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LEARNERS' VIEWS OF COMPUTER SCIENCE IN SCOTTISH SCHOOLS



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Overview

This report presents the findings of a survey about secondary-school learners' views of how computer science (CS) is taught in Scotland. The survey was designed, implemented, analysed and presented by young people in the Computer Science Young People's Advisory Group with assistance from staff and students at the University of Edinburgh.

An important finding of the survey is that young people highly rate the quality of the teaching they receive (7 out of 10, the equivalent of an 'A' grade). Their ratings for enjoyment, engagement and interactivity of computing classes range between 6.5 and 7 out of 10 or a high 'B' grade). Learners who chose not to pursue their study of computing in the senior phase gave lower ratings, and young women gave lower ratings for enjoyment. The young people also commented on why people might choose to study computing or not, and what schools could do to encourage more learners to study computing qualifications. The report concludes with a reflection on the project and a set of recommendations developed by the team in response to the findings. The recommendations include giving learners access to the specialist computing equipment they need, making CS classes more engaging and relevant, informing young people about CS careers pathways earlier, improving the gender balance in CS and including children and young people in future consultations.

We hope that our contribution to the national debate about computer science education is constructive and that it is only the first stage of an ongoing dialogue between policymakers and learners.

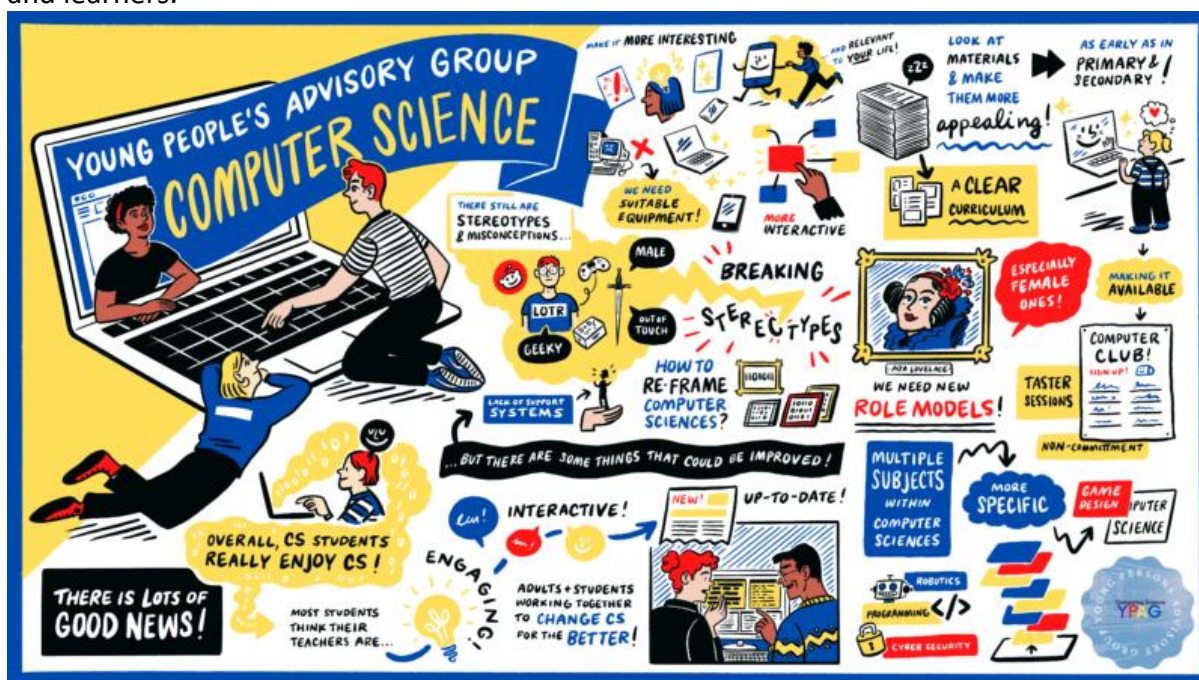


Figure 1. A mind-map of the discussion during the Young People's Advisory Group seminar with teachers. By Jules Scheele

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Introduction¹

Computer science education in Scottish schools is changing, both as a result of the Logan review of Scotland’s Technology Ecosystem review (Logan, 2020) and the wider educational reform consultation. Professor Muir’s recent report on Scottish educational reform supports the principle that “learners’ voices, experiences, perspective and rights are central to decision making” (Muir, 2022; p16). It is therefore essential that young people’s perspectives about computing should be considered as new policy decisions are made. This report, produced by the Computer Science Young Person’s Advisory Group in partnership with staff and students from the University of Edinburgh, **shares Scottish young people’s current views and experiences of computing at school and their recommendations for the future.**

The project was initiated by Professor Judy Robertson and led by Dr Christina McMellon and Dr Laura Wright. The Young Person’s Advisory Group for Computer Science (CSYPAG) was established in March 2021 through online recruitment. It originally consisted of eight members aged from 13-to 18 from Glasgow, Fife, West Lothian and Midlothian. Six of the group were young men and two young women. The group met online 12 times between March 2021 and March 2022 and completed a significant amount of individual and paired work outside these meetings. The group’s engagement included two phases (Phase 1: March to November 2021; Phase 2: December to March 2022). Eight group members were involved with Phase 1, and 6 group members chose to stay engaged for Phase 2 to lead and support knowledge exchange activities. The members received an honorarium for their work for each phase which Amazon kindly donated. The CSYPAG designed a survey and collected data from 537 Scottish young people. They analysed the data with assistance from two fourth-year University of Edinburgh School of Informatics students. They presented their findings to computing teachers and other stakeholders in March 2022 to inform the computing science community of learners’ experiences, reflections, and recommendations and to hear additional perspectives from the adults.

This report is presented creatively to reflect the diverse individual and collaborative contributions to the project. We know it’s long, so if you’re short of time, you could look at the illustration in Figure 1 which summarises much of our discussion well. This might be a handy way to share the findings with other young people in a classroom setting. Different team members wrote the report sections according to their own expertise and contributions to the project, which is why the writing style changes throughout. We chose to do this because we thought it was important for the team members to express themselves in their own words. We’ve added footnotes to the report to show which authors wrote which section.

The CSYPAG members are all learners who study computer science in Scottish schools. They have been learning research skills with Laura Wright and Christina McMellon throughout their meetings. Some CSYPAG members have personal interest and expertise in women in STEM issues which has been helpful to the analysis. Laura Wright and Christina McMellon have extensive experience in involving children and young people in participatory research (qualitative and quantitative) both in-person and online on a wide range of topics but are not experts in computing. Judy Robertson is a computer science education researcher with

¹ Written by Judy Robertson, Laura Wright and Christina McMellon

experience in participatory technology design with children. She wasn't involved in the day-to-day running of the project although she connected the CSYPAG members with other stakeholders and students who could help with analysis. Alan Kong and Daniel Spencer are fourth-year students at the University of Edinburgh School of Informatics who volunteered their data analysis skills to help with the CSYPAG with data cleaning, quantitative analysis and the sheer volume of qualitative analysis.

This project was granted ethical approval (JR15022021-1) by the ethics committee of the Moray House School of Education and Sport at the University of Edinburgh.

Survey with young people²

Methodology

Young people were invited to apply for the Computing Science Young People Advisory group via the various academics' existing networks (e.g. schools, community groups, computing science teachers, etc.) and through social media. The recruitment strategy encouraged young people (13 to 18 years) from diverse background and lived experiences both active and non-active in computing science. As highlighted above, a total of 8 were active as CSYPAG member with 6 continuing to phase 2.

As the period of this project took place during the peak of COVID19 the CSYPAG occurred entirely online. This required us to adapt our creative and participatory approaches to online methods to build a community to carry out the research. We began each meeting with a welcome a check-in energizer (e.g. what weather/fruit/animal do you feel like today) to support members to get to know one another and check-in on people's energy and emotions. Our first session involved a welcome, an introduction activity, and then an introduction of the project and explanation of our end goal which was to collect information on young people's perception of Computing Science in Scottish schools. We began brainstorming on an interactive online tool (Miro board) about the best way to accomplish this. The "adult" researchers introduced a variety of qualitative and quantitative ideas for the young people to explore. The team decided to create a survey as the young people felt it would be most effective to send out to schools allowing for a wide variety of opinions, a short time commitment of peers, and easy to pull the information together. After we had decided on a survey, we began work on the topics that we wanted the questions to cover. We were mindful that often surveys can be boring to fill out so came to a compromise where people answered on a scale from 1 to 10 for most of the questions but had the option to expand on their answer if they wished so that those who got bored did not have to fill out long and wordy answers. As for the topics covered we decided the areas that most interested us were: stereotypes surrounding the subject, reasons people did or did not take the subject, quality of teaching and barriers which stop females joining the subject.

² Prepared by the CSYPAG and Christina McMellon

There was quite a long process of group members inputting the questions into online survey software, rewording questions to check they were easily understandable and testing the survey logic so that all participants would answer the right questions. Once we launched the survey, CSYPAG circulated it in their schools and the academics circulated the survey to their contacts to share with young people.

The group reconvened after the survey had closed to look at the data. We focused primarily on the qualitative data and had a meeting where we introduced thematic data analysis through a participatory coding activity. In between meetings, pairs of group members were assigned two questions to start exploring and identifying themes using a template developed for this purpose. The group chose to use google classroom to gather these thoughts. At the next group meeting, the pairs presented their thoughts and shared quotations that evidenced their key themes. Using a Miro Board the group were guided through a discussion where these initial themes were developed and challenged. We then looked at themes emerging across the questions and discussed these themes from the perspectives of the group members. Given that the CSYPAG members are peer researchers who fit the criteria for research participants we consider their perspectives that build on the data gathered is also valid in the research findings.

Phase two of the project considered how to share our learning from the survey. After an initial meeting, each CSYPAG member wrote up our findings on one question and shared this in the Google classroom where we discussed and developed our sections together. This writing informed some sections of this report and also our presentation about the research. The findings and insights can be further shared in knowledge exchange activities to inform Computing Science in schools across Scotland.

Participants³

We opened the survey to Scottish students between 12 and 18, regardless of whether they took computing. The dataset contains 537 responses. 472 respondents took Computer Science at the time, and 65 did not.

We had a similar number of responses from 11–13-year-olds and 14–15-year-olds – 37% and 38% respectively (see Table 1). 88% of our respondents took computing Science, though almost half of these were in the class as a compulsory subject. 2.2% of people did not have access to studying computing. This number will be higher in the general student population of Scotland however as we shared the survey through mainly computing related networks and therefore it'll reach more students who are in the class.

Age bracket	Number of responses	% of responses
11-13	202	37.62
14-15	202	37.62
16-18	133	24.77

Table 1. Participants by age bracket

57% of students who answered were male (see Table 2).

Gender	Number of responses	% of responses
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³ Written by CSYPAG, Alan Kong, Daniel Spencer

Male	307	57.17
Female	206	38.36
Prefer not to say	13	2.42
Non-binary	11	2.05

Table 2. Participants by gender

The geographical split of answers was skewed significantly to Fife with 44% of respondents living there (see Table 3). The average number of answers per Local Authority was 19.6 or 3.7%. There were 5 local authorities who we did not reach and had no respondents from. The Local Authorities that are not represented in the dataset only represent 4.5% of the population; however, there may be underlying reasons that no students from these areas participated. Any future work should aim to include these areas. As of 2021, there were 300,954 secondary school students in Scotland⁴, with 537 responses, 0.18% of students in secondary school in Scotland were involved in the questionnaire. We only get a snapshot of a small sample of students; we cannot speak for every pupil in Scotland, however the perspectives of respondents provide valuable insights into computer science education.

Area	Number of Responses	% of responses
Fife	234	43.58%
East Lothian	97	18.06%
West Lothian	38	7.08%
Aberdeenshire	23	4.28%
Highland	22	4.10%
North Lanarkshire	22	4.10%
Falkirk	21	3.91%
Edinburgh	13	2.42%
Glasgow	12	2.23%
East Dunbartonshire	10	1.86%
Aberdeen	5	0.93%
Renfrewshire	5	0.94%
Dumfries and Galloway	4	0.74%
Argyll and Bute	3	0.56%
Dundee	3	0.56%
Inverclyde	3	0.56%
Midlothian	3	0.56%
Moray	3	0.56%
North Ayrshire	3	0.56%
South Lanarkshire	3	0.56%
East Ayrshire	2	0.37%
East Renfrewshire	2	0.37%

⁴ <https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2019/07/pupil-census-supplementary-tables/documents/pupil-census-2021-supplementary-statistics/pupil-census-2021-supplementary-statistics/govscot%5C%3Adocument/Pupils%5C%2Bin%5C%2BScotland%5C%2B2021%5C%2B-%5C%2BExcel%5C%2BAbridged%5C%2BWeb%5C%2BVersion.xlsx>.

West Dunbartonshire	2	0.37%
Angus	1	0.19%
Perth and Kinross	1	0.19%
Shetland	1	0.19%
South Ayrshire	1	0.19%

Table 3. Participants by local authority area

It is important to note that the CSYPAG carried out this questionnaire in 2021; the pupils surveyed had their learning affected by the Covid-19 pandemic. Throughout 2020 and at the beginning of 2021, Scotland was still experiencing lock-downs which included remote learning for many students. Remote learning will have undoubtedly influenced their educational experience and may have caused some variation in these results compared to other unaffected years.

Overview by the Young People’s Advisory Group⁵

We got tremendous positive feedback from students who do study computing science, and their enjoyment of it. Most people thought it was interactive, and felt it was up to date and engaging. The teaching was also tremendously positive. It was rated pretty high in how up to date it was, how interactive, and the quality of teaching, and most front by both groups, both those who do study and those who don't. The specific factors that they enjoyed were the real world examples and the practical work that went along with it. Why they chose to study was the practical side of the subject and the transferable skills, with a few people quite liking the creativity of it, and the opportunities that would give them in the future. These were all patterns that we noticed quite easily which could be placed into categories. Our survey revealed that one of the main reasons people enjoy and choose to study Computing Science at school is practical software development. This was overwhelmingly the most popular response with many saying they find it fun and consider it useful for their future careers. Similarly, a large proportion of responses mentioned other skills – such as problem solving and logical thinking – that they expect to be useful to them in the future. However, we saw from the survey that not everyone had access to CS and this perhaps worsened over Covid. A lot of people also didn't think that it would carry on and get them to their future career, or that it wasn't as crucial as other subjects were. They may have found it interesting, but it wasn't as interesting compared to the other subjects. Some showed an interest in a more creative side of computing: creating websites. It appears that these people especially enjoy designing websites when given the freedom to express themselves and build their site around a topic they are genuinely interested in. Finally, with the growing prominence and importance of computers in our society, a lot of young people who are studying CS say they intend to further their computing education at university and work in one of the multitudes of different jobs relating to the field.

Teaching Quality⁶

As seen in Table 4, students rate their teachers highly, evidenced by a mean score of 7.3 out of 10. Looking at the teacher quality rating by student status, we can see that there is a difference between those who are currently studying the subject, the “Compulsory” and “Chosen” groups, and the “Not chosen” group. There is only a small difference between the groups of students studying computer science with students who have taken the subject

⁵ Prepared by the CSYPAG

⁶ Written by Daniel Spencer

rating it only 0.3 higher than those who have no choice. The students who have not chosen to take computer science rated it significantly lower. This group’s mean rating of 5.72 was 1.61 lower than that of those taking the subject compulsory. Their median answer at 6 was also two full points lower.

Study status	Mean	Median	Standard deviation
All (537)	7.31	8.0	2.45
Not chosen (9.9%)	5.72	6.0	2.57
Compulsory (40.6%)	7.33	8.0	2.21
Chosen (47.3%)	7.63	8.0	2.50

Table 4. Teacher quality rating by study status. On a scale of 1-10, where 0=the worst possible and 10= the best you can imagine, Please rate the following: “The quality of the teaching that you received”

The answer spread remains constant throughout, with the compulsory students having the smallest spread at 2.21 and the not chosen the largest at 2.57. It could be that those who have not chosen to study the subject have more varied views on it, but this difference is relatively small, so we cannot say. Note that the “Not available” study status is excluded as there is no data available.

We also analysed the free text comments in which participants gave reasons for their numerical rating of teacher quality. Many descriptions of the teachers and their perceived opinion of the teaching often seem to be positive. One extremely positive answer was, “My computing science teachers were fantastic, they went out of their way to make every lesson count and especially encouraged more girls to study the subject”. Another student said “my teacher has been really good at preparing me for the exam, as well as engaging my class with relevant projects” or more simply “My teacher is very good”.

The responses were overwhelmingly positive for this code; however, there were a few exceptions, such as “I feel like the teacher didn’t really make it a good experience and didn’t know everything properly” and “often the teachers are unknowledgeable”.

Students seemed to value the help of the teachers and rated teachers whom they perceived to be helping them highly. One respondent said “Teachers were very informative and helpful” and another “My computing teacher is great. He helps me to understand Computing and if required give a detailed example regarding a particular aspect of computing”.

Throughout this analysis, it is helpful to consider patterns of responses from students who identify as male and female, as we know that fewer young women study computer science and we need to understand more about why. The views of people who don’t identify as male or female are also important. In this sample, however, few comments from respondents in this category make identifying patterns difficult. Looking at the responses by gender, we see that the reasons for positive responses are the same for male and female students. There is general praise of the teacher and their teaching. However, when we look at the negative responses, there are differences. Male students were more likely to describe their teacher negatively, such as “teacher not great” and other similar themed responses. In contrast, female students talked about how the subject was less attractive to them “the teaching is fine but I’m not a big fan of the subject” and “the teaching is good but I just don’t find the subject interesting”. Female students also mentioned careers “they never went into detail on what computer science is for and what it could do in the future”. As seen in the previous question, we observe how careers are more important to female students than males.

Enjoyment⁷

The group that has chosen to study computer science gave the subject higher enjoyment ratings. Those who studied CS because it was compulsory rated it much lower at 5.58. This finding is interesting, especially when it is considered that they rated the quality of the teaching they received at 7.33. This shows that students can appreciate a good teacher even when they dislike the subject. There were no answers for the group that had not chosen to study the subject; Table 5 reflects this.

Study status	Mean	Median	Standard deviation
All (537)	6.49	7.0	2.57
Not chosen (9.9%)	N/A	N/A	N/A
Compulsory (40.6%)	5.58	6.0	2.62
Chosen (47.3%)	7.28	8.0	2.25

Table 5. CS enjoyment rating by study status. On a scale of 1-10, where 0=not at all and 10=it is the thing I most enjoy: "How much do you enjoy computing"

Enjoyment and interest are both present in many of the free text responses. Many of these responses use very positive language such as; "I love programming and enjoy the subject.", "Subject interested me" and "I enjoy the subject and have been interested in it for a while". Enjoyment of the subject appears to be a crucial factor in students picking the subject. Many students describe how they enjoy the subject "it was fun and challenged me, I enjoyed it" and "I enjoy the class and the teachers also made it enjoyable". The students that rated their enjoyment the highest often said that computer science was their favourite subject, with many saying "I enjoy programming and find computers interesting". Some students had more mixed views or said they enjoyed the classes despite some other reasons "I enjoy the subject but at points the course can be tricky" and "Not my favourite but still enjoyed studying this subject". This response was one of the most common, describing either that they enjoyed the subject or did not but not expanding on their answer. There are lots of responses that mention that they dislike a particular topic but overall enjoy computer science. For example "I found the programming topic very difficult and didn't enjoy it as much as the other topics" and "Some things are fun but others are slow and boring". In future, it would be interesting to see which topics in particular learners found boring; these responses show that a lack of interest in a particular topic can affect the perception of the whole subject. Many responses mention how difficult the work can be; often, this is negative and was especially common among the students who rated their enjoyment as low. For example, some responses said that CS is "really hard" and "it's a bit hard and confusing at times". However, some students enjoy the subject despite the difficulty "I do enjoy the subject but sometimes the work can get really hard". However, these responses were in the minority. Overall we can see that students who find the subject challenging are less likely to enjoy it. Many students said taking the subject is beneficial for the future. Examples include "I felt that computing would be a very useful subject for me to take and could be important to have in the future" and "It is a passion and something that I want to study at university and it is my preferred career path". Many students believe computers will be necessary in many jobs in the future, "the world is always changing as computers are used in almost every job". Here we see that students are looking ahead and believe that computer science will be a valuable tool for their future.

⁷ Written by Daniel Spencer

Gender	Mean	Median	Standard Deviation
All (537)	6.59	7.0	2.57
Female (38.4%)	6.00	6.0	2.60
Male (57.2%)	6.75	7.0	2.53
Non-binary (2.0%)	7.40	8.0	2.41
Prefer not to say (2.4%)	7.08	7.5	2.35

Table 6. CS enjoyment rating by gender. On a scale of 1-10, where 0=not at all and 10=it is the thing I most enjoy: "How much do you enjoy computing"

We see in Table 6 that male students rated their enjoyment of CS as 6.75, higher than female students at 6.00. However, both of these are lower than the teaching quality ratings that they gave. The non-binary and prefer not to say mean scores were high at 7.40 and 7.08, respectively. Due to the small sample size for these groups at 2.4% and 2.0% of the responses, no conclusion can be drawn. (Please note that we chose not to include the gender breakdown for teaching quality, engagement and interactivity as the data across gender varied very little.)

Comparing the free text responses by gender, we see many of the same responses for male and female students. Both groups of students mentioned enjoying the subject, finding it interesting and fun. The other central theme for both was that it would be helpful in their future. Female students had a more comprehensive range of answers. They said that computer science was "useful for business" and also mentioned future pay "I like it and it's good pay". Both groups of students consider their future; however, we can conclude that female students are more likely to consider concrete factors such as pay. The more positive responses for both groups included finding the subject fun and enjoying it. There were, however, some differences in the negative responses. Female students were more likely to mention that teaching could be improved, while male students were more likely to mention a topic they disliked. Overall, there were no strong trends identified between the two groups.

Enjoyment of the subject looks to be an important factor in the decision to study CS. The differences in the ratings by gender support this, with male respondents rating their enjoyment of CS higher. This difference in enjoyment could be one of the reasons that there are more male CS students than females.

Engagement⁸

Looking at the differences between the study status groups, presented in Table 7, we see the same trend as the teacher quality. The students who have chosen the subject rated the engagement highest, next came the students who study it compulsory, then those who have not chosen come last. However, there are more gaps compared to the teacher quality ratings, especially between the compulsory and chosen. The gap is 1.09 compared to the smaller 0.3 gaps observed in the teacher quality rating. The spread of answers remains relatively similar, with the standard distributions in the 2.29-2.55 range, similar to the teacher quality rating.

Study status	Mean	Median	Standard Deviation
All (537)	6.77	7.0	2.47
Not chosen (9.9%)	5.08	5.0	2.53
Compulsory (40.6%)	6.37	7.0	2.39

⁸ Written by Daniel Spencer

Chosen (47.3%)	7.46	8.0	2.29
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Table 7. Engagement by study status. On a scale of 1-10, where 0=completely out of date and 10= 100% up to date, please rate the following: “How up-to-date and engaging your classes were”

Like the teaching quality we have seen before, we can infer from this data that engagement is a factor in determining whether students will take a subject. Overall we can infer that higher engagement is a marker of students who are more likely to take CS.

There are many descriptions in the free text comments relating to how up to date students feel their classes are. Some students are very positive “Classes are up so [to] date and very hands on” but this was not universal: “The classes are quite interesting, however some of the resources we use are quite old and have been used for many years”. One student said “not sure about up to date but very engaging” while others admitted that they do not know how up to date their lessons were “I feel like they were up to date enough although I don’t fully know how up to date it was”.

Comparing the responses by gender, we find the same positive themes in both responses. One female student said “Some of the material is a little old but it is very engaging and I enjoy” while a male student said “their not always up to date but there very engaging”. Female students were more likely to mention the teacher in their response “The teacher wasn’t good at making the classes engaging and interactive”. In contrast, male students were more likely to mention the technology used. One student said “It works but all the computers are extremely slow and run windows 7” and another, “Until a few months ago our technology was a bit outdated in the classroom, but after an upgrade it has been more enjoyable working in class.”. These responses provide further evidence for one of the findings from the previous question; improved resources make computer science more enjoyable, making students more likely to choose to study it.

There were not any strong trends by gender, with a relatively similar number of positive to negative responses for female and male students. Overall we can see that the reasons given are similar for male and female students.

Interactivity⁹

The interactivity rating numbers are comparable to the engagement rating numbers. They are much more closely related to these than the teaching quality rating.

Study status	Mean	Median	Standard deviation
All (537)	6.72	7.0	2.63
Not chosen (9.9%)	5.46	5.5	2.88
Compulsory (40.6%)	6.32	7.0	2.65
Chosen (47.3%)	7.30	8.0	2.40

Table 8. Interactivity by study status. On a scale of 1-10, where 0=not interactive at all and 10= completely interactive, please rate the following: “How interactive your classes were”

Looking at the result by study status in Table 8, we see that the students who have chosen to study the subject have rated it highly at 7.30. Those who did not choose it rated it poorly; the median value of 5.5 was low but not relatively as low as that of the same group for engagement rating at 5. Overall, the answers had a slightly wider distribution than previous questions, from 2.4 for those who chose the subject to 2.88 for those who did not.

Some students replied that they had little interaction “Rarely did we interact as a class”. However, others had more positive experiences “Classes are very interactive, we are set to do research or projects through the year. We are also given the opportunity to work with others in our class on some of these to strengthen teamwork skills”. Some students mention

⁹ Written by Daniel Spencer

that they work by themselves, saying they carry out “Quite a lot of solo work” with others describing the nature of their classes “We do a lot of practical work” and “we get asked question and sometimes we work together”. These mixed responses show that there is variation in the way that computer science classes are taught in Scotland. Students described the role of their teacher in terms of interactivity, saying, “Most of my lessons were interactive and the teacher always managed to engage the class.” and also “The teachers do interact a lot but that may just be because they have to show us how to do some things themselves because the resources are out of date.” Comparing the responses by gender, we see that positive female responses were more likely to include constructive criticism “classes interactive but could be improved”. In comparison, male responses were more likely to mention the teacher saying “the teacher is very involved” and “teachers do interact a lot but that may be just because they have to show us how to do some things themselves because the resources are out of date”. Here we see the students mention resources again, a recurring point across the responses to all the questions we have seen so far. Female students were more likely to mention the pandemic affecting interactivity “because of the pandemic we weren’t able to do a lot of interactive work”. In contrast, male students were more likely to criticise the content of their lessons, with responses including “I feel there was too much theory”.

Preferences for types of learning activities¹⁰

Learners were provided with the opportunity to state the types of activities they have experienced during their CS lessons. Learners could choose from a choice of six options: teacher teaching the whole class from the front of the classroom, pair/group work, real-world examples, project work, external experts coming into the class, taking part in national/local competitions, and extra-curricular coding clubs.

In addition to sharing their experiences, learners were also provided with the opportunity to describe the types of activities they preferred to take part in during lessons in a free-form textbox. Preferences were then coded into the same themes. Not all learners responded to this question - 168 learners did not express a preference or gave inappropriate answers.

One issue with the data is that despite the question not constraining the learner to a single activity, the majority of learners only expressed a preference for a single activity, which explains some of the differences in the count of actual vs preferred for each activity, especially for lecture-style/the teacher teaching in front of the class. Therefore, instead of viewing the data in a side-by-side bar chart, it is more useful to examine it with a separate chart for actual activity count and preferred activity count (see Figure 2) than to observe the rank of each activity.

¹⁰ Written by Alan Kong

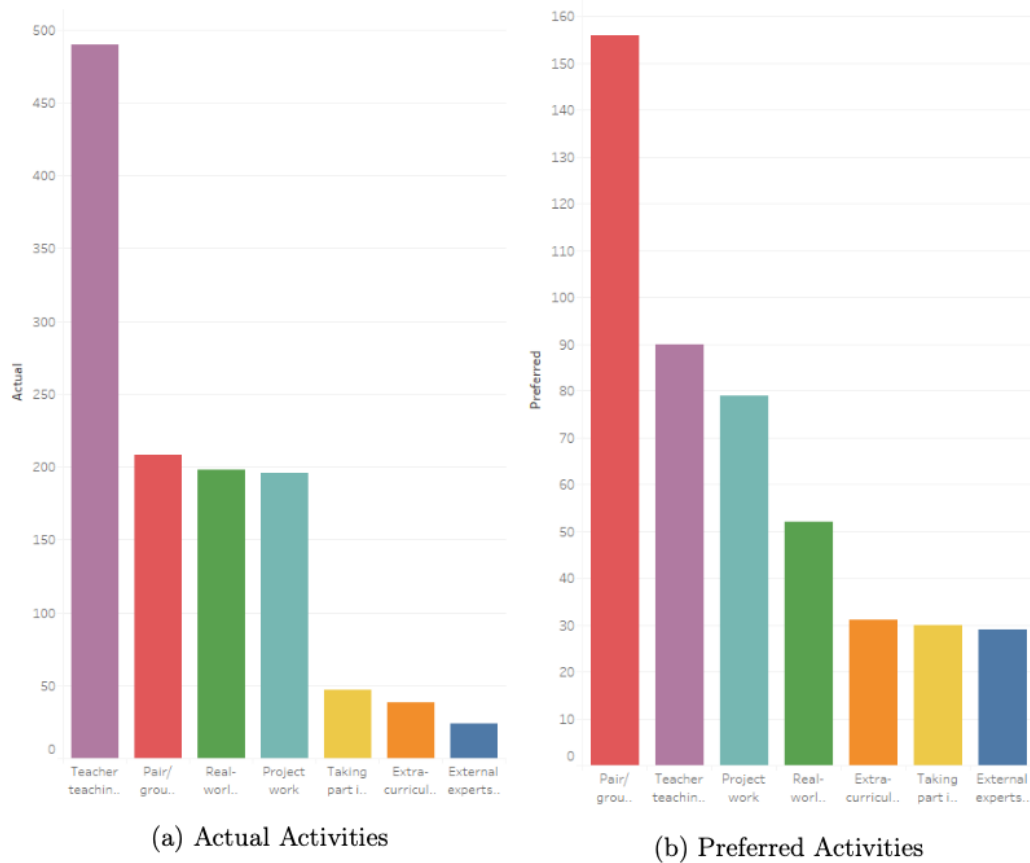


Figure 2. Purple=Teaching in front, Red = Pair/Group work, Green = Real-world examples, Cyan = Project work, Yellow = Competitions, Orange = Extracurricular clubs, Blue = External experts. Note that the y-axis scales are not matching and the purpose of the graph is to look at the differences in the percentage of actual vs preferred responses for each activity, project work appears to be the activity with the least variation. This may suggest that it is a preferred activity based on the positive experiences learners have had with project work, rather than a prediction of what is actually better. A number of learners described project work as a good way to put their skills into practice, and 24 learners preferred pair work and project work together. 12 learners mentioned the sharing of ideas in their justification for their preference for pair/group work, and reflect on their experiences to refine the project or consolidate new skills. This preference is also reflected in the mean teaching quality, engagement, and interactivity ratings as students that have experienced project work give higher ratings versus students that have not experienced project work (+0.96pts, +0.77pts, +0.88pts respectively). The pair/group work theme has the greatest delta between actual and preferred experiences. The most common sentiment expressed by learners is the opportunity to share ideas and to help each other. Another interesting result is the difference in students preferring real-world examples to be used in class and students preferring real-world experts to contribute to lessons. When conducting this analysis, I expected both to have similar levels of preference from learners. This is because external experts are working on real-world (examples) as part of their work. The difference between the percentage of learners actually experiencing the use of real-world examples in lessons and learners preferring it is also interesting, as it is part of the CS Engagement Practices Framework ("Use meaningful and relevant content") (Women in Information Technology 2021). This 5% difference provides an opportunity to explore how different learners want real-world examples introduced into lessons.

Learners are also looking for extra-curricular coding clubs, with 2% of learners from the questionnaire saying they have participated in these clubs, and 6.21% of learners saying they would prefer to participate in this kind of activity (regardless of whether they have done it before). Learners that expressed a preference for code clubs mention themes around "independence" and "challenge".

Activity	% of actual responses	% of preferred responses	Delta
Teacher teaching the whole class from the front of the classroom	40.80	19.27	21.53
Real-world examples	16.49	11.13	5.35
Project work	16.32	16.92	-0.60
Taking part in national/local competitions	3.91	6.42	-2.51
Extra-curricular coding clubs	3.16	6.64	-3.47
External experts coming in to the class	2.00	6.21	-4.21
Pair/group work	17.32	33.40	-16.09

Table 9. Preferences and experiences of teaching activities

Stereotypes and misconceptions¹¹

The responses from our survey highlighted the deep embedded stereotypes and misconceptions that comes with being labelled as a computing student or as a computing science fan. The reoccurring stereotype that most responses conveyed was there is a large link to computing and gender due to the fact that computing science students were described as primarily male. Furthermore, these males were typically said to be nerdier and enjoyed activities such as video gaming, coding and watching sci-fi shows and movies such as Star Trek.

Additionally, some responses linked computing to academic achievement and ability as many assume that computing science students are very intelligent, and are more likely to enjoy and excel in STEM subjects such science, technology, engineering, and maths, whereas they would expect these students to be unsuccessful in creative subjects and activities such as music and art.

Finally, the survey revealed that there is a stereotype that students who are involved within computing, particularly young men, might experience depression and general unhappiness.

Why are young women less likely to study CS?¹²

There are multiple reasons why young women are less likely to study CS. Our survey asked this question and received quite a large variation in ideas. One semi-common occurrence with the answers was that respondents who weren't women didn't answer and said they couldn't as they weren't women. We can see that allyship can be an issue in this respect. Where young people did answer the question, there were two main components to the answers given: structural and personal. The structural barriers mentioned included things such as lack of support systems, the assumed societal stereotypes, and the history of computing is relayed in a male-centric way. The personal reasons that were given came in varying proportions of number of answers and included things such as, social identity threat,

¹¹ Written by the CSYPAG

¹² Written by the CSYPAG

imposter syndrome, fear of knowing less about the subject and the lack of women role models. A combination of these reasons are most likely at play in every scenario of a young woman not choosing Computing Science.

What could schools do differently to encourage more young people to study Computing Science?¹³

Students who had chosen not to take computer science answered this question. The question has a small sample size as this group only made up 9.9% of the responses. From the responses, we see that students want improvements in their teaching. One student said they wanted “better teachers” with another echoing this view “probably to have a better teacher for the subject, because the teacher I had in first and second year was not actually a Computing Science teacher”. We can see here that having a non-specialist teacher could have discouraged students from taking computer science. Another student mentions how important having a good teacher is to them “A relationship being built between the teacher and the class as you are more likely to take a subject if you like a teacher and want to make them proud/happy”.

Students also answered regarding the resources available to them. One student suggested “Better more reliable computers” would have had a positive impact. Another echoed this sentiment saying “better developed software to help expand our knowledge and encourage us”.

Looking at the differences in responses by gender, we see those female respondents answered in terms of career. They said: “wasn’t the best at it and didn’t want to continue as career”, “[I am] choosing career in medicine”, “if it was useful in job when older” and “career options talked about more”. These responses contrast with male respondents who focused on enjoyment, fun and interest in the subject. They suggested “make some tasks more fun and not as complicated” with another student suggesting an “easier and gentler introduction. Felt I was just thrown into the deep end”.

Overall, we can see that teachers and students’ teaching significantly impacted their computer science experience; it was the most consistently mentioned theme in their answers and not having good teaching was mentioned as a push factor from the subject. The responses received from our survey clearly showed some common ideas on how schools could encourage more young people to study Computing Science. One important idea was to ensure that suitable equipment is available to everyone, not only at school but also at home to allow students to become more familiar with the coding languages and software that they would be using when studying the subject. Another recurring result was for the teachers to make the subject more interactive and enjoyable and to show its relevancy to a wide range of future careers. Many people also wanted students to be informed about the contents of future courses for those without older siblings to help them make their course choices for later years in school. A final trend found in the data revealed that young women needed an improved representation in the subject. Many suggested that this could be done through creating clubs that are specifically exclusive to young women interested in computing and more positive female examples used in classes.

¹³ Written by the CSYPAG and Daniel Spencer

Teachers' Responses to Young Peoples' Views¹⁴

Consultation with Teachers

The findings were presented a member of the Scottish Government STER team in March 2022, followed by a public online seminar open to teachers and other stakeholders. The seminar was prepared and led by Clara, Logan and Korre, with assistance from Judy, Laura and Christina¹⁵. The artist Jules Scheele illustrated the seminar live as it took place (see Figure 1). The purpose of this seminar was to allow computing teachers to hear the young people's views, discuss the issues raised, ask questions, and give feedback. Forty-two people signed up for the event, including computing teachers, student teachers, and staff from universities and colleges, Scotland IS, the SQA, and Computing at Schools. After a presentation about the findings, participants were asked to supply written comments to the following questions:

1. Most young people prefer real-world examples, project work and clubs. What support do teachers need to teach in the ways that YP want them to teach?
2. How can we make sure that the teaching materials and resources in schools stay up-to-date and relevant?
3. What are the stereotypes of CS teachers?
4. What can we do to break down these stereotypes?
5. Why do you think less women study Computing Science?
6. Do you notice any years that have a significant drop in young women's take-up?
7. Is there anything that we've found that surprises you?
8. Does what we've found fit with your experience?
9. Is there anything we've missed that you think is important?
10. Do you have any questions for us?

We recommend that additional consultation with teachers be carried out over a longer period, as this initial seminar was small.

Findings

The teachers generally commented that their experiences were consistent with the views reported by the young people. They appreciated seeing the findings all in one study as a confirmation of the situation in their schools. One teacher noted that it was "great to see kids really enjoying subject. I think that shows if kids got the subject the uptake [would] increase".

When asked what support teachers need to match the young people's preferences, they replied that high quality preprepared resources that are fun, up-to-date and relevant to careers would be useful. They also requested support from industry about how to make the material relevant to working practices. It was also noted that teachers need time to plan lessons and keep their skills up to date, perhaps more so with this fast-moving subject than with other more traditional curriculum areas. Working with HE and FE providers was also

¹⁴ Written by Judy Robertson

¹⁵ You can find the seminar recording here: <https://dataschools.education/learners-views-about-computer-science-in-scottish-schools/>

thought to be beneficial for keeping materials up to date and a shared communication platform for teachers. Teachers wanted access to professional learning about software and systems and time to attend such courses and network with colleagues. One participant suggested that short sabbaticals or industry placements should be offered to teachers. Concerning the lack of female learners studying computing at school, the teachers thought that the drop-off in numbers happened at all stages but particularly between the second and third years. In the seminar discussion, it was thought that giving primary schools exciting computing opportunities would help increase the subject's profile with all learners. The participants agreed with the young people's analysis of why young women might be put off studying computing, adding that competitive work in the class can be off-putting and positive experiences with collaborative group work might be beneficial. Some participants raised the issue that it can be challenging to be the only woman in a CS classroom and that young women must contend with the societal perception that CS is not "for" women. The comment that there are "not enough positive stories to counter the emerging male-led narrative" suggests that including more visibility of the accomplishments of female computer scientists within the curriculum would be helpful. It was also recommended that more efforts could be made to link computing to the careers in which young women are interested and invite more female role models from industry to the classroom. Finding cross-curricular links and creative computing projects were both considered to be promising paths to increasing women's representation in the subject.

Reflections on the project¹⁶

The most encouraging aspect of the research findings is that Scottish learners value the high quality of teaching in their computing classes (mean rating of 7 out of 10). For example, one learner wrote: “my teacher is incredibly creative, enthusiastic and great at teaching - he manages to make everything seem more exciting”. Another commented that “our teacher taught in a way that was very understandable for me as it was my first time taking computing; I have a firm grasp on each topic and understand how to tackle each problem”. In our rush to transform our technology ecosystem, it is valuable to pause to recognise and thank the hardworking professionals who are already effectively contributing to learners’ experiences. We should prioritise constructively supporting teachers through high-quality professional learning, access to up-to-date materials and partnerships with appropriately trained industry employees and university and college staff and students. Most of all, we should free up time for teachers to enable them to develop their skills and learn about emerging technologies.

In the same way the survey respondents value their computing teachers, the teachers who attended the seminar appreciated the young people’s work. One attendee commented, “I appreciate the evidence you have shown. It gives us ammunition for change.” Another wrote that it was “great to see young people leading in this way”. The CSYPAG members valued having an audience of adults who wanted to hear their views.

The project highlights the positive relationship between CS learners and their teachers. This relationship can be crucial in helping learners to decide whether to study the subject further. One of the CSYPAG members noted, “I did quite enjoy the programming bits...I sat quite close to the teacher, and the conversations with her really improved the subject for me”. His colleague agreed, saying that, “My relationship with a teacher can make or break a subject.” This is not likely to be news to members of the teaching profession or their learners. Still, it is often under-acknowledged in discussions about how to “fix the problem” of computing education at schools. It highlights the need to free up the time of our existing teachers so that any new requirements to “upskill” in technical areas do not come at the expense of their crucial role in supporting young learners.

A striking aspect of this project was the talent and energy of the young people as they carried out and presented this research. The project required a high commitment in terms of attending workshops and tasks in between meetings. Ideally, the group would have met in person at least initially, but this was not possible as a result of the Covid-19 pandemic, and prior experience suggests that it can be difficult for a group to come together online. This group also included participants of different ages and stages in their journey with CS. However, despite what could have been a challenging situation, the group operated from a strengths-based approach and were extremely supportive of each other and demonstrated commitment to the project.

In a session reflecting on their experiences in the group members discussed their ‘journeys’ through the project. Several group members noted that they were glad of something to do during lockdown while others were less enthusiastic at the beginning and found it a bit daunting to meet new people or were mostly doing it for their CV. Aspects which group

¹⁶ This section was written by Judy Robertson, Christina McMellon and Laura Wright with input from the CSYAP members

members mentioned that helped make the process easier were having ice-breaker activities so that they got to know each other a little bit and working in break-out rooms with clear tasks to complete. All group members found developing the survey and analysing the responses new and interesting. Several mentioned enjoying presenting their findings to adults and all thought that working with the live illustrator was an effective and accessible way to share their learning.

Quotes from that session include:

“My teacher just emailed me and said ‘you should sign up, it'll be good for your cv’ and I thought I might as well. I was a bit reluctant - but as I got involved I enjoyed it!”

“It was good to get to know other people in other places and other ages.”

“I enjoyed making the survey, it was tricky finding the balance of getting good info but not boring everyone to death.”

“I enjoyed seeing different responses to the survey.”

“It was really interesting to do the analysis – I enjoyed finding patterns and doing the colour coding.”

“Sometimes I couldn't make meetings but you contacted us afterwards and I found different ways to contribute.”

“I'm proud of what we've accomplished.”

“The whole thing was a new experience, I've never done out of school stuff before and it good fun. Going forward I feel more social and I've met people from across the country.”

“I hope it will change some things about how computer science is taught.”

The group's participation has brought new knowledge to the ongoing discussion about CS education. The young people in the group were not used to working in advisory groups or participatory research and had chosen to get in touch primarily because of their interest in the topic. They developed high-level skills in research design, recruitment, data collection, analysis, report writing, communication and online facilitation, which clearly demonstrates that they are valuable contributors to the national debate. In particular, researchers were impressed with how quickly they picked up the principles of coding qualitative data and noted interesting conversations about the transferability of CS skills to research. Additionally, they contributed their own expertise in visuals (e.g. the logo) and creative recruitment strategies. Furthermore, the unique structure of the Young People's Advisory Group allowed for intergenerational co-production and mutual learning and teaching exchange whereby the young people acted as experts in Computer Science and Christina and Laura (the “adults” without knowledge of CS) and had the opportunity to develop research skills.

Although the methodology used is well-tested in Childhood Studies and other social science disciplines, this approach was innovative in bringing co-production with young people into Computing Science. The project demonstrates that it is vital to hear young people's views of their CS education and that involving young people in designing and carrying out research can bring new questions and new insights, ensuring that the research is relevant to young people's experiences. Learners don't need adults to plan their educational futures without them, and they don't (always) need teachers to speak for them. They need regular opportunities to contribute to discussions about their education. For this reason, we recommend that working groups developing plans about CS education for school-aged

learners should systematically include groups of children and young people, either locally or nationally.

Recommendations¹⁷

1. *Give learners access to the equipment they need*- ensure that suitable equipment is available to CS learners at school and home.
2. *Make CS classes engaging and relevant* - make the subject more interactive and enjoyable to show its relevance to a wide range of future careers.
3. *Inform young people about CS futures earlier* - better inform them about the content of future courses to help them make their course choices for later years in school.
4. *Improve the gender balance* – create CS clubs specifically for young women and use more positive female examples in class.
5. *Include learners and teachers in ongoing conversations* – young people and teachers are knowledgeable and articulate. They should routinely be represented in discussions about policy changes in computing education and schools.

¹⁷ Prepared by the CSYPAG and Judy Robertson

References

Logan, M. (2020). *SCOTTISH TECHNOLOGY ECOSYSTEM REVIEW*.

<https://www.gov.scot/publications/scottish-technology-ecosystem-review/documents/>

Muir, K. (2022). *Putting Learners at the Centre: Towards a Future Vision for Scottish Education*. <https://www.gov.scot/publications/putting-learners-centre-towards-future-vision-scottish-education/>

Women in Information Technology, National Centre for (May 2021). Engagement Practices Framework: National Center for Women Information Technology. url:

<https://ncwit.org/engagement-practices-framework/>.

Appendix 1 – Survey Questions

1. How old are you?
2. Do you go to school in Scotland?
3. Which Local Authority area do you live in?
4. What gender are you?
5. Do you currently study Computing Science in school?
6. How long ago did you stop studying Computing Science?
7. What could have encouraged you to study Computing Science?
8. On a scale of 1-10, where 0=the worst possible and 10= the best you can imagine Please rate the following:
 - 8.1. The quality of the teaching that you received
 - 8.a. Explain why you chose that number
9. On a scale of 1-10, where 0=completely out of date and 10= 100% up to date, please rate the following:
 - 9.1. How up-to-date and engaging your classes were
 - 9.a. Explain why you chose that number
10. On a scale of 1-10, where 0=not interactive at all and 10= completely interactive, please rate the following:
 - 10.1. How interactive your classes were
 - 10.a. Explain why you chose that number
11. Which have the following have you experienced in Computing Science classes?
 - 11.a. Which of the above do you prefer? Why?
12. Why do you not study computing science?
13. What could schools do differently to encourage more young people to study Computing Science?
14. Why do you think fewer young women study Computing Science?
 - 14.a. What could schools do to encourage more young women to study Computing Science?
15. What do you think a typical computing science student would like or would be into?
16. Do you think that is a positive stereotype or a negative one?
17. Why did you choose to study Computing Science?
18. What do you like about Computing Science?
19. On a scale of 1-10, where 1=not at all and 10=it is the thing I most enjoy:
 - 19.1. How much do you enjoy computing
 - 19.a. Explain why you chose that number
20. On a scale of 1-10, where 0=the worst possible and 10= the best you can imagine Please rate the following:
 - 20.1. The quality of the teaching that you receive
 - 20.a. Explain why you chose that number
21. On a scale of 1-10, where 0=completely out of date and 10= 100% up to date and engaging, please rate the following:

- 21.1. How up-to-date and engaging your classes are
- 21.a. Explain why you chose that number
22. On a scale of 1-10, where 0=not interactive at all and 10= completely interactive, please rate the following:
 - 22.1. How interactive your classes were
 - 22.a. Explain why you chose that number
23. Which of the following have you experienced in Computing Science classes?
 - 23.a. Which of the above do you prefer? Why?
24. What do you think a typical computing science student would like or would be into?
 - 24.a. Do you think that is a positive stereotype or a negative one?
 - 24.b. Is there anything else you'd like to say about this?
25. Do you know any people who have chosen not to study Computing Science? If yes, do you know their reasons for not studying Computing Science?
26. What could schools do differently to encourage more young people to study Computing Science?
27. Why do you think fewer young women study Computing Science?
 - 27.a. What could schools do to encourage more young women to study Computing Science?
28. Five participants will be chosen at random to receive a £20 amazon voucher. If you want to be included in the prize draw you will need to give us your email address, but these will be deleted before we look at the results of the survey and no one will know who said what. This is completely voluntary.