Higher Applications of Mathematics: A new qualification to increase post-compulsory participation

Jamie Lawson and Sue Pope

Research and Evaluation, Scottish Qualifications Authority

Higher Applications of Mathematics launched as a new qualification in Scotland in 2021. The qualification aims to increase post-compulsory mathematics participation by providing an alternative pathway, emphasising real-world application, from pre-existing qualifications. Surveys of current learners and practitioners indicate the course is achieving its aims of developing skills in analysing real-world problems involving mathematics, statistics, data modelling, and software use. Learners and practitioners find the course interesting and engaging, although some learners struggle with the statistics and software components. Overall, the course provides a rigorous and worthwhile alternative mathematics pathway.

Post-compulsory mathematics; learner experience; practitioner experience; mathematical literacy; statistical literacy

Introduction

Higher Applications of Mathematics was launched in 2021 as a new mathematics qualification with a specific emphasis on real world contexts and the use of digital technology. The qualification was designed to 'meet an increasing need for mathematical and statistical literacy' (Brown et al., 2019) for Scottish learners in the Senior Phase, in response to calls from the Scottish Government and others to increase STEM literacy (Hodgen et al., 2013; Scottish Government, 2017, Smith, 2004; CBI and Pearson, 2016) and to make Scotland a 'maths positive nation' (Making Maths Count, 2016). Prior its launch, post-compulsory mathematics education was largely served by the well-established Higher Mathematics, which is suitable for learners who have been successful in National 5 Mathematics. There was no progression route from National 5 Applications of Mathematics (see Figure 1). Higher Applications of Mathematics provides an alternative and distinctive pathway for both National 5 courses. In this paper, we evaluate the success of Higher Applications of Mathematics, using attainment data from its first cohort, and drawing on a mixed methods survey of current (2023) learners and practitioners. We aim to show how a clear real-world focus and a sense of connection to content – found most clearly in learner reaction to the qualification's statistics project – can enhance the attractiveness and accessibility of post-compulsory mathematics education.

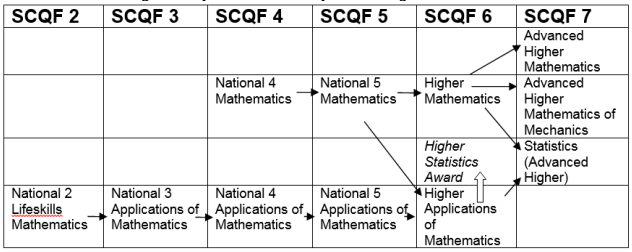

Figure 1: Scottish Mathematics Qualifications Pathways, from Brown et al. 2019

Description of the qualification

Higher Applications of Mathematics aims to provide learners with the necessary mathematical and statistical skills to model and analyse complex real-life situations. The course specification lists the following skills, knowledge and understanding learners develop on the course: i) analysing complex, real-life stations and problems involving mathematics; ii) selecting and applying skills in finance, statistics and probability, iii) data modelling, and planning and decision making; iv) communicating mathematical information with complex features; v) selecting and applying skills in numeracy; vi) using mathematical reasoning skills to extract and interpret information and draw conclusions or justify decisions; vii) using software where appropriate to model and analyse statistical, mathematical, and financial problems. Learners would be typically expected to take the qualification in either S5 or S6, ie the final two years of the Senior Phase, at roughly 17-18 years old.

The qualification is assessed by exam and coursework. The exam assesses learners' abilities to demonstrate skills in the areas of finance, statistics, data modelling, planning and decision making, and the communication of mathematical information by requiring students to, for example, construct and use GANTT or PERT charts to model workflows, to calculate loan repayment schedules for a given rate of interest, to select and justify the selection of a statistical test for a given context or type of data, and to solve mathematical and statistical problems using appropriate software. All exam questions have explicit real-world contexts. The statistics project involves learners selecting a topic for statistical analysis, locating an appropriate set of data (generally drawing from publicly available sources online), and selecting and running appropriate tests for their analysis. Assessments involve the use of Excel and RStudio (or similar tool), which learners are introduced to during the course.

Early cohorts

The first – 2022 – cohort comprised 866 learners, 351 female and 515 male. 496 learners took the qualification in S5 and 370 in S6 (see Table 1). Chi-squared tests showed no statistically significant impact of either gender or stage, either individually or in combination, on attainment ($p>0.05$). Looking at progression pathways into Higher Applications of Mathematics, 211 learners taking the qualification at S5 had previously taken National 5 Mathematics, with 380 coming from National 5 Applications of Mathematics. In S6, 110 had taken National 5 Applications of Mathematics, 76 had taken National 5 Mathematics, and 95 Higher Mathematics. Some learners are choosing to widen their mathematics knowledge by taking the new Higher. The current cohort (2023) has seen an increase in uptake of roughly 89%, with 1633 learners entered for the qualification. At the time of writing further data on these learners in terms of gender, stage and attainment is not available.

Experiential surveys

In order to better understand the experiences of learners and practitioners (teachers) of the new qualifications, we launched two surveys in early 2023. The surveys asked questions focused on experiences of the qualification in terms of 1) the extent to which the aims from the course specification were being realised; 2) whether the course was interesting and engaging; 3) what specific challenges the course presented to learners and practitioners; 4) specific experiences of the statistics project. The surveys comprised a series of closed questions, generally 5-point, attitudinal Likert

scales from ‘Strongly agree’ to ‘Strongly disagree’, with follow-up, open, free text questions, giving respondents the opportunity to clarify their quantitative responses, or add more context. 129 learners and 33 practitioners responded to the surveys.

Meeting the objectives

Both learners and practitioners indicated that, in their view, the intended skills, knowledge and understanding outcomes (listed above) were achieved. Across all seven outcomes, the majority of both survey samples indicated that they either agreed or strongly agreed that each was met (see Table 1).

Skills, knowledge and understanding outcome	Learners (n=129)	Practitoners (n=33)
Analysing complex real-life situations and problems involving mathematics	70%	82%
Selecting and applying skills in finance, statistics and probability, data modelling, and planning and decision making.	72%	91%
Communicating mathematical information with complex features	55%	55%
Selecting and applying skills in numeracy	77%	58%
Using mathematical reasoning skills to extract and interpret information and draw conclusions or justify decisions	64%	73%
Using software where appropriate, for example to model and analyse statistical, mathematical, and financial problems	74%	91%

Table 1: The respective percentages of learners and practitioners who agreed or strongly agreed that skills, knowledge and understanding outcomes were achieved by the course.

Practitioner Experiences

Practitioners reported positive feelings about the course overall. On a 5-point ‘Strongly agree – Strongly disagree’ Likert scale, the majority of practitioners reported that they agreed or strongly agreed with the following propositions: ‘I found the course interesting to teach’ (52% Agree, 39% Strongly Agree), ‘I would be likely to recommend the course to interested students’ (33% Agree, 58% Strongly agree), ‘Most of my students seemed to enjoy the course’ (52% Agree, 21% Strongly agree), and ‘My experience of the course was positive overall’ (52% Agree, 21% Strongly agree) – see Figure 2. In general, practitioners had positive views of the course, citing its real-world applicability as a key benefit ‘[we are] finally … able to answer the question, when are we ever going to use this?’. The only statement to receive a less positive response was ‘I was well supported in teaching the course (eg by my school, by training, or by SQA’s resources)’, where 39% Disagreed. This is consistent with 42% of the practitioners responding that they found the course ‘somewhat more difficult than expected’ to teach. Free text comments explained that this difficulty came from the newness of the course – being only in its second year – and a lack of support materials. Practitioners felt they had gaps to fill in their own knowledge regarding the use of RStudio and/or Excel, and/or some of the content – in particular statistics.

Practitioner responses suggested that some learners required more support than others to be brought up to sufficient mathematical competency to handle the new material. In line with this, 60% of practitioners agreed that the course was accessible to learners, but identified a number of potential issues. Class size was one issue, with smaller classes allowing practitioners to spend more time with individual learners

who were struggling. Prior attainment was another, with practitioners reporting that students without strong passes at National 5 (Mathematics and/or Applications of Mathematics) struggled to keep up. Practitioners also flagged the availability of a PC at home on which to practice as a particular accessibility issue.

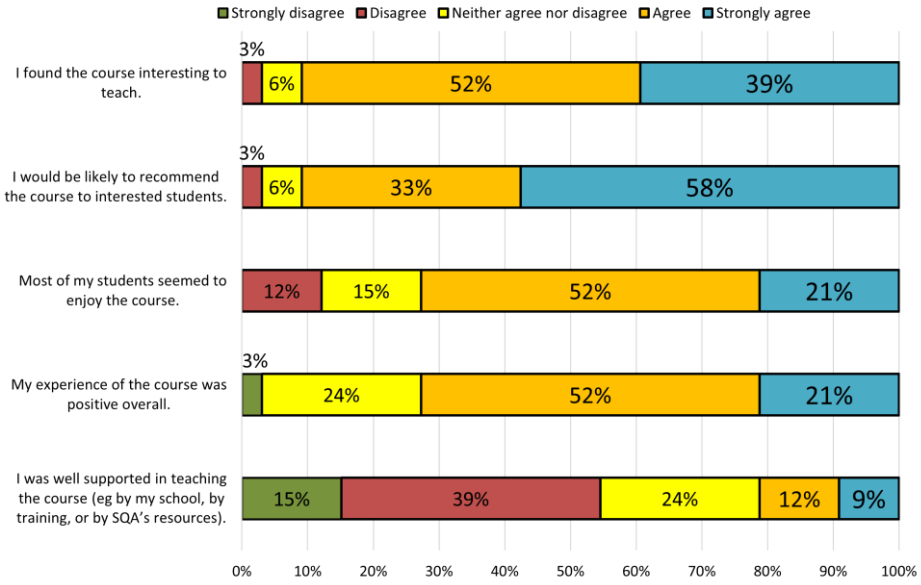

Figure 2: Experiences of the course from the practitioner survey.

Learner experiences

Learners demonstrated broadly positive feelings about the course. On 5-point 'Strongly disagree to Strongly agree' Likert scales, the majority of learners either agreed or felt neutrally about the following statements: 'I would be likely to recommend the course to other students' (23% Neither agree nor disagree, 34% Agree); 'My experience of the course has been positive overall' (27% Neither agree nor disagree, 38% Agree); 'I have found the course engaging and interesting' (27% Neither agree nor disagree, 41% Agree); and 'I have looked forward to my lessons on this course" (32% Neither agree nor disagree, 29% Agree) – see figure 3. 57% of learners indicated that the course was harder than they expected, with only 9% suggesting they found it easier.

Learner comments suggested that the wide variety of topics covered made the course appealing, and again that the real-world application of the content was well received: 'I liked everything because the things we learned can be implemented into real life scenarios, from tax, loans, to graphs and hundreds more useful things'. Other comments emphasised the fact that the course was different from anything else they had studied and that this led to their positive view. 36% of learners said 'Yes' to a question asking whether they had found the content useful to other courses, or outside academic learning. Other subjects where students found their study of Higher Applications of Mathematics helpful included STEM and computing subjects; subjects with similar 'real-world' numerical applicability (eg Business Management or Finance); and subjects where an ability to grasp statistics or evaluate the reliability of a source were advantageous, such as Geography, Modern Studies, Journalism, or English. Outside academic learning, students drew connections with future needs for financial reasoning skills, for example, managing a personal budget at university, buying a house, or paying tax.

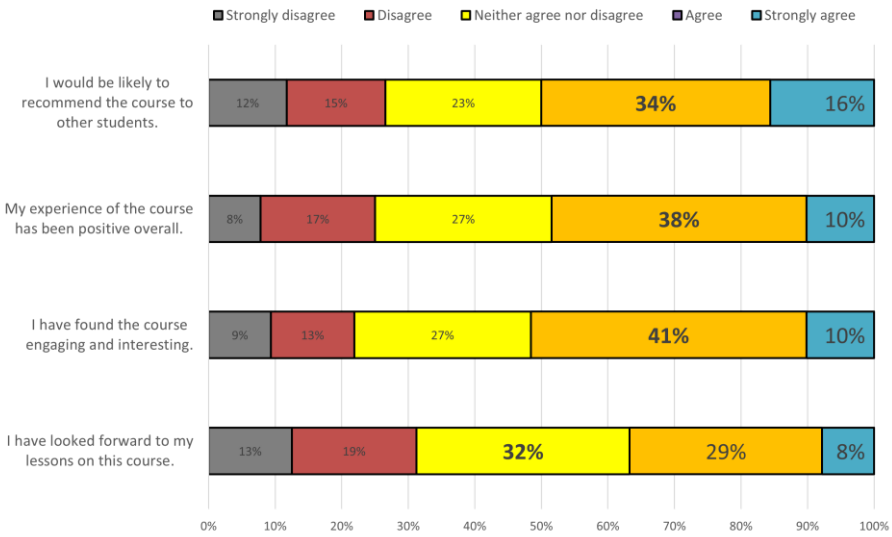

Figure 3: Experiences of the course from the learner survey.

Despite the largely positive response from learners, there were some negative experiences reported. Free text suggested that the focus on computer use came as an unwelcome surprise, with one learner saying that the qualification 'should not be called maths but computing'. Other learners reported that the assessment format was unfamiliar to them, or that the difference from National 5 Applications of Mathematics was larger than expected. This point also appeared in practitioner comments, where the need to upskill learners without strong passes at National 5 Mathematics and/or National 5 Applications of Mathematics was identified as a particular challenge. Practitioners also stated that, in their view, learners who had prior experience of computer or administration focused courses were at an advantage. Learners expressing negative reactions to the course often asserted that a lack of information regarding what the course would be like contributed to their dissatisfaction. It is possible that this reflects an expectation that the new qualification would be an easier alternative to Higher Mathematics.

The Statistics Project

Overall, learners reported that they found the project stressful but useful – that the stresses inherent to the process of quantitative research were offset by acquiring skills and demonstrating them. A question on project focus produced a wide range of areas, summarised as a word cloud below (figure 4). The range reflects the most reported positive aspects the project for learners; that they choose their own topic, and so feel personally connected to it. Unusually for mathematics qualifications, this also offers an opportunity for creativity. Again, learners stated that skills they were developing via the statistics project were clearly applicable elsewhere in their studies, and to their future career.

Practitioners indicated that they found the statistics project particularly worthwhile and beneficial, and that it presented an opportunity for critical, analytical thinking that had wide applications outside the Higher Applications of Mathematics classroom. In their view, the majority of learners enjoyed the experience of selecting a topic, finding data and thinking about its reliability, while those who struggled did so around areas that relate almost exclusively to the process of statistical analysis – for example having to deal with the disheartening experience of obtaining a

nonsignificant result – or as a consequence of having to learn a – for some - unfamiliar and unintuitive piece of software, RStudio.

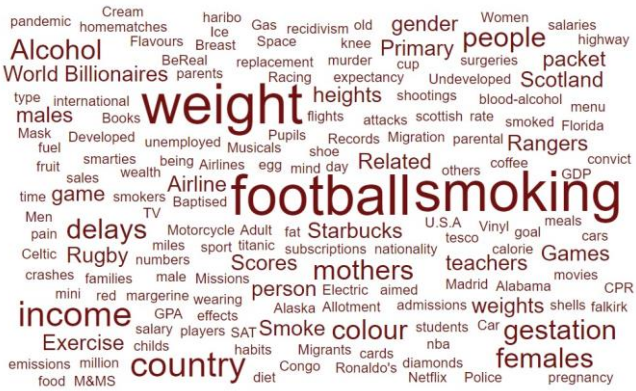

Figure 4: A word cloud of responses to the question 'On what topic did you do your statistics project?'

Conclusion

Higher Applications of Mathematics represents an important step in diversifying post-compulsory mathematics education in Scotland. Early results indicate the new qualification is achieving its aims of increasing participation and developing real-world mathematical and statistical skills. Some challenges remain in providing adequate support for learners and practitioners in the statistics and software components of the course, and in addressing learner apprehensions that the qualification represents an easier alternative to Higher Mathematics. Overall, the qualification provides a worthwhile alternative pathway that is engaging for learners. As the course embeds over time, Higher Applications of Mathematics can play an important role in making mathematics more accessible, applicable, and attractive to learners.

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