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EDITED BY
Veruska De Caro-barek,
Norwegian University of Science and Technology, Norway

REVIEWED BY
Anupkumar D. Dhanvijay,
All India Institute of Medical Sciences, Deoghar (AIIMS Deoghar), India
Impiani Zagoto,
Universitas Nias Raya, Indonesia

*CORRESPONDENCE
Sandra Fernando
sandra.fernando@rave.ac.uk

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Are online lectures effective? Evidence from a flipped classroom pilot in UK higher education

Sandra Fernando[1]*, Bal Virdee[2], John R. Woodward[3] and Colin Haikin[4]

[1]School of Computing, Ravensbourne University London, London, United Kingdom, [2]School of Computing and Digital Media, London Metropolitan University, London, United Kingdom, [3]School of Mathematical and Computer Science, Heriot-Watt University Dubai, Dubai, United Arab Emirates, [4]Independent Education Reviewer, London, United Kingdom

Online and asynchronous lectures expanded rapidly across higher education during Covid 19, and they remain widely used today, but a central question persists: do they deliver learning benefits comparable to more traditional active or hybrid approaches, and under what conditions? This study evaluates a flipped delivery model within an Inner London university programming module, informed by evidence that students learn most effectively through active engagement, practice, and timely feedback. We analysed mixed-methods data from a cohort of 128 undergraduate students, combining institutional attendance records and assessment performance data with structured survey responses from 69 students. This study therefore provides initial observations from one module context, rather than definitive evidence of causal impact. Quantitative analysis focused on descriptive patterns and straightforward associations, including group comparisons and correlations, to examine how engagement with the flipped elements related to outcomes. Qualitative free-text responses were analysed thematically to capture perceived benefits and barriers. Overall, the exploratory findings provide context-specific evidence of student engagement with both pre-class preparation and in-class active learning, while the weak and non-significant associations between attendance, performance, and subgroup differences mean that these patterns should be interpreted cautiously. Thematic results converged with the quantitative evidence, emphasising the value of interactive support during class and the flexibility of self-paced materials, while also highlighting areas for improvement in structure, pacing, and resource organisation. Collectively, the results suggest that, in this module context, online lectures may be more educationally useful when used as an asynchronous foundation within a feedback-rich flipped or hybrid design, rather than as a stand-alone substitute for interactive teaching.

KEYWORDS
asynchronous learning, attendance, flipped classroom, learning analytics, mixed methods, online lectures, programming education

1 Introduction

Online educational delivery became the dominant mode of instruction during the Covid-19 pandemic, requiring higher education (HE) institutions to rapidly adapt teaching practices at scale. Although most universities in the UK have since reverted predominantly to in-person delivery, recent declines in overseas student enrolments have created significant financial pressures across the sector. In response, many institutions are increasingly adopting online and asynchronous delivery as a cost-saving measure.

This renewed shift towards online and asynchronous lectures, often implemented without systematic evaluation, raises important questions about their effectiveness in supporting student learning. In particular, concerns have emerged regarding whether these approaches can deliver learning outcomes comparable to those associated with more active, interactive, or hybrid pedagogical models. While online delivery offers flexibility and scalability, there is a risk that it may encourage predominantly passive forms of engagement if not carefully designed.

A consistent finding across the learning sciences and higher education pedagogy literature is that students learn more effectively when instructional designs require active engagement, deliberate practice, and timely feedback, rather than relying primarily on passive exposure to content (Freeman et al., 2014; Prince, 2004). Meta-analyses demonstrate that active learning approaches are associated with improved conceptual understanding, higher achievement, and reduced failure rates compared with traditional lecture-based instruction.

Within this context, online lectures should be conceptualised not as a direct replacement for teaching, but as one component within a broader learning design. To be pedagogically effective, online and asynchronous materials must be integrated with opportunities for interaction, formative assessment, and guided application of knowledge. Without such integration, there is a risk that cost-driven adoption of online delivery may undermine the quality of the learning experience rather than enhance it.

Flipped and blended models provide a structured way to achieve this integration. In flipped designs, students engage with core content before class and then use synchronous time for guided practice, peer learning, and feedback, making class time more cognitively demanding and supportive (Bishop and Verleger, 2013; Lage et al., 2000). Theory-based accounts highlight potential benefits, but also note, implementation risks, including uneven preparation, increased cognitive load, and misalignment between pre-class materials and in-class tasks (Abeysekera and Dawson, 2015). At a broader level, evidence suggests that blended learning can match or exceed face-to-face outcomes; however, observed gains often reflect instructional design features, time on task, and opportunities for interaction, rather than the online medium itself (Means et al., 2010).

These issues are particularly salient in computer science programming education, where learning practical skills depends on repeated practice, debugging, and rapid feedback, and where misconceptions can persist if not dealt with early (Robins et al., 2003). They are also closely linked to equity concerns. Contemporary HE cohorts are diverse, including younger students still developing self-regulation skills, mature students balancing work and caring responsibilities, and students facing constraints related to connectivity, devices, or study space. International students may encounter additional barriers associated with language ability and reduced local support networks (IT or social). Research on student engagement and persistence indicates that such contextual factors shape participation and outcomes, suggesting that institutional decisions about online delivery are also decisions about inclusion (Kahu, 2013; Tinto, 2012).

This article provides an exploratory, context-specific evaluation of a flipped delivery model in an Inner London undergraduate programming module. Rather than seeking to establish definitive causal effects, the study aims to identify and illustrate potential conditions under which asynchronous lectures may support effective learning when combined with structured in-class practice, feedback, and student support. Using mixed-methods data that combine attendance records, assessment performance, and student survey responses, we examine engagement with pre-class preparation and in-class active learning, explore associations with learning outcomes, with students' qualitative accounts of factors that supported or hindered their learning. The aim is to inform course design and institutional policy by identifying conditions under which asynchronous lectures contribute to effective and equitable learning within a hybrid approach.

2 Literature and pedagogical framing

HE teaching is most effective when learning design aligns intended outcomes, learning activities, and assessment (constructive alignment). Across disciplines, research on university learning emphasises that students learn most deeply through active engagement, prompt feedback, and opportunities to apply concepts not through passive exposure to content alone (Biggs and Tang, 2011; Chickering and Gamson, 1987; Freeman et al., 2014). Online lectures can therefore be understood as a flexible resource for explanation and rehearsal, but they need to be embedded within an activity- and feedback-rich pedagogy to produce reliable gains.

In the UK, HE cohorts are also heterogeneous in life stage and study conditions. Many young adults are still developing academic self-regulation and benefit from structure, social learning, and rapid feedback loops. Mature and part-time learners commonly study while time-poor (work and caring responsibilities) and may depend more heavily on flexible study pathways; adult-learning perspectives highlight relevance, autonomy, and practical application as key motivators (HESA, 2025; Knowles, 1984; Tinto, 2012, 2017; UK Parliament, 2017). These realities strengthen the case for hybrid designs that combine accessible asynchronous materials with protected, high-value synchronous time for practice, coaching, and peer interaction.

Equity considerations cut across delivery modes. Students from deprived backgrounds can face digital poverty (device access, data costs, and unreliable connectivity), which risks widening attainment gaps when online components are assumed rather than supported (Jisc, 2024a; OECD, 2023). International students may also experience additional barriers in online delivery, including foreign language interpreting, cultural differences, and isolation (i.e., lack of peer network), which can reduce participation and belonging if interaction is not

intentionally designed (Karkar-Esperat, 2018; Wang and Liu, 2024). Free online courses frequently report completion rates below 10%, indicating drop-out rates above 90%, largely due to low barriers to enrolment and limited learner commitment (Reich and Ruipérez-Valiente, 2019). Accordingly, the pedagogical question is not whether online lectures are effective in principle, but under what access conditions and learning-design choices support participation, achievement, and student experience in HE.

2.1 Prior evidence on online lectures and hybrid/flipped delivery

Table 1 summarises influential evidence that frames online/asynchronous lectures as most effective when combined with active learning and structured support. Across meta-analyses, blended or flipped designs tend to outperform purely lecture-based delivery, but effects depend on design quality (e.g., formative quizzes, alignment between pre-class materials and in-class practice) and on student access and self-regulation.

The above evidence converges on a consistent message. Online materials work best when they are integrated into a deliberately designed learning sequence (not used as a standalone substitute for teaching). Across meta-analyses and HE studies, the strongest outcomes tend to be reported for blended or flipped designs that combine flexible pre-class resources with structured in-class practice, interaction, and feedback provided students have adequate access, support, and clear expectations.

Across this literature, two recurring messages are particularly relevant to programming modules. First, asynchronous video lectures are rarely a complete substitute for interactive learning; learning gains are typically strongest when online materials are integrated with active, coached practice, peer interaction, and timely feedback (Freeman et al., 2014; van Alten et al., 2019). Second, student behaviours (preparation, attendance, and strategic use of recordings) moderate outcomes: recordings can support review and accessibility but may not fully compensate for sustained non-attendance or weak self-regulation (Edwards

TABLE 1 Summary of prior evidence on online lecture delivery and hybrid approaches.

Table	Design/context	Key findings	Suggestions
Means et al. (2010)	Meta-analysis (online vs. F2F; blended vs. F2F)	Blended conditions often show better outcomes than purely F2F; effects depend on implementation.	Supports hybrid designs rather than 'online only'.
Bernard et al. (2004)	Meta-analysis (distance vs. classroom)	Average effects ~0 with high variability; modality matters (synchronous vs. asynchronous).	Expect heterogeneity; examine design and context.
Freeman et al. (2014)	Meta-analysis (active learning in STEM)	Active learning increases performance and reduces failure compared to traditional lecturing.	Justifies prioritising practice, feedback, and peer instruction.
van Alten et al. (2019)	Meta-analysis (flipped classroom)	Small positive effect on learning outcomes; no consistent satisfaction gain; quizzes and preserved contact time help.	Design details (quizzes, alignment) likely drive benefits.
Akçayır and Akçayır (2018)	Review (flipped classroom challenges/benefits)	Benefits include performance and flexibility; challenges include preparation and workload.	Anticipate preparation barriers; provide scaffolds.
Bishop and Verleger (2013)	Survey/review (flipped classroom)	Flipped combines video lectures with active problem solving; evidence base growing but mixed.	Need local evaluation of engagement and outcomes.
Edwards and Clinton (2019)	UK HE empirical study (lecture capture)	Lecture attendance predicts attainment; capture availability may reduce attendance; viewing doesn't fully compensate for non-attendance.	Monitor attendance; treat recordings as supplement not replacement.
Nordmann et al. (2019)	UK HE empirical study (attendance+recordings)	In early years, attendance and recording use can both predict performance; effects vary by year.	Expect different patterns across cohorts; target first-year support.
Hodges et al. (2020)	Conceptual (ERT vs. online learning)	Emergency remote teaching differs from designed online learning; evaluation must consider this distinction.	Interpret findings in light of intentional design vs. rapid pivot.
Office for Students (2023)	UK regulatory view (blended learning)	Providers must ensure quality academic experience, resources, support, and clear communication in blended models.	Policy framing transparency, student engagement, and adequate resourcing.
Biggs and Tang (2011)	HE pedagogy (constructive alignment)	Learning quality improves when outcomes, learning activities, and assessment are aligned; students learn through doing and feedback, not content exposure alone.	Frames online lectures as part of an aligned sequence: pre-class explanation must connect to in-class practice and assessment.
Jisc (2024a)	UK HE sector evidence (2023/24 survey) (student digital experience)	A substantial minority of students report poor Wi-Fi/data costs and unequal digital access/skills, affecting engagement with online learning.	Supports explicit access/readiness checks and targeted support so hybrid delivery does not widen disadvantage.
Karkar-Esperat (2018)	Case study (international graduate students in asynchronous online classes)	International students reported challenges with language, isolation, and unclear instructor expectations alongside flexibility benefits.	Highlights the need for inclusive communication, clear guidance, and designed interaction for international students in hybrid models.

and Clinton 2019; Nordmann et al., 2019). Therefore, evaluations of 'online lectures' should focus less on the media format and more on the learning design, support structures, and analytics-to-intervention loops that make engagement actionable (Hodges et al., 2020; Office for Students, 2023).

Flipped learning is commonly defined as a combination of (a) direct instruction content (often video or reading) completed before class and (b) interactive, group-based learning activities during class. Studies and reviews report potential benefits such as improved performance, engagement, and learner autonomy, while also noting implementation challenges particularly around the quality and accessibility of out-of-class materials and student compliance with preparation. In STEM contexts, active learning has been associated with higher examination performance and reduced failure rates (Freeman et al., 2014).

3 Methodology

A mixed methods evaluation was conducted two months into delivery of the Level 4 Computer Science Programming module, where Level 4 refers to first-year undergraduate study in the UK higher education framework. The module carried 30 UK credits, representing a substantial module within the academic year. using routinely collected module data alongside a student survey completed with informed ethical consent. The module used a flipped delivery model, with core content completed before class and class time dedicated to active practice, discussion, and feedback. The dataset includes 69 undergraduate students who took the survey, enrolled in computing-related programmes. All 69 rows is a row the same as a student were retained. Missing categorical values were recoded as 'Not known'; missing numeric outcomes were left as missing and handled via available-case analysis (pairwise deletion) for correlations and group comparisons.

Attendance was defined as recorded presence in scheduled module sessions, with programming attendance referring specifically to sessions focused on programming practice and related assessed skills. The survey was administered approximately two months into module delivery, after students had experienced both pre-class asynchronous materials and in-class active learning activities. MCQ performance refers to the Semester 1 multiple-choice assessment covering core programming concepts taught during the module. Open-ended responses were coded inductively, with recurring ideas grouped into themes through iterative review.

Descriptive statistics summarised distributions and missingness. Comparative analyses explored relationships between attendance, demographics, perceptions, and MCQ results. Open-ended responses were analyzed thematically using an inductive coding approach. Initial coding was conducted by the lead author, who reviewed all responses to identify recurring ideas and patterns. Codes were then grouped into broader categories through iterative comparison, and the final themes were refined to ensure they accurately represented the student comments. To improve transparency, one or two short illustrative excerpts from student responses were included alongside the themes. For example, students highlighted the value of "in-class support" and "working through coding problems together", while also requesting "clearer resources" and "better structure" for pre-class materials.

The cohort is demographically diverse and unevenly distributed across categories as in Table 2. Several fields include a small 'Not known' group, which is retained to avoid excluding students in a small dataset. These characteristics matter for interpretation: overall findings reflect this cohort context and should be generalised cautiously, while equity considerations (e.g., access and support needs) remain central.

The cohort was predominantly male (81.2%). In terms of ethnicity, 49.3% were recorded as BAME and 15.9% as White, while 34.8% were recorded as 'Not known'. BAME refers to Black, Asian and Minority Ethnic students, a commonly used UK reporting category. The term is used here because it reflects the available institutional demographic categories; however, it is recognized that this broad grouping can mask important differences between individual ethnic groups. The largest programme groups were BSc Computer Networking ($n = 20$) and BSc Computer Science ($n = 14$).

The eligible cohort consisted of 128 undergraduate students enrolled on the module. Of these, 69 students completed the survey, giving a response rate of 53.9%. This response rate is acceptable for an exploratory module evaluation, but it also means that the survey findings should be interpreted cautiously. Students who completed the survey may have been more engaged, more confident, or more willing to provide feedback than those who did not respond. Therefore, non-response bias cannot be ruled out.

Figure 1 flow diagram shows the total eligible cohort ($n = 128$), the number of students who completed the survey ($n = 69$), and the subset with available MCQ performance data ($n = 48$), illustrating the samples used across different analyses.

3.1 This section outlines the survey questions and the rationale underpinning their design

> Q1 Preparation: How often did you watch or read the pre class materials before the session?

TABLE 2 Student demographics ($N = 69$).

Category	Group	N	Percentage (%)
Gender	Male	56	81.2
Gender	Female	13	18.8
Ethnicity	BAME	34	49.3
Ethnicity	Not known	24	34.8
Ethnicity	White	11	15.9
Course enrolled	BSc Computer Networking	20	29.0
Course enrolled	BSc Computer Science	14	20.3
Course enrolled	BEng Computer Systems	8	11.6
Course enrolled	BEng AI & Robotics	8	11.6
Course enrolled	BSc Data Science	6	8.7
Course enrolled	BSc Digital Forensics	5	7.2
Course enrolled	BSc Computing	5	7.2
Course enrolled	BEng Electronic Engineering	2	2.9
Course enrolled	Not known	1	1.4

> Q2 Understanding: The pre class materials helped me understand the topic

> Q3 Engagement: The in-class coding and discussion activities supported my learning

> Q4 Confidence: The module helped me feel confident applying concepts to problems

> Q5 Overall preference: I prefer this flipped approach compared with a traditional lecture only approach

> Q6 Open response: What worked well, what did not, and what should be improved in this delivery approach?

The survey was designed to capture the flipped model as a simple learning pathway from preparation to outcomes. Q1 measures behavioural engagement with the asynchronous materials, since preparation is a key condition for a flipped approach to function as intended. Q2 assesses whether those materials supported understanding, linking preparation to perceived learning value. Q3 focuses on the core added value of the flipped design, namely active in class practice and interaction. Q4 captures perceived capability to apply learning, which is especially important in programming where competence depends on practice. Q5 provides an overall judgement of acceptability and comparative preference against traditional delivery. Q6 allows students to explain drivers behind their ratings, identify barriers, and suggest improvements, enabling triangulation with attendance and assessment data.

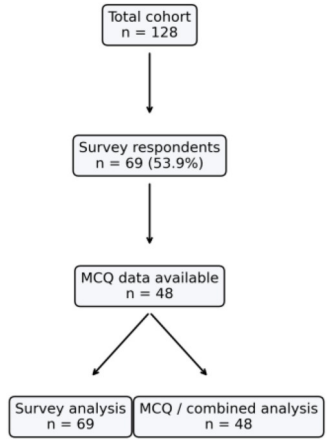

FIGURE 1
Participant inclusion and data availability across analyses.

4 Results

Table 3 summarises attendance and attainment show moderate central values with substantial variability. Overall attendance averages 52.7% (range 9.0–87.0), while programming attendance averages 38.6% (range 0–87), indicating that engagement differs widely between students. Semester 1 MCQ performance centres around the mid-50s (mean 55.4; IQR 45.0–65.0; range 20.0–90.0). IQR is the interquartile range, showing where the middle 50 percent of values lie, from the 25th percentile to the 75th percentile.

For example, an IQR of 38.8 to 67.0 for Overall Attendance means half of students' attendance fell between 38.8 percent and 67.0 percent.suggesting a mixed-attainment cohort where both support needs and opportunities for extension are likely present.

MCQ results were available for 48 of 69 students (69.6%). Overall attendance was broadly mid-range (median 54%), with programming attendance showing a similar median (40%) but wider spread.

Group comparisons suggest some differences summarised in Table 4, but they should be interpreted cautiously because subgroup sizes are small (e.g., females $n = 8$). In this sample, female students have a higher average MCQ score (66.2) than male students (53.3); however, uncertainty is high given the small female subgroup. Ethnicity group means are broadly similar, with any apparent gaps likely sensitive to small numbers and missingness, so the most defensible conclusion is that attainment varies within groups more than between groups.

Female students showed higher average MCQ scores than male students, though the sample of females with MCQ data was small ($n = 8$). Differences across ethnicity groups were not clear in this dataset.

Table 5 presents the relationships between attendance and MCQ performance. Attendance alone explained little variance in MCQ performance. Programming attendance showed a weak, non-significant positive association with MCQ outcomes ($r = 0.22$, $p = 0.126$), while overall attendance showed a near-zero, non-significant association ($r = 0.06$, $p = 0.681$). Although this tentative pattern is educationally plausible, as attendance in sessions most closely aligned to assessed skills may matter more

TABLE 4 MCQ performance by gender and ethnicity (available MCQ $n = 48$).

Group	Category	n	Mean%	Std Dev%	Median%
Gender	Female	8	66.2	16.6	65.0
Gender	Male	40	53.3	15.3	52.5
Ethnicity	BAME	22	56.4	16.1	52.5
Ethnicity	Not known	18	57.8	16.3	57.5
Ethnicity	White	8	47.5	15.1	52.5

TABLE 3 Descriptive statistics for attendance and MCQ performance.

Measure	n	Mean %	SD%	Median%	IQR (25–75%)	Range
Overall Attendance	68	52.7	19.8	54.0	38.8–67.0	9.0–87.0
Programming Attendance	69	38.6	17.2	40.0	27.0–46.0	0–87
Sem1 MCQ results	48	55.4	16.1	55.0	45.0–65.0	20.0–90.0

than overall presence, these findings should be interpreted as descriptive only rather than evidence of a reliable relationship between attendance and attainment.

4.1 Descriptive and comparative visualisations

MCQ scores have a mean 55.4 with range 20.0–90.0. Figure 2 distribution indicates a cohort with heterogeneous prior knowledge and learning conditions, supporting the case for a hybrid design that combines core explanation (asynchronous) with targeted practice and feedback (in-class) so that lower-scoring students can catch up while higher-scoring students can be extended.

Figure 3 scatter plot has a shallow upward tendency student with higher programming attendance often have higher MCQ scores consistent with the modest positive correlation ($r = 0.22$). However, the wide vertical spread at similar attendance levels implies that attendance alone does not explain attainment; quality of engagement, prior preparation, and access/readiness factors likely contribute to differences.

The gender comparison visualises a higher central tendency for females than males in this dataset, aligning with the higher female mean in Figure 4. Because the female subgroup is small, the key message is not a definitive gender effect but that subgroup patterns can look different in small cohorts reinforcing the need for inclusive design and ongoing monitoring rather than assumptions about who benefits.

Scores tend to be higher in the upper programming-attendance quartiles, which is consistent with the modest positive association in Figure 5. This suggests that the learning activities captured in "programming attendance" are likely aligned with assessed outcomes and may be a useful lever for improvement (e.g., by strengthening support and motivation for regular participation).

TABLE 5 Relationships between attendance and MCQ performance.

Attendance metric	Pearson r with MCQ	*p*-value	Interpretation
Programming attendance	0.22	0.126	Weak positive
Overall attendance	0.06	0.681	Near-zero

4.1 Student perceptions by survey item

Closed-item responses indicated strong engagement with the flipped design. Preparation (Q1) was high, with 82.6% responding 'Always' or 'Often'. For Q2–Q4, a majority selected 'Agree/Strongly agree' (63.8%–72.5%). Preference (Q5) was more mixed, with 42.0% selecting 'Agree/Strongly agree' and 39.1% selecting 'Sometimes'. This indicates that students' perceptions of the flipped classroom are generally positive.

Figure 6 illustrates, through a bar chart, that students report strong engagement with preparatory materials and generally positive perceptions of the learning benefits. For preparation, 44.9% reported "Always" engaging with pre-class materials and 37.7% reported "Often". Across learning outcomes, agreement is high: understanding (Q2) 63.8% agree/strongly agree, engagement (Q3) 72.5%, confidence (Q4) 60.8%, while preference (Q5) is more mixed (42.0% agree/strongly agree), suggesting that students value the approach but do not experience it uniformly.

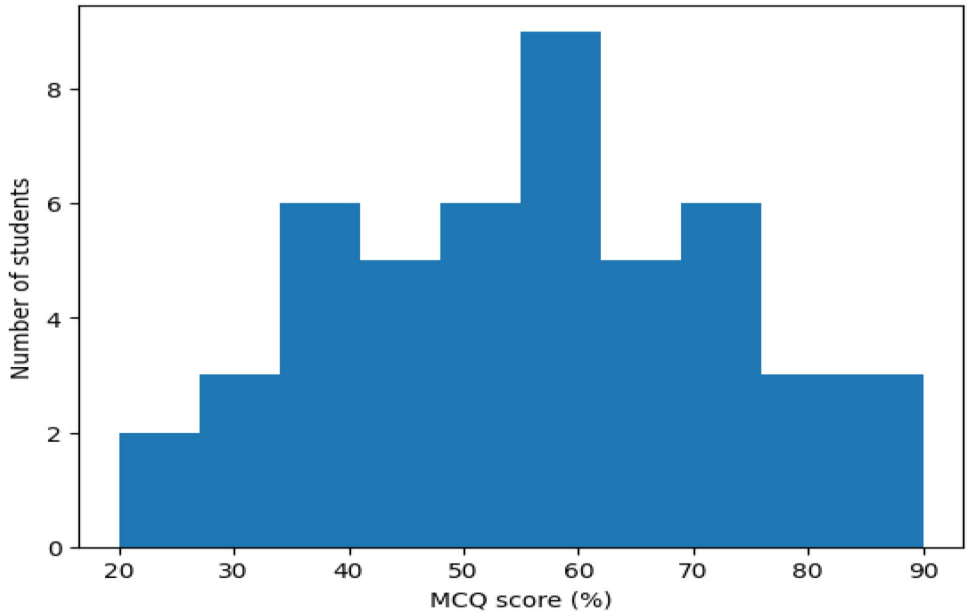

FIGURE 2
Distribution of semester 1 MCQ results ($n = 48$).

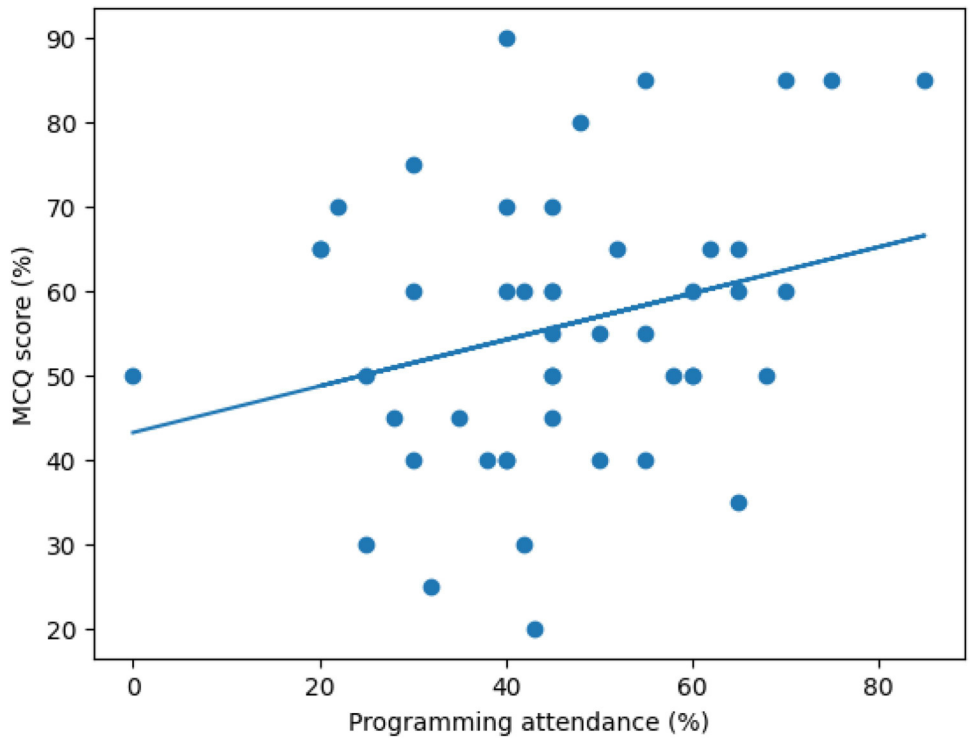

FIGURE 3
Programming attendance vs. MCQ results (points=students with both measures).

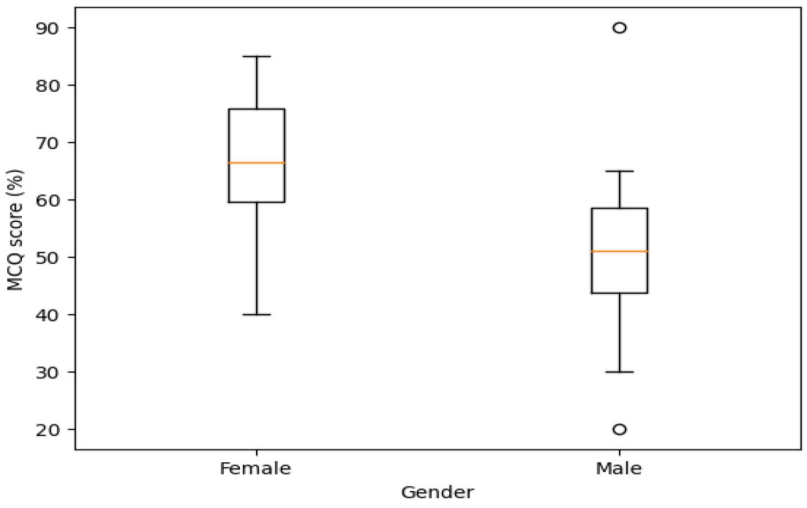

FIGURE 4
MCQ results by gender (available MCQ $n = 48$).

4.2 Survey response distributions

> Q1 Preparation: How often did you watch or read the pre class materials before the session?

Figure 7 illustrates that most students report consistent pre-class preparation, with nearly half selecting "Always" and a further substantial group selecting "Often". This pattern supports the feasibility of a flipped/hybrid model in this cohort, while the small "Sometimes/Never" group highlights the importance of scaffolding, reminders, and low-stakes accountability to avoid widening gaps.

> Q2 Understanding: The pre class materials helped me understand the topic

> Q3 Engagement: The in-class coding and discussion activities supported my learning

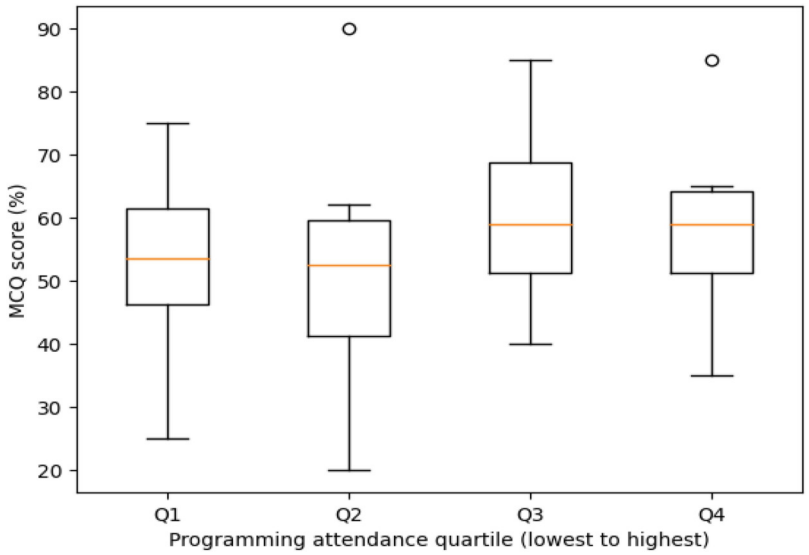

FIGURE 5
MCQ results across programming attendance quartiles.

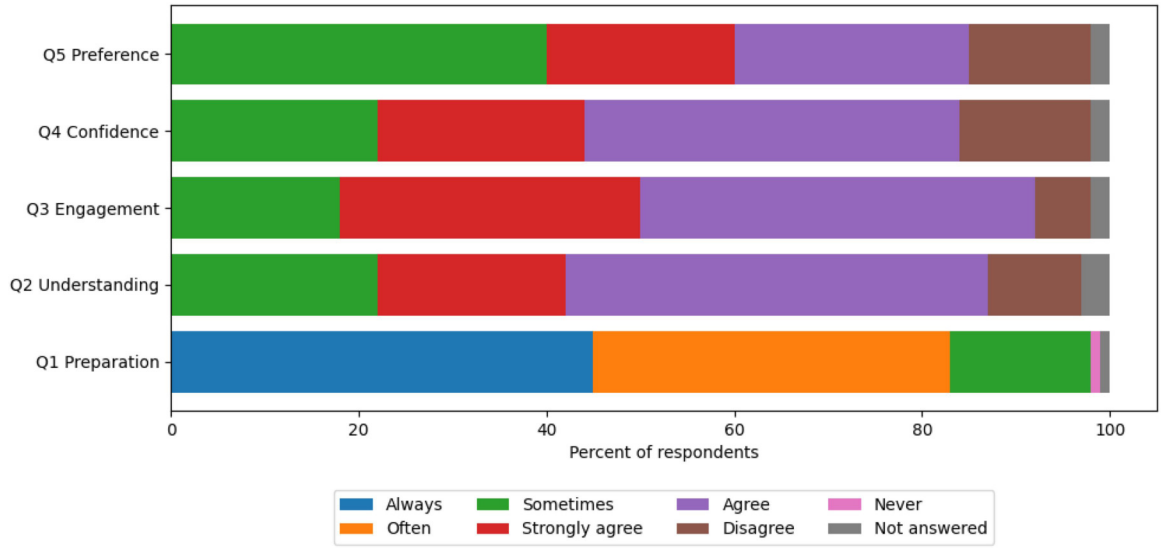

FIGURE 6
Response distributions for closed survey items ($N = 69$).

> Q4 Confidence: The module helped me feel confident applying concepts to problems

> Q5 Overall preference: I prefer this flipped approach compared with a traditional lecture only approach

As in Figure 8, the strongest agreement is seen for engagement and understanding (Q2–Q3), followed by confidence (Q4). Preference (Q5) shows more neutral/mixed responses, indicating that "what works" differs across students often reflecting time constraints, commuting, caring responsibilities, and digital access. The implication is that hybrid delivery should preserve choice and flexibility while protecting interactive learning time and structured support.

Exploratory associations suggested that self-reported preparation (Q1) was positively associated with programming attendance (Spearman ρ=0.24, $p = 0.046$; $n = 68$). Other perception items showed small, non-significant associations with attendance and MCQ performance in this dataset.

4.3 Thematic analysis of open-ended responses

> Q6 Open response: What worked well, what did not, and what should be improved in this delivery approach

Open-ended comments were provided by 44 students (excluding 'Not answered/Not known'). Inductive coding identified five

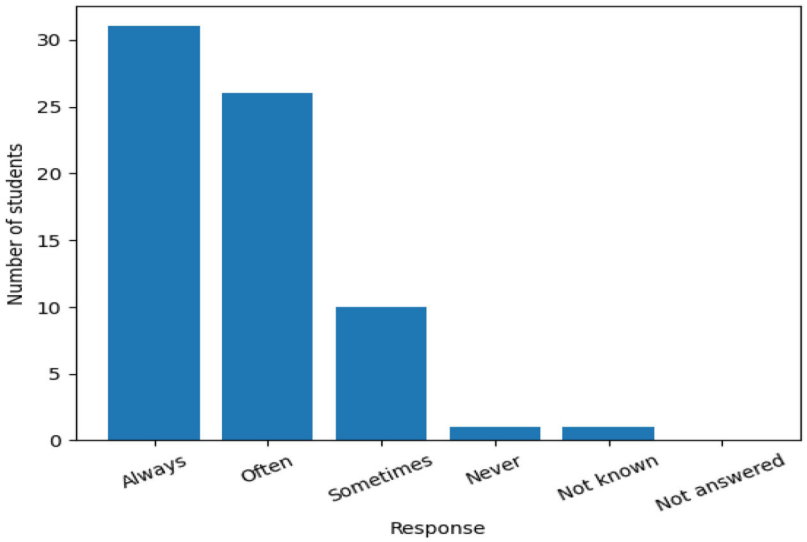

FIGURE 7
Response distribution for Q1 (pre-class preparation).

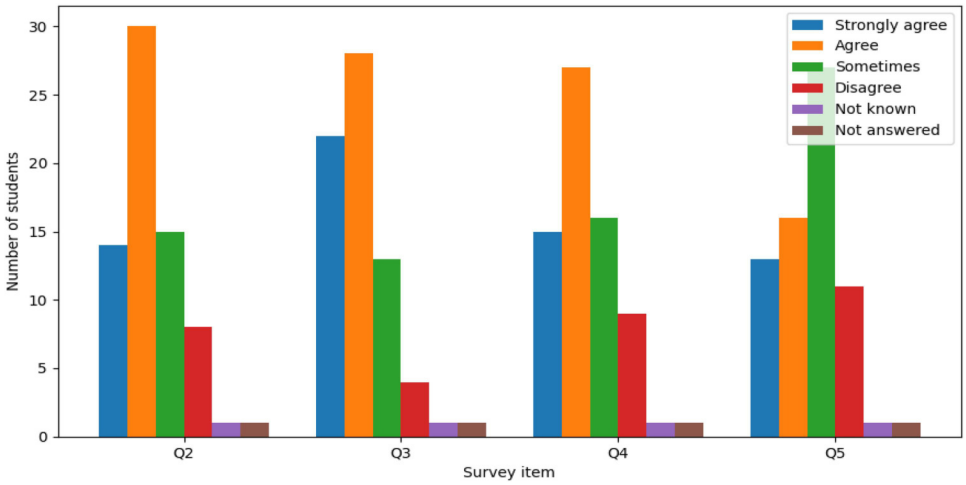

FIGURE 8
Response distribution for Q2–Q5 (understanding, engagement, confidence, and preference).

prominent themes (Table 6), including strong emphasis on interactive support and practical work, alongside concrete suggestions for improving resource design and pacing.

Qualitative themes reinforce the quantitative pattern: students frequently emphasise practical improvements and the value of interaction. The most common theme was "Areas to improve (resources/structure)" (56.8%), closely followed by "In-class interaction & support" (54.5%). Together, these themes indicate that students want hybrid delivery that is well-structured and resourced, and that uses on-campus time for help, feedback, and problem-solving rather than repeating content.

TABLE 6 Prominent themes in open-ended responses ($n = 44$).

Theme	Count (responses mentioning)	% of respondents
Areas to improve (resources/structure)	25	56.8
In-class interaction & support	24	54.5
Flexibility & self-paced prep	18	40.9
Confidence & understanding	17	38.6
Hands-on practice & problem-solving	13	29.5

4.4 Word cloud and theme frequency

The word cloud in Figure 9 highlights the vocabulary most frequently used by students when describing the learning

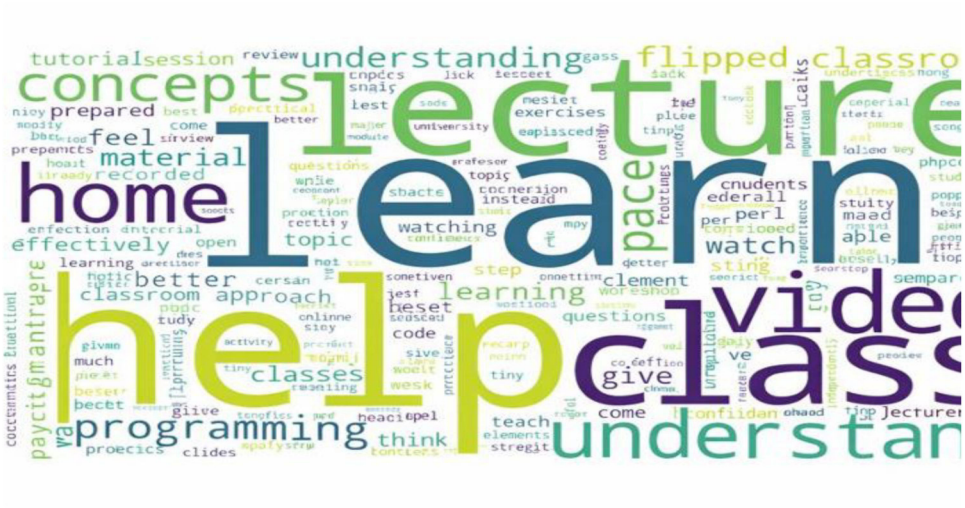

FIGURE 9
Word cloud of open-ended responses.

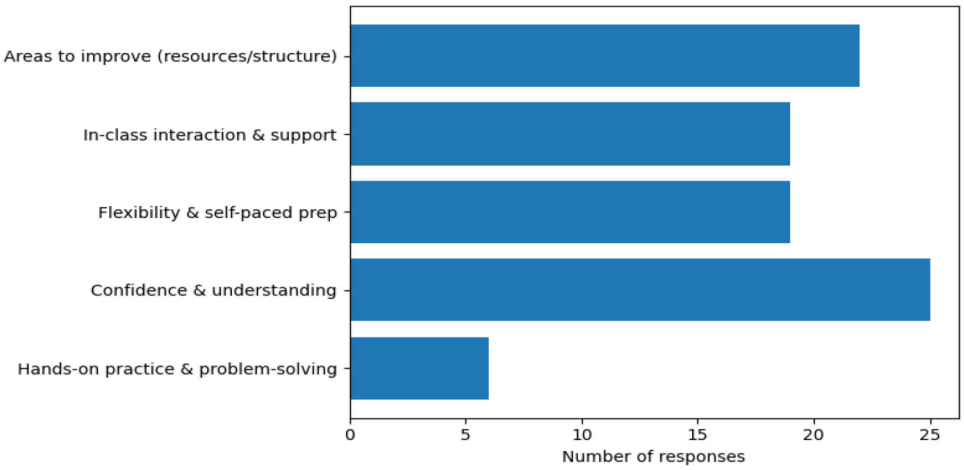

FIGURE 10
Number of responses mentioning each theme.

experience. The prominence of terms related to support, understanding, and structure is consistent with the thematic results, suggesting that students judge online components less by "delivery mode" and more by whether materials are clear, well-organised, and connected to in-class practice.

Figure 10 theme-frequency chart shows that comments concentrate around two priorities: improving structure/resources and maintaining strong in-class interaction and support. The distribution also indicates substantial demand for flexibility and self-paced preparation, supporting a hybrid approach that combines high-quality asynchronous materials with protected time for active, supported learning.

1. **Context:** The cohort is diverse by ethnicity and programme, but predominantly male. Missingness in demographics and MCQ outcomes highlights the importance of designing evaluation systems that are robust to incomplete reporting.
2. **Analysis:** Quantitative results indicate that attendance measures alone are weak predictors of MCQ performance. However, the weak positive association between programming attendance and MCQ performance, combined with the significant link between preparation and programming attendance, suggests that the mechanism of benefit is likely not 'being present' *per se* but participating in practice and feedback cycles.

5 Discussion

To integrate findings into a Context, Analysis, Practice, Evaluation (CAPE lens) we interpret the results as follows (Anderson, 2017):

These findings align with prior research showing that active learning and flipped designs tend to improve engagement and learning outcomes when compared with passive lecture-based approaches (Freeman et al., 2014; van Alten et al., 2019). Consistent with Edwards and Clinton (2019) and Nordmann

et al. (2019), the results also suggest that attendance alone is not a strong predictor of attainment, and that how students engage with learning activities may matter more than simple presence. More broadly, the findings support the view that online materials are most effective when integrated within a structured learning design that includes interaction, feedback, and guided practice (Hodges et al., 2020; Means et al., 2010).

3. **Practice:** Survey responses and themes converge on a consistent message: students value the interactive, guided practice component of the flipped design. They also request improvements to the structure, clarity, and pacing of asynchronous materials consistent with known implementation challenges for flipped delivery.
4. **Evaluation:** The overall pattern supports a hybrid interpretation of online lecture

Effectiveness: *Asynchronous lectures can provide flexibility and baseline understanding, but learning is most reliably achieved when they are tightly coupled with active practice, rapid feedback, and inclusive support structures.*

5.1 Proposed hybrid framework for implementation

Based on the quantitative and qualitative results, we propose a CAPE-informed Hierarchy of Asynchronous Learning Design that treats asynchronous lectures as a foundation rather than the whole intervention. Figure 11 framework is represented as a layered pyramid to emphasise that higher-level outcomes depend on strong lower-level enabling conditions.

The pyramid emphasises dependency: higher-level outcomes (achievement, belonging, equity) are unlikely to be realised unless the lower layers (access/readiness and a coherent asynchronous core) are reliably in place. In practical terms, this means institutions should treat devices/connectivity, onboarding, and course design quality as foundational requirements, then build interactive practice and feedback routines on top to turn online lectures into measurable learning gains.

Below we give a list of implementation guidelines which follow from our analysis.

Implementation guidance:

1. **Access & readiness:** confirm device/connectivity access; provide short orientation materials and time-management prompts.
2. **Asynchronous core:** provide micro-lectures (≤10–12 min), worked examples, and quick checks for understanding.
3. **Active synchronous/in-class practice:** use guided labs, pair programming, and peer instruction; explicitly connect each activity to the pre-class materials.
4. **Analytics & feedback:** combine attendance signals, formative checks, and MCQ diagnostics to identify students needing support; offer targeted catch-up resources.
5. **Achievement & equity:** evaluate not only scores but also confidence and participation; iterate materials based on student feedback and learning analytics.

5.2 Higher education policy implications

Implementation at scale requires treating hybrid learning as a regulated quality and equality issue, not a purely local teaching choice. At programme level, providers should publish transparent expectations about contact time, the purpose of online lecture components, and the forms of interaction students can rely on and then assure these through module approval, periodic review, and student feedback loops (Office for

FIGURE 11
Proposed hierarchy of asynchronous learning design.

Students 2023; QAA, 2023). At institutional level, widening-participation commitments imply routine monitoring of digital access and participation (e.g., early-term checks and referral routes for device/connectivity support), and staff development focused on learning design, inclusive online communication, and assessment literacy.

Policy implication for HE leaders is therefore to invest in (i) baseline digital inclusion (devices, connectivity, skills support), (ii) curriculum design capacity (templates, learning design teams, and quality standards for asynchronous materials), and (iii) evidence-informed evaluation (learning analytics used ethically and triangulated with student voice). Where resourcing is constrained, prioritising the pyramid's lower layers (access/readiness and coherent asynchronous core) is likely to deliver the largest marginal gains, because weaknesses there can undermine all higher-level improvements.

Quality and transparency: Sector regulators emphasise that blended delivery must still provide a high-quality academic experience with appropriate resources, support, and student engagement. In practice, this means clearly communicating what is delivered online vs. in person, how each component supports learning outcomes, and how students can access help (Office for Students, 2023).

Parity of learning opportunity and inclusion: Quality guidance highlights the need for inclusive learning and teaching, with parity of quality for all students 'wherever or however' learning is enabled. For hybrid models this strengthens the case for monitoring digital access (devices/connectivity), accessibility of recorded materials (captions, chunked micro-lectures), and timely academic support for students who are working or commuting (QAA, 2023).

Evidence-informed curriculum design: 'Beyond blended' work in the UK stresses that institutions should treat place, platform, pace, blend, flexibility and support as explicit design dimensions, not operational afterthoughts. The CAPE-informed pyramid proposed here aligns with this by positioning access/readiness and asynchronous core materials as prerequisites for effective in-class practice and feedback (Jisc, 2024b).

Learning analytics with an intervention ethic: The present results suggest that attendance alone is a weak predictor of MCQ performance; however, combining signals (attendance, formative checks, short quizzes, and reflective prompts) can help identify who needs support. Policy-wise, institutions should treat analytics as part of a 'support loop' with clear consent, transparency, and targeted interventions rather than surveillance.

Staff workload and professional development: Hybrid delivery increases demand on staff time (resource production, moderation, feedback, analytics). Flexible learning frameworks emphasise aligning institutional policy, administrative systems, and infrastructure to support staff capability e.g., media support teams, template learning designs, and workload models that recognise digital production (Advance, 2024).

5.2.1 Below we list several practical recommendations for HE

- Publish a clear 'learning contract' for each module: expected weekly time, which elements are asynchronous vs. synchronous, and how they connect.
- Adopt minimum standards for asynchronous materials (e.g., micro-lecture length, captions, worked examples, and weekly formative checks).
- Protect active contact time for guided practice (labs, peer instruction, structured problem solving) and explicitly link tasks to pre-class content.
- Implement an analytics-to-support workflow (early alerts +follow-up + targeted resources) with transparent data use and opt-out where feasible.
- Audit access and inclusion (devices, bandwidth, accessibility needs) and provide alternatives (low-bandwidth versions, transcripts, on-campus study spaces).

Together, these actions can help HE providers strengthen engagement and equity while ensuring that flexible delivery still supports consistent learning outcomes across diverse student cohorts.

6 Limitations

This study offers useful early evidence about how asynchronous online lectures can support a flipped programming module. At the same time, the findings should be read as indicative and context specific, rather than as definitive claims that will transfer unchanged to every setting. As a general principle, results are strongest when interpreted within the range of the data and the learning context from which they were produced.

First, the evaluation focuses on one cohort within a single institution and discipline. This provides a clear, coherent case study, but it also means that patterns of engagement and preparation may look different in other courses, year groups, or institutional cultures.

Second, attainment evidence is incomplete, with MCQ results available for 48 of the 69 survey respondents. This reduces the strength of subgroup comparisons and makes correlational patterns less precise. The survey response rate was 53.9% (69 of 128 eligible students), so non-response bias is possible because respondents may not fully represent the wider cohort. In addition, attendance was captured at session level, which is appropriate for a module evaluation but does not allow more detailed insights into how students engaged within each session or activity.

Third, several measures rely on self-reported preparation, understanding, and confidence. These perspectives are valuable in education research because they reflect students lived experience, but they can be influenced by recall and social desirability. It is also possible that students who felt more engaged were more likely to complete the survey, which may slightly tilt the overall picture in a positive direction.

Fourth, the study does not include a control or comparison condition. As a result, the evidence supports interpretation of relationships between preparation, attendance, and attainment within this module, but it cannot establish that the flipped model caused the observed outcomes when compared with other delivery formats.

Fifth, learning outcomes were assessed using a single MCQ test, which is well suited to checking conceptual understanding

but does not capture the full range of programming competence, such as debugging, sustained problem solving, or project-based development. A wider assessment portfolio would provide a fuller view of learning.

Finally, the evaluation represents a mid-module snapshot. Student behaviours and perceptions can shift across a semester as workload increases, assessment approaches, and support needs change. Longer follow up would help to understand whether the observed patterns persist or evolve over time.

Taken together, these points highlight promising directions for future work, such as repeating the evaluation across multiple cohorts, combining survey responses with richer learning traces (for example, video engagement and code submission activity), and using broader assessment evidence. In particular, programming is a distinctive skill domain, so it is sensible to treat these findings as most directly applicable to similar computing contexts, while using further studies to explore how far they travel to other disciplines and settings.

7 Conclusion

In this computer programming module, the findings provide indicative and context-specific evidence that asynchronous online lecture components may support learning when embedded within a flipped, hybrid approach that includes interactive practice and feedback. However, the observed associations between attendance and MCQ performance were weak and not statistically significant, so the findings should not be interpreted as causal or generalizable evidence. The findings should therefore be understood as exploratory and context-specific, identifying potential design conditions for effective asynchronous lecture use rather than definitively establishing their general effectiveness. Attendance measures alone were weak predictors of MCQ performance in this small dataset (with partial MCQ availability), suggesting that 'being present' is not a sufficient mechanism. Student perceptions and open comments converged on a consistent message: asynchronous resources support flexibility and baseline understanding, but students still need structured pacing, explicit links to in-class tasks, and accessible support to benefit fully.

A CAPE-informed interpretation indicates that asynchronous lectures can deliver baseline understanding, but learning gains are most reliable when tightly coupled to active, coached practice (labs, pair programming, peer instruction), frequent formative checks, and a feedback loop that turns engagement signals into timely support. The proposed pyramid framework operationalises this by sequencing access/readiness, asynchronous core resources, active practice, analytics and feedback, and achievement and equity outcomes.

For higher education policy and institutional strategy, the implication is to move beyond a 'modality debate' and focus on assuring design quality, transparency, and inclusive support in blended provision. Aligning modules to sector expectations on a high-quality academic experience and parity of learning opportunity supports minimum standards for asynchronous resources (captions, chunking, worked examples, structured weekly checks), protected active learning time, and an analytics-to-intervention workflow with transparent, student-centred use of learner data.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: Data can be provided upon request. Requests to access these datasets should be directed to sandra.fernando@rave.ac.uk.

Ethics statement

The requirement of ethical approval was waived by the University Research Ethics Sub-Committee (RESC), London Metropolitan University for the studies involving humans due to the low-risk nature of the study, which involved a voluntary student survey and the use of anonymised learning-related data reported only in aggregate form. All data were handled in accordance with institutional data protection policies and UK GDPR requirements. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board also waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because the study was low risk, involved a voluntary student survey, and used anonymised learning-related data. Collecting signed consent forms was not necessary for the study design and could have affected participant anonymity. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

SF: Conceptualization, Data curation, Methodology, Visualization, Writing – original draft. BV: Project administration, Supervision, Validation, Writing – review & editing. JW: Formal analysis, Validation, Writing – review & editing. CH: Validation, Writing – review & editing.

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