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Exploring the Impact of School Location on Young People's Likelihood of Studying Computing in Scotland

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ABSTRACT

Uptake of Computing Science (CS) in schools in Scotland is far lower than desired, because of young people both not being able to access the subject and not choosing to study it. Moreover, over the last two decades, uptake across the country has been dropping, and gender balance in uptake is not only poor but worsening. As a first step to gaining insight into how we could work to improve uptake of CS, we have analysed data for secondary schools in Scotland over the last three years, with a focus on publicly-funded schools, to explore where inequalities and context-specific drivers have an impact. In this paper, we discuss how the location of a school in a certain socio-economic area and in an urban/rural/remote location impact the chances of young people studying CS. The data indicates that socio-economic advantage is a positive factor in accessing CS. It also indicates that urban locations tend to be advantageous in this respect, though the data around this is more complicated.

CCS CONCEPTS

• **Social and professional topics → K-12 education**; *Computing education programs*; **Geographic characteristics**; *Cultural characteristics*; • **General and reference →** *Evaluation.*

KEYWORDS

computing education, socio-economic inequality, geographical inequality, K-12 education, access to computing

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1 INTRODUCTION

Uptake of CS in schools in Scotland is declining, which is translating into a significant skills shortage and is hindering growth in the industry base; a challenge explored in depth in the Scottish Government's recent review of the Scottish Technology ecosystem[11].

We believe that we cannot effectively and equitably work to increase uptake in CS without first having a deeper understanding of where and why this lack of uptake occurs. There are two main challenges: many pupils do not have the opportunity to study CS; and of those that do, many choose not to. There is international research and anecdotal evidence in Scotland to suggest that both these factors are likely to have strong demographic influences. As a first step, we are analysing all the data we can access that gives us a deeper understanding of CS uptake in Scotland. Our overriding belief is that *only if we can deeply understand the factors that influence the likelihood of young people studying CS can we significantly and equitably increase the number of young people choosing the subject.* We briefly discuss in Section 7 our plans for further work to explore other factors. The research questions guiding the work discussed in this paper are: (*i)* Does socio-economic background have an impact on the likelihood of young people in Scotland studying CS at exam level? (*ii)* Does geographic location – how urban, rural or remote a school is – have an impact on the likelihood of young people in Scotland studying CS at exam level? (*iii)* Are any inequalities discovered in socio-economic status constant across different geographical locations, or are there locations where these inequalities are less pronounced?

The data we are currently working with relates only to Scotland, and only enables us to make definitive statements within this context. Scotland differs culturally and educationally from other educational systems (see Section 3). Nevertheless there are many cultural similarities between Scotland and other countries, and there is reason to believe that trends discovered here may be replicated in other places. In addition, the data we are analysing covers the last three years and includes two years that were strongly influenced by the Covid-19 pandemic. We hope that this local analysis is therefore of interest worldwide, and can be part of comparative studies to explore CS uptake internationally.

2 BACKGROUND

Inequality in access to CS education has been studied widely, with a particular focus on gender inequality and, to a lesser extent, race inequality. The British Computer Society (BCS)'s landscape review [16] analysed computing uptake across the four nations of the UK, highlighting the fall in CS uptake in Scotland and the gender imbalance throughout the four nations, but did not analyse data on school location. Prior research indicates a link between low socio-economic status and low uptake of CS. For example, the RaspberryPi Foundation [3] evidences this for England; interestingly, they found uptake varied for boys and girls. In Section 7 we discuss future work to explore gender differences.

There is less research on the impact of rural and remote inequalities. [19] discusses rural inequality in education in general, with a particular focus on Australia. Whilst they do not reference CS, they do discuss how access to computers and good internet is reduced by rurality; this will have a strong impact on ability to study CS successfully. [10] reports similar findings in the US, whilst pointing to both a lack of data and a lack of serious engagement with this issue. We are not aware of research specifically focussing on CS in this context. However, CS is a subject that is likely to be particularly affected by the digital divide – for example, [15] discusses the impact of rurality on the digital divide in Scotland.

3 EDUCATION IN SCOTLAND

All state (publicly-funded) and most private schools use the Curriculum for Excellence (CfE), a nation-wide framework overseen by Education Scotland [4], which has been in place since 2010. Pupils are in the Broad General Education phase (BGE) which lasts from pre-school to the age or 13/14, when they enter the senior phase. In their Senior 4 (S4) year (aged 13/14), most pupils choose 6-8 subjects (including some core subjects like English and Mathematics and non-core subjects which they can select from a broader list available to study in their school or authority) which they will study for their National 5 (N5) exams, public exams taken at the end of S4, after which some pupils choose to leave school. At S5, pupils will usually take up to 5 subjects for their Higher exams, which are the primary entry requirement for Scottish universities. Pupils who continue to S6 either take more Highers, move on to Advanced Highers (Advanced), or do a combination of both. Advanced Highers provide an excellent grounding for university-level education, and are often required for entry into universities outside Scotland.

The CfE is designed and administered centrally. Ultimately the Scottish Government is responsible for all Scottish state schools; however the CfE allows for considerable variation and is teacher-led. Schools are administered by the local education authority, one each for the 32 local authorities [5] responsible for local government [6]. Funding for Scottish schools is administered centrally, providing equality of financial resources between schools across the country. Moreover, the Scottish Government Pupil Equity Fund – an initiative aimed at closing the attainment gap – provides additional funding for schools on the basis of the number of children they have on free school meals (an approximate measure for disadvantage).

3.1 Computing Science in Scottish Schools

The theoretical provision for CS in Scotland is excellent, with a requirement that it is integrated into the technology area throughout the BGE phase. In practice, there have been significant challenges in implementing this, with a lack of specialised teachers, a low level of CS expertise (and STEM expertise in general) in primary school teachers, and a lack of proper equipment. Figures from 2016 [1] showed that 17% of Scottish schools do not offer CS at all, and many of those that do are significantly under-resourced. It also highlighted the fact that new teachers in CS were down by 67% and that there had been an overall drop in CS teachers of 25% over the last ten years (from 2006), suggesting numbers are likely to be much lower now. However, in some of these cases, pupils will be able to study the subject at a nearby school or college.

3.2 Socio-economic and geographic distinctions

Scotland has a population of approximately 5.5 million, a land area of 30,090 square (sq) miles which means a population density of 174 people per sq mile. Around 70% of the country's population (3.5 million) live in the Central Belt, with the Highlands and Islands having low population density; Na h-Eileanan Siar (the Western Isles) has the lowest population density at 23/sq mile. Despite being a small country, this huge variation in population density means that large areas of the country are remote and hard to access, which produces challenges with resourcing in education.

In Scotland, socio-economic context is measured through the Scottish Index of Multiple Deprivation (SIMD) [8]. Individuals are categorised into quintiles (SIMD Q1-5), with people in SIMD Q1 living in areas within the 20% most deprived parts of Scotland, and people in SIMD Q5 living in areas with the 20% least deprivation. The extremes of affluence tend to be focussed in the more populated areas, with the majority of both SIMD Q1 and Q5 areas in the Central Belt.

Pupils and schools can be classified using the 8-fold urban / rural classifications [9]: large urban areas, other urban areas, accessible small towns, remote small towns, very remote small towns, accessible rural, remote rural and very remote rural areas.

4 METHODOLOGY

4.1 Data Sourcing

The Scottish Qualifications Authority (SQA) [17] is responsible for exams for national qualifications at all levels in Scotland. The analysis carried out was driven by data provided by the SQA [18] on pupil entries in CS for three secondary school qualifications: *N5*, *Higher* and *Advanced* from 2017–2021 for all schools. This was supplemented by open access education statistics and demographic data published by the Scottish Government (gov.scot) [7], which focuses mainly on state schools, with limited coverage of independent schools (~5% of secondary level pupils). However, prior to 2019, school demographic data was published with sufficiently different structure and at too low a level of detail to allow useful comparison with subsequent years, or reliable conclusions to be drawn from the results of the analysis required. Therefore we had to exclude the CS data for 2017-18. Additional data on independents, published at a relatively high level, was sourced from the Scottish

Council of Independent Schools (SCIS) [2, 14]. Data on SIMD and urban/rural classification was obtained from gov.scot [9] and the National Records of Scotland (NRS) Geography dataset [13].

4.2 Data Cleaning

Two key challenges were faced preparing the data for analysis – variation in coverage and detail over time along with inconsistency in entity names and terminology. To enable meaningful comparison across data sources and over time, the unique identifier for each school (common across the datasets) was used with the name specified in the SQA dataset. Authorities and *settlements* with urban / rural classifications were normalised to the name recommended by the Scottish Government, e.g., *Na h-Eileanan Siar* preferred to *Western Isles*; or the most consistent format found across different datasets, e.g., *(The) City of Edinburgh* vs. *Edinburgh City*; and to standardise the use of ampersands (&) rather than *and* in, e.g., *Dumfries & Galloway*.

Some datasets had variations of the urban/rural fold classification and we had to translate this data to the 8-fold classification. SIMD profiles are provided as quintiles or ranges for pupils based on residence and also ranking for public schools. We enriched the dataset to include both ranking and quintile for all schools.

Pupils may take SQA qualifications at any stage. In 2021:

- 81% and 13% of pupils (87% and 8% CS) took N5 at S4 and S5 respectively,
- 69% and 27% of pupils (77% and 21% CS) took Higher at S5 and S6 respectively
- 95% of pupils (96% CS) took Advanced at S6.

These proportions are relatively consistent over time; to standardise the analysis we map N5, Higher and Advanced to S4, S5 and S6 respectively, the year in which the majority take each qualification.

4.2.1 Masked, Missing and Incomplete Data. To prevent identification of individuals, pupil counts of between 1 and 4 are masked across the demographic data. Additionally one other value is randomly masked to prevent derivation of masked figures from totals. At least one key field (including pupil rolls, gender, SIMD classification) is masked for 46% of records for the data from 2019 to 2021. 3% of rolls for senior schools are masked, and 14% report no rolls; the latter includes schools that have closed or that do not present pupils at all stages. Filtering out all such records would result in too small a dataset to obtain useful results; we therefore normalise and/or project values for masked or missing data, to the extent possible, and only filter out records where not doing so prevents analysis. In presenting our analysis we highlight where data filtering due to masking impacts representability of results and ability to draw confident conclusions.

Pupil rolls vary significantly across the country; totals in the (more remote) islands, Highlands and Borders areas can be just over 20 pupils while the largest schools in Glasgow can have over 2,000. A key component of our analysis is therefore calculating the ***proportion*** of CS entries by school, SQA qualification and authority. The SQA dataset however only reports non-zero counts; blank cells may therefore refer to schools that do not offer CS at the level concerned or for particular years, or to cases where no student took CS. Pupil rolls help to clarify this, where data is not missing or masked. Where missing data prevents proportions from being calculated we make the following assumptions:

- where the roll for a stage corresponds to *not applicable* (N/A) we assume a school does not teach at that stage, and therefore return a proportion of N/A, allowing subsequent analysis to treat this as a special case;
- where a school reports no entries for a qualification across all years we assume that the school does not offer CS at that level and stage, and return proportion N/A;
- where pupil rolls exist for a stage, whether masked or not, we assume that pupils had the option to, but none took CS in that year and at that level, and return 0% uptake.

5 ANALYSIS

We discuss in this section the methodology followed in exploring the impact on CS uptake of each of (1) socio-economic background of pupils and (2) geographical location of the schools.

As a first step, in answering each question: the data was subset using standard, predefined categories – one or more of SIMD, urban / rural classification, and/or authority. Each category was further split by qualification and year, and the likelihood of a pupil taking CS calculated, based on the population of pupils in the relevant year group from each school.

5.1 Does attending school in a remote, rural or urban setting influence CS uptake?

Table 1 shows the differences of likelihood of studying CS in the different settings and illustrates mixed results. N5 sees consistent increase in uptake for **very remote rural areas**. **Accessible** and **remote rural areas** see rise in uptake from 2019 before plateauing. 2019 generally sees lower uptake, except for **accessible small towns**, where it peaks. Higher sees consistent increase in uptake for **very remote small towns**, and, overall, slightly higher uptake in 2021, after a slight dip in 2020 for all but **accessible small towns**, which peaks then. Advanced sees a dip across the board in 2020 all areas, and general decrease overall for all classifications but **accessible rural areas**, which sees a sharp rise in 2021.

Figure 1 gives more detail for the 3 years over each of the 8-fold urban / rural classes for one example: the distribution of Higher CS uptake. Relative uptake follows similar patterns for the urban / rural setting across all three levels; however, there is a significant drop in the proportion taking CS from N5 to Higher to Advanced.

5.2 Does SIMD classification influence CS uptake?

For this initial study we compared schools with the majority of pupils at the extremes – SIMD Q1 and Q5 (most and least deprived respectively). Table 2 shows the differences in likelihood of entries for all CS qualifications over the 3 years for schools with the majority of pupils in the most deprived areas and those with a majority in the least deprived areas. We see significantly higher uptake amongst least deprived pupils. This varies across the different qualifications, with inequality becoming more pronounced as the level of qualification rises. Further exploration of trends for SIMD 2–4 is necessary to determine whether these trends persist across pupils not at the extremes.

Table 1: Likelihood of studying CS in different urban / rural locations

	Urban Areas		Small Towns			Rural Areas		
	Large	Other	Accessible	Remote	Very Remote	Accessible	Remote	Very Remote
National 5	12.1	11.8	11.7	8.3	**14.3**	9.8	7.9	10.5
Higher	7.1	7.2	7.5	5.9	**8.8**	6	3.2	3.1
Advanced Higher	1.9	2.3	2.1	2	1.1	**2.4**	0.8	1.7

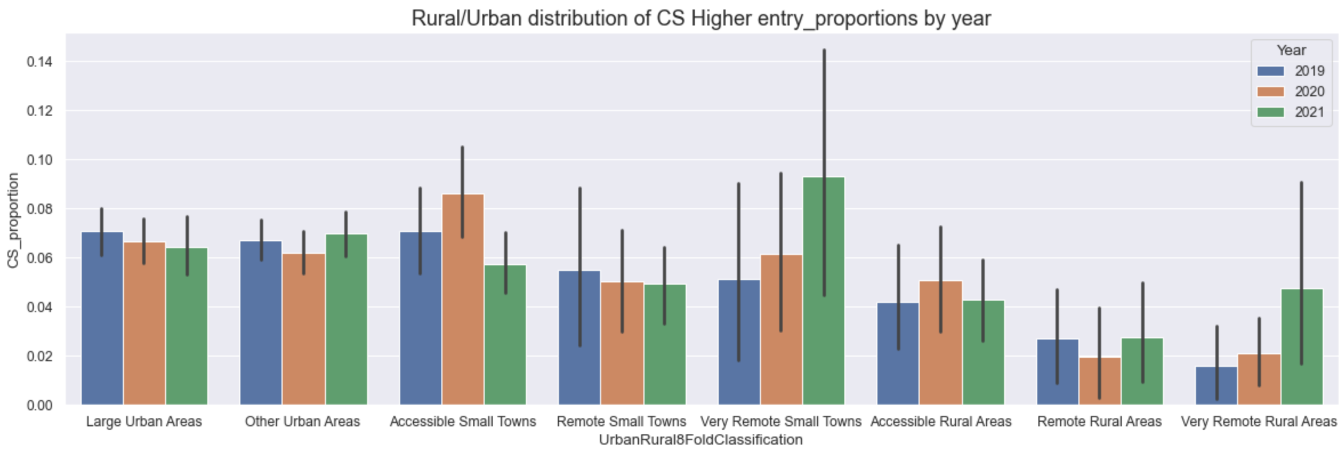


Figure 1: Proportion of pupils taking CS across Scotland year-on-year, for Higher broken down by 8-fold urban / rural distribution. Tables showing the detail for N5 and Advanced Higher may be found on Figshare [12]

5.3 Does the impact of socio-economic disadvantage vary across different geographical locations?

As an example of the trends, Figure 2 compares the distribution of CS Higher uptake in each of the 8-fold classes, between schools with the majority of pupils in most deprived areas and those with pupils in the least deprived (SIMD 1 and 5 respectively). Whilst the urban advantage discussed in Section 5.1 does seem to be present to some extent at both ends of the deprivation spectrum, it is much more pronounced for the least deprived. Being in a rural or remote area correlates with lower CS uptake for most pupils. However, for those most deprived pupils who already see relatively lower CS uptake, living in a rural or remote area appears to have a much smaller additional impact.

It should be noted that these results are at best an indicator of interaction between the two factors. The absence of data in remote and very remote rural areas in these figures suggests that pupils in these areas tend to fall predominantly in SIMD2–4, the middle from a socio-economic point of view, with very few pupils at the extremes of deprivation.

6 DISCUSSION

It is important to emphasise when considering the data that what is being measured is entry to CS – i.e., those that sign up to take the qualification – and not completion. The figures will therefore include pupils who dropped out or failed. The last two years are also highly non-standard years due to the Covid-19 pandemic. We believe that figures for 2020 should be unaffected by this as the decision to register for CS qualifications will have been taken before the pandemic hit. Decisions to register for CS qualifications taken in 2021 will have been taken in the middle of the pandemic, after the schools had been closed for some time, and it is possible that this will change the observable patterns.

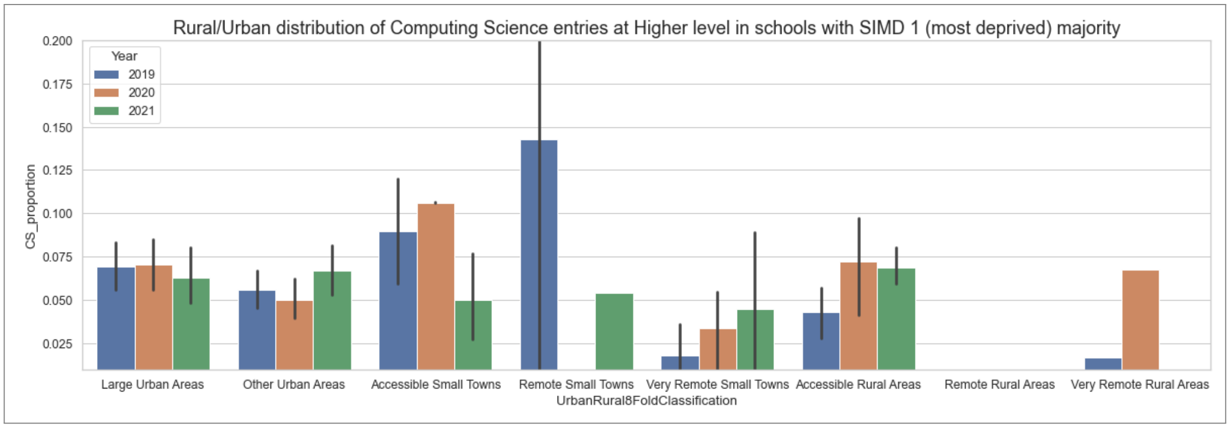
6.1 Disparity in uptake by deprivation

The differences between young people accessing CS in least deprived or most deprived environments is in line with earlier research. However, there are significant initiatives in place in Scotland that we would hope to see mitigate this inequality: the equity in funding in Scottish schools which, in addition to the Pupil Equity Fund, mean schools in disadvantaged areas should have similar or greater financial resources to other schools; the integration of CS throughout school-level education; and the push for access to devices and internet for all. And yet these do not appear to be succeeding. Understanding the basis of the observed inequalities requires much deeper research into the nature of provision in the schools and, potentially, whether individual pupils consider CS to be a subject appropriate for them. Our initial thoughts on potential influences are given below.

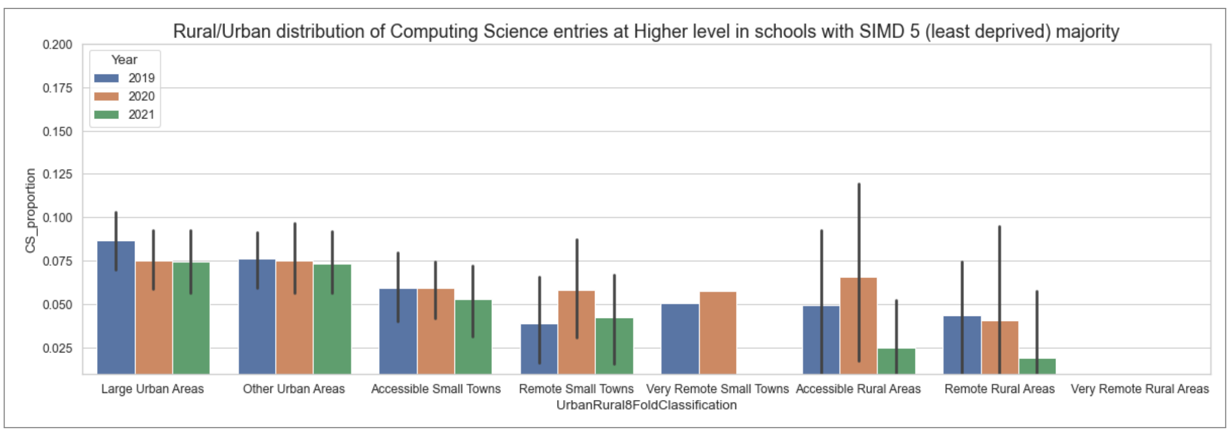
- There is an assumption, which needs to be fully evidenced, that pupils in schools in deprived areas study fewer subjects, beyond the compulsory core subjects. This will clearly have a significant effect on uptake of non-core subjects in those schools, and allow less flexibility to pupils. However, this would lead us to expect a flattening out of inequality at

Table 2: Likelihood of studying CS where the majority of pupils in a schools are in SIMD Q1 or Q5

	2019			2020			2021		
	SIMD 1 majority	SIMD 5 majority	Difference	SIMD 1 majority	SIMD 5 majority	Difference	SIMD 1 majority	SIMD 5 majority	Difference
National 5	17.5	23.8	**36%**	17.3	22.02	**27%**	17.3	23.2	**34%**
Higher	8.3	12.4	**49%**	8.4	11.8	**40%**	9.2	12.6	**36%**
Advanced Higher	1.9	3.8	**100%**	1.2	2.4	**100%**	1.09	2.8	**156%**



(a)



(b)

Figure 2: CS uptake at Higher level for schools with majority of most deprived pupils compared to schools with majority least deprived pupils across the 8-fold urban / rural classification.

Higher level, as all schools allow pupils to do up to 5 Highers. Instead, we see these inequalities broadening.

- The comparatively lower uptake of CS at Higher and Advanced Higher in more deprived schools is likely a reflection of the fact that young people from more deprived areas are less likely to take qualifications at these levels in any subject. Additional research is needed to explore this further.
- The differences at Advanced Higher are severe, and most likely a reflection of the fact that schools in more deprived areas do not offer this qualification. This could be argued to be unimportant, as it is extremely unusual for these to be required for entry into Scottish universities. Nevertheless, they offer excellent preparation for university study and mean that young people from more deprived areas lacking this experience, are likely to struggle more to adapt to Higher Education.
- We know that many schools in Scotland either have no CS capacity, or are understaffed in CS, and we know of schools in deprived areas that are affected by this. It is plausible that this is an issue that disproportionately affects these schools, where there can be additional challenges to attracting teachers, and may be at least partially responsible for the disparity in uptake. Further research is needed here.

- We know that where cut-backs are necessary and/or space is becoming an issue, schools may decide to remove their computing suites: once taken this step is difficult to reverse. Whilst there is still a requirement to provide some CS provision – for example, on Apple iPads, this will inevitably make studying computing more difficult and less attractive. However, given the funding model for Scottish schools, it is not obvious that this is a factor that disproportionately affects schools in disadvantaged areas.

6.2 Disparity in uptake by location

The data analysis for impact of urban/rural/remote location is more difficult to interpret. Overall, there appears to be an advantage in attending school in an urban or accessible location, with lower uptake in rural and remote areas. This is in line with existing research indicating that rural pupils can be disadvantaged compared to their urban counterparts.

One obvious issue is that teacher recruitment is more difficult in remote areas. The Computing at Schools Scotland report [1] confirms that areas with sparse population density are far more likely to either have no CS teachers, or only a single CS teacher. We intend to carry out a study comparing schools in different areas that have similar CS provision.

Another known factor is the difficulty accessing high-quality internet access in remote areas. Whilst there has been considerable investment by the Scottish Government in recent years, there is still inequality of provision. It is not obviously the case that this will correlate with a lower uptake of CS, but it could be that it may contribute towards young people using computers less.

There may also be broader sociological factors such as parental aspiration for young people in different areas, and the visibility of different career paths.

There is, however, an interesting anomaly in the results, with very remote small towns – which prior research and the trends in our own data would lead to expectations of poor performance – performing very well, in some cases better than urban locations. We don't as yet have much insight into why this is happening. One potentially relevant fact is that three of the six schools in this category are on islands, which, as discussed in Section 5.2 tend not to have a lot of socio-economic disadvantage. They are also mostly quite large schools: being in very remote areas means some pupils travel a long way to attend them (weekly boarding is not uncommon in the Highlands and Islands). This may mean they have a wider provision and better resources than other remote schools. We also aware of excellent practice in at least one of these schools, with a highly proactive CS teacher.

6.3 Interaction of these variables in terms of uptake

In terms of CS uptake, the advantage conferred by being least deprived seems to be greatly reduced by living in a rural or remote location. This may be due in part to anecdotal evidence showing that schools in more remote areas have difficulty accessing staff even if the school body is relatively privileged. On the other hand, for the most deprived pupils, the additional disadvantage of living in a rural or remote location is less pronounced. The reasons for this are not immediately obvious. Further work looking at smaller SIMD bands (5 or 10%) could provide more detail for the reasons underlying the trends seen in the less densely populated rural areas.

7 NEXT STEPS AND CONCLUSIONS

Whilst our findings largely reflect what might be expected, we believe this research is valuable for adding to the body of evidence and may help us to target efforts to increase uptake of CS more effectively, and for the following insights:

- The equality of funding plus pupil premium for schools in Scotland means that schools in deprived areas have more funding than those in least deprived areas and we would expect this to lead to closer equity in outcomes. However, we do not see a significant difference in outcomes for CS education - so school funding alone is clearly not the answer.
- Rural areas appear to show more equity of outcome between least and most deprived pupils, largely because the advantages attached to being least deprived seem to be significantly reduced by being rural, whereas the disadvantages of being most deprived do not seem to be particularly compounded by a rural location.

Plenty of open questions remain:

- We know more about where uptake is low, but not why. To what extent can the data be explained by schools in more deprived and more rural or remote areas being less likely to offer CS at all? If offered, will CS uptake be similar to schools with different profiles, or will inequalities persist?
- Where are the pockets of excellence, and what generalisable lessons can we extract from them? We are beginning to examine this data at a local authority level, and it is clear that the inequalities are more pronounced in some regions than others. Further research is needed to explore why.
- Is gender inequality consistent, or does living in the least or most deprived area or attending a school in a different geographical location lead to a different profile of gender inequality?
- How do the levels of uptake of CS in the different contexts we have discussed here align with levels of uptake at different levels in other subjects? Does CS particularly struggle in some areas, or is it following general patterns?

Ultimately, we are aiming to build towards a bank of knowledge that could provide opportunity more equitably to young people across the country, and to provide generalised insights that are of relevance across different educational systems.

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