Digital exclusion in education:

What the online learning technology Scholar tells us about inequality in Scottish secondary schools

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Executive Summary

Introduction

Digital inequality operates in the same way as traditional inequalities, through income, age, gender, race, ethnicity, disability and social class. These create inequalities in access to, experience of and success in education. Even before we consider digital inequality, there is a substantial attainment gap between the poorest and richest children.

Educational inequality, and digital inequality in education, came to the fore when the Covid-19 pandemic closed schools for long periods from 23rd March 2020.

This project explores the patterns and impacts of inequalities in the access to (**participation**) and use of (**engagement**) digital technologies in secondary schools, with an emphasis on young people experiencing socioeconomic and other inequalities.

We aimed to test and use a proxy for digital inequality using data from an online digital platform in Scotland, called Scholar. Scholar[1] delivers online e-learning services to 346 out of a total of 357 (97%) of Scotland's publicly funded secondary schools (encompassing 31 out of 32 council areas) and 31 out of 42 (74%) of the independent schools that put their students forward for Scottish qualifications. No other provider in Scotland (or the UK) offers complete online course materials specifically created for the Scottish Qualification Authority (SQA) National Qualifications (NQs) within a platform that allows teaching staff to track and report on their students. In this study we use the data from publicly funded schools only. This project has full population data for all the students in the 346 secondary schools from 2018-19, before the pandemic lockdown year, and subsequent to it, 2020-21.

Research questions

We address the following research questions:

1) What is the patterning in the use of online learning for exam-aged students (S4-S6) over time?
2) How has the use of online learning changed during and after the Covid-19 school closures?
3) What is the extent of the variation in use of online learning resources across secondary schools in Scotland?

Methods

Our analysis uses the three examination levels in the Scottish education system: National 5, Higher and Advanced Higher. Rather than analysing individual courses, the decision was taken to create portfolios of courses, for reasons fully explained in chapter 2. We created four learning portfolios across the three levels (n=12) for the years 2018-19 and 2020-21 (n=24): a) English; b) Mathematics; c) Modern Languages; and d) Sciences. All of these portfolios are available at all levels for each of the two years except Science, which is not available at National 5 level in 2018/19.

The anonymised data generated by Scholar was analysed using descriptive statistics to understand the patterns of usage across levels and portfolios, and multilevel models to ascertain the extent of the variation across schools and its association with deprivation and other characteristics.

[1] The Scholar Forum is a legal not-for-profit partnership between Heriot-Watt University and ADES, the Association of Directors of Education in Scotland, with the Education Authorities as members paying an annual subscription. Key stakeholders, including Education Scotland, SQA and School Leaders Scotland, are part of the Forum's consultation framework. https://scholar.hw.ac.uk/about.html

In this study, we use multilevel modelling to allow us to estimate the variation between schools and students simultaneously, alongside the effect of the school characteristics (deprivation, FSM eligibility, rurality and size) on the student-level outcomes, that is, **engagement** and **participation**.

For the level of **engagement** with online learning, i.e. the number of pages visited by active student enrolments, we used multilevel negative binomial models, which are fully explained in chapter 2 and Appendix B.

To analyse **participation** in online learning, i.e. the propensity of being an active student in the course portfolios they are enrolled, we used multilevel binary logistic models, which are described in more detail in appendix C.

For the purpose of describing the socioeconomic gap, we compared the percentage of active student enrolments (participation) and the average number of page visits (engagement) of the students in the least deprived schools (lowest percentage of FSM eligible students) with the students in the most deprived schools in both academic years.

Findings

Overall, both engagement and participation have increased substantially from pre-Covid times (2018/19) to during/post-Covid times (2020/21).

For all students, participation increases across the school years and qualification levels and peaks at Advanced Higher level across all the portfolios. The Science and Modern Languages portfolios have the greatest levels of participation with the largest percentage of active student enrolments in 2020/21 (74.14% and 57.09%, respectively). Participation in 2018/19 follows a slightly different pattern, where the most accessed portfolios are the Science courses at the Advanced Higher level (53.2%) and Higher level (36.08%), with Higher Modern Languages at the third place (32.83%).

Across all the learning portfolios except English, there have been patterns of increasing participation and engagement of students in deprived schools from 2018-19 to 2020-21. The findings show that what schools do accounts for around a fifth of the variation in participation and up to a third of the variation in engagement of all students. This provides strong evidence that what schools do matters – especially for low-income children. The data do not elucidate what it is that schools do that makes such a difference, but it is likely to be the provision of devices and connectivity, their adoption of the platform, their use of it in lessons, and in their encouragement of students to make use of it for homework and study.

While this is promising, there remain socioeconomic inequalities in participation and engagement as the students from more deprived schools are often starting from a lower base in terms of engagement with Scholar. While the level of inequality by socioeconomic position did decrease between the two years, students in the most deprived schools remain less likely to engage with Scholar in 2020-21. Further, if we look beyond the most and least deprived, we see that schools in the middle FSM band appear to have a widening gap compared to the least deprived group; that is, inequality appears to be increasing for those students. It is important not to lose sight of the middle band of students and schools.

There are also differences in socioeconomic inequalities by subject area studied. The English portfolio uniquely shows a large increase in inequality.

Participation and engagement increase as the students get older and the qualification levels get more advanced. There is likely to be a self-selection here of the most able and committed students accessing the four portfolios at more advanced levels.

This study presents evidence that students in rural schools engaged with online learning between a quarter and a third more than students in urban schools do. Not only are students in rural schools more likely to participate, students in rural schools also have a sharper increase over time in participation compared to their urban counterparts. Although the data does not explain why students in rural schools are more likely to participate and engage in online learning, this may be a function of lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning.

Recommendations for policy and practice

The following are some of the specific changes that we feel would help to improve the participation and engagement of pupils from schools with medium and high levels of deprivation and reduce their digital inequality in education.

Recommendations for schools

- For schools to recognise and build upon their importance in pupils' engagement with online materials in school and at home. Schools account for around a third in the variation in engagement, which previous research suggests is roughly equal to the role played by the student's physical resources at home.
- For teachers to upskill in relation to digital learning and teaching, which has already started since the Covid-19 pandemic outbreak.
- For schools to work with local authorities to ensure that every child who needs it has a device and connectivity.
- For schools to provide Wi-Fi and a secure space for children to access digital learning as they may not have the physical space or resources at home.
- Schools could work with community partners and local authorities to upskill parents to be able to provide stronger support to their children with the technical aspects of, and encouragement to use, the digital tools available.

Policy recommendations

- To ensure all pupils who need them have a device and connectivity, i.e., access to a stable internet connection, at home and school. This is especially pertinent for low-income students and those living in remote communities.
- To support schools in their ability to do the points above by providing funding, guidance, training, and accountability frameworks.
- To have a parent specific adult learning programme for digital skills focussing on the most marginalised groups of parents, e.g., lone parents, non-English speakers, migrants less familiar with the education system, and those in insecure/transitory accommodation.

Contents

1 Introduction and background

1.1 Defining digital (in)equalities

The evidence in this introduction is drawn from across the UK and is not always Scotland-specific. Digital inequality operates in the same way as traditional inequalities relating to poverty, age, gender, race, and class (Robinson et al., 2015). It is another facet of the deep inequality running through the social fabric of the UK that is more common than people realise (Holmes & Burgess, 2020), and so ought to be treated as any other traditional form of inequality (Robinson et al., 2015). The main complicating factor about digital inequality is that there is no universally accepted definition, which makes studying the phenomenon complicated as numerous definitions are in use, and no study succeeds in measuring every facet associated with the state of being digitally excluded. Even the terminology is varied and derives from whichever prominent definition of digital exclusion the author embraces.

Some of the numerous terms to describe the inequality associated with the use of digital technologies that connect to the internet are the digital: divide, access, inclusion, participation, engagement, literacy, understanding and skills (Bowyer, 2019). Often these terms are used interchangeably, although they capture different aspects of the wider phenomenon of digital inequality. Moving towards a definition, digital inequality is often defined through: access to devices and the internet, known as first-level digital inequality; and participation, engagement, literacy and skills, known as second-level digital inequality (Bowyer, 2019, Katz et al., 2019). For the purposes of this study, we use the terms 'digital inequality' and 'digital equality' to denote exclusion and inclusion respectively.

Although providing access to quality devices and connectivity for families with children is important to alleviate digital inequality, resolving first-level inequality is not enough; low-income parents and children need to be enabled to develop the skills to engage fully online (Katz et al., 2019). Of course, solving first-level digital inequality is a prerequisite for alleviating second-level inequality, and where this has been successful for disadvantaged parents, the benefit accrues to their children (Katz et al., 2019). However, without understanding the need to tackle all facets of digital inequality, the results of digital inclusion programmes are rarely consistently favourable or transformative for all participants (Davies et al, 2017: 80).

Carnegie Trust UK have a comprehensive programme of work on digital equality. They have come up with a definition that they believe covers all aspects of the experience. To be fully digitally included, they argue, requires five key components to be in place: a device, a connection, skills, a safe online environment, and sustainability of access (Bowyer et al, 2021: 16). It is vital that digital inequality does not exacerbate already-existing inequalities (Bowyer, Grant, & White, 2020). This becomes more pressing as more of our lives depend on digital technologies. There is the risk that people facing digital inequality lose their voice and visibility as government services and democratic participation are increasingly conducted online (Bowyer et al., 2020). Further, this inequality will adversely affect children and young people, in particular their rights to education, information and participation. (Bowyer et al., 2020).

1.2 Digital (in)equalities in education

Digital inequality operates in the same way as traditional inequalities, through income, age, gender, race, ethnicity, disability and social class. These create inequalities in access to, experience of and success in education. Even before we consider digital inequality, there is a substantial attainment gap between the poorest and richest children. Disadvantaged students who perform strongly in primary school are much more likely, compared to more advantaged high attaining students, to fall behind at secondary school (Montacute, 2018). Lower achieving wealthier children overtake their higher

achieving more impoverished classmates at around 6.5 years old (Feinstein, 2003). These gaps widen during the course of a child's education, with low-income, high achieving children at primary school having a twenty percentage point lower chance of achieving top marks at GCSE than their better-off peers with the same prior attainment (Cullinane & Montacute, 2020).

The attainment gap is largest for children and young people eligible for free school meals, which is the best proxy measure of economic disadvantage available on a per-student or per-school basis (EEF, 2017). Additionally, prolonged periods of absence from school risks further widening this attainment gap (Cullinane & Montacute, 2020). For example, attainment gaps between economically advantaged and disadvantaged students widen during the summer holidays, with poorer students falling further behind (Stewart, Watson, & Campbell, 2018). There is also increasing evidence that large socioeconomic gaps in educational investments at home are key drivers of the poverty-related attainment gap (Andrew et al., 2020).

These same social cleavages associated with inequality generally also drive digital inequality. The factors associated with lower access to digital technologies are: low levels of education, having a disability, being female, being a lone parent and being unemployed (Helsper and Reisdorf, 2016). While these findings pertain to the adult population, they have implications for the children and young people of those adults; for example, lone parents are more likely to have lower levels of education, to live in poverty and to have a disabled family member in the household (Treanor, 2020), which suggests that children and young people in lone parent families are even more likely to be digitally excluded.

Children and young people in low-income groups are also more likely only to have internet access via mobile phones, rather than a fixed broadband connection in the home (Sanders, 2020). In 2018, across the UK, 36% of 16-24- year olds lived in mobile-only households, which increases the risk of their and their families' digital exclusion (Bowyer, 2019). Children and young people living in low-income households were also less likely to own the hardware necessary to access the online world (Bowyer, 2019).

Also in 2018, 700,000 (12%) children aged between 11 and 18 years reported having no internet access at home from a computer or tablet, while a further 60,000 reported having no home internet access at all (Lloyds Bank, 2018). 68% of those in this age group who did have home internet access said they would find it difficult to complete school work without it, which, suggests negative impacts on the education of those without internet access (Lloyds Bank, 2018; ONS, 2019). Income is strongly associated with digital inequality, with more advantaged families more able to provide their children with the resources needed for learning, including a device and a desk of their own (Andrew et al., 2020).

Educational inequality, and digital inequality in education, came to the fore when the Covid-19 pandemic closed schools for long periods from 23rd March 2020. The pandemic and subsequent lockdown revealed the extent and depth of existing inequalities and highlighted the importance of digital inequality for children and their education (McKinney, 2020). The following section looks at the learning gained from the Covid-19 lockdowns in relation to digital inequality in education.

1.3 Covid-19 and digital (in)equalities in education

At the outset of the first of the Covid-19 lockdowns, it was difficult to say what the exact nature of the long-term adverse impacts on low-income children would be, but there was agreement that the attainment gap would widen, that digital inequality would be thrown into sharp relief, and that children's social and emotional development would be interrupted. In addition to the educational impacts of the pandemic, there was concern that the economic impacts - poverty, food insecurity, and

the stress of family financial worries – would also adversely affect children and young people (Andrew et al., 2020; Cullinane & Montacute, 2020). As children from more impoverished backgrounds already had lower achievement on average than their less disadvantaged classmates, and time out of school corresponds to lost learning, especially for more deprived children, there was grave concern that months out of school would set back children's learning and development to an unprecedented extent (Andrew et al., 2020).

At the outset of the Covid-19 lockdown, it was estimated that between 1.14 million and 1.78 million children in the UK under the age of 18 had no access to a laptop, desktop or tablet, and between 227,000 and 559,000 students lived in households without internet access (Howard et al, 2021: 12). As for empirical evidence of the effects of Covid-19 lockdowns on digital inequality, there has been a multitude of quick response research projects since the first lockdown in 2020, mostly focusing on how parents and schools responded. In summary, there was a heterogeneous response but it did cleave to the traditional socioeconomic inequalities, as outlined below.

Children's experiences

Andrew et al (2020) found considerable heterogeneity in children's learning experiences at home during lockdown, which were strongly associated with family income. They found that the shift of learning from school to home created great disparities in the amount of time children spent learning, the activities they undertook and the resources they had available to them to assist their learning (Andrew et al., 2020). Specifically, how productive children were in self-directed learning, or indeed in parent-taught learning, was a function of the quality of the home-learning resources provided by schools and the quality of the home-learning environment available to them (Andrew et al., 2020). Children from more advantaged families reported spending 30% more time on home learning than those from less advantaged families (Howard et al, 2021).

What parents did

More advantaged parents were able to spend time and money supporting their children and providing additional educational resources, including children's own digital devices, whereas less advantaged children were working in cramped housing conditions, with inadequate access to devices or internet connectivity, and with parents less able to support their learning (Cullinane & Montacute, 2020).

Parents in middle-income households reported particular difficulties supporting their children's learning through lockdown because they were more likely to be working at home, compared to the lowest income households, and had fewer resources to support home learning compared to the highest income households (Andrew et al., 2020; Green, 2020).

Teachers in the most deprived schools reported lower parental engagement than the least deprived schools (Lucas et al., 2020). Parents of both primary and secondary school students said they found supporting home learning difficult (Howard, Khan, & Lockyer, 2021).

What schools did

Teachers in the most deprived schools were far less likely to be in touch with their students at the beginning of school closures (c.50%) compared to teachers in the least deprived schools (67%) (Lucas, Nelson, & Sims, 2020). Schools in more deprived areas were more likely to assign work using physical worksheets or workbooks (48% versus 22% in the least deprived schools), out of concern that many of their students might not be able to access online content (Cullinane & Montacute, 2020). Just 9% of teachers in the least deprived state schools, and only 2% in the most deprived state schools, thought all of their students would have adequate access to a device for learning at home, compared to 42% of teachers in private schools (Cullinane & Montacute, 2020).

To mitigate digital inequality gaps, 21% of teachers in state schools reported their school providing students with devices to use at home, although this occurred more frequently at secondary schools (31%) compared to primary schools (11%) (Cullinane & Montacute, 2020). However, we know that a key component of digital inequality is low or poor access to the internet, and only 2% of primary schools and 6% of secondary schools reported their school providing students with internet access (Cullinane & Montacute, 2020). Therefore, providing devices without connectivity at the outset may not have had the desired effect. Further, even within state schools there was inequality in likelihood of receiving a device, with 28% of teachers in the least deprived schools saying their school had done so, compared to only 15% of teachers in the most deprived schools (Cullinane & Montacute, 2020).

What schools did mattered – especially for low-income children. Andrew et al (2020) found that school-directed home learning activities had a similar effect size to that of physical resources available at home. Further, they found that home-learning resources appeared to be a less powerful, although still substantial, mediator of the relationship between family income and learning at the secondary school level (Andrew et al., 2020). This is important because more deprived children had less access to active school support, such as online classes and video conferencing, and were more likely to receive passive support, such as physical worksheets or workbooks (Andrew et al., 2020). The associated downside to this is that children with limited or no access to electronic devices were less likely to receive feedback from teachers on their work (Green, 2020). In fact, just 53% of students attending a state school and 40% of students eligible for free school meals had their work checked by a teacher compared to 76% of students in private schools (Green, 2020).

Access to digital devices and connectivity improved in the autumn term of 2020 (Howard et al, 2021); yet, in spite of this, students in the most deprived schools were still less likely than students in the least deprived schools to attend online lessons (59% and 78%, respectively) and return set work (47% and 67%, respectively) (Nelson, Andrade, & Donkin, 2021). In closing the schools and enforcing education at home, the Covid-19 lockdowns attenuated the equalising role that schools usually play in the learning of the most and least deprived children (Andrew et al., 2020). For better or for worse, lockdown illuminated the existence of, and the educational and social consequences of, digital inequality for children and young people (McKinney, 2020).

UK and Scottish governments' response to Covid-19 and digital (in)equalities in education

Both the UK and Scottish governments were credited for responding to the digital inequality highlighted in the first lockdown in a timely and responsive fashion (Bowyer, Grant, & Nielson, 2021). In the Autumn Term 2020 and Spring Term 2021, the UK Government provided devices to students who did

> *'not have access to a device and whose face-to-face education is disrupted; those aged 16 to 19 who receive free meals in further education; those over the age of 19 with an education, health and care plan (EHCP) who also receive free school meals; those in any year group who have been advised to shield because they (or someone they live with) are clinically extremely vulnerable; and those in any year group, including 16 to 19 education, attending a hospital school'* (Bowyer et al, 2021: 13).

However, there were delays in delivery of technology so not all students received a device or connectivity.

The Scottish Government put measures in place to mitigate digital exclusion, including allocating £30 million to provide laptops for disadvantaged children. The Scottish government recognised that

> *'in-home learning takes many forms (including support from families) and is by no means all IT based, an approach to digital learning should be implemented to mitigate negative impacts on equity. This will specifically focus on providing digital access for students who do not have this at present'* (Scottish Government, 2020: 3).

However, once again there were delays in delivery of technology so not all students received a device or connectivity.

What governments do matters. As Bowyer et al (2020: 7) note, what it means to experience digital inequality will change over time and therefore tackling it will need sustained intervention, resourcing and attention by all governments.

Education in Scotland

The education system for secondary schooling in Scotland has little differentiation of institutions, excluding a minority of people who attend an independent school, compared to other countries (Iannelli & Duta, 2018). For example, the Scottish system is different from the English system which has greater levels of school differentiation, especially since the creation of academies and free schools, and has standardised testing and more prescriptive curricula (Iannelli & Duta, 2018: 70). The Scottish system is different too, from the Irish system, as detailed by Iannelli et al (2016) thus:

> *'Secondary schooling takes place in schools that are broadly comprehensive in orientation and is compulsory until the age of 16. Both systems differ substantially in terms of horizontal curriculum differentiation in post-compulsory schooling. In Ireland upper secondary students typically take six to eight subjects (usually seven) in the Leaving Certificate exam. All students are required to take English, maths and Irish. In Scotland students can choose between different subjects (with no core subjects that all students need to study) and sit the corresponding exams in the 5th and 6th years of secondary schooling. Students can choose not only the type of subjects but also the number of subjects to study. The majority of Scottish students sit exams in five or six subjects in upper secondary education. In both systems, the extent to which take-up of subject reflects student preference, school allocation or teacher preference varies across and within schools*'. (Iannelli, Smyth, & Klein, 2016: 564)

The outcome of Scotland having a comprehensive school system, with low differentiation of institutions and high differentiation within schools in the number and types of subjects studied by students in their final years of secondary school, is that subject choice matters for future outcomes in both access to higher education, in particular the prestigious, ancient universities, and in employment (Iannelli & Duta, 2018; Iannelli & Smyth, 2017; Iannelli et al., 2016). It was found that specific subjects facilitate access to Russell Group universities; these are: English, languages, maths, history, physics, chemistry, biology and geography (Russell Group Dossier, 2011). What this means for students in Scotland in practice is that less deprived schools are more likely to offer and to encourage the take up of these facilitating subjects, whereas, on average, more deprived schools are more likely to offer less academic, more vocational subjects, and remote rural schools suffer from chronic teacher shortages so can be limited in numerous ways. The result of this is that, in Scotland, schools matter for young people's subject choice selection and future access to the best education and employment, which can further entrench social inequalities.

1.4 Analysing digital (in)equalities in education

Section 1.1 sets out the difficulties inherent in defining and measuring digital inequality. Bowyer et al (2021) propose a comprehensive and wide-reaching definition based on five key components: a device, a connection, skills, a safe online environment, and sustainability of access. However, there is

currently no agreed definition and studies often focus on one or two aspects of digital inequality. While Bowyer et al (2021) caution against analyses that only take into account hours spent learning online, as they can ignore the importance of other factors in determining outcomes, there are good reasons why, in this study, the analysis of the use of a nationwide online digital platform is preferred.

We accept that there are several important factors that we cannot measure in our study of digital inequality; for example, access to a device and connection, skills, parental skills and support, home learning resources and home learning environments. Instead, we aim to test and use a proxy for digital inequality based on the data to which we do have access. For the purposes of this study, in as much due to what the data can show, digital inequality is defined in relation to access to (participation) and ongoing use of (engagement) in a population-wide digital learning platform used in secondary schools in Scotland, called Scholar.

1.5 The Scholar data

Scholar[2] delivers online e-learning services to 346 out of a total of 357 (97%) of Scotland's publicly funded secondary schools (encompassing 31 out of 32 council areas) and 31 out of 42 (74%) of the independent schools that put their students forward for Scottish qualifications. No other provider in Scotland (or the UK) offers complete online course materials specifically created for the Scottish Qualification Authority (SQA) National Qualifications (NQs) within a platform that allows teaching staff to track and report on their students. In this study we use the data from publicly funded schools only.

In Scotland, there is one national body examining students from S4 to S6. Across these three final years, students follow a range of courses at SCQF levels 2-7.[3] National 5 courses are most commonly undertaken by pupils in S4, Highers most commonly by pupils in S5, and Advanced Highers most commonly by pupils in S6. The main qualifications for access to university are the Highers usually taken at S5 and so, there are far fewer students taking Advanced Highers in S6. This is reflected in the numbers of students participating and engaging in online learning in the Scholar data.

The advantage of the Scholar data is that, to the best of our knowledge, it is the only online learning platform of its kind in Scotland or anywhere else, as it is aimed at a single, national exam system and has almost complete coverage of the whole of Scotland. We do not use a sample of these data but the whole population.

1.6 Structure of the report

This study explores the patterns and impacts of inequalities in the access to (**participation**) and use of (**engagement**) digital technologies in secondary schools, with an emphasis on young people experiencing socioeconomic and other inequalities.

We address the following research questions:

1) What is the patterning in the use of online learning for exam-aged students (S4-S6) over time?
2) How has the use of online learning changed during and after the Covid-19 school closures?
3) What is the extent of the variation in use of online learning resources across secondary schools in Scotland?

[2] The Scholar Forum is a legal not-for-profit partnership between Heriot-Watt University and ADES, the Association of Directors of Education in Scotland, with the Education Authorities as members paying an annual subscription. Key stakeholders, including Education Scotland, SQA and School Leaders Scotland, are part of the Forum's consultation framework. https://scholar.hw.ac.uk/about.html

[3] https://scqf.org.uk/about-the-framework/interactive-framework/

This project also aims to test the use of Scholar data as a measure of digital inequality in online learning. Due its unique nature in offering complete online course materials specifically written for the Scottish Qualifications Authority, within a platform providing full learner tracking, we believe Scholar is a suitable proxy for participation in digital learning in Scotland. However, it has never been used for research, being an administrative dataset, and so this project also aims to test its utility for research purposes.

The report is structured as follows. Chapter 2 describes the whole population administrative dataset, Scholar, that is used in this study to explore participation and engagement in online learning, used as a proxy for digital inequality. Chapter 3 presents the results, giving both descriptive and inferential statistics on participation and engagement across two years 2018-2019 (pre-Covid lockdowns) and 2020-21 (during- and post-Covid lockdowns). Scholar data were assessed as being unreliable for the school year 2019-20 due to measures taken during the first Covid-19 lockdown. Thus, we assess the change in digital participation and engagement in the year immediately preceding and succeeding the first Covid-19 pandemic lockdown. Chapter 5 discusses the results through the lens of socioeconomic inequality, as measured by the percentage of children in receipt of free school meals, measured at the school-level; through geographic disparities, in particular urban/rural classification; and through time, assessing change between 2018-19 and 2020-21, particularly in relation to socioeconomic gaps, acting in this study as a proxy for digital inequalities. Chapter 6 concludes the study and identifies implications for schools and recommendations for policy.

The appendices are:

- Appendix A: Weighting procedure for the number of page visits.
- Appendix B: Algebraic form of the multilevel negative binomial model for page visits.
- Appendix C: Algebraic form of the multilevel binary logistic model for the propensity of being an active student.
- Appendix D: Scholar Protocol for the generation of a fully anonymised dataset.

2 Data

2.1 Description of Scholar

Scholar delivers online e-learning services to 346 out of a total of 357 (97%) of Scotland's publicly funded secondary schools (encompassing 31 out of 32 council areas) and 31 out of 42 (74%) of the independent schools that put their students forward for Scottish qualifications. No other provider in Scotland (or the UK) offers complete online course materials specifically created for the Scottish Qualification Authority (SQA) National Qualifications (NQs) within a platform that allows teaching staff to track and report on their students.

Scholar has online course materials for the majority of Scottish qualifications taken at the three examinations stages: National 5 (most commonly taken at age 15-16 in S4), Highers (most commonly taken in S5 at age 16-17), and Advanced Highers (most commonly taken in S6 at age 17-18). The main qualifications for access to university are the Highers usually taken at S5 and so, there are far fewer students taking Advanced Highers in S6. This is reflected in the numbers of students participating and engaging in online learning in the Scholar data. It would be unwieldly to try to use all the courses available in Scholar, especially as by S6 there are often very low levels of students taking particular courses; therefore, decisions had to be made as to which course materials and which levels to use in this project.

We use Scholar data from two academic years: pre-pandemic 2018-19 and 2020-21. This gives us a measure of how Scholar was being used prior to the Covid-19 pandemic and most recently (but not quite post-pandemic). The data from the first pandemic semester was unusable, due to various reasons relating to contingency measures implemented to ensure continuous access to schools and students, as explained by the Scholar team, e.g. use of shared accounts.

2.2 Learning portfolios

We decided to use data from all three levels of exam qualifications as 1) more students are registered for S4 examinations taken at age 15/16 than any other; and 2) we wanted to track change between stages as well as over time. Therefore, our analysis uses all three examination levels: National 5, Higher and Advanced Higher.

We also had to make decisions about which courses to use. We decided not to use individual courses but to create portfolios of courses. The main reasons for doing this were 1) there was a huge disparity in how courses were used individually; for example, Biology had far more students than did Physics, and we were not concerned with them as individual courses but as a broader learning portfolio called ‘Science’; and 2) we wanted to look at portfolios of ‘core’ learning of subjects that have a compulsory element until age 16 in Scotland. From a more practical perspective, the disparity in student numbers in the Science courses also meant that in some smaller schools, students could become identifiable and hence collapsing them into a portfolio was a sensible trade-off to avoid losing data.

For these reasons, we divided courses into four learning portfolios across the three levels (n=12) for the years 2018-19 and 2020-21 (n=24): a) English; b) Mathematics; c) Modern Languages; and d) Sciences. All of these portfolios are available at all levels for each of the two years except Science, which is not available at National 5 level in 2018/19. The courses included in each portfolio are as follows:

Table 1: Learning portfolios in Scholar data

Level	Portfolio	Courses
National 5	English	English
	Mathematics	Mathematics
	Science*	Biology Chemistry Physics Computing Science
	Modern Languages	Gaelic (learners) French Spanish German Mandarin
Higher	English	English
	Mathematics	Mathematics
	Science	Biology Chemistry Human Biology Psychology Physics Computing Science
	Modern Languages	Gaelic (learners) French Spanish German
Advanced Higher	English	English
	Mathematics	Mathematics
	Science	Biology Chemistry Physics Computing Science
	Modern Languages	French German Spanish

***Note:** Not available in the academic year 2018/19

2.3 Student-level data

At the level of students, our data contains the number of page hits within portfolio/subject in a specific time period (Year 1: June 2018 to June 2019 and Year 2: June 2020 to June 2021) as well as the number of courses within portfolio in which a student is enrolled. Scholar records the activity of enrolled students storing the pages they visit each time they log into the system as well as the time at which they log in. Courses not only vary in the nature of the content itself, but also in their overall length and content per page, time needed for completion, and even perceived popularity. To account for all these differences, page hits within portfolios are proportionally weighted according to the procedure explained in appendix A.

Additionally, our data does not contain records for all possible students or schools. The data was anonymised by Scholar prior to sharing with researchers for data protection and confidentiality reasons. The protocol for generating fully anonymised data is given in appendix D. Following conventional principles of statistical disclosure, where a school had fewer than 10 registered students

in a portfolio/course, all records were suppressed. This also resulted in some smaller schools being excluded from the research dataset.

In analysing the activity of enrolled students in Scholar portfolios, we find that there are more students enrolled in courses in Scholar than took the SQA examination that year. This is because when students choose a course, they are automatically enrolled onto Scholar by their school; however, if at some point after this they withdraw from the course, their Scholar enrolment is not deleted. Therefore, in all cases, the percentage of pupils studying a course using Scholar will be higher than our calculated figures would suggest. This is outlined here as an explanation of the higher numbers of students studying a course in Scholar than sat the examination in reality. As this occurs across all courses, it does not detract from the patterns and themes emerging from our analysis and, indeed, merely means that our estimates are somewhat conservative in nature.

2.4 School-level data

Apart from student-level data on page hits in portfolios, our data also contains anonymised school identifiers and school characteristics that have been banded to reduce the risk of school identification, as part of the anonymisation process run by Scholar prior to sharing data with researchers. The details of this can also found in the protocol for generating fully anonymised data in appendix D.

There are four school-level characteristics in our dataset: free school meal (FSM) entitlement (banded); urban/rural classification (binary); deprivation as measured by the Scottish Index of Multiple Deprivation (SIMD)[4] (banded); and school size (banded). Although Scholar does have lots of information at the individual student level, with a unique identifier for each student in Scotland, the Scholar team did not provide any individual level data, except for the participation and engagement in Scholar, due to concerns with anonymity and confidentiality. Thus, FSM is a school-level rather than an individual level datum, and SIMD relates to the school rather than the students' homes. The typical student in Scotland attends their catchment area secondary school, discounting those that attend private school, which would suggest that higher area deprivation of the school means higher home area deprivation of the student. However, only about 50% of people living in poverty in Scotland live in a deprived area as measured by SIMD. This means we have to exercise caution about assuming a more deprived school equals a more deprived student. The likelihood will be greater but it is not a certitude.

[4] The Scottish Index of Multiple Deprivation is a relative measure of deprivation across 6,976 small areas (called data zones). If an area is identified as 'deprived', this can relate to people having a low income but it can also mean fewer resources or opportunities. SIMD looks at the extent to which an area is deprived across seven domains: income, employment, education, health, access to services, crime and housing. https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/ and https://simd.scot/#/simd2020/BTTTFTT/9/-4.0000/55.9000/

Table 2: Description of school characteristics

Variable	Description
FSM band	Percentage of FSM-eligible students. Banded in terciles as follows: 1 = Between 0% and 10% (least deprived) 2 = Between 10.1% and 17.6% 3 = 17.7% or more (most deprived)
Urban/Rural	Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban. This category includes: Large urban areas; Accessible small towns and Other urban areas. 2 = Mostly rural. This category includes: Remote rural areas; Remote small towns and Accessible rural areas.
Deprivation	Percentage of students living in quintile 1 (most deprived) areas according to the Scottish Index of Multiple Deprivation (SIMD). Banded in terciles as follows: 1 = Between 0% and 7.56% (least deprived) 2 = Between 7.57% and 30.87% 3 = 30.88% or more (most deprived)
School size	Number of enrolled students in the school. Banded in terciles as follows: 1 = Between 0 and 672 (smallest) 2 = Between 673 and 984 3 = 985 or more (largest)

2.5 Methods

The anonymised data generated by Scholar was analysed using descriptive statistics to understand the patterns of usage across levels and portfolios/subjects, and multilevel models to ascertain the extent of the variation across schools and its association with deprivation and other characteristics.

In this study, we used multilevel modelling (Goldstein, 2011; Hox et al., 2017; Snijders & Bosker, 2011), which has a long tradition in international research on a variety of educational and non-educational outcomes (Goldstein, 1997; Leckie, 2009; Rasbash et al., 2010; Timmermans et al., 2013; Treanor & Troncoso, 2022; Troncoso, 2019; Troncoso et al., 2016; Troncoso & Humphrey, 2021; Yang et al., 2002). Multilevel modelling allows us to estimate the variation between schools and students simultaneously, alongside the effect of the school characteristics (deprivation, FSM eligibility, rurality and size) on the student-level outcomes, that is, engagement and participation.

For the level of engagement with online learning, i.e. the number of pages visited by active student enrolments, we used multilevel negative binomial models, the algebraic form of which is given in appendix B. This is a convenient and widely used modelling technique for count data that allows us to account for the overdispersion in the data, i.e., where the variance is larger than the mean. The negative binomial model can be thought of as an extension of the Poisson regression model that allows for overdispersion by estimating an extra parameter to represent individual random variation (Leckie et al., 2020).

To analyse participation in online learning, i.e. the propensity of a student being active in a particular portfolio in which they are enrolled, we used multilevel binary logistic models, which are described in more detail in appendix C. This technique allows us to model a student-level binary measure (that is, being an active student or not) whilst controlling for the variation at the school level, which in turn enables the estimation of the relative variability due to each level of analysis. It also allows us to control for previously mentioned associated factors at the school level.

For the purpose of describing the socioeconomic gap, we proceeded to compare the percentage of active student enrolments (participation) and the average number of page visits (engagement) of the students in the least deprived schools (lowest percentage of FSM eligible students) with the students in the most deprived schools in both academic years. This procedure results in two relevant indicators: firstly, the within-year difference, where a negative value would indicate that the most deprived students are more active/engaged than the least deprived and secondly, the relative change over time, where a negative value would indicate that there has been a reduction in the socioeconomic gap over time.

Further details can be found in the appendices:

- Appendix A: Weighting procedure for the number of page visits.
- Appendix B: Algebraic form of the multilevel negative binomial model for page visits.
- Appendix C: Algebraic form of the multilevel binary logistic model for the propensity of being an active student.
- Appendix D: Scholar Protocol for the generation of a fully anonymised dataset.

3 Analysis

This chapter addresses the following research questions:

1) What is the patterning in the use of online learning for exam-aged students (S4-S6) over time?
2) How has the use of online learning changed during and after the Covid-19 school closures?
3) What is the extent of the variation in use of online learning resources across secondary schools in Scotland?

3.1 Descriptive Statistics

The following statistics are for Years 1 and 2. Year 1 covers the period June 2018 to June 2019; and Year 2 covers the period June 2020 to June 2021. Table 3 gives the total number of students per level and academic year enrolled in Scholar. Totals per academic year cannot be added together because students can be registered at different levels simultaneously and, for the reasons explained in section 2.3, do not necessarily correspond with the total number of students sitting the exams by the end of the academic year.

Table 3: Total number of students per level and academic year

Level	**2018/19**	**2020/21**
National 5	80,467	93,692
Highers	55,627	54,156
Advanced Highers	10,715	8,053

As outlined in chapter 1, digital inequality in this project using Scholar data gives a measure of engagement and one of participation. The average number of visits to the Scholar course pages measures the overall level of engagement with online learning and the level of participation is measured using the percentage of active student enrolments (those with at least one visit). In summary:

- Participation = the percentage of active student enrolments (those with at least one visit).
- Engagement = the average number of visits to the Scholar course pages.

Table 4 shows that participation and engagement vary widely across portfolios, levels and academic years. Participation increases as the students get older and the qualification levels get more advanced. Most notably, engagement seems to be substantially higher for the Sciences at all levels (National 5, Higher and Advanced Higher), across all portfolios and in both academic years (2018/19 and 2020/21). The larger averages for the Science portfolio seem to be driven mainly by the larger percentages of active student enrolments at all levels.

Table 4: Overall page views by portfolio, level and academic year

		2018/19							2020/21						
Portfolio	**Level**	**All students**			**Active student enrolments**				**All students**			**Active student enrolments**			
		Mean	**SD**	**N**	**Mean**	**SD**	**% active**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**% active**	**N**
Maths	National 5	1.69	13.66	67076	20.95	43.71	8.07%	5414	2.06	18.77	66278	27.22	62.97	7.58%	5024
	Higher	3.72	21.98	25996	23.27	50.69	15.98%	4154	6.13	38.76	20783	33.9	85.81	18.10%	3761
	Advanced Higher	13.19	55.46	3977	50.59	99.56	26.07%	1037	21.73	104.17	2642	72.5	180.4	29.98%	792
English	National 5	1.15	9.74	61539	18.58	34.84	6.17%	3795	2.46	15.69	70869	31.22	47.17	7.89%	5590
	Higher	1.60	10.79	41518	15.17	29.93	10.57%	4390	5.81	26.33	36598	38.51	57.75	15.09%	5524
	Advanced Higher	1.76	13.25	4054	19.11	39.74	9.20%	373	4.71	22.37	2215	31.43	50.04	14.99%	332
Science	National 5	-	-	-	-	-	-	-	16.84	66.05	61937	59.07	113.17	28.51%	17661
	Higher	16.89	59.51	33811	46.82	91.74	36.08%	12200	38.71	98.06	28114	78.03	127.73	49.61%	13948
	Advanced Higher	54.18	136.40	6428	101.83	173.55	53.20%	3420	96.98	173.9	5154	130.82	190.7	74.14%	3821
Modern Languages	National 5	1.33	6.12	18991	11.23	14.33	11.82%	2245	0.99	5.67	26245	12.88	16.31	7.65%	2009
	Higher	8.77	28.69	8292	26.71	45.05	32.83%	2722	14.29	43.6	6049	36.6	63.65	39.05%	2362
	Advanced Higher	8.40	29.95	660	37.19	53.99	22.58%	149	30.11	57.55	501	52.75	67.92	57.09%	286

Participation, measured by the percentage of active student enrolments, is highlighted in yellow in Table 4 for years 2018-19 and 2020-21.

Engagement, measured by the average number of visits to the Scholar course pages, is highlighted in green in Table 4 for years 2018-19 and 2020-21.

In Table 4, we see that in the academic year 2020/21, the average active student visited the SCHOLAR Science courses approximately 59 times at National 5 level, around 78 times at Higher level, and around 131 times at Advanced Higher level. This is a reasonably large increase compared to the academic year 2018/19, where the average student registered to take Highers visited the SCHOLAR Science courses only about 47 times; and the average Advanced Highers student, around 102 times. The increase at the Higher level is 66.67%, and the increase at Advanced Higher level is 28.35%.

Overall, participation increases across the school years and qualification levels and peaks at the Advanced Higher level across all the portfolios. The Science and Modern Languages portfolios have the greatest levels of participation with the largest percentage of active student enrolments in 2020/21 (74.14% and 57.09%, respectively). Participation in 2018/19 follows a slightly different pattern, where the most accessed portfolios are the Science courses at the Advanced Higher level (53.2%) and Higher level (36.08%), with Higher Modern Languages in third place (32.83%).

In contrast, participation at National 5 is rather poor in both academic years compared to the Higher and Advanced Higher levels across all portfolios. Participation is below 10% for nearly all National 5 courses, except for Modern Languages in 2018/19 (11.82%) and Science in 2020/21, where the percentage of active student enrolments is considerably higher (28.51%). A possible explanation for this phenomenon would be that the stakes are much higher for the Highers and Advanced Highers students as compared to National 5, and there is a higher degree of maturity in the students themselves, which would prompt a higher degree of motivation, and hence, participation and engagement with online resources.[5]

[5] There is also a methodological reason that may in part account for lower levels of participation at the National 5 level, and that is the enrolment of students initially taught in composite N4/N5 classes. This would create Scholar enrolments for these pupils in an N5 course when they are actually N4 pupils. We cannot identify or quantify such cases in the dataset.

Figure 1: Participation (Percentage of active student enrolments) by portfolio, level of study and academic year

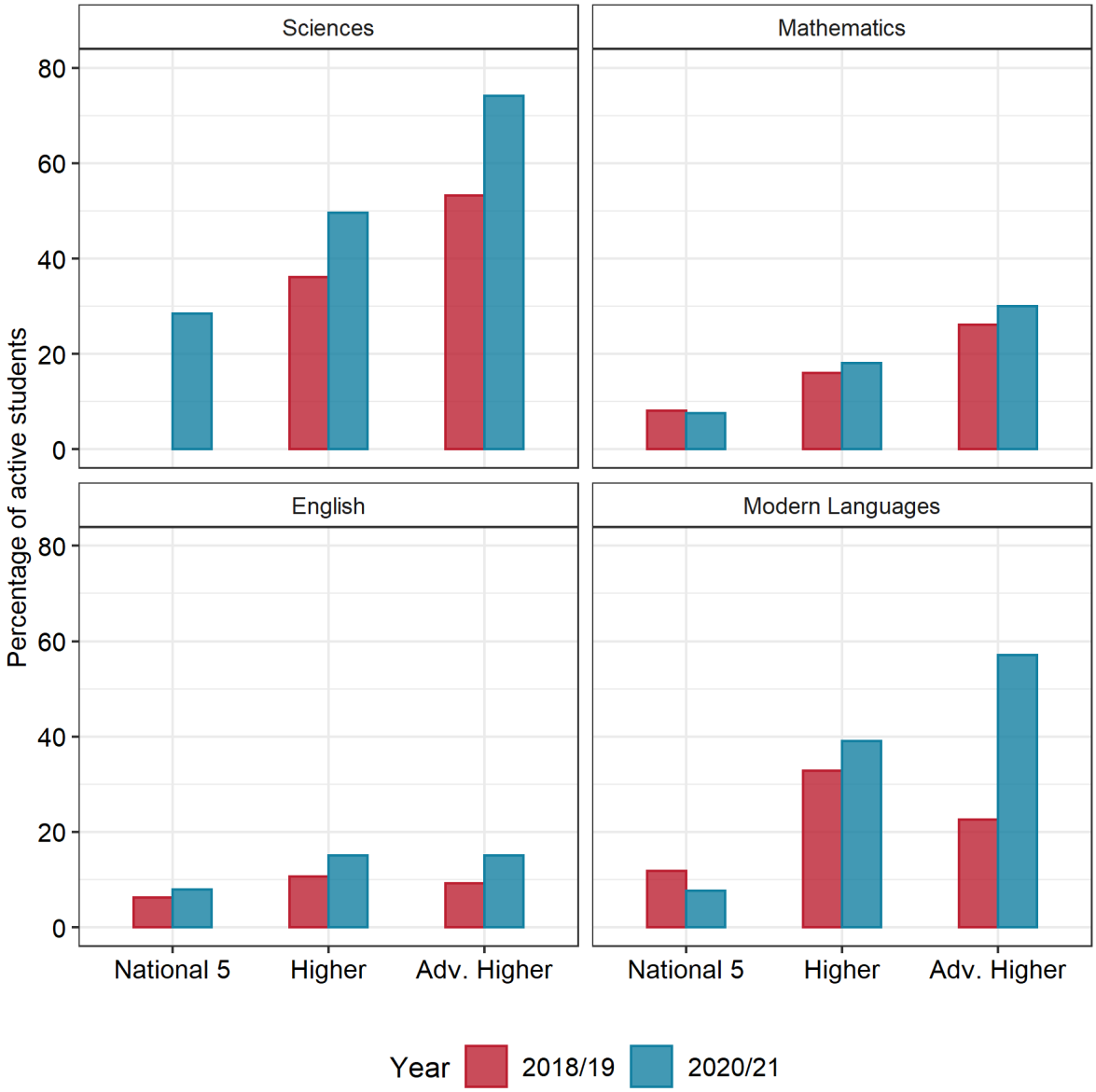


Figure 1 shows that participation is highest for Science in both years, followed by Modern Languages. For these two portfolios, there has also been the greatest increase in participation between 2018-19 and 2020-21.

Figure 2: Engagement (Overall page views) by portfolio, level of study and academic year

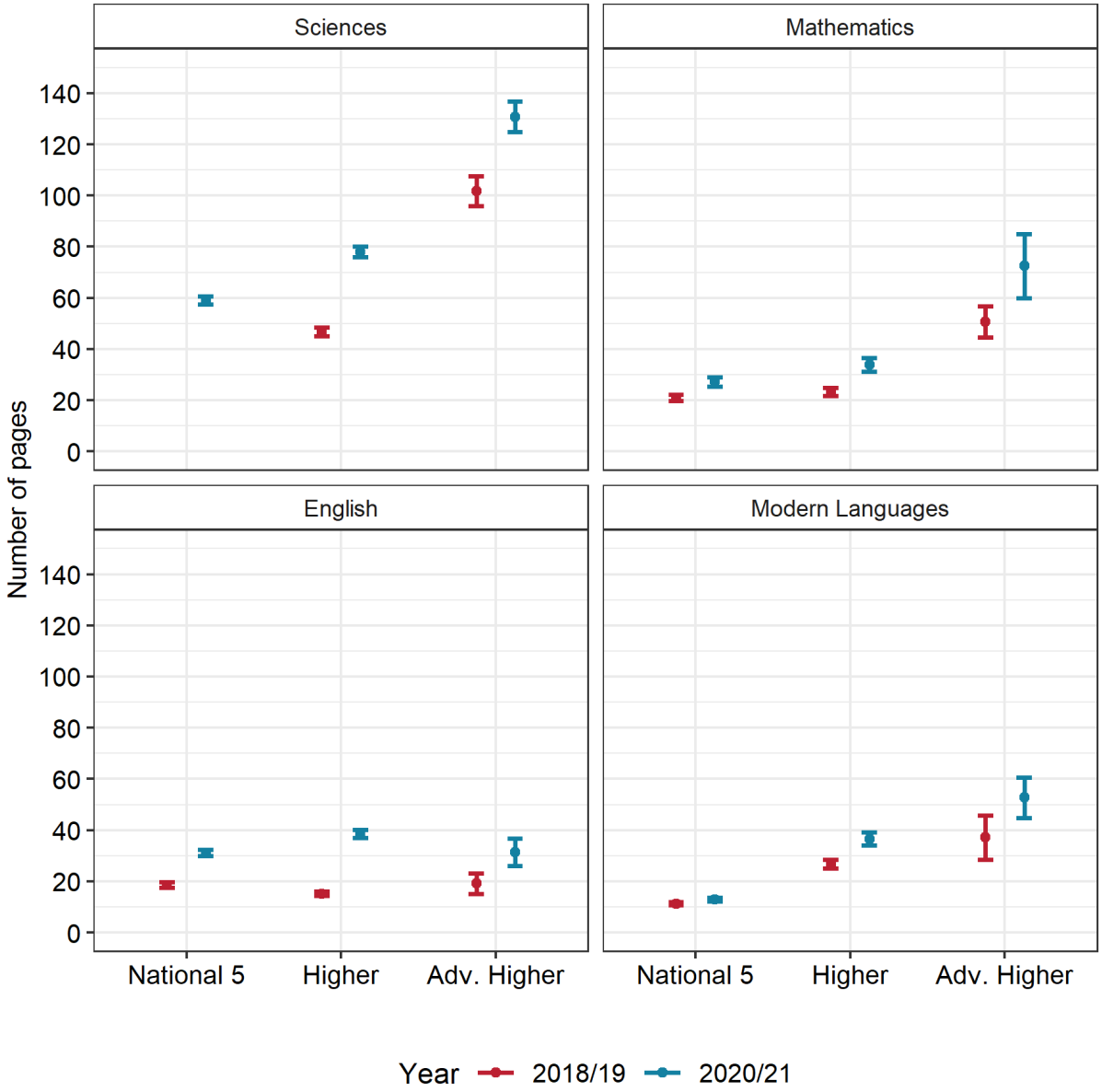


Figure 2 shows that engagement in Science has increased the most between 2018-19 and 2020-21. Engagement with mathematics and English has also increased and is statistically significant across all levels. In modern languages, engagement has increased at the Higher level; however, the apparent increases at the other levels are not statistically significant.

In the following sections, we explore the differences in the levels of engagement and participation by school characteristics and academic year.

3.2 Engagement and participation by school-level FSM eligibility

Here we examine participation (% active) and engagement (average page views) by the percentage of students eligible for free-school meals within school (banded in terciles). Table 5 presents this for the year 2018-19 and table 6 gives this for the year 2020-21.

Table 5: Participation (% active) and Engagement (Page views) by portfolio, level and school FSM band in 2018/19

			All students			Active student enrolments			
Portfolio	**FSM band**	**Level**	**Mean**	**SD**	**N**	**Mean**	**SD**	**% active**	**N**
Maths	1	National 5	1.93	14.24	21864	21.85	43.13	8.84%	1932
	2	National 5	2.02	16.47	22856	20.67	48.88	9.78%	2235
	3	National 5	1.12	9.21	22184	20.25	33.81	5.54%	1230
	1	Higher	4.59	24.63	9155	23.91	51.98	19.18%	1756
	2	Higher	4.19	22.90	8732	24.38	50.59	17.19%	1501
	3	Higher	2.23	17.23	8050	20.19	48.26	11.04%	889
	1	Adv. Higher	14.81	59.60	1870	54.09	104.23	27.38%	512
	2	Adv. Higher	13.36	56.62	1257	46.27	97.96	28.88%	363
	3	Adv. Higher	9.38	42.68	850	49.22	87.37	19.06%	162
English	1	National 5	1.68	10.62	19883	19.45	31.05	8.62%	1713
	2	National 5	0.77	7.06	21055	13.57	26.55	5.68%	1196
	3	National 5	1.02	11.13	20445	23.66	48.27	4.32%	884
	1	Higher	2.32	11.64	14051	16.35	26.94	14.19%	1994
	2	Higher	1.21	7.24	14224	12.99	20.22	9.34%	1328
	3	Higher	1.27	12.85	13170	15.75	42.68	8.06%	1062
	1	Adv. Higher	1.68	13.59	1670	17.14	40.29	9.82%	164
	2	Adv. Higher	1.88	10.12	1429	17.45	26.13	10.78%	154
	3	Adv. Higher	1.71	16.42	953	29.65	62.53	5.77%	55
Science	1	National 5	--	--	--	--	--	--	--
	2	National 5	--	--	--	--	--	--	--
	3	National 5	--	--	--	--	--	--	--
	1	Higher	20.00	66.92	12177	49.32	97.98	40.54%	4937
	2	Higher	16.92	57.53	11723	44.84	86.70	37.75%	4425
	3	Higher	12.89	51.18	9860	45.16	87.88	28.54%	2814
	1	Adv. Higher	62.40	155.65	2931	113.59	195.69	54.93%	1610
	2	Adv. Higher	53.04	130.47	2246	96.61	163.73	54.90%	1233
	3	Adv. Higher	36.96	88.55	1251	80.14	116.41	46.12%	577
Modern Languages	1	National 5	1.23	5.90	8094	10.88	14.23	11.32%	916
	2	National 5	1.50	6.01	5788	10.21	12.54	14.69%	850
	3	National 5	1.29	6.58	5067	13.73	17.04	9.41%	477
	1	Higher	10.50	29.46	3272	28.14	42.77	37.32%	1221
	2	Higher	8.82	27.38	2869	25.82	41.91	34.16%	980
	3	Higher	6.06	29.04	2150	25.01	54.87	24.23%	521
	1	Adv. Higher	8.37	27.08	428	35.84	46.56	23.36%	100
	2	Adv. Higher	5.82	22.92	179	27.42	43.80	21.23%	38
	3	Adv. Higher	17.28	58.69	53	83.27	108.93	20.75%	11

Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

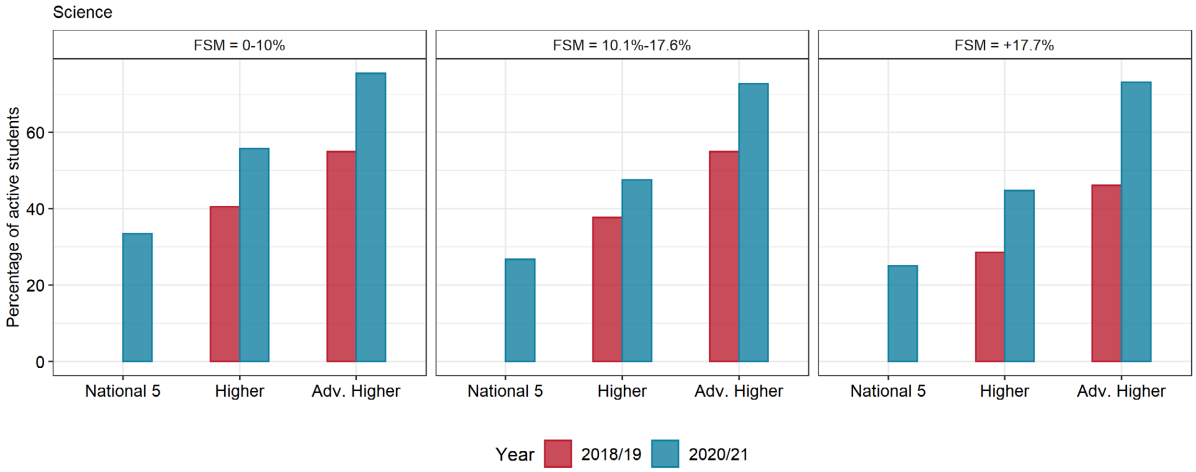
Table 6: Participation (% active) and Engagement (Page views) by portfolio, level and school's FSM percentage band in 2020/21

Portfolio	FSM band	Level	All students			Active student enrolments			
			Mean	SD	N	Mean	SD	%	N
Maths	1	National 5	2.68	19.86	23558	29.01	59.30	9.22%	2172
	2	National 5	1.92	20.55	23596	25.79	71.24	7.42%	1752
	3	National 5	1.51	14.69	18654	25.90	55.45	5.83%	1087
	1	Higher	7.49	44.69	7918	35.70	92.31	20.96%	1660
	2	Higher	5.94	32.45	6906	32.18	69.76	18.45%	1274
	3	Higher	4.79	37.85	5651	32.91	94.46	14.56%	823
	1	Adv. Higher	27.99	121.02	1398	85.61	199.80	32.69%	457
	2	Adv. Higher	16.83	95.43	779	62.43	176.19	26.96%	210
	3	Adv. Higher	11.40	46.83	451	42.83	83.27	26.61%	120
English	1	National 5	3.93	19.59	23923	32.35	47.38	12.13%	2903
	2	National 5	2.14	15.32	25450	33.16	51.02	6.46%	1645
	3	National 5	1.22	10.20	20991	25.07	39.33	4.85%	1019
	1	Higher	9.17	32.76	12821	44.27	60.25	20.71%	2655
	2	Higher	5.20	25.40	12663	37.93	58.87	13.71%	1736
	3	Higher	2.72	17.21	10766	26.06	47.20	10.45%	1125
	1	Adv. Higher	7.16	29.57	989	37.48	58.76	19.11%	189
	2	Adv. Higher	3.40	15.87	745	25.05	36.42	13.56%	101
	3	Adv. Higher	1.17	7.09	457	18.48	22.10	6.35%	29
Science	1	National 5	21.99	78.06	21582	65.65	123.81	33.49%	7228
	2	National 5	14.79	60.20	22144	55.41	106.43	26.69%	5910
	3	National 5	13.31	56.32	17764	53.21	102.77	25.01%	4442
	1	Higher	48.25	108.48	10727	86.41	133.34	55.84%	5990
	2	Higher	32.98	91.99	9614	69.32	123.56	47.58%	4574
	3	Higher	33.39	89.68	7467	74.61	122.07	44.74%	3341
	1	Adv. Higher	108.70	190.14	2500	143.93	206.89	75.52%	1888
	2	Adv. Higher	83.85	155.95	1722	115.33	172.70	72.71%	1252
	3	Adv. Higher	91.41	158.92	901	124.98	174.19	73.14%	659
Modern Languages	1	National 5	0.89	5.37	11187	12.97	16.22	6.88%	770
	2	National 5	1.10	6.13	9725	13.02	17.01	8.46%	823
	3	National 5	0.98	5.42	5186	12.59	15.26	7.77%	403
	1	Higher	16.45	50.42	2418	37.92	71.05	43.38%	1049
	2	Higher	14.78	37.82	2003	36.19	52.24	40.84%	818
	3	Higher	10.70	39.51	1566	35.26	65.47	30.33%	475
	1	Adv. Higher	33.90	65.52	332	58.32	77.27	58.13%	193
	2	Adv. Higher	20.30	32.66	122	38.70	36.41	52.46%	64
	3	Adv. Higher	28.83	44.09	47	46.72	48.24	61.70%	29

Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

The following figures (3 – 10) look more closely at participation and engagement for each portfolio individually by year and free school meal band.

Figure 3: Participation (Percentage of active student enrolments) in the Science portfolio by level of study, academic year and school FSM percentage band

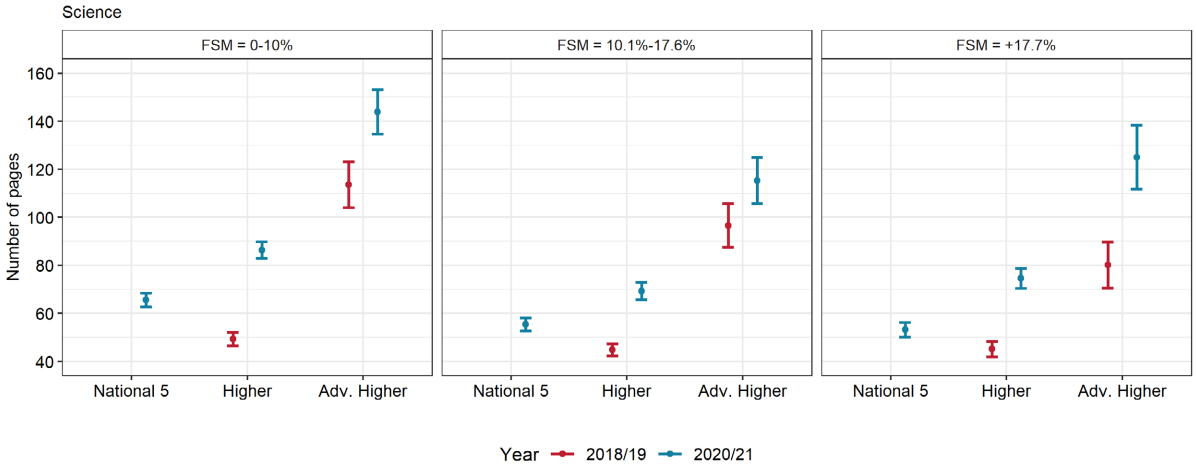


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 3 shows that participation in Scholar in the Science portfolio increased by a large percentage between 2018-19 and 2020-21, but especially for the highest banded (most deprived) FSM schools. The Science portfolio was the most dramatic increase of all the portfolios from the highest base. Some points to note are:

- At the Higher level, there is a 16-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Higher level, there is a 15-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Advanced Higher level, there is a 27-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 20-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Higher level, there is a social gradient in participation by FSM entitlement across both years, although this reduces in the later year 2020-21.
- For the first time in 2020-21 for Advanced Higher level, there is no real difference in participation by FSM entitlement. This is unique to Science, however, and may be an expression of the ability and commitment of students who take one or more sciences to such a high level. It may also suggest that pupils taking Advanced Higher Science are not low income themselves as we are using school-level FSM entitlement.

Figure 4: Engagement (Page views of active students) in the Science portfolio by level of study, academic year and school FSM percentage band

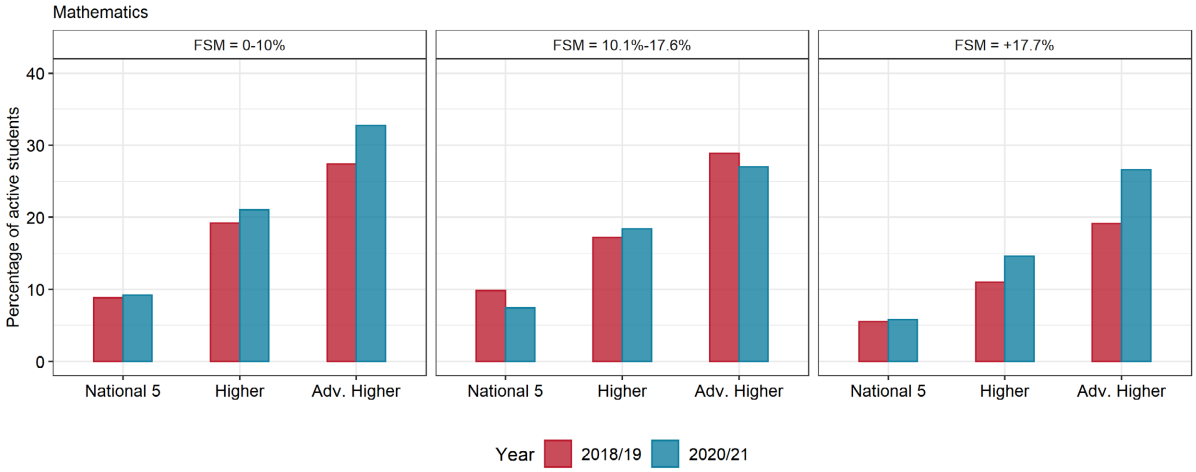


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 4 shows that engagement in Scholar in the Science portfolio increased by a large percentage between 2018-19 and 2020-21, especially for the highest (most deprived) and lowest (least deprived) FSM schools. The Science portfolio was the most dramatic increase of all the portfolios from the highest base. Some points to note are:

- At the Higher level, there is a 60% increase in engagement (45 pages to 75 pages) between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Higher level, there is a 76% increase in engagement (49 pages to 86 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Advanced Higher level, there is a 56% increase in engagement between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 26% increase in engagement between 2018-19 and 2020-21 for students at the **least** deprived schools.
- This means that the most dramatic increase in engagement with the Advanced Higher Science portfolio is for the highest FSM schools. Again, this is likely a function of the motivation and capability of students who take one or more science to such a high level, but it is heartening to see this increase in engagement.

Figure 5: Participation (Percentage of active student enrolments) in the Mathematics portfolio by level of study, academic year and school FSM percentage band

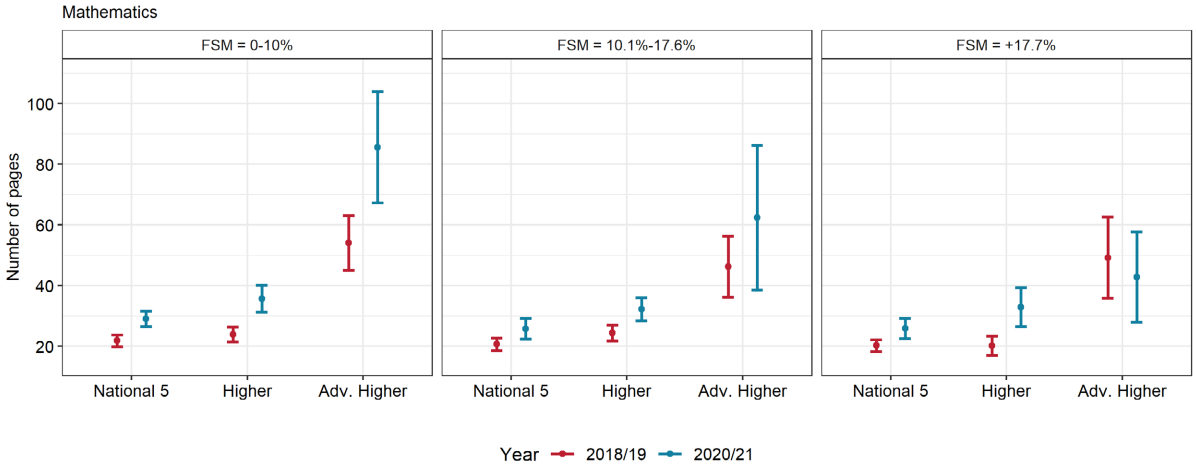


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 5 shows that participation in Scholar in Mathematics increased between 2018-19 and 2020-21, with the greatest increase being for the highest banded FSM schools (most deprived) at the Higher and Advanced Higher levels and the lowest banded (least deprived) FSM schools at the Advanced Higher level. The percentage of active student enrolments baseline for Mathematics is lower than that for the Science portfolio. Some points to note are:

- At the Higher level, there is a 3.5-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 7.5-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 5-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Higher level, there is a social gradient in participation by FSM entitlement, with students at the least deprived schools having the most engagement.
- Overall, while there has been an increase in participation by the students at the **most** deprived schools between 2018-19 and 2020-21, participation is still highest in schools with lower FSM entitlement.

Figure 6: Engagement (Page views of active student enrolments) in the Mathematics portfolio by level of study, academic year and school FSM percentage band

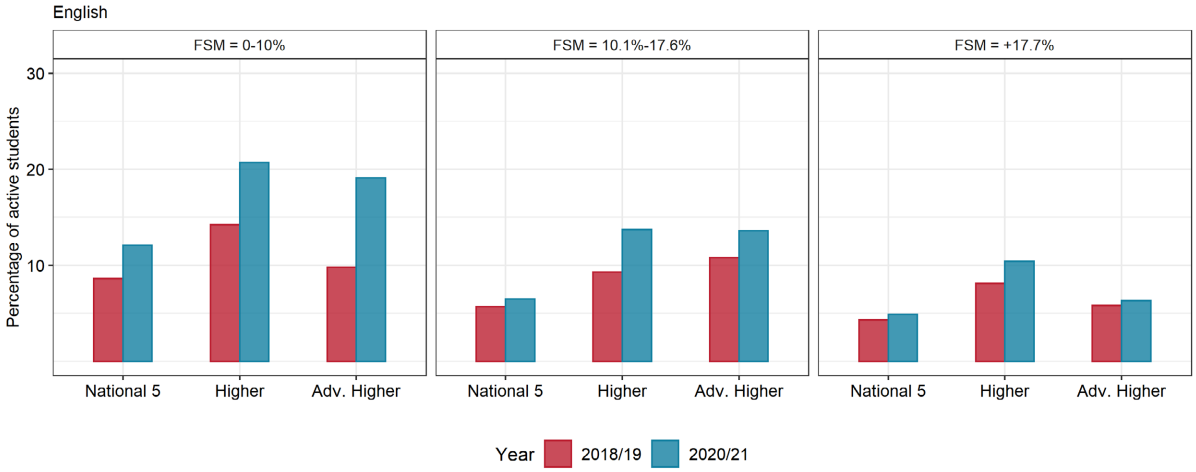


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 6 shows that engagement in Scholar in Mathematics on the whole increased between 2018-19 and 2020-21. Some points to note are:

- Engagement increased most dramatically for students at the lowest FSM (**least** deprived) schools at the Advanced Higher level.
- At the Advanced Higher level, there is a 12% **decrease** in engagement (49 pages to 43 pages) between 2018-19 and 2020-21 for students at the most deprived schools. This is the only decrease in the Mathematics portfolio.
- At the Advanced Higher level, there is a 59% increase in engagement (54 pages to 86 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Higher level, there is approximately a 50% increase in engagement (24 pages to 36 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Higher level, there is a 65% increase in engagement (20 pages to 33 pages) between 2018-19 and 2020-21 for students at the **most** deprived schools.

Figure 7: Participation (Percentage of active student enrolments) in the English portfolio by level of study, academic year and school FSM percentage band

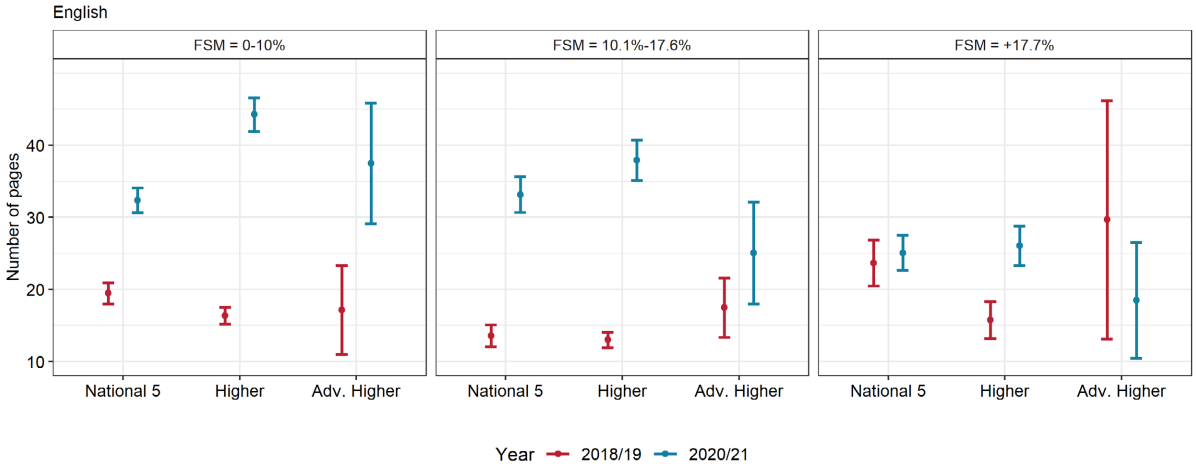


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 7 shows that participation in Scholar in English increased between 2018-19 and 2020-21, but especially for the lowest banded FSM (least deprived) schools. Some points to note are:

- At the Higher level, there is a 2-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Higher level, there is a 6.5-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Advanced Higher level, there is **no change** in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 9-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Higher level, there is a social gradient in participation by FSM entitlement across both years, which becomes more pronounced in the later year 2020-21.
- In participation in English across the board, inequality has **increased** from the earlier to the later period.

Figure 8: Engagement (Page views of active student enrolments) in the English portfolio by level of study, academic year and school FSM percentage band

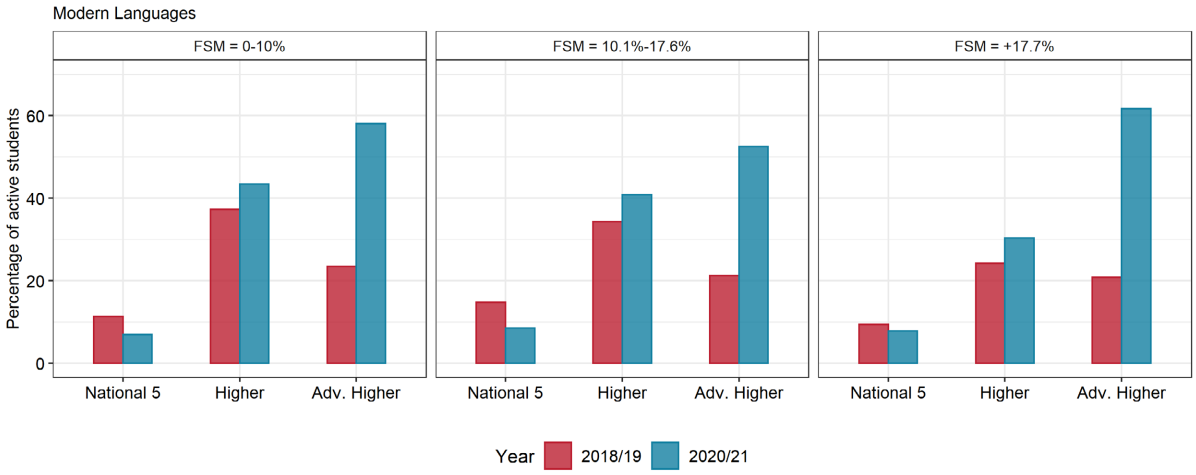


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 8 shows that engagement in Scholar in English increased by a large percentage between 2018-19 and 2020-21 for the lowest (least deprived) FSM students across all levels of study. Some points to note are:

- At the Higher level, there is a 62% increase in engagement (16 pages to 26 pages) between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Higher level, there is a 175% increase in engagement (16 pages to 44 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools. This means that students at the least deprived schools almost tripled their engagement in the Higher English portfolio.
- At the Advanced Higher level, there is a 40% decrease in engagement (30 pages to 18 pages) between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Advanced Higher level, there is a 118% increase in engagement (17 pages to 37 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools. This means that students at the least deprived schools more than doubled their engagement in the Advanced Higher English portfolio.
- In engagement in English across the board, inequality has **increased** from the earlier to the later period.

Figure 9: Participation (Percentage of active student enrolments) in the Modern Languages portfolio by level of study, academic year and school FSM percentage band

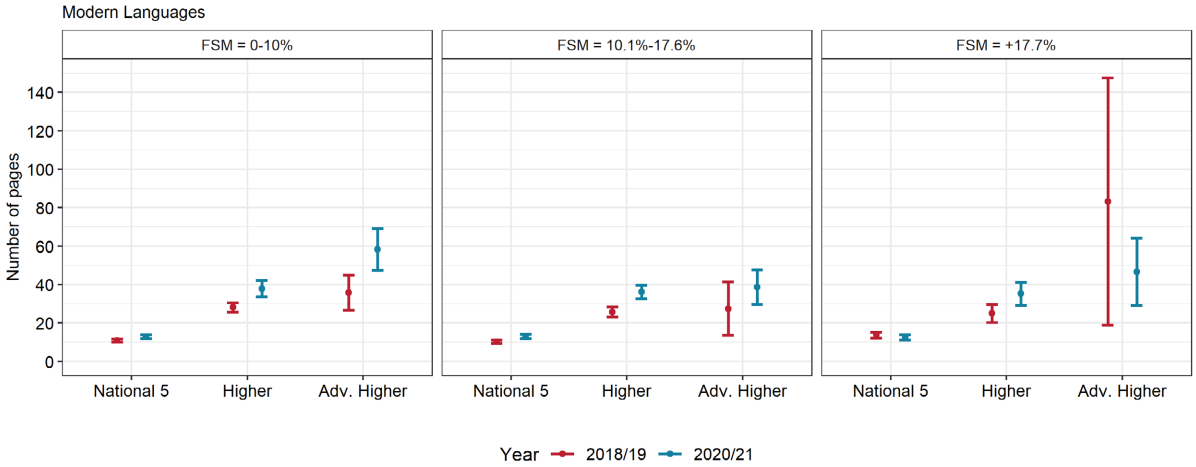


Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 9 shows that participation in Scholar in the Modern Languages portfolio increased by a large percentage for the Advanced Higher level between 2018-19 and 2020-21 for all bands of school FSM entitlement. Some points to note are:

- At the Higher level, there is a 6-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools.
- At the Higher level, there is a 6-percentage point increase in participation between 2018-19 and 2020-21 for students at the least deprived schools. The baseline at the least deprived schools is much higher than in the **most** deprived schools.
- At the Advanced Higher level, there is a 41-percentage point increase in participation between 2018-19 and 2020-21 for students at the **most** deprived schools. This means that students in the most deprived schools have almost tripled their participation across the two periods at Advanced Higher level.
- At the Advanced Higher level, there is a 35-percentage point increase in participation between 2018-19 and 2020-21 for students at the **least** deprived schools. This means that students in the least deprived schools more than doubled their participation across the two periods at Advanced Higher level.
- At the Higher level, there is a social gradient in participation by FSM entitlement across both years.
- For the first time in 2020-21 for Advanced Higher level, there is not a major difference in participation by FSM entitlement.

Figure 10: Engagement (Page views of active student enrolments) in the Modern Languages portfolio by level of study, academic year and school FSM percentage band



Note: FSM bands - 1 = least deprived, 2 = medium, 3 = most deprived.

Figure 10 shows that engagement in Scholar in the Modern Languages portfolio increased between 2018-19 and 2020-21, mainly for the lowest FSM (least deprived) schools. Some points to note are:

- At the Higher level, there is a 40% increase in engagement (25 pages to 35 pages) between 2018-19 and 2020-21 for students inat the **most** deprived schools.
- At the Higher level, there is a 36% increase in engagement (28 pages to 38 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools.
- At the Advanced Higher level, there is a 43% **decrease** in engagement (83 pages to 47 pages) between 2018-19 and 2020-21 for students at the **most** deprived schools. This means that engagement at the Advanced Higher level in the **most** deprived schools almost halved across the period.
- At the Advanced Higher level, there is a 60% increase in engagement (36 pages to 58 pages) between 2018-19 and 2020-21 for students at the **least** deprived schools.

3.3 Engagement and participation by school-level rurality

Here we examine participation (% active) and engagement (average page views) by the urban/rural classification of the school (dichotomous banding). Table 7 presents this for the year 2018-19 and table 8 gives this for the year 2020-21.

Table 7: Participation (% active) and Engagement (Page views) by portfolio, level and school Urban/Rural classification in 2018/19

			All students			Active student enrolments			
Portfolio	**Urban/Rural**	**Level**	**Mean**	**SD**	**N**	**Mean**	**SD**	**% active**	**N**
Maths	1	National 5	1.48	12.93	5770	20.26	43.77	7.28%	4201
	2	National 5	3.04	17.54	9302	23.34	43.44	13.04%	1213
	1	Higher	3.42	20.57	2236	22.45	48.50	15.23%	3406
	2	Higher	5.60	29.23	3607	27.02	59.58	20.71%	747
	1	Ad. Higher	12.61	52.12	3566	49.89	94.32	25.27%	901
	2	Adv. Higher	18.28	78.64	411	55.25	129.32	33.09%	136
English	1	National 5	1.09	9.57	5256	17.99	34.84	6.04%	3173
	2	National 5	1.51	10.68	8912	21.59	34.68	6.98%	622
	1	Higher	1.51	10.58	3554	14.60	29.83	10.36%	3681
	2	Higher	2.16	12.00	5950	18.17	30.33	11.90%	708
	1	Adv. Higher	1.64	11.31	3499	17.75	33.22	9.23%	323
	2	Adv. Higher	2.52	21.83	553	27.92	68.14	9.04%	50
Science	1	National 5	--	--	--	--	--	--	--
	2	National 5	--	--	--	--	--	--	--
	1	Higher	16.02	56.72	2892	46.02	88.65	34.82%	1007
	2	Higher	22.07	73.76	4885	50.62	105.05	43.60%	2130
	1	Adv. Higher	53.27	134.01	5623	100.86	170.90	52.82%	2970
	2	Adv. Higher	60.49	151.95	805	108.20	190.19	55.90%	450
Modern Languages	1	National 5	1.25	5.90	1681	11.06	14.13	11.29%	1899
	2	National 5	1.95	7.60	2159	12.18	15.40	15.98%	345
	1	Higher	8.66	27.86	7275	26.19	43.46	33.07%	2406
	2	Higher	9.54	34.07	1016	30.68	55.58	31.10%	316
	1	Adv. Higher	8.35	29.76	595	38.23	54.09	21.85%	130
	2	Adv. Higher	8.80	31.90	65	30.11	54.23	29.23%	19

Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Table 8: Participation (% active) and Engagement (Page views) by portfolio, level and school Urban/Rural classification in 2020/21

Portfolio	Urban/Rural	Level	All students			Active student enrolments			
			Mean	SD	N	Mean	SD	% active	N
Maths	1	National 5	1.76	16.98	5739	26.04	60.23	6.77%	3884
	2	National 5	4.17	28.15	8543	31.29	71.42	13.33%	1139
	1	Higher	5.91	38.85	1774	34.16	88.09	17.30%	3071
	2	Higher	8.25	40.16	2738	32.78	74.90	25.16%	689
	1	Adv. Higher	20.56	105.4	2381	74.39	190.4	27.64%	658
	2	Adv. Higher	34.13	93.44	247	65.34	121.3	52.23%	129
English	1	National 5	2.27	14.73	6111	30.56	45.30	7.44%	4547
	2	National 5	3.76	21.03	9415	34.17	54.59	11.01%	1037
	1	Higher	5.73	26.42	3134	39.70	59.06	14.43%	4524
	2	Higher	6.68	26.54	4949	33.21	51.20	20.13%	996
	1	Adv. Higher	4.40	20.35	1932	30.81	45.74	14.29%	276
	2	Adv. Higher	6.36	33.31	259	38.28	74.59	16.60%	43
Science	1	National 5	14.45	58.28	5339	53.99	102.7	26.77%	1429
	2	National 5	32.68	101.9	8285	80.51	147.5	40.59%	3363
	1	Higher	35.60	93.50	2393	74.07	123.8	48.06%	1150
	2	Higher	60.22	122.4	3913	96.94	143.4	62.13%	2431
	1	Adv. Higher	93.23	169.5	4458	126.79	186.5	73.53%	3278
	2	Adv. Higher	124.6	201.6	665	159.07	215.4	78.35%	521
Modern Languages	1	National 5	0.85	5.28	2311	12.13	16.14	7.01%	1621
	2	National 5	2.06	8.02	3025	16.03	16.67	12.83%	388
	1	Higher	13.53	42.68	5273	36.06	63.60	37.51%	1978
	2	Higher	20.75	50.88	714	40.69	65.36	50.98%	364
	1	Adv. Higher	27.78	53.03	459	50.20	62.94	55.34%	254
	2	Adv. Higher	55.62	90.83	42	73.00	97.99	76.19%	32

Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

The following figures (11 – 18) look more closely at participation and engagement for each portfolio individually by year and urban/rural classification.

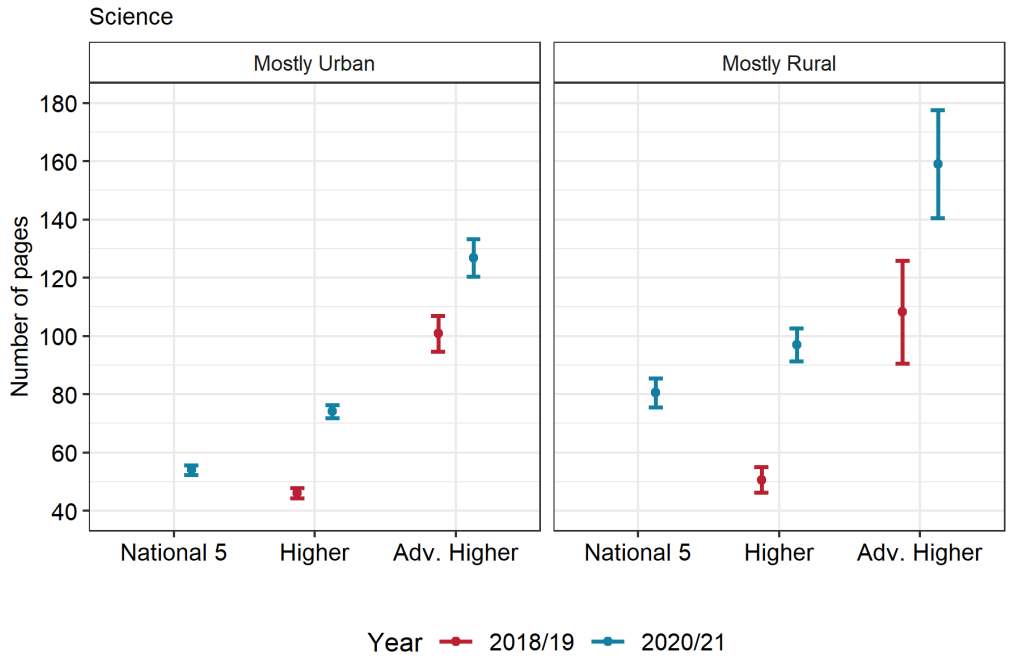
Figure 11: Participation (Percentage of active student enrolments) in Science by level, academic year and school Urban/Rural classification

Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 11 shows that participation in Scholar in the Science portfolio is higher in rural schools, although the difference is not large. The Science portfolio shows the most dramatic increase of all the portfolios from the highest base. Some points to note are:

- At the Higher level, there is an 18.5-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 13-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 22-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 20.5-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.

Figure 12: Engagement (Page views of active students) in Science by level, academic year and school Urban/Rural classification

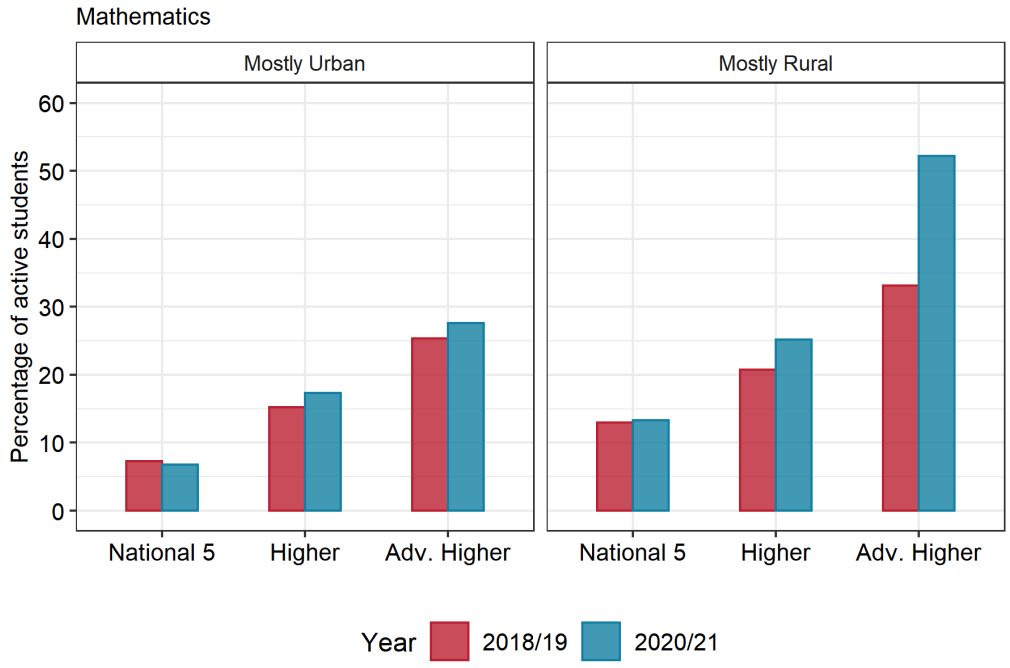


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 12 shows that engagement in Scholar in the Science portfolio increased by a reasonably large percentage between 2018-19 and 2020-21 for mostly rural schools in particular. The Science portfolio was the most dramatic increase of all the portfolios from the highest base. Some points to note are:

- At the Higher level, there is a 90% increase in engagement (51 pages to 97 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 61% increase in engagement (46 pages to 74 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 47% increase in engagement (108 pages to 159 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 26% increase in engagement (101 pages to 127 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.
- This means that the most dramatic increase in engagement with the Advanced Higher Science portfolio is for mostly **rural** schools.

Figure 13: Participation (Percentage of active student enrolments) in Mathematics by level, academic year and school Urban/Rural classification

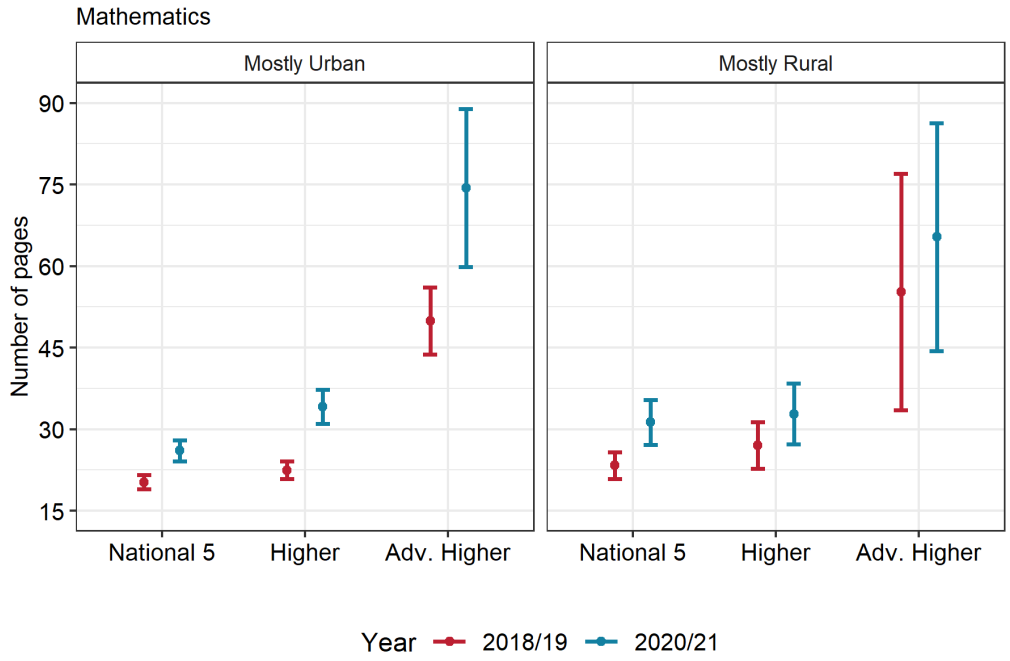


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 13 shows that participation in Scholar in Mathematics increased between 2018-19 and 2020-21, with the greatest increase being for mostly rural schools at the Advanced Higher level. The percentage of active student enrolments baseline for Mathematics is lower than that for the Science portfolio. Some points to note are:

- At the Higher level, there is a 4-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 2-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 19-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 2-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.
- Overall, while there has been an increase in participation by the students in the mostly urban schools between 2018-19 and 2020-21, participation is still highest in mostly **rural** schools.

Figure 14: Engagement (Page views of active students) in Mathematics by level, academic year and school Urban/Rural classification

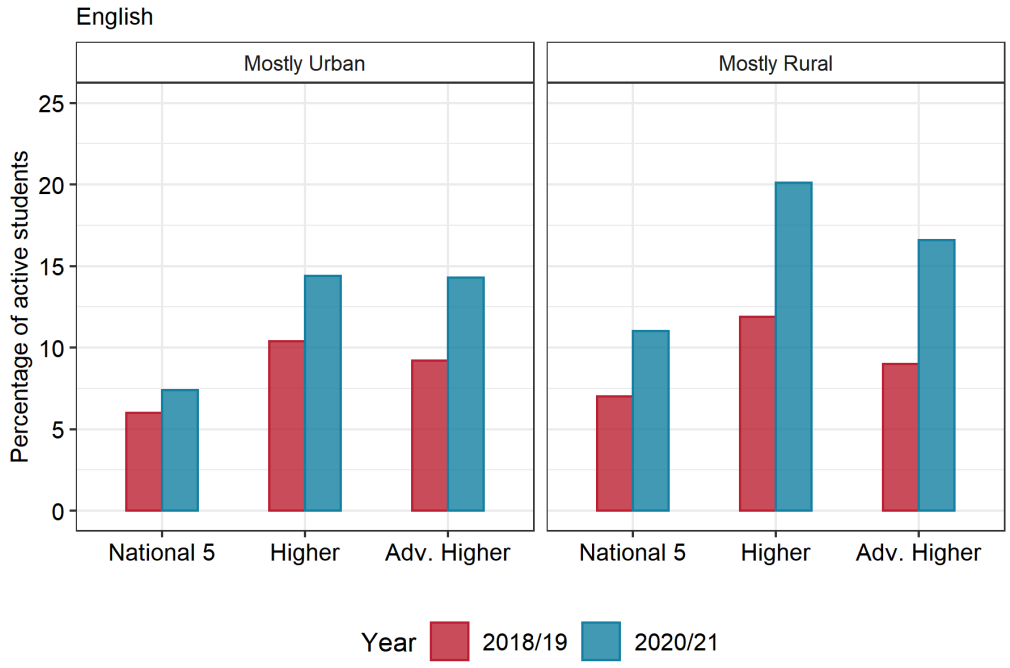


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 14 shows that engagement in Scholar in Mathematics on the whole increased between 2018-19 and 2020-21. Some points to note are:

- Engagement increased most dramatically for students in mostly **urban** schools at the Advanced Higher level.
- At the Advanced Higher level, there is a 18% increase in engagement (55 pages to 65 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 48% increase in engagement (50 pages to 74 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Higher level, there is approximately a 36% increase in engagement (22 pages to 34 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Higher level, there is a 20% increase in engagement (27 pages to 33 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.

Figure 15: Participation (Percentage of active student enrolments) in English by level, academic year and school Urban/Rural classification

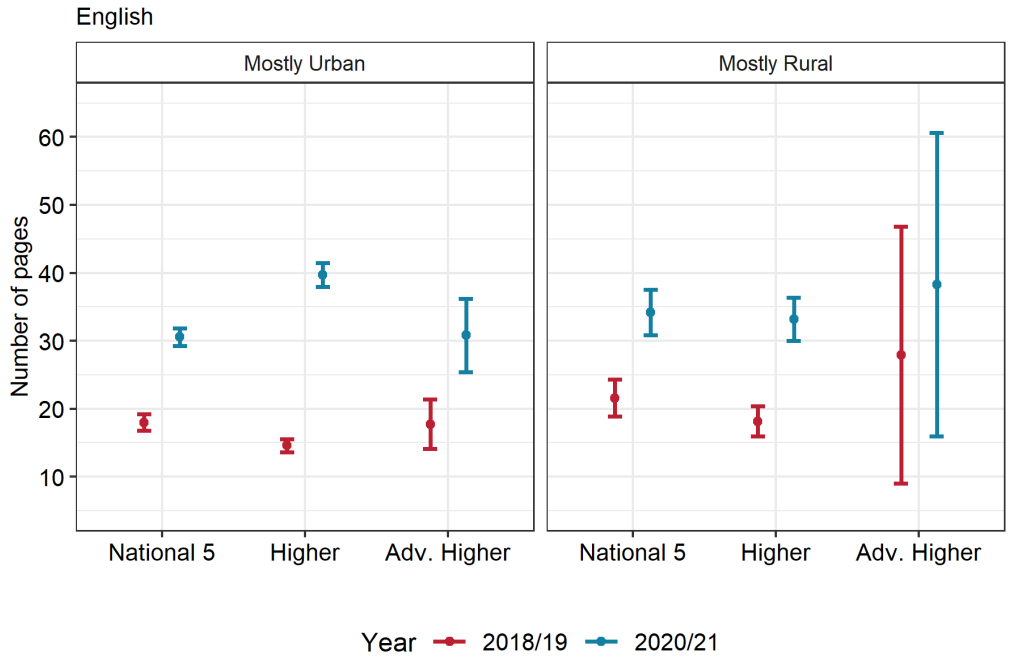


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 15 shows that participation in Scholar in English increased between 2018-19 and 2020-21, mainly for the mostly rural schools. Some points to note are:

- At the Higher level, there is an 8-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 4-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 7.5-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 5-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.

Figure 16: Engagement (Page views of active students) in English by level, academic year and school Urban/Rural classification

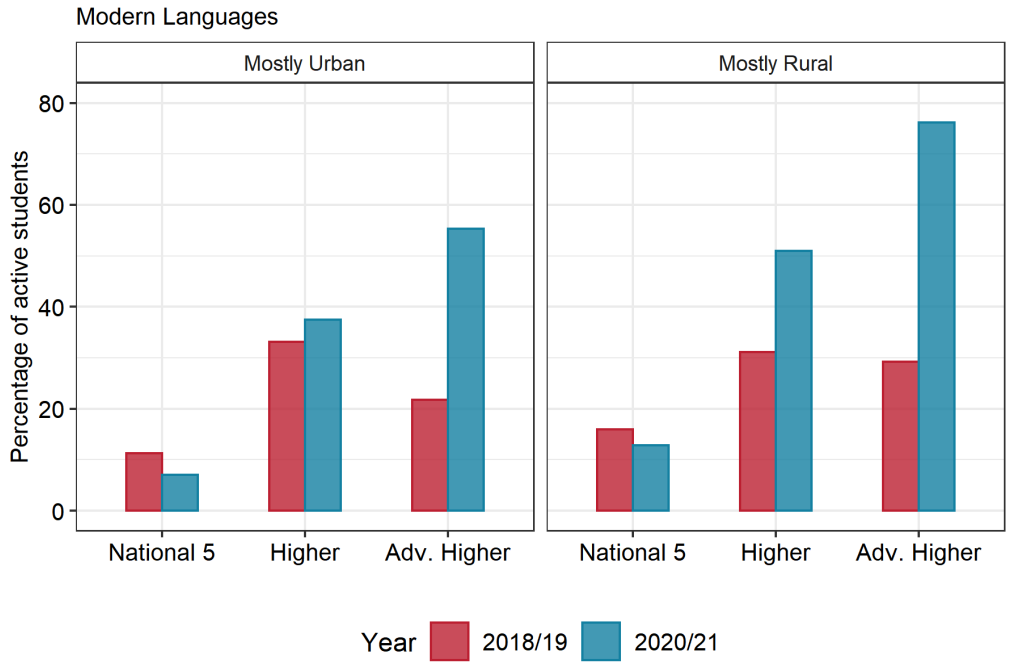


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 16 shows that there is very little difference in engagement in Scholar in English by urban/rural classification in either of the two years; however, engagement has increased across the board from 2018-19 to 2020-21. Some points to note are:

- At the Higher level, there is an 83% increase in engagement (18 pages to 33 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 16% increase in engagement (15 pages to 40 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools. This means that students in mostly **urban** schools had more than 2.5 times the engagement in the Higher English portfolio.
- At the Advanced Higher level, there is a 36% increase in engagement (28 pages to 38 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Advanced Higher level, there is a 72% increase in engagement (18 pages to 31 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.

Figure 17: Participation (Percentage of active student enrolments) in Modern Languages by level, academic year and school Urban/Rural classification

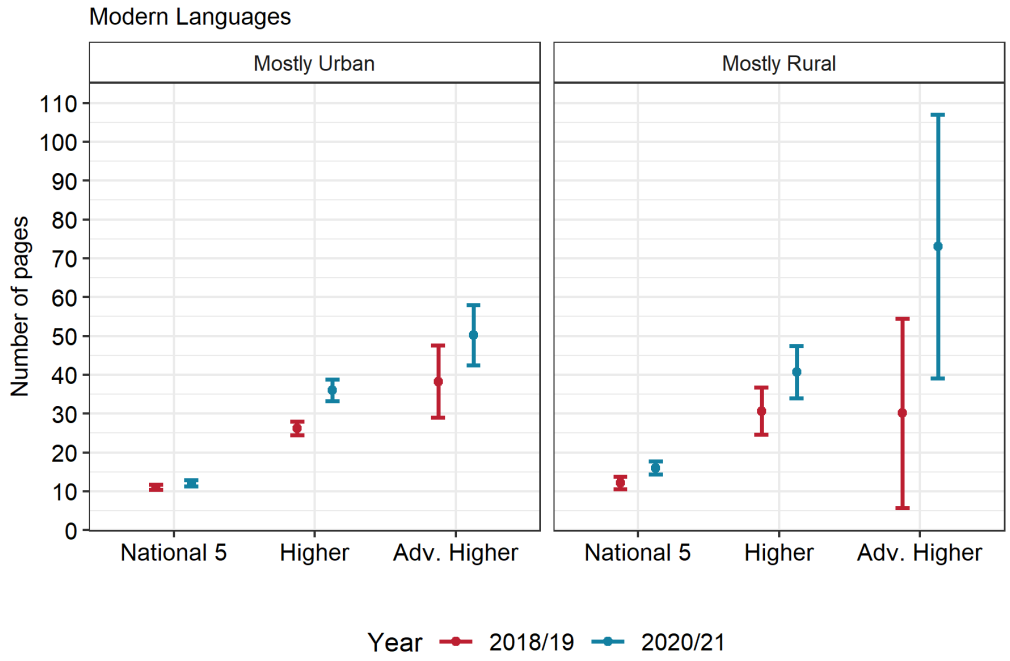


Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

Figure 17 shows that participation in Scholar in the Modern Languages portfolio increased by a large percentage for the Advanced Higher level between 2018-19 and 2020-21 for all urban/rural classification and for mostly rural schools at the Higher level. Some points to note are:

- At the Higher level, there is a 20-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 4-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 47-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **rural** schools. This means that students in the mostly rural schools were 2.5 times more likely to participate across the two periods at Advanced Higher level.
- At the Advanced Higher level, there is a 33-percentage point increase in participation between 2018-19 and 2020-21 for students in mostly **urban** schools. This means that students in mostly urban schools more than doubled their participation across the two periods at Advanced Higher level.

Figure 18: Engagement (Page views of active students) in Modern Languages by level, academic year and school Urban/Rural classification



Note: Dichotomous classification based on the Scottish Government's 6-fold urban/rural classification. Coded as follows: 1 = Mostly urban and 2 = Mostly rural.

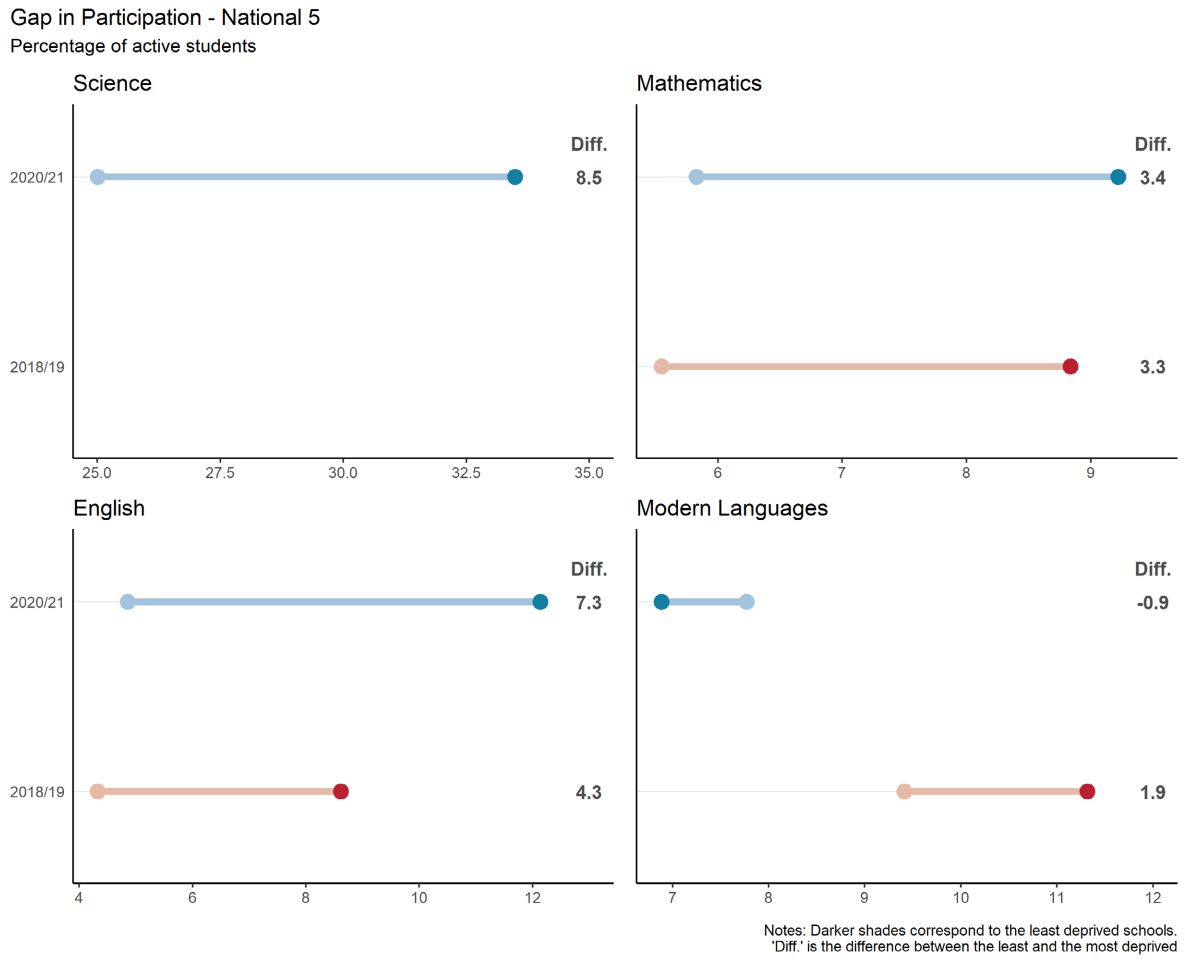
Figure 18 shows that engagement in Scholar in the Modern Languages portfolio increased between 2018-19 and 2020-21, mainly for mostly rural schools. Some points to note are:

- At the Higher level, there is a 30% increase in engagement (31 pages to 41 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools.
- At the Higher level, there is a 38% increase in engagement (26 pages to 36 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.
- At the Advanced Higher level, there is a 143% increase in engagement (30 pages to 73 pages) between 2018-19 and 2020-21 for students in mostly **rural** schools. This means that engagement at the Advanced Higher level in mostly rural schools more than doubled across the period.
- At the Advanced Higher level, there is a 32% increase in engagement (38 pages to 50 pages) between 2018-19 and 2020-21 for students in mostly **urban** schools.

3.4 Narrowing the gap?

In this section, we explore the socioeconomic gap in more detail as we delve into the longitudinal differences between the least and most deprived schools in their levels of participation and engagement. In the Science portfolio there is no data for National 5 in 2018-19.

Figure 19: Difference in participation of National 5 students (percentage active) between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in participation at National 5 in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measured by FSM bands). The blue bar in each chart shows the gap in participation at National 5 in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measured by FSM bands).

The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in participation between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

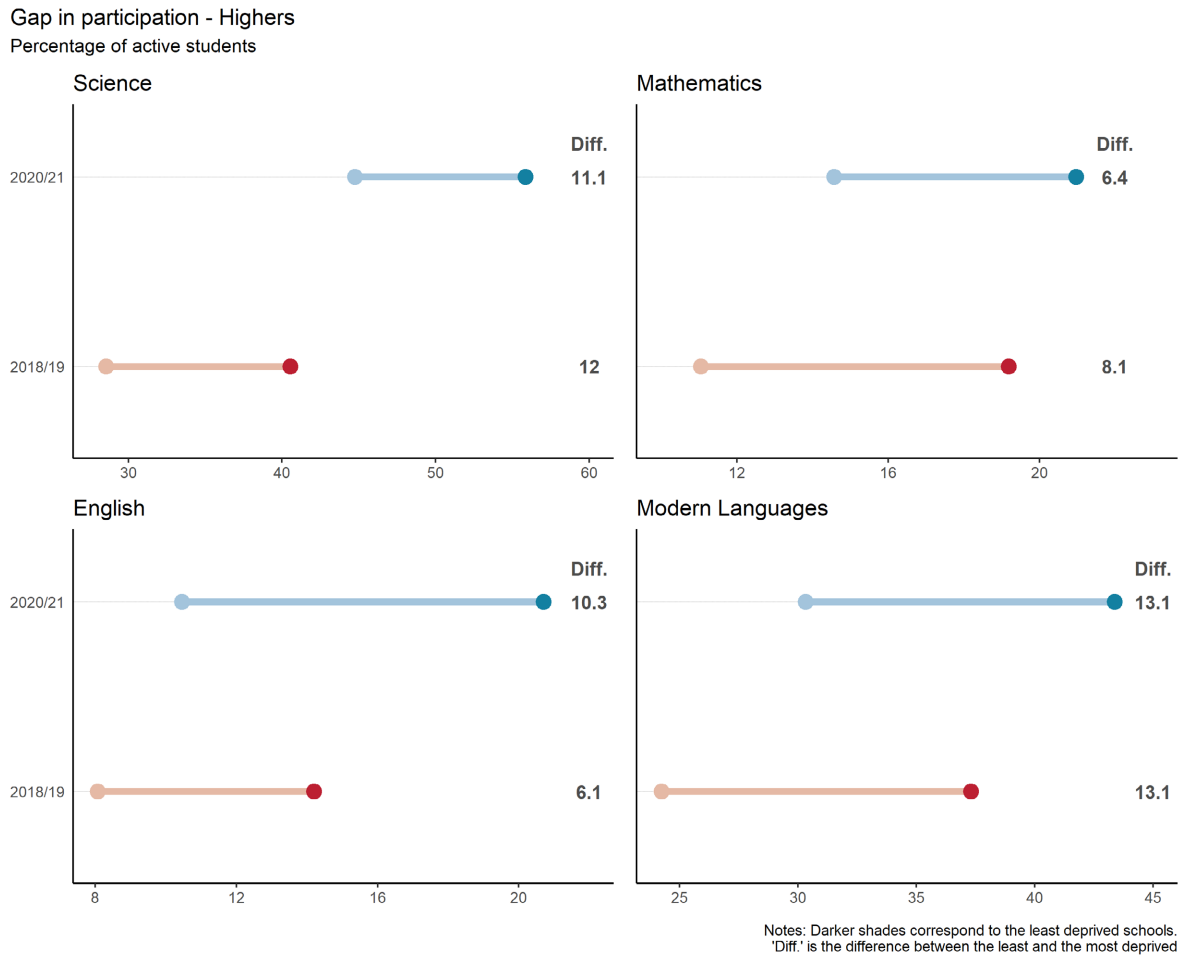
To calculate the relative change in the gap in participation at National 5 from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in participation results in either a negative value, which indicates a decrease in the

gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in participation and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in participation.

For each of the four portfolios the relative change in the gap at National 5 between 2018-29 and 2020-21 is as follows:

- Science: NA
- Mathematics: 0.1 – there is virtually no change in the participation of the least and most deprived across the two year groups.
- English: 3 – there is an increase in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has increased.
- Modern Languages: -2.8 – there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.

Figure 20: Difference in participation of Higher level students (percentage active) between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in participation at Higher level in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measure by FSM bands). The blue bar in each chart shows the gap in participation at Higher level in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measure by FSM bands).

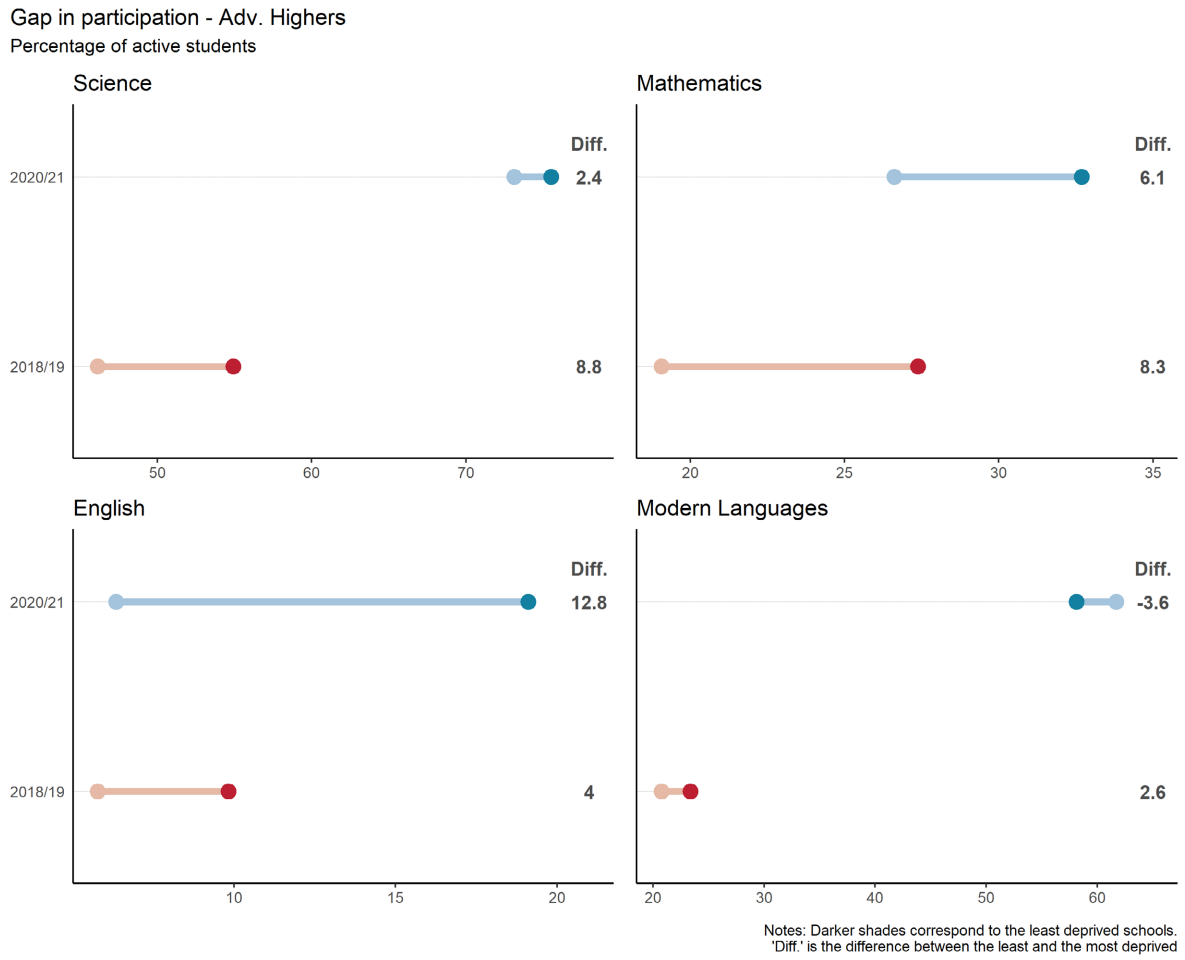
The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in participation between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

To calculate the relative change in the gap in participation at Higher level from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in participation results in either a negative value, which indicates a decrease in the gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in participation and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in participation.

For each of the four portfolios the relative change in the gap at Higher level between 2018-19 and 2020-21 is as follows:

- Science: -0.9 - there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.
- Mathematics: -1.7 - there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.
- English: 4.2 - there is an increase in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has increased.
- Modern Languages: 0 - there is no change in the participation of the least and most deprived across the two year groups.

Figure 21: Difference in participation of Advanced Higher students (percentage active) between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in participation at Advanced Higher in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measure by FSM bands). The blue bar in each chart shows the gap in participation at Advanced Higher in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measure by FSM bands).

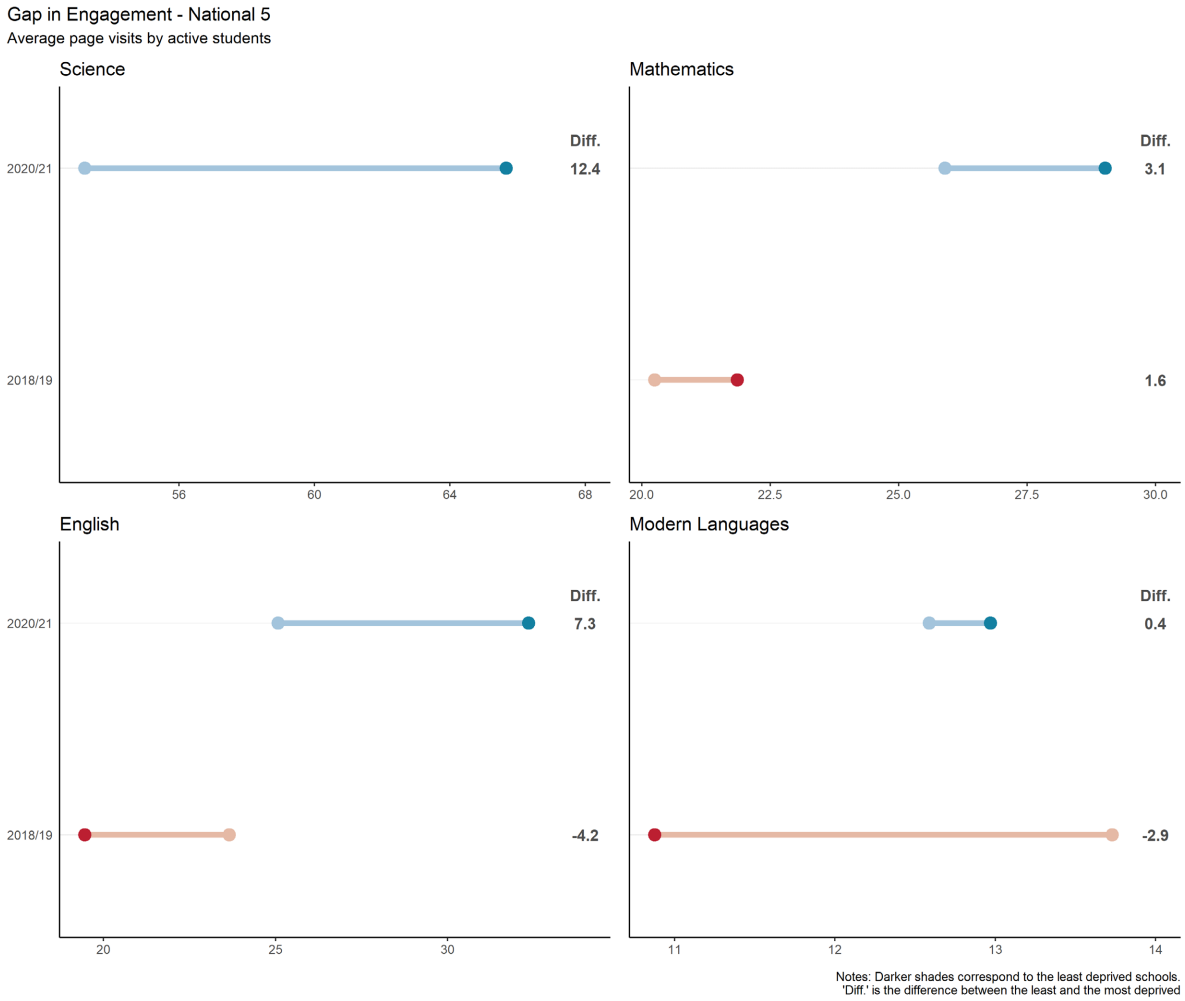
The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in participation between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

To calculate the relative change in the gap in participation at Advanced Higher from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in participation results in either a negative value, which indicates a decrease in the gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in participation and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in participation.

For each of the four portfolios the relative change in the gap at Advanced Higher between 2018-19 and 2020-21 is as follows:

- Science: -6.4 - there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.
- Mathematics: -2.2 - there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.
- English: 8.8 - there is an increase in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has increased.
- Modern Languages: -6.2 - there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time.

Figure 22: Difference in engagement (average page views) of National 5 students between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in engagement at National 5 in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measure by FSM bands). The blue bar in each chart shows the gap in engagement at National 5 in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measure by FSM bands).

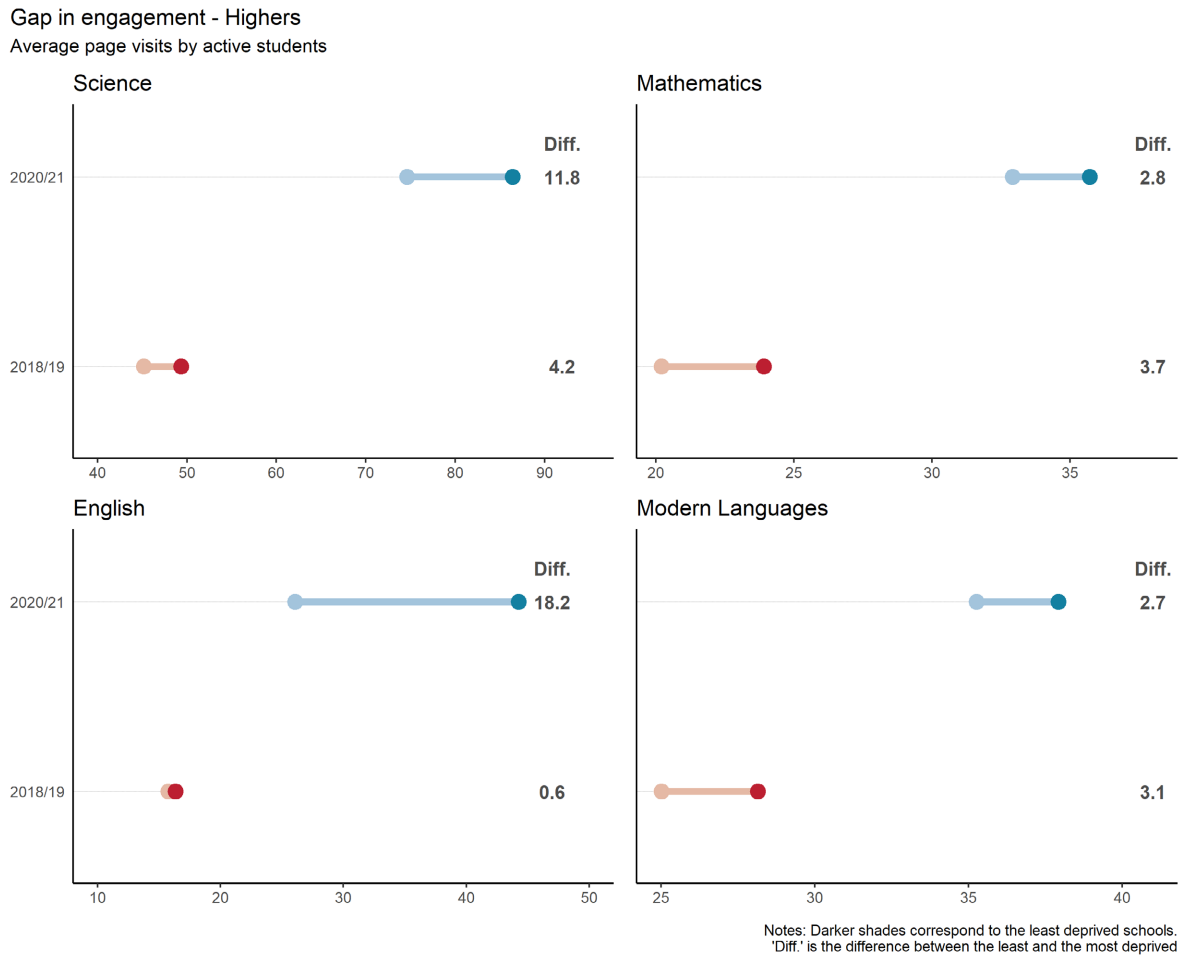
The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in engagement between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

To calculate the relative change in the gap in participation at National 5 from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in participation results in either a negative value, which indicates a decrease in the gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in engagement and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in engagement.

For each of the four portfolios the relative change in the gap at National 5 between 2018-29 and 2020-21 is as follows:

- Science: NA
- Mathematics: 1.5 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- English: 11.5 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- Modern Languages: 3.3 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.

Figure 23: Difference in engagement (average page views) of Higher students between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in participation at Higher level in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measure by FSM bands). The blue bar in each chart shows the gap in engagement at Higher level in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measure by FSM bands).

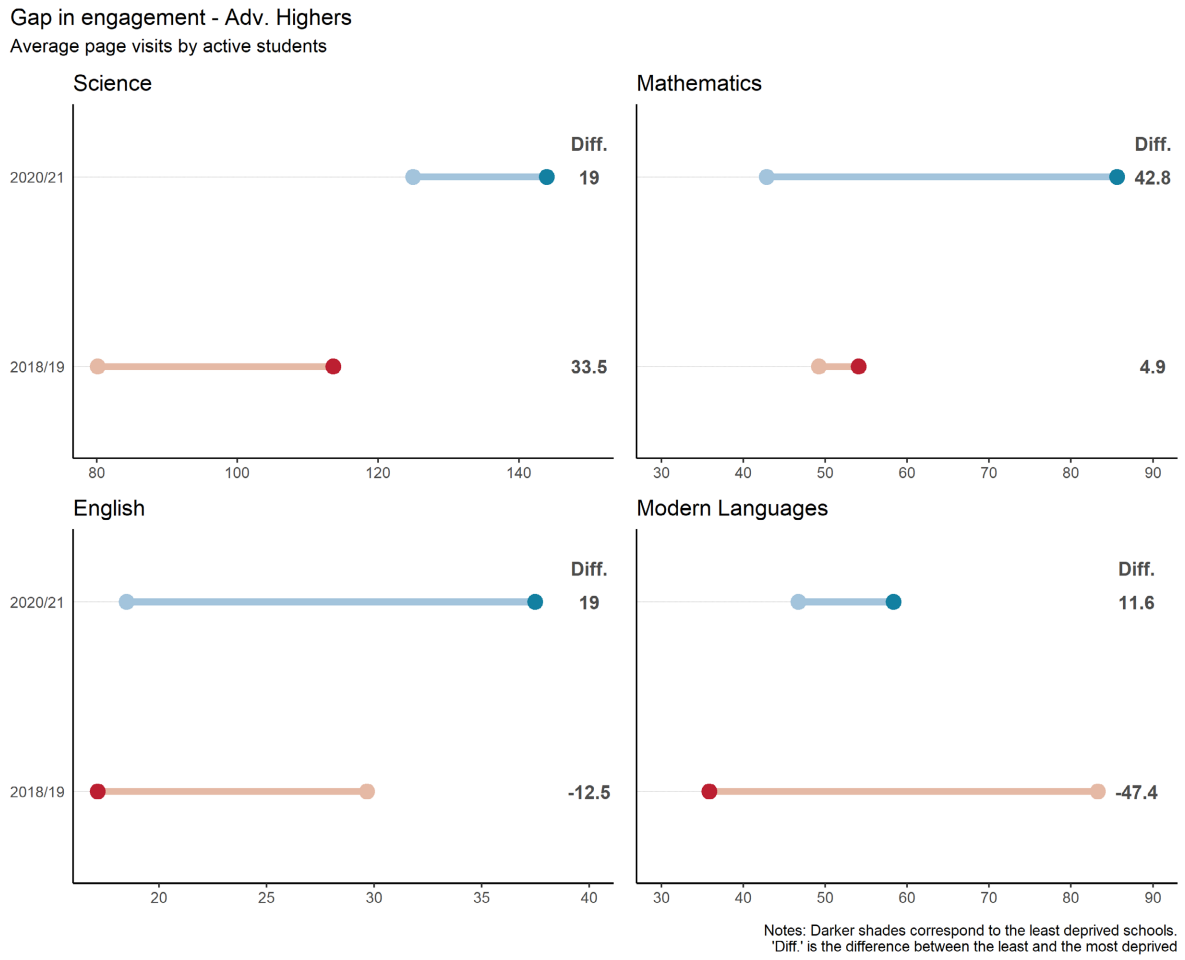
The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in engagement between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

To calculate the relative change in the gap in engagement at Higher level from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in engagement results in either a negative value, which indicates a decrease in the gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in engagement and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in engagement.

For each of the four portfolios the relative change in the gap at Higher level between 2018-19 and 2020-21 is as follows:

- Science: 7.6 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- Mathematics: -0.9 - there is a decrease in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has decreased.
- English: 17.6 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- Modern Languages: -0.4 - there is a decrease in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has decreased.

Figure 24: Difference in engagement (average page views) of Advanced Highers students between the least and most deprived schools by portfolio and academic year



The pink-red bar in each chart shows the gap in engagement at Advanced Higher in 2018-19. The darker shade corresponds to the least deprived schools and the lighter (pink) shade corresponds to the most deprived schools (as measure by FSM bands). The blue bar in each chart shows the gap in engagement at Advanced Higher in 2020-21. The darker shade corresponds to the least deprived schools and the lighter shade corresponds to the most deprived schools (as measure by FSM bands).

The figure given in the right-hand side column (Diff.) is the difference, or size of the gap, in engagement between the least and most deprived schools in 2018-19 (red) and 2020-21 (blue) respectively.

To calculate the relative change in the gap in engagement at Advanced Higher from 2018-19 to 2020-21, for the least and most deprived schools, we subtract the later gap (diff.) from the earlier one. This relative change in the gap in engagement results in either a negative value, which indicates a decrease in the gap over time, or a positive value, which indicates an increase in the gap over time. A decrease in the gap over time (negative value) suggests a decrease in socioeconomic inequality in engagement and an increase (positive value) in the gap over time suggests an increase in socioeconomic inequality in engagement.

For each of the four portfolios the relative change in the gap at Advanced Higher between 2018-19 and 2020-21 is as follows:

- Science: -14.5 - there is a decrease in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has decreased.
- Mathematics: 37.9 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- English: 31.5 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.
- Modern Languages: 59 - there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased.

The large negative gap in Modern Languages in 2018/19, whereby the most deprived had much more engagement than the least deprived schools, is due to a small number (11) of students being (unusually) highly engaged.

3.5 Multilevel modelling of Engagement

This section presents multilevel models of engagement, as measured by the number of course pages visited by active student enrolments. The models are unconditional negative binomial multilevel models. As explained in the methods section and reproduced here for convenience, unconditional negative binomial multilevel models are a widely used modelling technique for count data that allows us to account for the overdispersion in the data, i.e., where the variance is larger than the mean. The negative binomial model can be thought of as an extension of the Poisson regression model that allows for overdispersion by estimating an extra parameter to represent individual random variation (Leckie et al., 2020). The full algebraic form of the multilevel negative binomial model for page visits (engagement) can be found in appendix B.

In these sections, 3.5 and 3.6, we model only the Science portfolio, by level of study and academic year, for two reasons, one academic and one pragmatic. The first reason is that the Science portfolio is the one students across the socioeconomic spectrum engage with most and so is the most interesting to model, having the most interesting data. The second is that were we to model all four portfolios there would be a huge number of models and tables that would not only be overwhelming to the reader but would not add anything to the findings.

The following models quantify the relative variation in engagement, i.e. the number of course pages visited by active student enrolments, at the different levels of analysis. The two levels of analysis in the multilevel models are the individual (active) student level and the school level. Table 9 gives the baseline empty models, which do not control for any explanatory variables. This allows us to measure the proportion of the overall variation at both the schools and the students levels of analysis. Table 10 gives the full models, which account for school and student variation (via random effects), the level of deprivation of the schools (measured via FSM eligibility), rurality and size of the schools.

The results show that the variation between schools in engagement is significant and the differences can be quite substantial. The results are given in Tables 9 and 10.

Table 9: Unconditional negative binomial multilevel models for engagement (number of pages visited by active students) in the Science portfolio by level of study and academic year

	National 5	**Highers**		**Adv. Highers**	
Parameter	**2020/21**	**2018/19**	**2020/21**	**2018/19**	**2020/21**
Fixed part	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**
Intercept	3.802 (0.038)	3.612 (0.037)	4.097 (0.037)	4.424 (0.041)	4.634 (0.047)
Random part	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
School variance	0.413	0.363	0.376	0.235	0.3826
Overdispersion	0.664	0.683	0.72	0.63	0.73
Coverage interval	(12.7; 65.2)	(11.4; 120.7)	(18.1; 200.1)	(32.3; 215.8)	(30.6; 346)
N (students)	17,661	12,200	13,948	3,420	3,821
N (schools)	335	329	325	266	249
Deviance	172652.8	114625.7	144769.6	37440.8	43832.8
VPC (Schools)	0.182	0.171	0.183	0.116	0.188

Note: Fixed- and Random-part parameters are in a logarithmic scale

From Table 9, we can use the Variance Partition Coefficient (VPC) to measure the proportion of the overall variation at both levels of analysis (schools and students). The models indicate that between 12% and 17% of the total variability in the number of pages visited is due to differences between schools at all levels of study in 2018/19; and between 18% to 19% of the total variability in the number of pages visited is due to differences between schools at all levels of study in 2020/21. This suggests that what schools do matters and that schools have increased their importance in this from 2018-19 to 2020-21. What schools do accounts for around a fifth of the variation in engagement of students in 2020/21. This is a variability that is outwith the students' control.

Assuming a normal distribution for the school effects, a coverage interval can be derived to estimate the magnitude of the variance in terms of the original scale of the outcome (number of pages visited). As such, it is estimated that 95% of randomly selected students at the level of National 5 will have visited between 12.71 and 65.24 pages in the Science portfolio courses of Scholar in 2020/21. Meanwhile, at Highers, students will have visited between 18 and 200 pages, and Advanced Highers students will have clicked on 31 to 346 pages. Comparing these intervals with the academic year 2018/19, this is a substantial increase for Highers and Advanced Highers.

The models given in table 9 are the baseline empty models and do not control for any explanatory variables. What they show is that the between-school and between-student variation is likely to reflect variations in socio-demographics and broader societal inequalities across Scotland, that is the variation that is outwith the students' control. The factors associated with variability beyond the students' control (at the school level and beyond) are 'structural' factors (Rasbash et al., 2010; Troncoso, 2019; Troncoso et al., 2016). Table 10 gives the full models, with explanatory variables, to account for some of these structural factors.

Table 10: Conditional negative binomial multilevel models for engagement (number of pages visited by active students) in the Science portfolio by level of study

Parameter	**National 5**				**Higher**				**Advanced Higher**			
Fixed part	**Coef.**	**S.E.**		**IRR**	**Coef.**	**(S.E.)**		**IRR**	**Coef.**	**S.E.**		**IRR**
Intercept	3.952	0.107	***		3.826	0.092	***		4.565	0.125	***	
Year 2020/21 (Year 2)	--	--			0.558	0.053	***	1.747	0.285	0.125	*	1.329
FSM Middle band	-0.159	0.088		0.853	-0.150	0.075	*	0.860	-0.157	0.087		0.855
FSM High band	-0.206	0.096	*	0.814	-0.219	0.081	**	0.803	-0.272	0.104	**	0.762
Mostly rural	0.293	0.105	**	1.340	0.047	0.089		1.049	0.074	0.116		1.076
Middle size band	-0.090	0.102		0.914	-0.052	0.087		0.949	0.106	0.124		1.112
Large size band	-0.159	0.088		0.853	-0.085	0.089		0.918	-0.028	0.123		0.973
Year2*Rural	--	--			0.091	0.049		1.095	0.215	0.106	*	1.240
Year2*FSM2	--	--			-0.054	0.037		0.948	-0.121	0.070		0.886
Year2*FSM3	--	--			0.048	0.043		1.049	0.130	0.091		1.139
Year2*Mid.Size	--	--			-0.054	0.053		0.947	-0.006	0.126		0.994
Year2*Large.Size	--	--			-0.122	0.052	*	0.885	-0.099	0.123		0.905
Random part	**Coef.**				**Coef.**				**Coef.**			
School variance	0.372				0.260				0.232			
Overdispersion	0.396				0.392				0.415			
N (students)	16,018				26,051				7,214			
N (schools)	324				325				281			
Deviance	156148.1				259051.7				81040.2			

Note: Reference categories: Year 2018/19 (Year 1); FSM Low band (least deprived); Mostly urban; and Small school size band. Significance codes: p<.001***; p<0.01**; p<0.05*

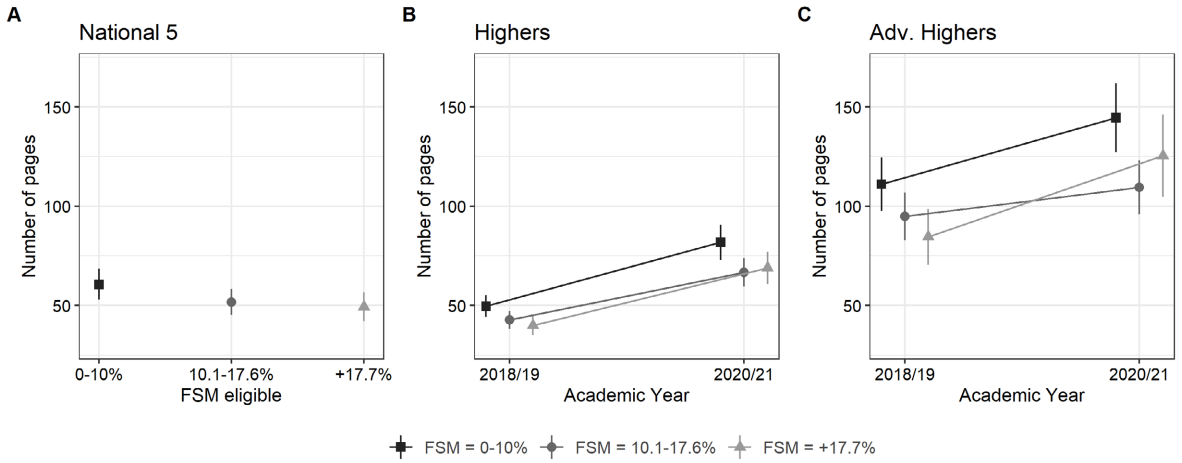
Table 10 shows that the increases over time in the engagement in Science that we saw in the descriptive statistics are statistically significant. At the Higher level model, students in 2020/21 visited Scholar 75% more frequently than students in 2018/19 (as shown by the incidence rate ratio - IRR). At the Advanced Highers level, this increase is smaller but still substantial; the students in 2020/21 visited Scholar 33% more than those in 2018/19 did.

Table 10 also shows that socioeconomic inequalities are present in students' engagement. Students from the most deprived schools, as measured by FSM banding, visited Scholar between 76% (Adv. Highers) and 81% (National 5) of the number of pages visited by the students in the least deprived schools, regardless of the academic year. That is, they engage with online learning a fifth to a quarter less, irrespective of the year.

Rurality was significant for students studying at National 5 level; students in rural schools visit Scholar 34% more than students in urban school do. Advanced Highers students in rural schools in 2020/21 visited Scholar 24% more than do their peers in urban schools. This may be a function of lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning.

Thus far, we have interpreted only the main effects in these models. It is equally important to analyse the interaction effects as interpreting only the main effects can be misleading. In figures 25 and 26, we illustrate these models using marginal effects for FSM bands and rurality.

Figure 25: Engagement (adjusted number of page visits by active students) by school FSM band, academic year and level of study (with 95% confidence intervals)



In Figure 25A, we only have data for National 5 students in 2020-21. Here, we see that students in the most deprived schools (+17.7% FSM eligible students in the school) have significantly lower engagement than their peers in the least deprived schools. Figures 25B and 25C show that students in the most deprived schools experienced a steeper increase in their engagement between 2018/19 and 2020/21, closing the gap in relation to the least deprived schools. This indicates that although students in the most deprived schools engaged less with Scholar in 2020-21 the level of inequality by socioeconomic position has decreased. What may be of concern here is that those schools in the middle are widening their gap; that is, inequality appears to be increasing for those students.

Figure 26: Engagement (adjusted number of page visits by active students) by school rurality, academic year and level of study (with 95% confidence intervals)

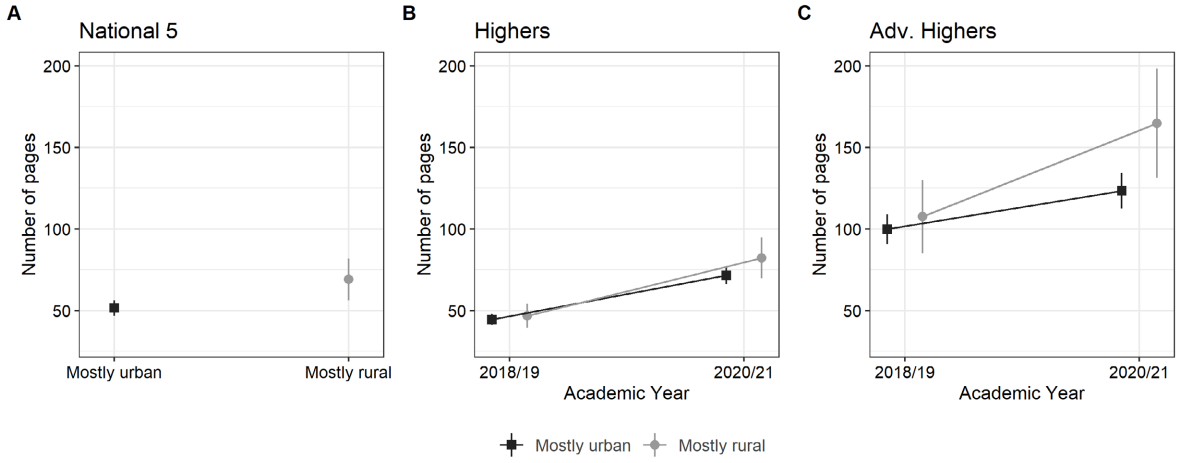


Figure 26A shows that students in rural schools visited Scholar significantly more than do students in urban schools, while keeping the other covariates at their means. Figures 26B and 26C also show a steeper increase over time for students in rural schools compared to students in urban schools. This means that the gap is widening over time in the inequality of engagement in Scholar, with urban students being at an apparent disadvantage here. However, as previously noted, this may be a function of lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning.

3.6 Multilevel modelling of Participation

This section presents multilevel models of participation, as measured by the propensity towards being an active student, at the different levels of analysis. The models are unconditional multilevel binary logistic models. The algebraic form of the multilevel negative binomial model for page visits can be found in appendix B. As before, only the models for the Science portfolio are presented here.

The models given in this section quantify the relative variation in the propensity towards being an active student at the different levels of analysis. The two levels of analysis in the multilevel models are the individual active student level and the school level. Table 11 gives the baseline empty models, which do not control for any explanatory variables. This allows us to measure the proportion of the overall variation at both the schools and the students levels of analysis. Table 12 gives the full models, which account for school and student variation (via random effects), the level of deprivation of the schools (measured via FSM eligibility), rurality and size of the schools.

The results suggest that the variation between schools in participation is significant and the differences can be quite substantial. The results are given in Tables 11 and 12.

Table 11: Unconditional multilevel binary logistic models for participation (the propensity towards being an active student) in the Science portfolio by level of study and academic year.

	National 5	**Highers**		**Adv. Highers**	
Parameter	**2020/21**	**2018/19**	**2020/21**	**2018/19**	**2020/21**
Fixed part	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**	**Coef. (S.E.)**
Intercept	-0.929 (0.074)	-0.592 (0.055)	0.157 (0.068)	0.157 (0.054)	1.294 (0.084)
Random part	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
School variance	1.790	0.932	1.395	0.516	1.196
Coverage interval	(0.028; 0.845)	(0.077; 0.786)	(0.104; 0.922)	(0.223; 0.827)	(0.299; 0.969)
N (students)	55,061	33,811	28,114	6,428	5,154
N (schools)	339	331	327	269	253
Deviance	57325.1	40146.9	33507.3	8547.5	43832.8
VPC (Schools)	0.352	0.221	0.298	0.136	0.267

Note: Fixed- and Random-part parameters are in a logarithm scale

From Table 11, we can use the Variance Partition Coefficient (VPC) to measure the proportion of the overall variation that is attributable to schools. The models vary widely over time and across levels of study. It is clear, though, that the variation that is attributable to schools increases over time from 13.6% - 22.1% in 2018/19 to 26.7% - 35.2% in 2020/21. The variation that is attributable to schools also changes at the level of the qualification being studied. The greatest proportion of variation attributable to schools occurs at the National 5 level in 2020/21, where it is estimated that more than a third of the total variation is due to schools (35.2%). We do not have data for National 5 level Science in 2018-19. The variation that is attributable to schools is lower for Highers and Advanced Highers in 2018/19 (22.1% and 13.6%, respectively), but sizable nonetheless. In 2020/21, however, the variation that is attributable to schools for the Higher level increases sharply to 29.8% and Advanced Highers nearly doubles to 26.7%. This is an indication that differences between schools have increased over time. This again indicates that what the school does is very important and accounts for up to a third in the variation in student participation.

Assuming a normal distribution for the school effects, a coverage interval can be derived to estimate of the magnitude of the variance in terms of the original scale of the outcome (probability of being an active student). As such, it is estimated that 95% of randomly selected schools will have at the level of National 5 between 2.8% and 84.5% of active student enrolments in the Science portfolio courses of Scholar in 2020/21. Meanwhile, at Highers, schools will between 10.4% and 92.2% of active student enrolments in 2020/21, and schools will have between 29.9% and 96.9% of active Advanced Highers students. Comparing these intervals with the academic year 2018/19, this is a substantial increase in activity for Highers and Advanced Highers.

Table 12 shows the results for the multilevel binary logistic models where we simultaneously adjust for academic year, school FSM bands rurality and school size.

Table 12: Conditional multilevel binary logistic models for participation (the propensity towards being an active student) in the Science portfolio by level of study

Parameter	**National 5**				**Higher**				**Advanced Higher**			
Fixed part	**Coef.**	**S.E.**		**OR**	**Coef.**	**(S.E.)**		**OR**	**Coef.**	**S.E.**		**OR**
Intercept	-0.440	0.202	*		-0.145	0.138			0.304	0.166		
Year 2020/21 (Year 2)	--	--			0.677	0.061	***	1.969	0.926	0.170	***	2.525
FSM Middle band	-0.599	0.169	***	0.550	-0.151	0.115		0.860	-0.040	0.120		0.961
FSM High band	-0.781	0.180	***	0.458	-0.669	0.122	***	0.512	-0.351	0.140	*	0.704
Mostly rural	0.604	0.194	**	1.830	0.208	0.133		1.231	0.081	0.157		1.084
Middle size band	-0.224	0.188		0.799	-0.141	0.129		0.869	0.026	0.162		1.026
Large size band	-0.599	0.169		0.550	-0.384	0.133	**	0.681	-0.120	0.161		0.887
Year2*Rural	--	--			0.242	0.058	***	1.274	0.247	0.152		1.280
Year2*FSM2	--	--			-0.274	0.042	***	0.760	-0.126	0.098		0.882
Year2*FSM3	--	--			0.092	0.047	*	1.097	0.188	0.123		1.207
Year2*Mid.Size	--	--			0.061	0.060		1.063	-0.016	0.169		0.984
Year2*Large.Size	--	--			-0.027	0.059		0.973	0.091	0.166		1.095
Random part	**Coef.**				**Coef.**				**Coef.**			
School variance	1.511				0.663				0.497			
N (students)	54,706				61,348				11,528			
N (schools)	330				326				283			
Deviance	57046.9				-37375.1				13985.1			

Note: Reference categories: Year 2018/19; FSM Low band (least deprived); SIMD Low band (least deprived); Mostly urban and; Small school size band. Significance codes: p<.001***; p<0.01**; p<0.05*

Trends in participation are consistent with trends in engagement. Highers and Advanced Highers students are much more likely to be active in 2020/21. They are between two and two and a half times more likely to be active in Scholar than students are in 2018/19, as shown by the odds ratios in the right-hand columns. These findings are statistically significant. Students in the most deprived schools are less likely to be active than students in the least deprived schools. Their odds of being active are between 30% (at Advanced Highers) and 54% (at National 5) less than students in the least deprived schools. On a more positive note, Highers students from the most deprived schools in 2020/21 do seem to bridge the gap significantly.

As noted before, these trends are more easily interpreted by inspecting the adjusted marginal effects in Figures 27 and 28.

Figure 27: Participation (adjusted probabilities of being an active student) by school FSM band, academic year and level of study (with 95% confidence intervals)

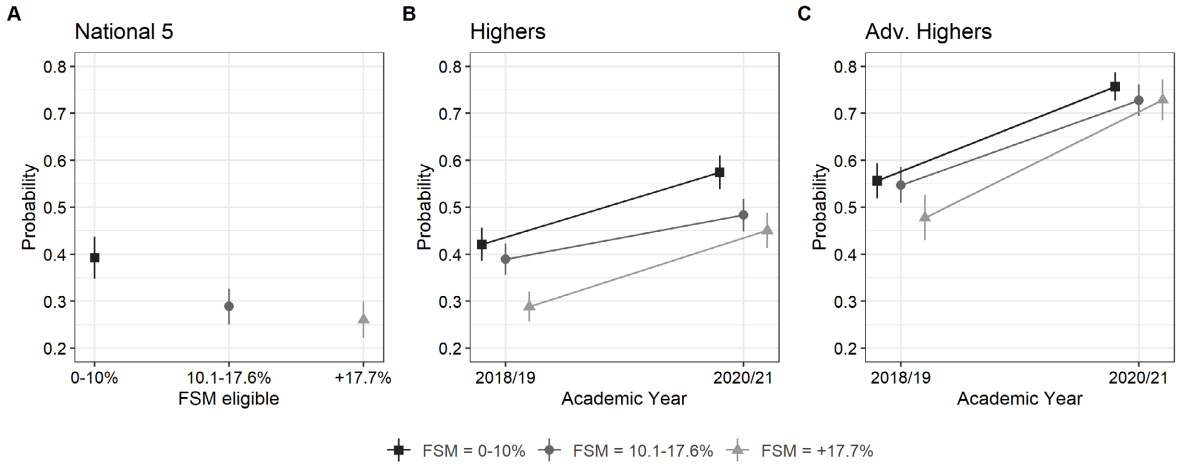


Figure 27A, we only have data for National 5 students in 2020-21. Here, we see a clear socioeconomic gradient in participation at the National 5 level, with students in the most deprived schools having significantly lower participation than their peers in the least deprived schools. However, on a more positive note, figures 27B and 27C show that students in the most deprived schools have a steeper increase over time in their likelihood of being active in Scholar, effectively closing the gap with the least deprived schools. This indicates that although students in the most deprived schools remain less likely to participate Scholar in 2020-21 the level of inequality by socioeconomic position has decreased substantially and, in fact, the gap at the Advanced Higher level has almost closed. This is while adjusting for the mean values of the other covariates in the model.

Figure 28: Participation (adjusted probabilities of being an active student) by school rurality, academic year and level of study (with 95% confidence intervals)

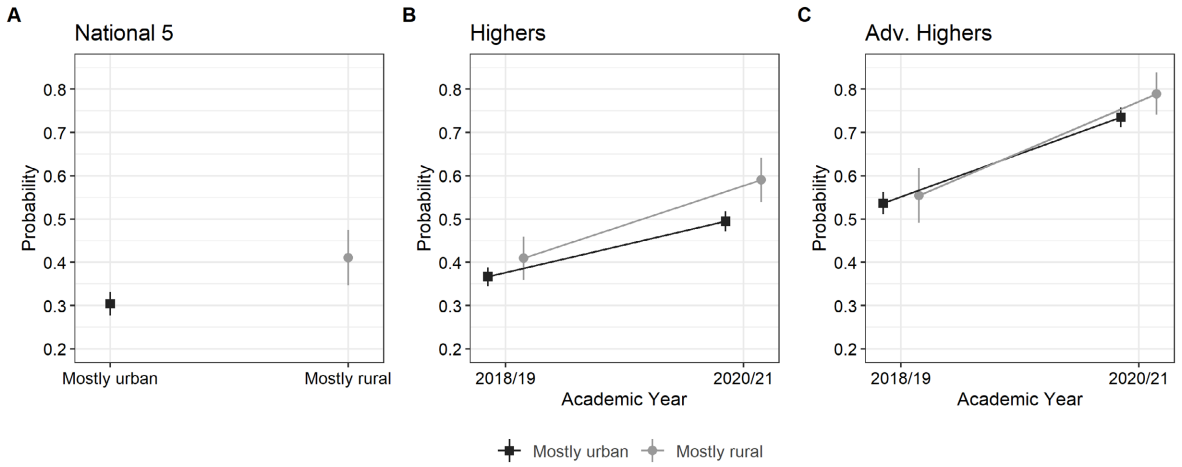


Figure 28 shows that in 2020-21 students in rural schools are more likely to be active in Scholar at the National 5 level significantly more than students in urban schools do, while keeping the other covariates at their means. Figures 28B and 28C also show a steeper increase over time for students in rural schools compared to students in urban schools. Students in rural schools have a sharper increase over time at the Highers and Advanced Highers levels. As previously noted, this may be a function of

lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning.

4 Conclusion

This final chapter brings together the different strands of our analysis and draws out its key conclusions. It has been a wide-ranging study analytically as the Scholar data were previously unused by researchers and contained vast amounts of data on almost all of Scotland's secondary state school population. In this chapter, we highlight and discuss the main findings and their implications. We also make policy and practice recommendations to address the issues identified in the previous chapters.

To reiterate, this project explored the patterns and impacts of inequalities in the access to (**participation**) and use of (**engagement**) digital technologies in secondary schools, with an emphasis on young people experiencing socioeconomic and other inequalities. It is increasingly recognised that digital inequality operates in the same way as traditional inequalities as regards poverty and other sociodemographic characteristics and this was thrown into particularly sharp relief when schools first closed because of Covid-19. While governments responded quickly to the digital inequality highlighted in the first lockdown, their efforts were hindered by delays in obtaining and distributing devices to schools and children. While schools also tried to respond quickly, they were not equipped for such an emergency and their responses showed a degree of social patterning, with better-off state schools able to hand out devices to their students at a greater rate than their more deprived counterparts.

In investigating digital inequality in education, we used data from an online learning platform called Scholar, which delivers online e-learning services to 346 out of 357 (97%) of Scotland's publicly funded secondary schools. There are two main advantages to using the Scholar data; the fact that it is the only online learning platform of its kind, as it is aimed at a single, national exam system, and the fact that it has almost complete coverage of the whole of Scotland.

We identified three research questions to help take forward knowledge in this field. These were:

1) What is the patterning in the use of online learning for exam-aged students (S4-S6) over time?
2) How has the use of online learning changed during and after the Covid-19 school closures?
3) What is the extent of the variation in use of online learning resources across secondary schools in Scotland?

As with all research, we should be aware of any limitations in our study, which could introduce bias to our results. These cannot always be avoided but help identify areas where we should be cautious in our conclusions. We have already outlined the advantages to our research of using Scholar data, but it also has some drawbacks. Working with a large, secondary dataset data for an almost entire national population of children is excellent in terms of scale, opportunities for statistical analysis and providing an authoritative overview. Yet, as with all secondary data, we were uninvolved in how the Scholar database was set-up and exactly how it operates. Scholar data were never collected for research purposes and we had to do a lot of work to extract the data in ways that would satisfy data protection issues relating to anonymity and confidentiality, as set out in appendix D, and to analyse the data once extracted.

Another limitation of our study is in our interpretation of digital inequality. Digital inequality is one of many terms used to describe the inequality associated with the use of digital technologies that connect to the internet. Not only is it currently undefined, in practice it covers a range of factors including having a device, a connection, skills, a safe online environment, and sustainability of access (Bowyer et al, 2021). This project did not have data on many of these factors so uses access to (participation) and use of (engagement) in the Scholar digital platform as a proxy for digital inequality to explore whether its use can tell us anything about the social patterning of participation and engagement in digital technology in education in Scotland.

A further limitation of our study is in our measure of participation. When looking at the data for participation, we need to remember that within the data for every course, there are in reality a number of students enrolled onto Scholar courses who do not proceed to the end of these courses. This means that the number of candidates for each SQA course is less than the number of students enrolled with Scholar, so the percentage of pupils studying a course using Scholar will be higher than the calculated figures would suggest. This limitation serves to make our analysis more conservative, but in a consistent way.

A final limitation of our data, which we did not anticipate at the start of the study, pertains to the portfolios in Scholar that were available to us for use in the research and the inequalities inherent in subject choice in education in Scotland. This study uses the most popular and populous subjects from the Scholar dataset: maths, English, science and modern languages, which, as we outline in section 1.3, are considered the most academic subjects which facilitate access to Russell Group universities. This means there is already inequality in who chooses these subjects, and who is able to choose these subjects, by both socioeconomic strata and geographical location. This has implications for the utility or otherwise of Scholar data for measuring digital inequality in education in Scotland, explored further in section 4.2.

4.1 Summary of main findings

We summarise the main findings from our research, organised under each of the three research questions. Some main overall themes are discussed afterwards.

What is the patterning in the use of online learning for exam-aged students (S4-S6) over time?

In participation in science at the Advanced Higher level, students at the most deprived schools increase their participation by 27-percentage points compared to 20-percentage points for students at the least deprived schools. Similarly for engagement, students at the most deprived schools increase their engagement by 56% between 2018-19 and 2020-21 compared to a 26% increase in engagement between 2018-19 and 2020-21 for students at the least deprived schools. This means that the most dramatic increase in engagement with the Advanced Higher Science portfolio is for the highest FSM schools. This pattern is repeated for Higher level mathematics, whereby students at the most deprived schools increase in engagement by 65% compared to 50% for students at the least deprived schools. This pattern is again repeated for Advanced Higher level modern languages, whereby students at the most deprived schools increase in engagement by 41% compared to 35% for students at the least deprived schools. While these patterns of increasing participation and engagement of students in deprived schools is promising there remain socioeconomic inequalities as these students are often starting from a lower base in terms of their participation and engagement. It should be noted that at the Advanced Higher level there is a strong selection by students themselves. As university entry requires qualifications at the Higher level, those pupils taking Advanced Highers are particularly committed and motivated or likely to be taking a subject at university that requires enhanced qualifications, e.g. medicine. It should also be noted that Advanced Higher students in deprived schools are not necessarily themselves from low-income families as FSM entitlement and area deprivation is measured at the school level in this study. However, about 50% of people living in poverty in Scotland live in a deprived area as measured by SIMD. This means that we must exercise caution about assuming a deprived school equals a deprived student. The likelihood will be greater, but it is not a certitude.

Overall, students from the most deprived schools visited Scholar between 76% (Adv. Highers) and 81% (National 5) of the number of pages visited by the students in the least deprived schools, regardless of the academic year. That is, they had a fifth to a quarter less engagement, irrespective of the year.

Students' participation in the most deprived schools is between 30% (at Advanced Highers) and 54% (at National 5) lower than students in the least deprived schools.

Although students in the most deprived schools remain less likely to engage with Scholar in 2020-21 the level of inequality by socioeconomic position did decrease. What may be of concern here is that those schools in the middle FSM band appear to have a widening gap; that is, inequality appears to be increasing for those students. There is a message here about not losing sight of the middle band of students and schools.

Participation and engagement increase as the students get older and the qualification levels get more advanced. There is likely to be a self-selection here of the most able and committed students accessing the four portfolios at more advanced levels. It is not unexpected, therefore, that engagement seems to be substantially higher for the Sciences at all levels (National 5, Higher and Advanced Higher), across all portfolios and in both academic years (2018/19 and 2020/21).

What is rather strikingly of note is the socioeconomic patterning in engagement in the English portfolio. It does not follow the pattern of science, mathematics and modern languages outlined above but instead shows a large increase in inequality. Whereas participation in the English portfolio is not massively different by socioeconomic position, engagement is. At the Higher level, there is a 62% increase in engagement between 2018-19 and 2020-21 for students at the most deprived schools compared to a 175% increase in engagement for students at the least deprived schools. Students at the least deprived schools almost tripled their engagement in the Higher English portfolio. Similarly, at the Advanced Higher level, there is a 40% **decrease** in engagement between 2018-19 and 2020-21 for students at the most deprived schools compared to a 118% increase in engagement for students at the least deprived schools. Students at the least deprived schools more than doubled their engagement in the Advanced Higher English portfolio. This shows clear inequality in engagement in English for more deprived students and is worthy of further study using other datasets for triangulation.

How has the use of online learning changed during and after the Covid-19 school closures?

The evidence review in chapter one revealed that in 2018, 700,000 (12%) children aged between 11 and 18 years reported having no internet access at home from a computer or tablet, while a further 60,000 reported having no home internet access at all (Lloyds Bank, 2018). At the outset of the Covid-19 lockdown, it was estimated that between 1.14 million and 1.78 million children in the UK under the age of 18 had no access to a laptop, desktop computer or tablet, and between 227,000 and 559,000 students lived in households without internet access (Howard et al, 2021). The first year of data that we use is from 2018-19.

Educational inequality, and digital inequality in education, came to the fore when the Covid-19 pandemic closed schools for long periods from 23rd March 2020. This project has full population data from before the pandemic lockdown year and subsequent to it, 2020-21.

The Covid-19 lockdown revealed that:

- There was grave concern that months out of school would set back children's learning and development to an unprecedented extent (Andrew et al., 2020).
- More advantaged parents were able to spend time and money supporting their children and providing additional educational resources, including children's own digital devices, whereas less advantaged children were working in cramped housing conditions, with inadequate access to devices or internet connectivity, and with parents less able to support their learning (Cullinane & Montacute, 2020).

- Within state schools there was inequality in likelihood of receiving a device, with 28% of teachers in the least deprived schools saying their school had done so, compared to only 15% of teachers in the most deprived schools (Cullinane & Montacute, 2020).
- What schools did mattered, i.e. how they responded to moving lessons online and supporting students to access and benefit from online teaching – especially for low-income children.

Our analysis also revealed that what schools do matters and, further, that schools have increased their importance in this from 2018-19 to 2020-21. What schools do accounts for around a fifth of the variation in engagement of students in 2020/21. This is a variability that is outwith the students' control. As for participation, in 2020/21 the variation that is attributable to schools for the Higher level increases sharply to 29.8% and Advanced Highers nearly doubles to 26.7%. This is an indication that differences between schools have increased over time. This again indicates that what the school does is very important and accounts for nearly up to a third in the variation in student participation. The data do not elucidate what it is that schools do that makes such a difference, but it is likely to be the provision of devices and connectivity, their adoption of the platform, their use of it in lessons, and in their encouragement of students to make use of it for homework and study.

Between 2018-19 and 2020-21 there were some positive changes in the use of online learning from before to after the first Covid-19 school closures. While we can outline these positive changes, and can measure the role of schools in terms of the percentage of the variation apportioned to them, we cannot say with certainty what it is that schools, or students, or their families are doing differently to bring about this change. At the outset of the study, we hoped to be able to use the distribution of devices and connectivity as an 'event', the introduction of which could be evaluated. However, with delays to distribution and the slow rollout of the programme, this is not possible. It is possible that it has had some effect. The positive changes are:

- Engagement in Science has increased. Students in 2020/21 visited Scholar 75% more than students did in 2018/19 at the Higher level and 33% more at the Advanced Highers level.
- Engagement in mathematics and English also increased, in modern languages engagement increased at the Higher level; however, the apparent increases at the other levels are not statistically significant.
- Highers and Advanced Highers students overall participate more and are two and a half times more likely to be active in 2020/21 than students in 2018/19.
- Participation in Scholar in the Science portfolio increased by a large percentage between 2018-19 and 2020-21, but especially for the highest banded (most deprived) FSM schools.
- In fact, students in the most deprived schools are closing the gap with the least deprived schools. Although students in the most deprived schools remain less likely to participate in Scholar in 2020-21, the level of inequality by socioeconomic position has decreased substantially and, in fact, the gap at the Advanced Higher level has almost closed completely.
- Participation in Scholar in Mathematics increased between 2018-19 and 2020-21, with the greatest increase being for the highest banded FSM schools (most deprived) at the Higher and Advanced Higher levels and the lowest banded (least deprived) FSM schools at the Advanced Higher level.
- Participation in Scholar in the Modern Languages portfolio increased by a large percentage for the Advanced Higher level between 2018-19 and 2020-21 for all bands of school FSM entitlement.

There are also changes that are not so good for reducing digital inequalities in education:

- Overall, while there has been an increase in participation by the students at the most deprived schools between 2018-19 and 2020-21, participation is still highest in schools with lower FSM entitlement.
- For engagement at the Advanced Higher level, there is a 12% **decrease** in engagement in mathematics between 2018-19 and 2020-21 for students at the most deprived schools. This is the only decrease in the Mathematics portfolio.
- Participation in Scholar in English increased between 2018-19 and 2020-21, but especially for the lowest banded FSM (least deprived) schools.
- In participation in English, inequality has increased from the earlier to the later period.
- In engagement in English, inequality has increased from the earlier to the later period.

There have been some reductions in the socioeconomic gap, whereby students in the most deprived schools are closer in terms of participation and engagement in Science and Modern Languages to the students in the least deprived schools. Reductions are, nevertheless, modest, not at all levels and even overshadowed by some large increases in the gaps in Mathematics and English. We now summarise the gaps in participation and engagement between the most and least deprived schools.

For engagement at the National 5 level for mathematics, English and modern languages, there is an increase in the gap of the least and most deprived across the two year groups, which means that inequality of engagement has increased. There are no data for National 5 science in 2018-19.

For participation at the National 5 level, there is no change in participation for mathematics for the least and most deprived across the two year groups. For English inequality of participation has increased and for modern languages, inequality of participation has decreased over time.

For engagement at the Higher level for English and science there is an increase in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has increased. For mathematics and modern languages, inequality of engagement has decreased.

For participation at the Higher level for science and mathematics, there is a decrease in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has decreased. For English inequality of participation has increased and there is no change in participation in modern languages.

For engagement at the Advanced Higher level for science there is a decrease in the gap in engagement of the least and most deprived across the two year groups, which means that inequality of engagement has decreased. For mathematics, English and modern languages, inequality of engagement has increased.

For participation at the Advanced Higher level for mathematics, science and modern languages, there is a decrease in the gap in participation of the least and most deprived across the two year groups, which means that inequality of participation has decreased over time. For English inequality of participation has increased.

There is much to be celebrated in these findings but still yet more to be done to reduce inequality in engagement and participation.

What is the extent of the variation in use of online learning resources across secondary schools in Scotland?

Geographical disparities in this study are measured by a dichotomous urban/rural binary variable as described in section 2.1. Overall, in this study, students attending schools in rural areas are the most active and engaged. They are also the ones who have increased their participation and engagement more over time.

For engagement, students in rural schools visited Scholar 34% more than students in urban school did at the National 5 level. At the Advanced Higher level, students in rural schools in 2020/21 visited Scholar 24% more than their peers in urban schools did.

For participation, students in rural schools are more likely to be active in Scholar at all levels significantly more than students in urban schools. While there has been an increase in participation by the students in the mostly urban schools between 2018-19 and 2020-21, participation is still highest in mostly rural schools. Students in rural schools also have a sharper increase over time in participation at the Highers and Advanced Highers levels. However, within individual portfolios there were some differences:

- In science, at all levels participation and engagement were higher and increased more in rural schools.
- In mathematics, participation increased by a greater percentage in mostly rural schools but mostly urban schools increased their levels of engagement by a greater percentage.
- In English, participation at the Higher and Advanced Higher levels increased most for those in mostly rural schools, whereas engagement increased most for students in mostly rural areas at the Higher level and for students in mostly urban schools at the Advanced Higher level.
- In modern languages, participation increased by a greater percentage in mostly rural schools at the Higher level, but engagement at the Higher level increased most in urban schools. At the Advanced Higher level, students in mostly rural schools increased their engagement and participation more than those in urban schools.

The higher levels of participation and engagement overall of students in mostly rural schools may be a function of lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning. This is in keeping with the shortage of teachers in rural areas and, especially, remote rural locations across Scotland. Rurality in Scotland is a significant factor as up to 38% of schools in Scotland are classed as 'rural'.[6]

4.2 Core themes

There are several findings emerging from our research that can provide new insights into digital inequality in education in Scotland as measured by proxy by the social patterning of participation and engagement in a Scotland-wide online learning platform.

Using Scholar to measure digital inequality in education in Scotland

This study was able to tap into certain aspects of digital inequality that could be measured by the participation and engagement in the Scholar digital learning platform. We were able to tap into those children with access to a device and a connection and to monitor their participation and engagement;

[6] https://teachinscotland.scot/become-a-teacher/teaching-in-rural-areas/#:~:text=It%20might%20surprise%20you%20to,play%20in%20these%20communities%2C%20too. (Accessed 12 January 2023)

however, we were not able to measure other factors that are crucial to whether or not children are able to participate in online learning, such as digital literacy and skills, parental skills and support, and a suitable environment for study. This does not negate the importance of this study or what it is able to reveal about how digital inequality operates in relation to children's participation and engagement in an online learning platform. Rather, this study reveals important and novel findings on participation and engagement at a population level; however, it cannot be argued to measure digital inequality in its entirety.

As mentioned earlier, a limitation of our data lies in the inequalities inherent in subject choice in education in Scotland and our use of the following learning portfolios from the Scholar dataset: maths, English, science and modern languages. The limitation is that there is already inequality in who chooses these types of subjects, and who is able to choose these subjects, by both socioeconomic strata and geographical location. This inherent inequality was not foreseen as these portfolios emerged during the early stages of the research in the protocol to extract the data. This means that Scholar data, while incredibly revealing and valuable, and worthy of study and research, does not measure digital inequality in education in Scotland in its entirety but rather digital inequality in participation and engagement of those children who are already undertaking the most esteemed subjects at the highest school level possible in Scotland. As previously outlined, there is inherent inequality in who is able to select this type of study.

The impact of socioeconomic inequalities on engagement and participation

Across all the learning portfolios except English, there have been patterns of increasing participation and engagement of students in deprived schools from 2018-19 to 2020-21. The reasons for this are not entirely clear but we know that what schools do accounts for around a fifth of the variation in participation and up to a third of the variation in engagement of all students.

This provides strong evidence that what schools do matters – especially for low-income children. During the pandemic lockdowns, Andrew et al (2020) found that the effect of school-directed home learning activities was roughly equivalent to that of physical resources available at home. This is important because we can measure the effect of schools in this study, which is up to a third for level of engagement, and we can extrapolate from this that physical resources at home might be of a similar proportion, based on Andrew et al (2020). When schools closed, the equalising role that schools usually play in the learning of the most and least deprived children was attenuated (Andrew et al., 2020). The evidence from this study supports the importance of the equalising role of schools in the learning of the most and least deprived children.

Other factors that may account for the closing of the gap in engagement and participation between the two years, but that are not measured in this study, are: the government roll-out of devices and connectivity, the reliance of rural schools on online teaching and learning due to a shortage of teachers, and the increasing skills of teachers in using and encouraging the use of online learning materials.

While this is promising, there remain socioeconomic inequalities in participation and engagement as the students from more deprived schools are often starting from a lower base. While the level of inequality by socioeconomic position did decrease between the two years, students in the most deprived schools remain less likely to engage with Scholar in 2020-21. Further, if we look beyond the most and least deprived, we see that schools in the middle FSM band appear to have a widening gap; that is, inequality appears to be increasing for those students. It is important not to lose sight of the middle band of students and schools.

There are also differences in socioeconomic inequalities by subject area studied. The English portfolio uniquely shows a large increase in inequality. Students at the least deprived schools more than doubled their engagement in the Advanced Higher English portfolio. This shows clear inequality in engagement in English for more deprived students and is worthy of further study using other datasets for triangulation. There is also a message to be taken here for more deprived schools to consider ways they might mitigate this inequality.

The impact of geographical disparities on engagement and participation

Rural Scotland has some of the most severe teacher shortages in Europe.[7] Scotland's geography presents a significant challenge in recruiting teachers and there are often fewer teachers in classes in rural locations compared to the more populous central belt. [8] One potential solution is the greater use of digital resources, which has been problematic because rural schools are less likely to have a strong and stable internet connection.[9] However, this is changing as more rural areas increasingly receive better broadband coverage. This study presents evidence that students in rural schools engaged with online learning between a quarter and a third more than students in urban schools. Not only are students in rural schools more likely to participate, students in rural schools also have a sharper increase over time in participation compared to their urban counterparts. Although the data does not explain why students in rural school are more likely to participate and engage in online learning, this may be a function of lower numbers of specialist teachers in rural schools, especially for students studying at the Advanced Higher level, who may rely more on online sources of teaching and learning.

Engagement and participation: Pre and post Covid

Overall, both engagement and participation have increased substantially from pre-Covid times (2018/19) to during/post-Covid times (2020/21). While we can outline these positive changes, and can measure the role of schools in terms of the percentage of the variation apportioned to them, we cannot say with certainty what it is that schools, or students, or their families are doing differently to bring about this change. In addition, we do not have data to elucidate whether this is a trend that will persist over the coming years.

4.3 Recommendations for policy and practice

Building on the above, the following are some of the specific changes that we feel would help to improve the participation and engagement of pupils from schools with medium and high levels of deprivation and reduce their digital inequality in education.

Recommendations for schools

- For schools to recognise and build upon their importance in pupils' engagement with online materials in school and at home. Schools account for around a third in the variation in engagement, which is roughly equal to the role played by the student's physical resources at home.
- For teachers to upskill in relation to digital learning and teaching, which has already started since the Covid-19 pandemic outbreak.
- For schools to work with local authorities to ensure that every child who needs it has a device and connectivity.

[7] https://www.thetimes.co.uk/article/teacher-shortages-in-remote-scotland-among-worst-in-europe-sk3rxwwqr (Accessed 12 January 2023)
[8] https://teachersresource.co.uk/why-is-there-a-lack-of-student-teachers-in-scotland/ (Accessed 12 January 2023)
[9] https://www.heraldscotland.com/news/17750449.radical-solution-needed-help-rural-schools-facing-teacher-shortages/ (Accessed 12 January 2023)

- For schools to provide Wi-Fi and a secure space for children to access digital learning as they may not have the physical space or resources at home.
- Schools could work with community partners and local authorities to upskill parents to be able to provide stronger support to their children with the technical aspects of, and encouragement to use, the digital tools available.

Policy recommendations

- To ensure all pupils who need them have a device and connectivity, i.e. access to a stable internet connection, at home and school. This is especially pertinent for low-income students and those living in remote communities.
- To support schools in their ability to do the points above by providing funding, guidance, training, and accountability frameworks.
- To have a parent specific adult learning programme for digital skills focussing on the most marginalised groups of parents, e.g. lone parents, non-English speakers, migrants less familiar with the education system, and those in insecure/transitory accommodation.

Future research

There is unlikely to be future research using Scholar data, which is a shame because Scholar holds a far richer resource than is used in this study. Firstly, every student in Scotland's schools has a unique identifier, called the Scottish Candidate Number (SCN). Scholar has the SCN of every pupil accessing the online platform and so a simple data linkage between Scholar use and exam results could help to unpick the role of digital inequality in educational attainment, an area that is likely to increase in importance in future.

Scholar also has data on a daily basis, by time of day. This means the data could be used to work out at home and in-school use, term time and holiday use. This would give an indication of inequality in participation and engagement by home and school, by deprivation and rurality. Although we used a binary measure of rurality and terciles of FSM entitlement, this was a result of the protocol to extract anonymised data, detailed in appendix D. If secure access to the data were facilitated, there could be a far more granular level of analysis by location and deprivation.

Scholar is a unique dataset which has illuminated much on the digital (in)equality in education in Scotland in this project.

The broader learning from this project raises three groups of questions in relation to digital learning that are worthy of further research:

- What is the impact of higher levels of online learning in rural areas on student attainment and outcomes? If benefits to student attainment and outcomes were found, could these be extended elsewhere?
- What is the effectiveness of different ways of incorporating digital tools such as Scholar into teaching and learning, both at school and at home, including an understanding of the current range of practices?
- What are student views on learning in this way? Are there groups of students that find it more effective than others do? Does this vary depending on the type of tasks or subject?

5 References

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6 Appendices

Appendix A: Weighting procedure for the number of page visits

This procedure is part of the anonymisation process, which is run by Scholar prior to sharing the data with the researchers. First, the weight of each course within a portfolio is determined as such:

$$w_{0j} = \left(\frac{n_j}{M}\right) \sum_{j=1}^{N} \sum_{i=1}^{n_j} p_{ij} \times \left(\sum_{i=1}^{n_j} p_{ij} \right)^{-1}$$

Where w_{0j} is the weight of each page hit in a course within a portfolio; p_{ij} is the number of pages viewed by each student "i" in a course "j" within a portfolio; n_j is the number of students in a course; M is the total number of students across all courses within a portfolio (sum of n_j); and N is the number of courses in a portfolio. $\sum_{i=1}^{n_j} p_{ij}$ is then the sum of all page hits within a course and $\sum_{j=1}^{N} \sum_{i=1}^{n_j} p_{ij}$ is the sum of all page hits across all courses within a portfolio. In the case of Mathematics and English, by definition, the value of w_{0j} is one.

Then for each student, a weighted average number of page hits per portfolio is calculated by:

$$\bar{p}_{i0} = \left(\frac{1}{N}\right) \sum_{j=1}^{N} w_{0j} p_{ij}$$

Where $\bar{p}_{i0}$ is the weighted average page hits per student "i" within a portfolio and N is the number of courses within a portfolio in which student "i" is enrolled. In the case of Mathematics and English, it follows that $\bar{p}_{i0} = p_{ij}$

The statistics presented here correspond to the values of the weighted averages ($\bar{p}_{i0}$).

Appendix B: Algebraic form of the multilevel negative binomial model for page visits

$$y_{ij}|\mu_{ij} \sim Poisson(\mu_{ij})$$

$$\ln(\mu_{ij}) = \beta_0 + Z_j\beta + u_{0j} + e_{ij}$$

$$u_{0j} \sim N(0, \sigma_u^2)$$

$$\exp(e_{ij}) \sim Gamma\left(\frac{1}{\alpha}, \alpha\right)$$

Where y_{ij} is the observed number of page visits by student "i" in school "j"; μ_{ij} is the expected number of page visits by student "i" in school "j"; β_0 is the conditional overall average of page visits (in the log scale); $Z_j\beta$ is a vector of explanatory school-level variables and their corresponding coefficients (in the log scale); u_{0j} represents the school-level residuals; and e_{ij} represents the student-level overdispersion random effect, which follows a Gamma distribution with shape and scale parameters $1/\alpha$ and α, respectively. The overdispersion parameter $1/\alpha$ is also referred to as "theta" (θ).

This is fitted in R, using the package "lme4", as such:

```
model <- glmer.nb(y ~  1 + covar + (1 | group), family = neg_binomial_2, data = data)
```

Where "y" is the observed number of pages; "covar" is a covariate of interest (more can be added); and "group" is the anonymised school identifier in our data.

The Variance Partitioning Coefficient (VPC) for the empty model is calculated using the formulae described in Leckie et al. (2020)

Appendix C: Algebraic form of the multilevel binary logistic model for the propensity of being an active student

$$logit(p_{ij}) = logit\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + Z_j\beta + u_{0j} + e_{ij}$$

$$u_{0j} \sim N(0, \sigma_u^2)$$

Where p_{ij} is a binary indicator for being an active student (1= active student; 0=otherwise) for student "i" in school "j"; β_0 is the conditional likelihood of being an active student (in the log-odds scale); $Z_j\beta$ is a vector of explanatory school-level variables and their corresponding coefficients (in the log-odds scale); u_{0j} represents the school-level residuals, which follow a Normal distribution with a mean of 0 and a variance σ_u^2 (estimated from the model). We used the conventional "logit" link function.

This is fitted in R, using the package "lme4", as such:

```
model <- glmer(y ~ 1 + covar + (1 | group), family = binomial, data = data)
```

Where "y" is the binary indicator for being an active student; "covar" is a covariate of interest (more can be added); and "group" is the anonymised school identifier in our data.

The Variance Partitioning Coefficient (VPC) for the empty model is calculated using a fixed value for the level-1 variance that is equal to $\frac{\pi^2}{3} = 3.29$ as explained in Browne et al. (2005).

Appendix D: Scholar Protocol for the generation of a fully anonymised dataset

The following appendix was written by the Scholar team as a standalone document and has its own appendices, numbered A-C. These are not to be confused with the appendices in the rest of this report.

SCHOLAR

Protocol for the generation of a fully anonymised dataset

Version 1.1

Step	Operation	Data available relating to each student	Comments
ONE	Generation of summary of number of pages hit for each course, for each learner, at each LA schools within 31 LA areas.	• School centre number • Scottish candidate number • Courses they were studying • Total number of page hits for each course • Number of page hits for each course that occurred during the school day	Candidate, school and local authority can all be identified. This data set will include "Temporary Student" accounts, in addition to a significant number of learners who dropped a particular course or left school early in the session. <u>Exclusions:</u> • Virtual schools • Centres 8304734, 5702631 and 8470332 (Two of these schools have unique "fingerprint" profiles in step seven allowing their identification, and one is included in Scholar Glasgow City data, but is not a council-funded school.) • ESOL and Art and Design courses
TWO	Removal of "Planning cohort"	• School centre number • Scottish candidate number • Courses they were studying • Total number of page hits for each course • Number of page hits for each course that occurred during the school day	In the past three or so years, to reduce the number of "zombie" enrolments- enrolments created at the start of session for students that later dropped out, the set of enrolments created at the start of session has been known as the "Planning cohort". Around October, an updated snapshot of all of the enrolments is obtained. By removing any enrolments only present in the "Planning cohort" all students who stopped studying this course at this school prior to October would be removed.

Step	Operation	Data available relating to each student	Comments
THREE	Removal of "Temporary student" accounts	• School centre number • Scottish candidate number • Courses they were studying • Total number of page hits for each course • Number of page hits for each course that occurred during the school day	One temporary student account is created for each class, leading to a minimum of one temporary student per course per school. The vast majority of these temporary accounts are never used. Currently there are around 51,000 temporary student accounts for the current cohort, of which only 312 have been used. If the temporary students are left in the data set, it would appear to show almost 51,000 students failing to access digital learning.

<table>
<tr>
<td>FOUR</td>
<td>Aggregation of course data into portfolio data</td>
<td>

School centre number
Scottish candidate number
Number of courses within each Portfolio that the student was studying
Weighted average number of page hits for each portfolio
Weighted average number of page hits for each portfolio that occurred during the school day

</td>
<td>
For each learner, “content weighted” averages[10] for the numbers of page hits for courses they are enrolled in within a “portfolio” would be added.
<table>
<tr><th>Portfolio</th><th>Courses included in the weighted average number of page hits</th></tr>
<tr><td>National 5 English</td><td>National 5 English</td></tr>
<tr><td>National 5 Mathematics</td><td>National 5 Mathematics</td></tr>
<tr><td>National 5 Sciences</td><td>National 5 Biology, Chemistry, Physics, Computing Science [Only available in 2020-2021 dataset]</td></tr>
<tr><td>National 5 Modern Languages</td><td>National 5 Gaelic (learners), French, Spanish, German, Mandarin</td></tr>
<tr><td>Higher English</td><td>Higher English</td></tr>
<tr><td>Higher Mathematics</td><td>Higher Mathematics</td></tr>
<tr><td>Higher Sciences</td><td>Higher Biology, Chemistry, Human Biology, Psychology, Physics, Computing Science</td></tr>
<tr><td>Higher Modern Languages</td><td>Higher Gaelic (learners), French, Spanish, German</td></tr>
<tr><td>Higher Business Subjects</td><td>Higher Accounting, Business Management, Economics</td></tr>
<tr><td>AH English</td><td>AH English</td></tr>
<tr><td>AH Mathematics</td><td>AH Mathematics</td></tr>
<tr><td>AH Sciences</td><td>AH Biology, Chemistry, Physics and Computing Science</td></tr>
<tr><td>AH Modern Languages</td><td>AH French, German, Spanish</td></tr>
<tr><td>AH Business Subjects</td><td>AH Accounting, Business Management, Economics</td></tr>
</table>
</td>
</tr>
</table>

Step	Operation	Data available relating to each student	Comments
FIVE	Removal of Portfolios with fewer than 10 learners	• School centre number • Scottish candidate number • Number of courses within each Portfolio that the student was studying • Weighted average number of page hits each portfolio • Weighted average number of page hits for each portfolio that occurred during the school day	Where any Portfolio within any school contains fewer than 10 learners, that portfolio result will be removed from the records for all of the learners at that school.
SIX	Replacement of SCN	• School centre number • Number of courses within each Portfolio that the student was studying • Weighted average number of page hits for each portfolio • Weighted average number of page hits for each portfolio that occurred during the school day	All SCN numbers are replaced with a new unique identifier (hash)

[10] "Content weighted" average is a misnomer. Please see Appendix A for details on the method for calculation of the these values.

Step	Operation	Data available relating to each student	Comments
SEVEN	Replacement of School centre number	• Selected characteristics describing the school they attended • Number of courses within each Portfolio that the student was studying • Weighted average number of page hits for each portfolio • Weighted average number of page hits for each portfolio that occurred during the school day	The school centre number would be replaced with a new school code (hash). For each of the new school codes, data would be provided[11] relating to: • School roll tercile • %FSM tercile • % of learners with addresses in SIMD-Quintile 1 areas (Most deprived) (tercile) • Binary, Urban/rural classification derived from Scottish Government 6-fold rural classification index No school within the final data set has a unique "fingerprint" profile preventing the identification of any individual school.

From the anonymised data set no individual, school or local authority can be identified.

[11] Appendix C Contains the Tercile cut-off values

APPENDIX A- Calculation of "content weighted" average number of page hits

Calculation of weighting factors

Within each portfolio, each subject is assigned a weighting factor to take account of differences in the approach adopted to the creation of online pages in different courses.

$$course\ weighting\ factor = \frac{\#\ pages\ viewed\ for\ the\ portfolio}{active\ enrolments\ within\ the\ portfolio} \times \frac{active\ enrolements\ within\ the\ course}{\#\ pages\ viewed\ for\ the\ course}$$

The weighting factors for each course are given in Appendix B. Please note, because the content of each course is revised annually, the weighting factors change from Academic session to Academic session.

Calculation of weighted average for the portfolio

$$weighted\ average\ for\ portfolio = \frac{\sum \#pages\ for\ each\ course \times course\ weighting\ factor\ for\ that\ course}{number\ of\ courses\ student\ enrolled\ on\ within\ Portfolio}$$

SCHOLAR

APPENDIX B- Weighting factors

		Academic Session 2018-2019			Academic Session 2020-2021		
Portfolio	**Course**	Pages hits for the 31 LAs	Active users in the 31 LA	**Content weighting**	Pages hits for the 31 LAs	Active users in the 31 LA	**Content weighting**
National 5 English	N5ENG	68723	3700	**1.0000**	159262	5403	**1.0000**
National 5 Mathematics	N5MTH	114880	5336	**1.0000**	131054	4994	**1.0000**
National 5 Sciences	N5BIO				479043	8029	**1.2647**
	N5CHE				623911	7190	**0.86960**
	N5CMP				398336	3466	**0.65659**
	N5PHY				292835	5091	**1.3119**
National 5 Modern Languages	N5CSM	301	22	**0.84244**	305	24	**1.04720**
	N5FRH	14660	1191	**0.93640**	14848	1020	**0.91422**
	N5GAE	323	37	**1.3203**	257	23	**1.1910**
	N5GER	2648	305	**1.3276**	3024	227	**0.9990**
	N5SPA	9189	798	**1.0010**	8821	754	**1.1375**
Higher English	H-CENG	63223	4170	**1.0000**	203092	5309	**1.0000**
Higher Mathematics	H-CMTH	92069	3979	**1.0000**	122212	3626	**1.0000**
Higher Sciences	H-CBIO	167230	3211	**1.0597**	307568	3699	**1.06101**
	H-CCHE	184361	4311	**1.2905**	482573	5275	**0.9644**
	H-CCMP	263603	2198	**0.46017**	305445	2058	**0.59441**
	H-CHBI	88248	2184	**1.3658**	187910	3199	**1.5019**
	H-CPHY	134167	3085	**1.2690**	313494	3691	**1.0387**
	H-CPSY	11956	405	**1.8695**	8733	279	**2.81849**
Higher Modern Languages	H-CFRH	31715	1286	**1.1365**	46728	1187	**0.9677**
	H-CGAE	430	19	**1.2384**	138	17	**4.6928**
	H-CGER	5032	259	**1.4426**	7989	223	**1.0633**
	H-CSPA	41832	1255	**0.84085**	47238	1253	**1.01046**
Higher Business Subjects	H-CACC	18700	441	**3.15681**	32836	495	**2.88476**
	H-CMBA	148422	2902	**2.61729**	172426	2797	**3.10416**
	H-CECO	23961	179	**1.00000**	33871	177	**1.00000**
Advanced Higher English	AHCENG	7146	355	**1.0000**	14233	451	**1.0000**
Advanced Higher Mathematics	AHCMTH	55727	1120	**1.0000**	76166	1117	**1.0000**
Advanced Higher Sciences	AHCBIO	163513	1523	**1.1460**	226015	2024	**1.2777**
	AHCCHE	182744	1532	**1.0315**	241612	1776	**1.0488**
	AHCCMP	91398	475	**0.63945**	89788	379	**0.60224**
	AHCPHY	99788	838	**1.0333**	204043	1158	**0.8097**
Advanced Modern Languages Subjects	AHCFRH	10877	331	**1.37539**	23888	337	**1.03291**
	AGCGER	5017	60	**0.54052**	5768	61	**0.77431**
	AGCSPA	12806	244	**0.86116**	19985	280	**1.02580**
Advanced Higher Business Subjects	AHCACC	3687	30	**0.79736**	3006	35	**1.32198**
	AHCMBA	21377	226	**1.0360**	32922	280	**0.9656**
	AHCECO	219	2	**0.89494**	518	6	**1.31512**

All weighting factors quotes to 5 significant figures.

APPENDIX C- Tercile Bands and Urban/Rural Classification

School's 6-fold urban/rural classification	Code	Description
Accessible rural areas	2	Accessible rural (areas with a population of less than 3,000 and within 30 minutes drive of a settlement with a population of 10,00 or more)
Accessible small towns	1	Accessible small town (settlements with population between 3,000 and 9,999 and within 30 minutes drive of a settlement with a population of 10,000 or more)
Large urban areas	1	Large urban areas (settlements with population greater than 125,000)
Other urban areas	1	Other urban (settlements with population between 10,000 and 124,999)
Remote rural areas	2	Remote rural (areas with a population of less than 3,000 and more than 30 minutes drive from a settlement with a population of 10,00 or more)
Remote small towns	2	Remote small town (settlements with population between 3,000 and 9,999 and more than 30 minutes drive from a settlement with a population of 10,000 or more)

School Roll	Band
>0	1
≥673	2
≥985	3

%FSM	Band
≥ 0%	1
≥ 10.1%	2
≥ 17.7%	3
If fewer than 5 learners receiving FSM in a school	#N/A

% living in SIMD Quintile 1	Band
≥ 0%	1
≥ 7.5682%	2
≥ 30.8769%	3
If fewer than 5 learners in this group at a school	#N/A

Source of data: School Level Summary Statistics 2019

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