CASE STUDY

Improving Mathematical Confidence in Biosciences Through Contextualised Support: A Two-Year Initiative

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Abstract

Many undergraduate biosciences students enter university with limited mathematical preparation, often having last studied mathematics at GCSE level and perceiving it as irrelevant to their discipline. This case study describes a two-year teaching initiative at Queen Mary University of London designed to improve mathematical confidence and competence among biochemistry, biology, zoology, and medical genetics students. Following diagnostic testing and collaboration with laboratory instructors, contextualised mathematics workshops were developed and aligned with laboratory experiments covering unit conversions, molarity, dilutions, and data interpretation. The programme evolved from bi-weekly sessions in Year 1 to weekly, lab-aligned workshops with scaffolded resources in Year 2. Results demonstrated improvements in diagnostic test performance and suggested improved confidence among workshop attendees, though attendance patterns revealed challenges with student engagement during assessment-heavy periods. The findings highlight both the benefits and challenges of voluntary contextualised mathematics support within biosciences education.

Keywords: Mathematics literacy, biosciences, contextualised support, student confidence, laboratory skills.

1. Introduction

Students in bioscience disciplines frequently encounter unexpected mathematical challenges during undergraduate studies, particularly when laboratory modules require fluency in unit conversions, solution preparation, dilutions, and quantitative data interpretation. The concern about mathematical competency has grown in recent years, with technological advances making biosciences increasingly quantitative (Durán and Marshall, 2019). This was formally recognised in 1995 through a report coining the term ‘Mathematics Problem’ (LMS et al., 1995).

Many bioscience students enter university with limited recent mathematical experience. Hillman (2014) reports that only 28% of biosciences students have taken A-Level mathematics, with the majority completing mathematics only to GCSE level. In the UK, GCSE (General Certificate of Secondary Education) is taken at age 15–16, whilst A-Levels (Advanced Levels) are the pre-university qualifications taken at age 17–18. This contributes to perceptions that mathematics is not central to biological sciences, leading to difficulties when mathematical skills are required (Hester et al., 2014). Research demonstrates that students face problems with mathematical aspects of their degrees, unable to use quantitative skills to solve biology problems (Hester et al., 2014; Tariq, 2008; Bowyer and Darlington, 2018).

This case study presents a two-year initiative to address these challenges through contextualised mathematics support for first-year biosciences students: Year 1 (2022–23) served as a pilot phase focusing on programme development and refinement, whilst Year 2 (2023–24) involved systematic data collection including pre- and post-diagnostic testing, attendance tracking, and formal evaluation of the refined programme.

At Queen Mary University of London (QMUL), the School of Biological and Behavioural Sciences (SBBS) identified mathematics literacy as a priority enhancement area. Many students entering programmes in biochemistry, biology, zoology, and medical genetics have limited recent mathematical experience, with most having completed mathematics only to GCSE level. This was reinforced through my experience teaching foundation mathematics and through reports from module organisers about students' inability to perform basic calculations in first-year laboratory experiments for courses BIO190 (Practical Molecular and Cellular Biology) and BCH198 (Practical Biochemistry). Following consultation with my mentor Dr Ewan Main and module organisers, we developed mathematics support sessions tailored to first-year biosciences students, aiming to improve computational skills, build confidence, and demonstrate mathematics relevance within biological contexts.

2. Context and Literature

Mathematics support for students in non-mathematics disciplines has gained increasing attention in higher education. Lawson et al. (2019) highlight key themes including student non-engagement and support positioning within programmes. Research demonstrates that many science students struggle with mathematical concepts due to anxiety, lack of confidence, and difficulty seeing abstract procedures' relevance (Wachsmuth et al., 2017).

Contextualised teaching—embedding mathematical concepts within discipline-specific examples—has been shown to improve engagement and learning outcomes (Beswick, 2011). Koenig (2011) reported that mathematics anxiety drastically affects confidence and motivation, though embedding mathematics in biological contexts helps address both.

Maths anxiety — defined as feelings of tension and apprehension that interfere with mathematical problem solving (Ashcraft and Kirk, 2001) — is a well-documented phenomenon among undergraduate science students. Wachsmuth et al. (2017) demonstrated that many biology students harbour negative emotions towards mathematics that go beyond simple disengagement. Such anxiety can manifest as avoidance behaviour, reluctance to attempt problems, and expressions of helplessness — patterns observed informally among students in the present study, who frequently expressed sentiments such as "I don't want to do maths" or "I always find it hard." Contextualised teaching within biological settings has been shown to help mitigate these responses by making mathematics feel more relevant and less threatening (Koenig, 2011).

The timing of mathematical challenges is critical; students benefit from "just-in-time" support aligning with when they need specific skills (Jackson and Johnson, 2013). Studies of undergraduate biochemistry students have similarly identified difficulties with topics requiring mathematical skills, highlighting the need for targeted support (Watters et al., 2022). The Quality Assurance Agency Subject Benchmark for Biosciences (2023) explicitly states that mathematics is a core requisite, with manipulation of equations, problem solving, and statistical analysis crucial to the degree.

3. Programme Design and Development

3.1. Baseline assessment and learning outcomes

Prior to launching support sessions, baseline assessment was conducted through questionnaires and diagnostic testing. Results indicated that 99% of students had completed GCSE mathematics, whilst 56% had studied mathematics at A-level. Despite this, only 42% reported feeling confident in their mathematical abilities, as measured through a baseline questionnaire administered at the start of the programme, which included the item: "How confident do you feel in your mathematical abilities?" (see Section 4 and Appendix A). The programme was open to all first-year students enrolled in BIO190 (Practical Molecular and Cellular Biology) and BCH198 (Practical Biochemistry),

covering undergraduate degrees in Biology, Zoology, Biochemistry, and Medical Genetics, as illustrated in Figure 1.

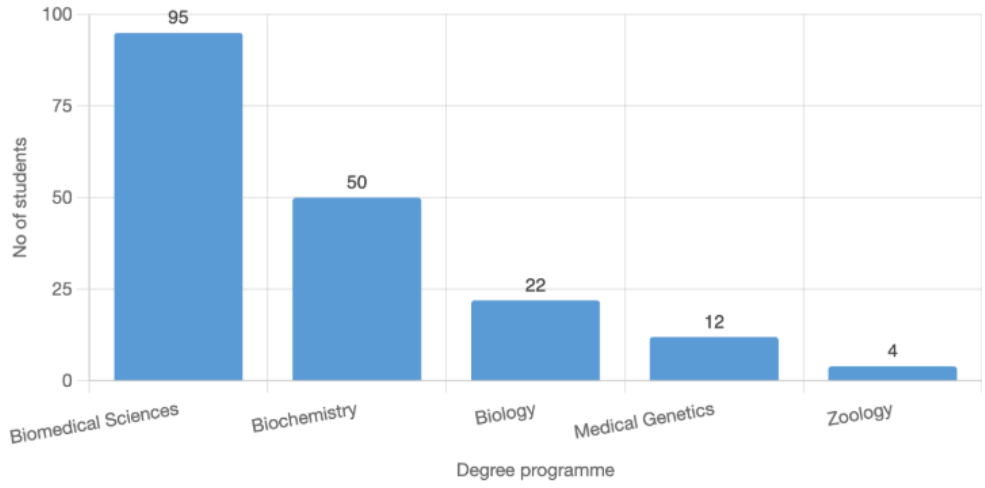


Figure 1. Distribution of students across biosciences degree programmes participating in the mathematics support programme.

The programme was structured around five core learning outcomes aligned with mathematical requirements of laboratory modules BIO190 and BCH198:

- Perform arithmetical calculations including unit conversions and precision;
- Calculate materials and solutions including molarity and dilutions;
- Manipulate and simplify algebraic and numerical expressions;
- Solve and develop equations using variables;
- Create and analyse graphs relating to different relationships.

These learning outcomes were aligned with SBBS categories to ensure curricular coherence and emphasise analytical skills development.

3.2. Year 1 implementation

The first year consisted of five one-hour sessions delivered every two weeks at 9:00 am, voluntary for all first-year biosciences students. The format centered on solving exercise sheets with brief introductions followed by guided practice.

Topics covered included: Units and Scientific Notation; Molarity and Dilutions; Numerical and Algebraic Expressions; Variables and Equations; and Graphs.

Initial implementation faced challenges. The bi-weekly schedule made it difficult to maintain momentum and alignment with concurrent laboratory activities. The one-hour format proved insufficient given the range of student abilities. Attendance declined across the five sessions, with students citing timing issues, competing commitments, and varying perceived need.

3.3. Year 2 enhancements

Based on Year 1 feedback and insights from the CETL-MSOR 2022 conference, significant changes were implemented. Sessions were restructured to run weekly, and topics were sequenced to align with laboratory experiments. This “just-in-time” approach ensured students learned mathematical concepts immediately before needing them practically.

Worksheets were redesigned to include three difficulty levels: basic "self-check" questions, standard problems aligned with laboratory requirements, and advanced challenge problems. This scaffolded approach better accommodated diverse mathematical backgrounds.

A dedicated QMplus page (Queen Mary University of London's online learning environment, available at https://qmplus.qmul.ac.uk) was established hosting all materials, additional resources, and optional online quizzes using Numbas (an open-source e-assessment system for mathematics; https://www.numbas.org.uk; Sangwin and Hunt, 2019). Plans were developed to incorporate short instructional videos for viewing before sessions. Students were encouraged to work collaboratively, and session timing was adjusted to later morning slots (around 11:00 am).

Throughout development, ongoing collaboration with module organisers ensured alignment between workshop content and laboratory requirements.

4. Evaluation Methods

The Year 2 programme was evaluated through multiple methods, following approaches recommended by MacGillivray and Croft (2011), who advocate triangulating multiple data sources rather than relying on any single measure. Patel and Little (2006) similarly emphasise the importance of measuring the impact of mathematics support through multiple indicators. Accordingly, data were collected through five complementary methods: diagnostic testing at programme start and end; attendance tracking across all sessions; questionnaires measuring confidence and perceived relevance; qualitative feedback through surveys and weekly QMplus comments; and informal discussions with students and colleagues.

The confidence and perceived relevance questionnaire was developed by the author based on the programme's learning outcomes and objectives and reviewed by mentor Dr. Ewan Main prior to administration. The full questionnaire is provided in Appendix A.

This study involved the routine evaluation of an educational support programme using anonymised, aggregated data. Participation in all questionnaires and diagnostic tests was voluntary, and students were informed at the outset that aggregated data may be used for evaluation and publication purposes. No individual students are identifiable in any output. This project was reviewed by the Queen Mary University of London Research Ethics Committee, which confirmed that no further ethical review is required (Reference number: QME26.2471, 11 May 2026).

The diagnostic test consisted of 20 questions covering core mathematical skills required for laboratory work, providing baseline and post-programme measures.

5. Results

5.1. Diagnostic test performance

An identical 20-question diagnostic test was administered at the start and end of the Year 2 programme (2023–24) to assess mathematical competence. Initial testing was conducted in September 2023 (n=185), whilst post-programme testing took place in December 2023 (n=110).

Initial testing revealed variation in mathematical preparedness, with 100 students (54.1%) scoring in the 0-10 range out of 20, indicating substantial areas requiring support.

Following the intervention, post-programme diagnostic testing showed clear descriptive improvements. Figure 2 illustrates the pre- and post-test score distributions side-by-side, demonstrating a shift towards higher performance. The proportion of students in the lowest

performance range (0-10) decreased from 54.1% to 18.2%, whilst the proportion in the highest range (16-20) increased from 10.8% to 27.3%.

As participation in both the pre- and post-diagnostic tests was voluntary, and the number of students completing each test differed (n=185 pre-test; n=110 post-test), it was not possible to conduct a matched-student analysis linking individual scores across both time points. This represents a limitation of the evaluation design. Statistical significance tests were not performed, as this study constitutes routine educational evaluation rather than formal research; results are therefore presented descriptively and should be interpreted with caution. Future iterations of the programme will incorporate anonymous but traceable identifiers and be designed with full ethical approval from the outset, enabling paired comparisons and more rigorous statistical evaluation.

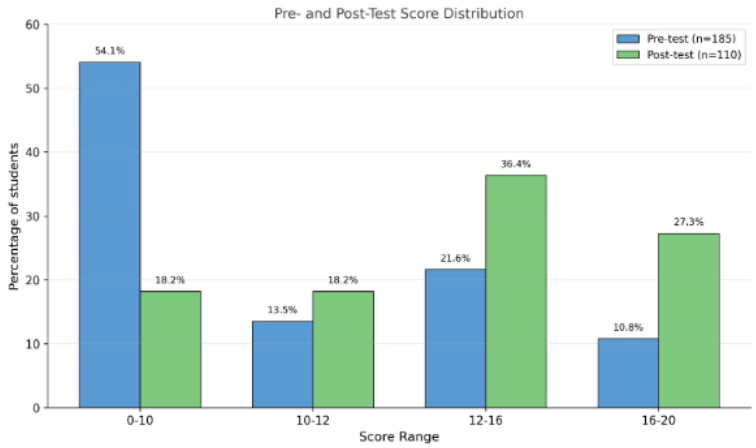


Figure 2. Pre- and post-test score distribution showing improvement in mathematical competence (n=185 pre-test, n=110 post-test).

5.2. Attendance patterns

Attendance data revealed clear engagement patterns across both years, with Figure 3 illustrating the comparative attendance trends for Year 1 (2022–23) and Year 2 (2023–24).

In Year 1, a consistent and steep decline was observed across the five bi-weekly sessions. Attendance began at 48 students in Session 1, declining to 27 students in Session 2, 16 students in Session 3, 12 students in Session 4, and 11 students in Session 5. This decline was particularly pronounced after Session 3, which preceded Week 7 — the university's designated reading week (a mid-semester break with no timetabled classes) — after which attendance did not recover.

In Year 2, the expanded programme of eight weekly sessions showed markedly improved engagement compared to Year 1. Initial attendance was considerably higher, beginning at approximately 60 students in both Sessions 1 and 2, before declining to approximately 45 students in Session 3 and 30 students in Session 4. Attendance then stabilised gradually, with approximately 25, 23, 22, and 20 students attending Sessions 5 through 8 respectively. Whilst a decline was still observed, the pattern was considerably less steep than in Year 1, suggesting that the enhancements introduced in Year 2 — including weekly scheduling, later morning timing, scaffolded worksheets, and improved alignment with laboratory activities — had a positive effect on both initial engagement and longer-term retention.

Qualitative feedback across both years revealed multiple factors contributing to declining attendance including competing commitments and varying perceived need. Some students felt confident after initial sessions and discontinued attendance, whilst others found the pace challenging.

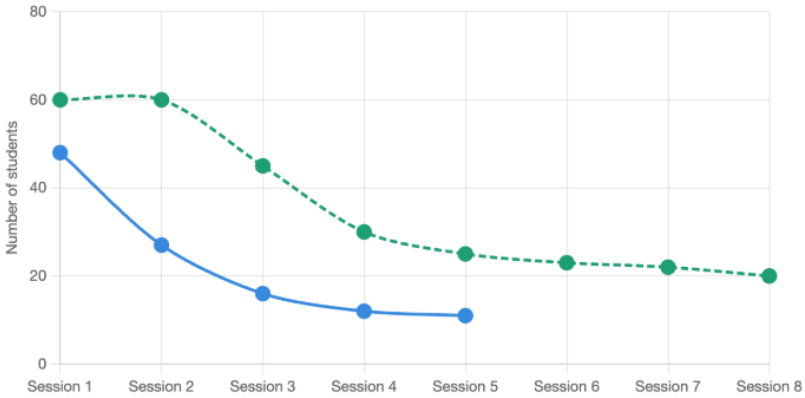


Figure 3. Attendance comparison across Year 1 (2022–23) and Year 2 (2023–24) mathematics support sessions.

5.3. Confidence and qualitative feedback

The results presented in this section relate primarily to Year 2 (2023–24), as Year 1 (2022–23) served as a pilot phase focused on programme development and refinement rather than systematic data collection. Baseline questionnaire responses from Year 2 indicated that 42% of students reported feeling confident in their mathematical abilities at programme start. Whilst no formal post-programme confidence questionnaire was administered, qualitative feedback collected from Year 2 workshop attendees through weekly QMplus comments and informal discussions suggested improved confidence among attendees, with students expressing greater comfort with laboratory calculations and unit conversions. This represents a limitation of the evaluation, as confidence data was not systematically collected using the same instrument post-intervention.

Formal end-of-programme evaluation revealed both appreciation and suggestions for enhancement. Representative comments included:

- “I am grateful for this class as a below average student in maths. It was really helpful”;
- “More questions”;
- “More interaction”;
- “More convenient time than 9am”;
- “More online quizzes”;
- “More session on graphs and analysing them”.

These comments reflect both positive impact and practical barriers affecting sustained engagement. Some explicitly stated they stopped attending because they had achieved their goals, suggesting the intervention succeeded in building confidence.

6. Discussion

The mathematics support programme demonstrated both successes and challenges common to voluntary initiatives. The contextualised approach—embedding mathematical concepts within biosciences applications and aligning sessions with laboratory activities—was effective in improving student confidence and competence for those who engaged, aligning with research showing that embedding mathematics in biological contexts helps motivation (Koenig, 2011).

The shift from bi-weekly to weekly sessions in Year 2, combined with improved laboratory schedule alignment, represented significant enhancement, implementing the “just-in-time” support model

(Jackson and Johnson, 2013). Scaffolded worksheets better accommodate the diverse cohort, whilst online resources provide valuable flexibility.

However, declining attendance presents an ongoing challenge. Whilst some attrition resulted from students achieving their goals, the 77% decline in Year 1 attendance from Session 1 to Session 5 (as shown in Figure 3) suggests competing pressures during assessment periods deterred students precisely when consolidation might be most valuable, reflecting broader challenges about life sciences students' attitudes towards mathematics (Wachsmuth et al., 2017). Despite improvements in Year 2, sustained attendance remained a substantial challenge, indicating that structural barriers and perceptions surrounding mathematics support persisted.

Maths anxiety is also likely to have played a role in both attendance patterns and student engagement. Informal observations during sessions revealed that several students exhibited classic indicators of maths anxiety, including reluctance to attempt problems independently and verbal expressions of fear or helplessness towards mathematics. Diagnostic tests may not fully capture student competence in the presence of anxiety, as performance under test conditions can be adversely affected by anxiety responses (Ashcraft and Kirk, 2001). The contextualised, low-stakes workshop environment was designed in part to address this by embedding mathematics within familiar biological contexts and encouraging collaborative working. Managing productive struggle and the emotions associated with learning mathematics is an important pedagogical consideration (Wachsmuth et al., 2017). Facilitators should be attentive to signs of anxiety and respond with encouragement rather than correction, fostering a growth-oriented rather than performance-oriented classroom culture.

The difficulty obtaining post-programme diagnostic test completion reflects challenges in evaluating voluntary support interventions (MacGillivray and Croft, 2011). The diverse mathematical backgrounds—ranging from those who found sessions too easy to those who struggled—highlights challenges that lack of mathematical knowledge adds to learning science (Park and Choi, 2013).

The findings suggest that whilst voluntary, contextualised mathematics support can be effective, consideration should be given to embedding some mathematical skill development directly within core modules to ensure all students receive necessary support. The workshops can supplement embedded provision, providing additional practice for those who seek it.

7. Future Developments

Based on two years of implementation, several enhancements are planned:

- Integration of LearnSci Smart Worksheets (interactive digital worksheets providing immediate feedback; https://learnsci.com) for more dynamic student engagement;
- Development of instructional videos (MathsCasts) for viewing before sessions, following evidence that such resources effectively complement in-person mathematics support (Loch et al., 2012);
- Implementation of centralised attendance tracking to identify students needing targeted outreach;
- Introduction of completion certificates to recognise participation;
- Improved signposting regarding workshop benefits;
- Exploration of curriculum embedding within laboratory modules;
- Reordering topics to begin with molarity and dilutions;
- Continued use of interactive tools such as Mentimeter (a live audience response platform enabling real-time polls and quizzes; https://www.mentimeter.com);

- Careful attention to feedback design, ensuring that feedback on mathematical performance promotes a growth mindset and builds confidence without exacerbating existing anxiety, in line with recommendations from Wachsmuth et al. (2017).

Future work will explore whether targeting the programme specifically at students scoring below 60% on diagnostic tests improves engagement and impact. Materials will be disseminated through incorporation into foundation mathematics course SEF040 (Foundation Mathematics) redesign, sharing with Peer-Led Team Learning (PLTL) sessions — a structured collaborative learning model in which trained student peers facilitate small group problem-solving workshops (Cracolice and Deming, 2001) — and presentation at conferences and in academic journals.

8. Conclusion

This case study demonstrates that contextualised mathematics support aligned with laboratory activities can improve confidence and competence in biosciences students, addressing the recognised challenge of mathematical literacy in life sciences education. The iterative development, responding to student feedback and insights from educational literature, highlights the importance of flexibility and responsiveness in designing support interventions.

Whilst voluntary support sessions face inherent challenges with sustained engagement—particularly given attitudes of many bioscience students towards mathematics—they serve an important role in providing targeted help to students who recognise their need for mathematical skill development. The combination of in-person workshops, online resources, and scaffolded materials accommodates diverse learning preferences and ability levels.

The programme's evolution from loosely structured bi-weekly sessions to weekly, lab-aligned workshops with multi-level resources demonstrates the value of action research approaches in educational development. Moving forward, a blended approach combining embedded mathematical skill development within core modules with voluntary enhancement workshops may offer the most comprehensive support, ensuring all students develop essential quantitative skills whilst providing additional resources for those seeking deeper understanding or facing particular challenges. The study highlights the importance of contextualised, responsive, and discipline-integrated mathematics support in improving engagement with quantitative skills in biosciences education.

Appendix A: Prior Knowledge Questionnaire 2023/2024

The following questionnaire was administered to all first-year biosciences students at the start of the Year 2 programme (2023–24) to assess prior knowledge, confidence, and attitudes towards mathematics.

1. What degree programme are you enrolled in?

2. What is the highest level of maths you have studied?

- GCSE / IGCSE / O-level
- A-level / IB / equivalent
- University-level maths
- Other

3. When was the last time you studied maths formally?

- Less than 1 year ago
- 1–2 years ago
- 3–5 years ago
- More than 5 years ago

4. How important do you think mathematics is for your degree?

- Very important
- Important
- Somewhat important
- Not important

5. How would you rate your overall confidence in your mathematical skills?

1 = Not confident at all 2 3 4 5 = Very confident

6. How confident are you in the following topics? (1 = Not confident at all, 5 = Very confident)

- Units and Conversions
- Numerical and Algebraic Operations
- Equations
- Graphs and Data Interpretation

7. Are you interested in improving your mathematical literacy?

Yes No

8. What challenges do you face when learning mathematics? (tick all that apply)

- Anxiety or lack of confidence
- Difficulty keeping up with pace of teaching
- Lack of practice opportunities
- Not seeing relevance to my degree
- Other

9. What type of support would be most useful to you? (tick all that apply)

- Revision of core topics
- Help with maths applied to biosciences (e.g., molarity, graphs, statistics)
- Practice questions / worksheets
- Online resources (videos, quizzes, tutorials)
- Drop-in sessions / one-to-one support
- Exam preparation

10. Which areas of your degree do you think will use mathematics the most?

- Chemistry / lab calculations
- Data analysis / statistics
- Physics / biomechanics
- Other

11. Why would you like to improve your maths skills?

- To pass exams
- To improve lab work
- For career development
- For general confidence
- Other

12. Is there anything else you would like us to know about your experience with maths?

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