exam scores. Science is a summary index of Chemistry and Physics. Humanities is a summary index of Agriculture, Geography, History, Life Skills and Social Science. Points is a measure of the students final overall grade. For each subject, the percentage scores is converted to a number of points between 1 and 9, where 1 is the best score, and 9 is the lowest score. The conversion is provided by the Malawi National Examinations Board (MANEB). The total number of points, also determined by MANEB, is the number of points obtained in English plus the number of points in the five other best subjects, where the best score is 6 points and the worst possible score is 54. We multiply the total number of points by −1 to ease interpretation of the coefficients in (5). Pass is an indicator equal to one if a student passes the school year. To pass the school year, students must pass their English course and five other courses and obtain a score of 6 points or less in at least one course. High (low) achievers defined as above (below) median exam scores at the baseline. In all regressions we include a control for the baseline measure of the outcome, an indicator for missing baseline measure, and strata fixed effects. Randomization was stratified by school, form, above median achievement and past internet use. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Randomization inference p-values based on 10,000 replications denoted as "p =".

Table 5
Time use, participation in class and career goals.

	(1)	(2)	(3)	(4)	(5)
	Time use (hours per day)			Participation in class (per day)	Career goal change
	Study	Recreational	Awake		
Panel A. Overall effects					
Treatment	−.029	−.286***	.007	−.025	.031
	(.071)	(.078)	(.086)	(.159)	(.042)
	p = .721	p = .004	p = .924	p = .877	p = .557
Panel B. Heterogeneous treatment effects					
Treatment x low achiever	−.038	−.348***	−.016	.118	.077
	(.098)	(.100)	(.123)	(.231)	(.058)
	p = .749	p = .014	p = .886	p = .604	p = .293
Treatment x high achiever	−.019	−.220*	.033	−.179	−.014
	(.104)	(.114)	(.119)	(.218)	(.062)
	p = .865	p = .132	p = .767	p = .427	p = .857
Mean of dependent variable in control	1.937	1.940	1.938	1.937	2.096
Strata FE	yes	yes	yes	yes	yes
Day-of-the-week FE	yes	yes	yes	yes	yes
Number of students	1402	1396	1398	1402	542

Notes: Treatment effects on time use and participation in class. (1), (2) and (3) refer to the time spent on studies, 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. We calculate Lee (2009) bounds in (1), (2) and (3) of Panel A to assess the robustness with respect to differential attrition. For recreational time, the bounds are [−.361, −.222] and both are statistically significant at the 5% level; for study time, the bounds are [−.149,.020]; awake time, [−.104,.090]. (4) 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. (5) shows change in career goal between baseline and endline surveys, defined as a change in career category or precision (e.g. "doctor" to "surgeon" is considered a change). High (low) achievers defined as above (below) median exam scores at the baseline. (1)–(2) include baseline controls and all regressions include strata and day-of-week fixed effects. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Randomization inference p-values based on 10,000 replications denoted as "p =".

It appears that students did not take time away from their studies to visit the digital library, and did not cut back on sleep (Columns 1 and 3 of Table 5). Rather, the digital library crowded out time spent hanging out with friends, playing sports, and attending religious

activities. Treated students spent 0.3 fewer hours per day on recreation (Column 2 of Table 5), which roughly corresponds to time spent browsing Wikipedia for general interest topics.[50] Low and high achievers reallocated their time in a similar way (Columns 1 to 3 in Panel B of Table 5).

Access to Wikipedia might affect class participation by increasing student confidence, motivation, or interest. 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 estimate Eq. (1).

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, nor by achievement level, though the point estimate of the treatment effect is positive for low achievers (Column 4 of Table 5).

Finally, Wikipedia might affect student aspirations, by helping students plan for a career or introducing new role models. 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 define an indicator variable for a change in career choice between baseline and endline.[51] We use Eq. (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, regardless of baseline achievement level, though the point estimate is positive for low achievers (Column 5 of Table 5). At endline, treatment students and control students choose similar types of careers, with most aspiring to healthcare positions. In Figure A3 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 A4, we present most likely and dream colleges reported by treatment and control students, and again see no systematic differences. We note that our pool of students had high aspirations at baseline, suggesting limited scope for an increase in self-reported aspirations. At baseline, one third of students hoped to become a doctor, specialist doctor or surgeon.

6. Discussion and conclusion

We find that restricting internet access to Wikipedia affects academic performance through two channels. First, students use the internet 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 positive gains in English exam scores, especially for low-achieving students. Second, students use the internet as a study tool for Biology, and prefer it to their textbooks. This has a significant impact on exam scores for low-achieving students, whose study time becomes more productive.

6.1. Mechanisms

Though students spent more than one hour per week in the digital library, and spent most of that time on topics unrelated to the school syllabus, restricted internet access did not have a negative impact on academic performance. Using 95 percent confidence intervals, we can rule out negative effects for English scores, and effects below -0.03σ for Biology. We also find no impact on scores in Mathematics, other science subjects, humanities subjects, or aggregate subject scores, with point estimates between -0.03σ and 0.04σ. The impact on Chichewa is insignificant at -0.07σ. We cannot rule out small substitution effects from Chichewa, as students shift their attention away from that subject towards subjects taught in English.

Rather, we find a positive impact on English exam scores, which leads us to view student browsing behavior in a different light. 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. If the restricted internet serves as a literacy intervention, it matters less whether students choose to read about academic topics. In fact, we posit that the internet is effective as a literacy tool precisely because it gives students access to reading material on any topic they choose. The effects may appear large given the browsing behavior of students. However, they are more plausible under the hypothesis that general interest reading, and not only school-related reading, can improve English language skills. Moreover, the effect sizes we observe are not unusual in this literature; Evans and Yuan (2020) find that the median education intervention in low- and middle-income countries increases learning by 0.1σ. Improvements in English language skills may be expected to persist over time, and impact other outcomes over the longer term. We will explore the long run impacts of this intervention in future research.

The impacts on both English and Biology exam scores are larger for low achievers, nearly half of whom had a failing score at baseline. Low achievers with access to Wikipedia score 0.20σ higher in English and 0.14σ higher in Biology than their counterparts without Wikipedia access. In the final term, the English score gap between low and high achievers is closed by one fifth due to Wikipedia access. Low achievers spent, on average, slightly less time in the digital library than high achievers. This suggests that heterogeneous treatment effects are not due to differences in use, and are instead due to the fact that reading is more important for students with low baseline ability. Because government boarding schools are academically competitive, a low-achieving student in one of the study schools may in fact better represent the typical Malawian secondary school student. For this reason, impacts among low achievers are particularly relevant.

We do not find any impact on high achievers for any subject. It appears that for highly literate students, access to online reading material serves as equal part distraction and input to academic performance, with a net effect of zero. While most students rely on school study resources, if high ability students are from wealthier families, they might have the means to purchase books. This might explain why they do not benefit from restricted internet access. However, there is no positive correlation between baseline achievement and socioeconomic status (−0.09), and we find no clear pattern of heterogeneity based on socioeconomic status (Appendix Table A10).[52]

Neither low nor high achievers increased their study time in response to the intervention, yet Biology scores improved for low achievers. 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. At endline, most treatment students stated a preference for Wikipedia over their Biology textbooks and teachers (Fig. 5). This is not the case for other subjects, and 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 (Fig. 2). 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 2).[53] Taken together, these results

[50] Time spent on general browsing (but not studying) in the digital library is an omitted category.

[51] 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).

[52] We define high socioeconomic status as having both electricity and running water at home. This describes approximately half of students.

[53] Both low and high achievers report that it is easy to find and understand information on Wikipedia (Appendix C).

indicate that online information can serve as a useful and accessible study tool for Biology, and that such a tool is more valuable to low achievers.

Our intervention may have improved academic performance through other channels, for example, by offering an improved study space or affecting student motivation. However, students had access to ample study space outside of class time, including a library and other study areas, and sometimes classrooms. Moreover, students were not permitted to use the digital library unless they were actively browsing the internet. Finally, we only observe an impact on academic performance in English and Biology, school subjects for which Wikipedia offers a potential advantage. This suggests a limited role for motivation or improved study space as a mechanism, but does not rule out the importance of providing a suitable space for quiet browsing. We also note that treated students spent less time on recreation, which might impact non-academic outcomes. We will explore the impact on social networks in particular in future work.

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 online. 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 positive spillovers. If these gains represent an improvement in English language ability, they are likely due to direct exposure to reading material. Spillovers between study friends 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 Appendix Table A7).

Exam scores might also be subject to spillovers which may not be captured by the network of study friends. In particular, the intervention could have had real negative impacts on learning for control students due to demotivation. However, we do not see differences in study time or career aspirations. Moreover, it is not clear how demotivation would generate the specific heterogeneity we observe across subjects and achievement levels. In Appendix Table A2, we show that while control students are more likely to view the intervention as unfair, they do not score lower on other measures of ambition, confidence or happiness. Low achievers in the control group do not appear to be worse affected than high achievers according to these measures. A second concern is that if teachers adjust exam scores to fit a particular distribution (i.e. grading on a curve), an increase in scores for treatment students could lead to a decrease in scores for control students. This would not produce spillovers on real learning outcomes, but would produce negative spillovers on numerical exam scores. If we compare exam scores to that of the previous cohort, such an effect does not appear likely: the distribution of scores shifted up for both control and treatment students (see Appendix Figure A5).

Other outcomes in the paper are likely subject to larger positive spillovers; some types of information spread easily. We find direct evidence for this in the case of the incentivized quiz (Columns 3 and 4 of Table 2). Despite not having access to any online resource, and no alternative source of news, half of control students were able to find the answer to the news question sometime between Endline A and Endline B. 70 percent of the control students who answered correctly reported learning the answer from a friend. The pattern is similar for the academic question (55 percent learned the answer from a friend). It is difficult to measure this type of spillover using a standard specification, as unlike study friendship networks, other types of information-sharing networks evolved significantly in response to the intervention. We will explore this evolution in detail in future work.

Because we randomized access to the restricted internet at the student level, our ability to measure general equilibrium effects is limited. For example, if all teachers and students had access to the internet, teachers might be able to incorporate it into their lesson plans. On the one hand, teachers follow a strict syllabus from the Ministry of Education with little room for adaptation. Moreover, students might find information online that contradicts, or goes beyond, the ideas put forth by textbooks and teachers. This might introduce incoherence and confusion in the classroom. Indeed, in the short term, the introduction of a new technology might disrupt learning. On the other hand, involving teachers typically improves the efficacy of literacy and other primary school interventions. There is less evidence in secondary schools, and this could be the subject of future research.

6.2. Cost-effectiveness, policy implications and external validity

Providing restricted internet access 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 less than $4 USD per student per month, or $28 USD per 0.1σ of improvement in English scores. This includes the cost of project management, digital library staff, internet-enabled devices and internet data packages. In many developing countries, Internet.org provides access to Wikipedia for free.[54] Providing access to Wikipedia through Internet.org would reduce the intervention cost to less than $3 USD per student per month. This is approximately equivalent to a school fee increase of 15 to 30 percent, or the cost of increasing the number of teachers per school from 35 to 38 (teachers are specialized by subject, and the average class has around 40 students). The intervention is more cost-effective than programs that provide reading material or financial incentives for reading, as most have no impact. It is also more cost-effective than many computer-aided learning programs.[55] Our cost-effectiveness is similar to many primary school interventions that increase the teacher–student ratio, provide incentives for teacher incentives, or provide remedial lessons, but lower 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.

Across southern Africa policymakers are facing the question of whether to allow or even provide internet access at school. Where textbooks are in short supply, the internet might serve as a useful and inexpensive substitute, but the full internet can serve as too much of a distraction. It is common for universities and workplaces to restrict access to certain websites, and secondary schools might do the same. Some online resources 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 the internet, and choose to spend a great deal of time reading. This translates to real gains in English language ability.

In the past few decades, education policy in Malawi, and across southern Africa, has shifted towards a learner-centered, inquiry-based model (Chisholm and Leyendecker, 2009; Mizrachi et al., 2010). The syllabus emphasizes the importance of appealing to student interests, student-led learning, and ICT skills. Indeed, at the outset, the Malawian educators involved in this study were enthusiastic about the prospect of broad information access for students. However, in some settings, policymakers, educators and parents might view this prospect as harmful, especially because 7 percent of browsing time was spent on topics

[54] Internet.org is a partnership between social media and telecommunications firms that provides free access to selected Internet services in poor countries.

[55] For example, Muralidharan et al. (2019) show that Mindspark, a computer-aided learning platform for primary school students, generates a language score impact at a cost of $39 per 0.1σ. However, they do also find a significant impact on Mathematics scores, suggesting that overall their program might be considered highly cost effective. Indeed, they find that this is more cost effective than default public spending in India.

related to sex and sexuality. Access to wide ranging and accurate information is not at odds with the goals set out in the *UNESCO Ministerial Commitment on Comprehensive Sexuality Education and Sexual and Reproductive Health Services for Adolescents and Young People in Eastern and Southern Africa*, which has been signed by at least 20 countries, including Malawi. This type of commitment may increase the willingness of schools to allow access to online information. Nevertheless, schools might wish to further restrict content. Too many restrictions might result in an intervention that no longer engages students. While teachers have been widely supportive of the shift to learner-centered education, it is difficult for teachers to implement effectively in large classrooms (Altinyelken and Hoeksma, 2021). This makes the internet an attractive option, if student engagement can be maintained.

Given the pace of internet adoption, we faced a tradeoff between clear experimental design and broad external validity. We chose to implement our experiment in boarding schools as opposed to day schools because they provided a unique, controlled environment. This allowed us to measure the impact of restricted access to online information and explore mechanisms which are likely relevant more broadly. The setting is also policy relevant; in many low-income countries, boarding schools constitute the majority, or a large minority, of public secondary schools.[56],[57] If internet sessions were supervised by teachers, or further restricted by topic, we might even expect students to spend more time on school subjects. Whether this leads to a larger impact on exam scores is a subject for future research.

Providing students with internet access restricted to Wikipedia serves as an appropriate introduction to online information, and might affect the way young people use the internet more broadly. 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 intervention on internet use and the ability to find accurate and trustworthy information online.

CRediT authorship contribution statement

Laura Derksen: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft Preparation, Writing – review & editing, Funding acquisition. **Catherine Michaud-Leclerc:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft, Preparation, Writing - review & editing. **Pedro C.L. Souza:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft Preparation, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jdeveco.2021.102810.

[56] For example, in Rwanda, Uganda and Tanzania, the majority of public secondary schools are boarding schools (Verspoor, 2008). In Malawi, approximately 12 percent of public secondary school students attend boarding schools (Ministry of Education Science and Technology, 2013). We argue that the internet is an effective reading resource because students find it engaging. However, we must be cautious in extrapolating our findings to day schools. Day school students might not stay after school to browse the restricted internet, especially if the unrestricted internet is available at home. In order to foster the same level of student engagement, day schools might offer restricted internet access as part of the required school day or as a formal after school program, and must be capable of restricting broader internet access.

[57] Interventions offered outside of class time can be very effective, even in day schools (Muralidharan et al., 2019).

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