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Bespoke, Relevant, and Inclusive Self-Paced, Online Modules to Build Tertiary Mathematics Engagement and Confidence

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Abstract

Tertiary mathematics teaching is predominantly face-to-face, yet large, diverse cohorts and limited contact hours constrain opportunities for individually paced practice and timely feedback. We developed three bespoke, self-paced online numeracy modules, each targeting a specific mathematical concept and disciplinary context. Module design was informed by learning theory (constructivist, active learning, Universal Design for Learning, inclusive learning practices). We ran a qualitative pilot study to gain insight into user perceptions of modules in terms of engagement and perceived learning support, conducting semi-structured interviews with undergraduate science students (n = 11) and educators (n = 7). We applied thematic analysis to interview data, which generated the following insights. Students—many reporting high mathematics anxiety—responded positively, valuing low-stakes iterative practice, clear stepwise scaffolding, multimodal presentation, contextualized examples aligned to their course, and a supportive instructor voice. These features were described as reducing anxiety, reframing errors as part of learning, and supporting inclusion, despite prevalent math avoidance in the cohort. Staff feedback was more cautious, recognizing similar strengths but focusing on areas for improvement. We argue that bespoke, contextualized modules can augment face-to-face instruction by delivering individualized pacing and immediate feedback at scale, while contributing to the creation of an accessible, inclusive, supportive learning environment. Future work should quantify learning outcomes, track affective changes longitudinally, and isolate contributions of specific design features across diverse cohorts and disciplines.

Keywords: student engagement; inclusive education; Universal Design for Learning; cultivating belonging; self-paced learning modules; growth mindset

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1. Introduction

At university, many students struggle to engage with mathematics learning. Insufficient prior preparation and foundational knowledge in mathematics are significant barriers to student success and engagement (Suleiman et al., 2024). Structural and contextual challenges—including heavy course loads, limited access to resources, and suboptimal teaching methods—further contribute to reduced engagement and achievement in university-level mathematics (Hari Rajan et al., 2024; Suleiman et al., 2024). Additionally, affective factors such as negative experiences of prior math learning, low motivation and mathematics anxiety can undermine students' willingness to engage and persist with challenging mathematical content (Canning et al., 2019; Daker et al., 2021; Khasawneh

et al., 2021; Muenks et al., 2020; O'Leary et al., 2017; Thomas & Maree, 2022; Wong et al., 2024). Global syntheses and OECD PISA analyses show that mathematics anxiety—tension or fear that interferes with performance—is widespread and negatively associated with performance in 39+ countries, and that classroom climate and formative assessment can mitigate anxiety (Dowker et al., 2016; OECD, 2017). This anxiety drives avoidance of quantitative tasks and prospectively predicts both taking fewer Science, Technology, Engineering, and Mathematics (STEM) courses and earning lower STEM grades across four years, even after controlling for math aptitude (Ashcraft, 2002; Daker et al., 2021; Dowker et al., 2016). Limited engagement with mathematics therefore presents a major challenge to student achievement of learning outcomes in STEM courses.

These challenges intersect with equity concerns. In Australia and internationally, gaps in numeracy and STEM participation persist across gender and minoritized groups, mirroring broader socioeconomic and structural inequities (ACARA, 2021; Department of Industry, Science and Resources, 2024; Valero & Meaney, 2014). Practical barriers compound these challenges: national student-experience data show that health/stress, financial difficulty, workload, and paid-work responsibilities are among the most common reasons students consider withdrawing from tertiary education—constraints that can limit attendance at face-to-face sessions and suppress help-seeking (QILT, 2023). These barriers are especially pronounced for students from diverse backgrounds, including those who had weaker math preparation in school and/or come from disadvantaged socioeconomic contexts, both in Australia and globally (ACARA, 2021; Bowman & Denson, 2022; Sedlacek et al., 2025; Valero & Meaney, 2014), and/or live with disability or neurodivergent conditions.

Meta-analyses of TIMSS/PISA across 69 nations reveal small average gender differences in achievement but larger, variable differences in attitudes and affect linked to national gender equity indicators (Else-Quest et al., 2010; OECD, 2017). Further, the debated "gender equality paradox" reports lower female STEM degree participation in some countries with high overall gender equality, despite strong school performance, underscoring complex societal and motivational factors (Richardson et al., 2020; Stoet & Geary, 2018). Beyond gender, UNESCO's global monitoring shows women still comprise ~35% of STEM graduates with little change in a decade, and regional data from Africa and Latin America highlight digital access, affordability, and infrastructure as persistent constraints that disproportionately affect underserved learners (UNESCO, 2024). Collectively, these affective, structural, and logistical barriers underscore the need for supportive, flexible interventions that help diverse learners re-enter mathematics learning with confidence.

In this context, online modules (incorporating active learning and feedback in a digital format) offer potential advantages as a learning tool. They provide a flexible and scalable mechanism for delivering self-paced learning content and immediate feedback to large, diverse cohorts (Martin et al., 2020). Online modules also lend themselves to the development of highly structured, step-by-step learning resources. For anxious or novice learners, as are commonly found in tertiary science courses, step-by-step guidance can reduce cognitive load and support learning by preventing "floundering" (Gula et al., 2015; Kirschner et al., 2006; Sweller et al., 2019). While sustaining student engagement and a sense of belonging in online settings remains a significant challenge in higher education (Muljana & Luo, 2019), meta-analyses show that online and blended formats yield outcomes equal or modestly superior to face-to-face when they incorporate interaction and cognitive supports (Bernard et al., 2014; Means et al., 2009).

There is substantial evidence for the benefit of online modules as learning tools in pre-university contexts (Q. Li & Ma, 2010; Cheung & Slavin, 2013); however, their use to scaffold numeracy development in tertiary STEM remains underexplored (Nguyen et al., 2021). Where modules have been utilized in math education, they are typically generic,

commercially available products. This is despite evidence from school and tertiary studies that contextualization is essential for effective mathematical application (Haines & Crouch, 2001; Tallman et al., 2016; Verschaffel et al., 1994). Where processes are taught or assessed in context-insensitive ways, learners tend to adopt procedural, context-blind strategies that impede transfer, modelling, interpretation, and validation. In contrast, contextualization has the potential to enhance student engagement, increase relevance, and improve the achievement of learning outcomes (Arcellana-Panlilio & Dyjur, 2021; Madrazo & Dio, 2020; Osika et al., 2022).

We present an early-stage evaluation of bespoke, self-paced modules designed to support mathematics learning in an undergraduate biological science context. Unlike most prior studies, our modules are custom-built and contextualized to the disciplinary content and needs of our student cohort, representing a novel approach in tertiary math education. We explore the potential for tailored, numeracy modules to engage students, build confidence, and foster a supportive and inclusive environment—contributors to belonging (Whiteside et al., 2023)—in tertiary STEM learning.

2. Materials and Methods

2.1. Study Context and Design

This manuscript presents the first stage of a broader project exploring the scaffolded implementation of unit-tailored numeracy modules across a program. The broader project asks whether bespoke numeracy modules:

RQ1. Improve tertiary students' confidence and engagement with core numeracy (and, in later phases, mastery/learning benefit)?
RQ2. Reduce student anxiety associated with numeracy?
RQ3. Promote student awareness of numeracy as a tool to explore global diversity?

To investigate the impact of bespoke, online, self-paced numeracy modules on these outcomes (RQ1–3), three pilot modules were developed, collectively called Diversity in Numbers (DiN) modules. Each module focused on a numeracy concept that is core for undergraduate STEM education (unit conversions, *t*-tests, and correlations and regressions). Modules were made available to both staff and student study participants prior to interviews to gather feedback. We anticipated that participant numbers would be low based on previous experiences with similar student cohorts, and therefore adopted an inductive qualitative approach, using semi-structured interviews that enabled participants to share their perspectives in a semi-directed, exploratory manner. Qualitative methods are well established as appropriate and robust for exploring complex experiences and perspectives, particularly in contexts where low participant numbers are expected and where depth of insight is prioritized over breadth (Braun & Clarke, 2013; Mason, 2010).

In the present pilot study, we report qualitative findings on:

RQ1: Students' experiences of engagement and confidence while using the modules (mastery/learning gains were not estimated at this stage);
RQ2: Baseline student attitudes to mathematics/numeracy and whether anxiety-support features were visible, acceptable, and/or valued;
RQ3: Whether diversity/representation features were visible, acceptable, and/or valued by students.

Educator interviews were also conducted and presented to triangulate student accounts and to surface implementation or other factors associated with the adoption of numeracy modules in a tertiary math education context. Semi-structured prompts in participant interviews (perceptions of the modules, RQ1; mathematics histories, RQ2; experiences of diversity in science, RQ3; see Section 2.4) were selected to elicit data aligned to these aims.

2.2. Design Features of Numeracy Modules

Each numeracy module was developed as an H5P Interactive Book®, which consisted of scaffolded content presented in concise blocks, interspersed with active learning elements. Supplementary Figure S1 provides an example of how content for one numeracy module, on correlations and regressions, was structured. Across modules, content was scaffolded to build numeracy skills progressively, without assuming prior learning, from foundational concepts to the level required at the tertiary level for STEM units.

Four overarching design principles were applied in the development of numeracy modules: integration of active learning approaches, implementation of Universal Design for Learning (UDL) principles, incorporation of curriculum design elements to support learner safety and representation, and the contextualization of learning. These four design principles, and examples of specific module design features associated with each of these principles, are summarized in Figure 1.

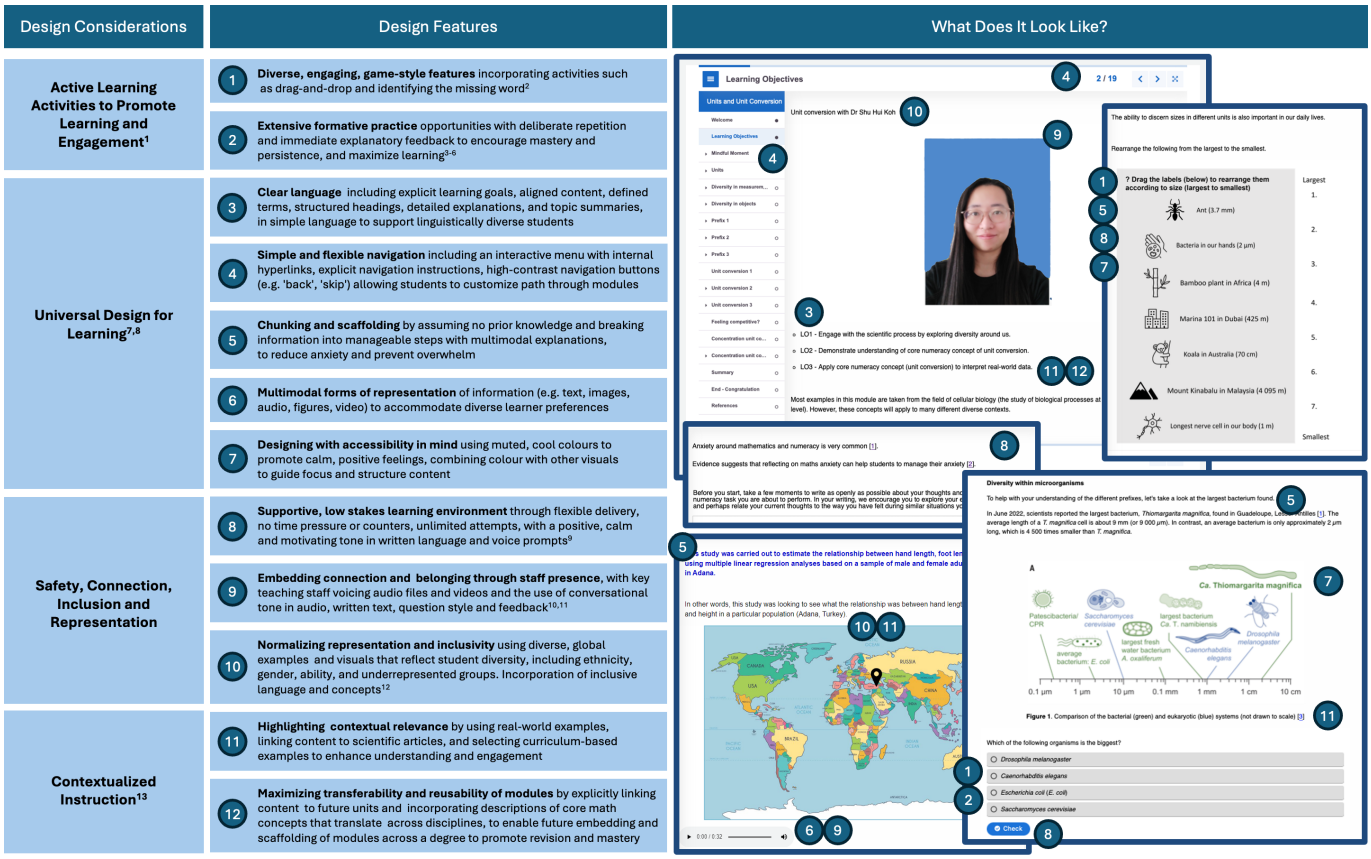


Figure 1. Overarching design principles and features of numeracy modules. Numbered design features (numbers in blue circles) correspond to examples illustrated and numbered on the accompanying images. [1] (Bonwell & Eison, 1991) [2] (M. Li et al., 2023) [3] (Mancenido et al., 2024) [4] (Bennett, 2011) [5] (Gikandi et al., 2011) [6] (Shute, 2008) [7] (Meyer et al., 2014) [8] (Yang et al., 2024) [9] (Rusticus et al., 2023) [10] (Kreijns et al., 2024) [11] (Costello et al., 2025) [12] (Duncan et al., 2023) [13] (Toan et al., 2025).

Consistent with the Interactive, Constructive, Active, Passive (ICAP) (Chi & Wylie, 2014) framework, we operationalized active learning as overt, cognitively engaged learner behavior elicited by the modules at the active (manipulation) and constructive (generation) levels. Active learning was implemented through inclusion of formative questions, presented using varied H5P® activity types, (e.g., drag and drop, fill in the blanks and find multiple hotspots; Figure 1: design features 1 and 2), Kahoot® quizzes, and multimodal delivery of content (incorporating text, images, lightboard videos and Vyond® animations;

Figure 1: design features 5 and 6). These activities require students to manipulate content (active) and generate responses or self-explanations (constructive). Modules return immediate, tailored information in direct response to student actions (see question responses, Figure 1: design features 2 and 8). Formative questions provide immediate, detailed, alternative-specific explanatory feedback, so students know whether their personal response is correct and why/why not. Most item types provide students with the option to reattempt items without penalty. This design embeds timely, explanatory feedback at scale and provides students with certainty about their understanding of component concepts as they work through the module. The focus on active learning elements reflects constructivist learning theory and aligns with evidence that technology-supported, individual active-learning tasks can improve performance and engagement in higher-education settings even without peer discussion (Opre et al., 2024; Wiggins et al., 2017). Consistent with this aim, the modules did not include dialogic, peer-to-peer activities associated with ICAP's interactive level. We adopt the contemporary view that active learning is a student-centered approach involving doing and thinking—not limited to group work (Chi & Wylie, 2014; Doolittle et al., 2023).

Drawing on Universal Design for Learning principles (Meyer et al., 2014) to maximize accessibility to learners with diverse needs, multiple forms of representation were incorporated, including text, audio (narrating the text) and video (with subtitles), although time constraints meant the level of incorporation of these features varied between modules. Simple and concise English was employed to support culturally and linguistically diverse students. Consistent formatting and explicit instructions on how to navigate through material were provided to further reduce the cognitive load of navigating through and transitioning between modules (Figure 1: design features 3–7).

Modules were designed intentionally to create a safe, supportive, inclusive online learning environment for diverse students, to promote success among diverse learners in the context of ongoing underrepresentation of diverse people in science (Department of Industry, Science and Resources, 2024). Module content was chosen to highlight and celebrate global diversity, and attention was given to creating a staff presence in modules through participation in embedded videos and the incorporation of a conversational style in module text (Figure 1: design features 8–10). Based on the findings of Ramirez and Beilock (2011), each module started with a brief written activity where students reflected on their thoughts and feelings about the numeracy content of the upcoming module, which is proposed to help with managing numeracy anxiety by encouraging students to articulate and reframe their thoughts and feelings before engaging with content.

Each module was designed for a particular course and disciplinary area (e.g., cell biology, physiology), to highlight the significance of math skills in a professional setting. Examples and active learning elements were drawn from relevant biological concepts covered in the course, to help students navigate new mathematical content and underline its relevance to their overall learning (Figure 1: design features 11 and 12). For example, a module on unit conversion for a cell biology course included exercises where students had to arrange biological structures (e.g., organelles, organisms) labelled with different units (e.g., microns, mm) in size order. Two of three modules (aimed at second-year courses) were framed around published scientific articles from their respective discipline areas, which were directly relevant to the content in the course for which the module was intended (see Supplementary Figure S1). In one example, students studying forensic anthropology were taught principles of correlation through the relationships between the length of specific bones and overall skeleton size, and the application of regression equations to estimate the stature of an individual from these measurements. While this contextualization was an important design feature, the core numeracy content in each module (e.g., descriptions of

how to perform unit conversions) was written to be relevant across learning contexts, to enable future repurposing of modules in other courses, by retaining numeracy descriptions but incorporating new examples relevant to a different student cohort.

2.3. Participants

A total of 11 students and 7 staff from Murdoch University participated in interviews. Student participants were recruited through announcements posted on the learning management system of three biology courses (combined annual enrollment of ~800 students from BIO152 Cell Biology, BMS213 Forensic Anatomy and Anthropology, and BMS206 Biomedical Physiology) and a student online community site for the School of Medical, Molecular and Forensic Sciences. To contextualize the convenience sample, we note that cohorts in the three source courses are primarily on-campus (face-to-face) with extremely limited online study; domestic students represent the majority of students, with 15–25% international enrolment depending on the unit. Enrolments were female-skewed (~60–70% female) with most learners (60–70% depending on the unit) concentrated in the 18–23 age band. These unit-level characteristics are provided for context and should not be interpreted as the demographics of the interview participants. All enrolled students were provided with access to a dedicated learning management system project site containing detailed study information and a consent form. Interested students reviewed the online information and provided informed consent through a secure, survey-based link hosted on the project site. This recruitment and consent process was designed to minimize burden, preserve anonymity at the point of consent, and reduce perceived power imbalances between staff and students. All recruitment and data collection procedures followed the approved Human Research Ethics Committee protocol (2022/093). As several of the researchers in this study were also course coordinators, data analysis took place only after the release of results to avoid any perceived conflict.

Staff participants were recruited by email based on professional expertise in the domains of numeracy, numeracy anxiety, learning design, equity, diversity and accessibility, student learning and support, and/or STEM education.

2.4. Interviews

We aimed to conduct focus groups to capture multiple student perspectives within each session; however, scheduling constraints related to participants' university and personal commitments meant that most data were collected through individual interviews. One of the nine student interviews consisted of more than one student (n = 3), while the remaining eight interviews were conducted one-on-one with individual participants, collectively referred to as the interviews (11 student participants in total). We acknowledge that individual interviews, while allowing for in-depth exploration of personal experiences, may limit the opportunity for participants to interact and build on each other's perspectives as would occur in a traditional focus group setting. Staff interviews consisted of two groups (n = 3 and 4 participants, respectively).

Prior to interviews, student and staff participants were given access to numeracy modules for a minimum of 10 days. Interviews were conducted by a research assistant and supervisor (non-faculty third parties, not involved in teaching or module design) via Microsoft Teams® or in person in a computer teaching laboratory on campus, allowing participants to access modules during interviews if they wanted to. Interviews ran for approximately 90 min, and audio transcriptions provided to the research team were de-identified (between 11 and 23 pages per interview).

The interviews were conducted in a semi-structured format, encouraging participants to lead the discussion with the facilitator intervening only as needed to maintain flow and

inclusivity. This format, particularly appropriate for an early-stage intervention (Kelly et al., 2010), encourages spontaneous accounts and allows issues to arise naturally from participants' experiences that might otherwise be overlooked. Interviews were structured around three key domains: perceptions of modules, math history and experience, and experience of diversity in science. Supplementary Table S1 provides a complete record of interview topics and prompts.

2.5. Data Analysis

Interview transcripts were de-identified by an independent third party prior to analysis (including removal of participant names, courses, and staff roles) and tagged with unique codes. Thematic analysis followed the six-phase process described by Braun and Clarke (2013): (1) familiarization with the data; (2) initial coding; (3) searching for themes; (4) reviewing themes; (5) defining and naming themes; and (6) producing the report. Thematic codes were assigned by two members of the research team, who first independently read all transcripts, identifying common and salient themes using an open-coding approach. Codes were iteratively compared and grouped into higher-order categories, which formed the basis of the development of themes. Codes and supporting quotations were collated in a shared spreadsheet. Coding decisions and theme definitions were subsequently reviewed, iteratively refined, and confirmed by the broader research team to ensure consistency and rigor. During this phase, theme development was considered in the context of the study's conceptual framework; active learning approaches; implementation of Universal Design for Learning (UDL) principles; incorporation of inclusive curriculum design elements and contextualization of learning. Codes and themes identified by the initial coders were assigned to the relevant design principles where appropriate; themes that did not align with this framework were presented independently in the results and discussion. Discrepancies were resolved through discussion and consensus (Braun & Clarke, 2013). Once themes were finalized, illustrative excerpts were selected to support each theme. Participant comments relating to minor technical issues (e.g., broken links, small errors) were excluded from analysis at this point. The analysis was conducted using Microsoft Excel® for data management and coding.

The research team's positionality reflects a range of backgrounds and perspectives. Most members are trained in biological sciences, while one brings expertise in humanities with a particular emphasis on social justice in higher education. Some team members identify as part of the LGBTIQA+ community, and/or have lived experience of disability and/or neurodivergence. While most team members were educated in Australia, one member completed their education internationally, contributing a cross-cultural perspective to the research. We recognize that these intersecting identities and disciplinary perspectives shape our approach to research design, data analysis, and interpretation.

As university staff, we are institutional insiders, which affords us familiarity with the context and structures of higher education. We acknowledge the limitations this positionality carries, particularly when analyzing responses from students who are still developing their professional knowledge and identity, and who often self-identify as "outsiders" within the academic environment. Throughout the research process, we engaged in collaborative reflexivity, discussing how our backgrounds and experiences might influence our understanding of participant perspectives and the framing of our findings.

3. Results

Semi-structured interviews with undergraduate science students and tertiary educators explored the potential of self-paced online numeracy modules to support learning and engagement with mathematics. Discussion prompts directed reflections across three

broad areas (mathematics histories and experiences, perceptions of the numeracy modules, and experiences of diversity in science); here, we present an analysis of student and staff responses that relate specifically to math learning.

3.1. Student Perceptions and Experience of Mathematics

Three overarching themes emerged in interviews with undergraduate science students (n = 11):

- Enduring anxiety and fixed self-perceptions limit student engagement with tertiary mathematics
- Math teachers and in-class learning environments have a profound, lasting, but often negative impact on engagement
- Self-paced online numeracy modules have the potential to support student enjoyment of and engagement with tertiary math learning

3.1.1. Enduring Anxiety and Fixed Self-Perceptions Limit Student Engagement with Tertiary Mathematics

In total, 8 of the 11 student participants in our study self-identified as having math anxiety, rating the intensity of their feelings at a 7 out of 10 or above (mean 7.2, 1 = no anxiety, 10 = highest anxiety). Student participants described a largely negative emotional response to mathematics (Table 1), similar to math learners in other contexts (Ashcraft, 2002; Dowker et al., 2016; Luttenberger et al., 2018). A history of math avoidance was common—students reported being overwhelmed by math and delaying or minimizing contact with mathematical tasks—with math anxiety both driving and reinforcing this pattern (Table 1, rows 1–3). Only a minority (3 of 11) of participants expressed generally positive experiences of math learning (Table 1, row 5), typically accompanied by an experience of high achievement in math.

Table 1. The dominant student perception of math involves anxiety and avoidance associated with past learning experiences.

Reaction	Student Feedback Highlights
Negative About Mathematics Generally	• The numbers start going over my head, and I start getting them confused. • I couldn't figure it out on my own. • I don't know how I got through math. • Math was just one thing I was forced to take. • I just started referring to math as my bad subject. • We can't do math. • I know a lot of my friends hate math. • If you get something wrong, you feel a bit silly. • I was just relieved that I don't really have to study math too much. • There's a social stigma or stereotype, with math. . . It's a very difficult subject. It's hard. • No one really likes math and numbers, and if they do, they probably need their head checked. • People who are good at math are always seen as nerds or geeks. • It's a bit scary. . . especially if you don't have a lecturer or. . . someone there to sort of help you with [math]. . . who is approachable. It can be definitely very difficult. • I don't like math. . . I just don't like math. • It's like math is math. . . they either don't like it, or they don't really have an opinion of it. • I hated math with a passion. It was the worst subject. . . If I'm looking at doing elective units that I don't have to do, I make sure there's no math component for it. • I used to equate [math]. . . to intelligent [sic] levels, so if I wasn't good at math then I thought of myself not intelligent enough. . . So, if I avoided it, then I didn't have to think of myself as stupid. • I very much struggle to. . . picture math in my head. . . I have to write it down and even when I write it down, I struggle. . . I just felt so stupid doing this even [though]. . . it was so simple. • Hate it! A lot. I hate it so much.

Table 1. *Cont.*

Reaction	Student Feedback Highlights
Stressed Because Too Much to Learn	• As you're progressing into high school, the syllabus gets even more bulky. Learning the formulas, trigonometry, algebra, there are just so many formulas. 20, 25. . . trying to learn that for exams. • [Math is]. . . a lot of memorization practice. I think that's where it really brings out the stress. • They look at it and they go, "How do you do that?" you know, "How do you work with all those numbers?" • Even as someone who's quite confident in math, it's very overwhelming. • If a unit is quite math-heavy, that can be quite intimidating because that's a lot of pressure to get a lot of content done, and correctly, every single time. • Math is never ending. There's [sic] so many different concepts and areas of it. . . if you don't get one kind of math then you. . . shy away from all the others that you maybe haven't tried.
Mathematics Anxiety	• I start getting anxious, and I'm not sure if I'm even right. • Algebra gives me panic attacks. • I think people think math is scary. • When I see numbers, I get nervous. . . Sometimes, if you have the pressure from the question and the time, plus I see numbers, I can sometimes freak out. • I got a bit nervous. . . It's a lot of numbers and I needed to interpret that to answer the questions. . . I guessed the answers because I just wasn't able to look at them. . . just seeing all those numbers together, [I]. . . just immediately. . . shut down. • [This module] is less scary because I don't see a lot of numbers in it. • That [math] unit makes me wanna [sic] cry.
Transitioning Negative to Neutral About Mathematics Generally	• I used to want to avoid [math]. . . as much as possible, but I've realized with my course and what I want to do, it is unavoidable. So, I've got to sort of learn to like it. . . Not like it, but be comfortable with it. . . not be so scared of it. • I mean, I don't hate it, but like, I don't care for it. I wouldn't go out of my way to do a math unit or anything. • At this point I feel a lot better about math. I still struggle with a lot of things.
Positive About Mathematics Generally	• I love math. . . There is one right answer. • My brothers and I have all always done quite well at math. So, we never really had any issues or anxiety surrounding math in my house. • When I was younger, I didn't like it. When I was in primary school, I didn't like it, but after secondary school onwards it was okay. I was doing well. I was doing well, so I enjoyed it.

Of particular concern in a mathematics education context, most student participants in our interviews revealed fixed mindsets around mathematics (row 1, Table 2). Participants often used fixed categories to describe math skills ("there is a group that are very good in math and our group that are not good in math"; "a numeracy brain or a literacy brain"), ascribing their association with a particular group to factors outside of their control ("it doesn't come to me naturally"; "third-generation with bad math skills"). Growth mindset accounts, emphasizing the importance of practice and persistence in math learning, were uncommon (row 2, Table 2). Several responses occupied a transitional space between fixed and growth mindsets—people were still described as being in a particular math "category," but the potential for individuals to transition between categories was considered (row 3, Table 2). These responses typically described an automatic anxiety response to numbers that could be regulated under specific conditions (adequate time, structured practice, safe-to-fail context). Taken together, these results suggest that a core challenge in tertiary math education is convincing students that math can be learned.

Table 2. Student math self-efficacy is mostly low to transitioning.

Category	Student Feedback Highlights
Fixed Mindset	• I'm a third-generation with bad math skills [sic]. • It was never taught to me to have a growth mindset. We were told, if we were bad at something, we would be bad for the rest of our lives. • In Australia, there is this weird system where, depending on how much you understand, there's what [classroom] you get put into. . . It is extremely harmful. • When we were younger, we got to do this test that sees [sic] if we had a numeracy brain or a literacy brain. If we had a literacy brain, we were more influenced to learn those sorts of things in primary school. If we had a numeracy brain, we were more influenced to do those sorts of things, and that's how I ended up in the bottom of the numeracy, and that's why I didn't catch up until year 11 in high school. • Those [math concepts]. . . I probably will never wrap my head around and it takes me a long time to get into it. • I think it's a society thing to be honest. I think people think math is hard and I can't do that. • There is a group that are very good in math and our group that are not good in math. . . I haven't met anyone in between. • Everyone's doing great [at math]. It's just me. • I'm gonna [sic] have to memorize all these mathematical equations. I can't do that. • I feel like the people around me are a lot better at math than I am. • I'm not a math whizz. It definitely takes me some time to get concepts. . . I've gotta [sic] have a lot of practice. It doesn't come to me naturally. . . I'm not one of those people
Growth Mindset	• Okay, if we just try a bit more, we can. • I've worked really hard to catch up. • If you told me when I was 15. . . that I could have a high distinction in Statistical Data Analysis. I would just laugh you out of the room. There's no way I would have ever believed it. • It's practice. It's believing that you can as well and realizing that math is there to help you. It's not there to freak you out. • OK, I can do this.
Transition to Growth Mindset	• I see a lot of numbers, and immediately, like, I'm, "Oh! I cannot do that", but if I calm down and start reading, I might be able to do them. • You're allowed to get things wrong. . . That's how you learn. • It just takes me longer to get things. • There's naturally some people that are able to grasp science, or are able to grasp English quicker. It's not necessarily that they're. . . stuck in that category. It's just, it comes faster to them. • When I was younger, I didn't like [math]. . . after secondary school onwards, it was okay. I was doing well. I was doing well, so I enjoyed it.

3.1.2. Math Teachers and In-Class Learning Environments Have a Profound, Lasting, but Often Negative Impact on Engagement

The influence of pre-university education on mathematics attitudes emerged strongly in our data (Table 3). Respondents with negative attitudes to math often described under-resourced learning environments; large classes, with low staff: student ratios that did not provide sufficient time, or individual flexibility, to support mathematics learning (row 1, Table 3). In these conditions, respondents with low math confidence described a downwards spiral of decreasing engagement and declining achievement—learners were reluctant to ask for help or engage in learning activities and so did not master content before the class moved on, finding it increasingly difficult to "catch up" over time (row 2, Table 3).

Teacher influence, negative or positive, emerged as the strongest individual driver of attitudes to mathematics among our respondents. Perceptions of math teachers as uncaring, unsupportive, or ineffective were common and associated with anxiety towards or disengagement from math learning (row 3, Table 3). Concerningly, some respondents described experiences of judgement or shaming by math teachers, with profoundly negative impacts on their self-confidence. Teacher impact was described as similarly potent in the

positive direction—even a single, supportive teacher who connected with the student and responded to their individual learning needs and context could foster confidence and persistence around math learning (row 4, Table 3).

Table 3. In-class experience of math has a lasting, often negative, impact on student confidence.

Category	Student Feedback Highlights
Undertrained and Under-Resourced Educators/Learning Environments	• I went from one of the lowest classes, to the highest classes in year 11. . . the lowest. . . there was 40 students in a classroom and in the highest one there was [sic] seven. . . The teacher had time for you in these high classes, but not in the lower classes. • I hate how [teachers]. . . don't make time for students who want to learn but have pre-existing issues with things. • In Australia, [teachers] are not [accessible]. It is horrible. Especially for people such as myself who were left behind in the public system, who really needed a tutor to catch me up, because no teacher had the time to just do it. • [Educators are]. . . severely underfunded and a lot of them in public high schools hate their jobs. • I did well in primary school and high school, except for mathematics, because I was never given. . . time to learn. • In high school, I never had any good experiences with my teachers and math. • [Educators]. . . didn't really understand that you could have a learning disability.
Students Left Behind and Can't Catch up	• In school, if you were bad at something, you were left behind. • I'm scared of saying "I don't know. I don't know how to do it." • You move on very quickly, from one topic to the next to the next, and it becomes more and more harder [sic] and confusing. . . if you're stuck at the start [of the syllabus] you get more and more anxiety as it goes on because it doesn't get easier. • You don't feel the confidence to speak out in class, so. . . you'd end up just falling behind in little aspects, because when it seems like everyone else is getting. . . that equation, you're sort of like, "Oh, well. I've gotta [sic] figure that out on my own," but I don't have the resources to do that. • If you struggle with math or if something else happens. . . you sort of lose those building blocks. . . You have to really relearn from the bottom up, but there's very little opportunity to actually do that. • I never learnt how to do the basics. How am I meant to do these hard ones? • I never really got the help I needed until year 10, 11 and 12, which made it really hard for me because I'd never had any help in the lower years to get that solid understanding. • In public school, if you got left behind in one grade, you could never catch up.
Uncaring and Unsupportive Teachers/Educators	• I feel this way with numbers because of my primary school teacher. . . she wasn't very good, she didn't help us. . . she just gave us papers to do. . . she didn't teach us. . . then we had to take a test. So, I think it's from there that I started building this anxiety. • I grew up in a high poverty area. . . you would be lucky if you found one teacher who actually cared to teach you. It was very hard. • I left school in 2001, and things were a lot different back then. . . [Teacher attitudes were]. . . "Either you make it or you don't. Too bad, we don't care." I think a lot of people would be surprised to learn that they're actually quite good at math if they're given the right support. • I think they just need to be more support [sic]. . . generally around math • The problem was that there was no explanation. There was no feedback. No one replied to my emails. . . in essence, they just expected that you'd know what to do. • No one really takes the time to show you how to do it. . . It's kind of just assumed you know what to do with data. • It really depends on how much support they give you. [If]. . . they just go through it in lectures and then they just give you the answer, with no practice questions, no tutorials, I'll freak out. • I had one bad teacher in year two and I never was able to recover from that content. • In any year of high school level math, they make it too [sic] complicated than it needs to be. • The teacher I had. . . wasn't very nice. . . it wasn't to do with the actual math, just to do with the individual.

Table 3. *Cont.*

Category	Student Feedback Highlights
Shamed by Teachers/Educators	• I had some really bad experiences in high school, especially with being judged by teachers for not being able to do math. • I used to get told I was dumb when I was a kid because I wasn't as advanced as the other kids. I was deaf. No one knew. I've always been behind. • I've been told 100 times that I'm not good at [math]. . . because I have ADHD. I've always needed more time, more support. . . I'm actually quite good at math, but I need to be given the appropriate time. • I was always just told that I wasn't good at [math]. . . because of my slow pace. • It's that fear that people are gonna [sic] judge you just because you don't know. . . basic stuff. • The teachers would [say]. . . "I don't understand why you're so bad at math when you're so good at all these other subjects." • They don't tell you [streamed classrooms are]. . . intelligent or dumb, but the teachers make it like that. • In those bottom classes, teachers didn't really think you wanted to be there to learn.
Positive Impact of Teachers/Educators	• It took one teacher in year 10. . . to realize, "You have a learning disability. I'm going to show you a way so that you can do math and get into university." Without that teacher, I wouldn't be here today. • I did get an EA in high school, and it was amazing. • Having the right teacher is everything. Someone who is passionate about what they're teaching, someone who knows what they're teaching and someone who gives you. . . context. • [The unit coordinator]. . . really cares for us. . . I don't wanna [sic] have bad grades because I don't wanna [sic] disappoint her. It really improved my grades a lot. • I just asked my teachers if I had any issues or any problems. • I had some teachers who would put in the effort to stay in for me at lunch to try to work through things that were taught weeks ago. • I was home-schooled. Math was something that. . . because I was home-schooled, Mum would take the time to go through and work it until I knew it. • In Steiner schools, as soon as you get into grade one, you get a teacher, and that teacher stays with you until you graduate primary school. You form really good relationships with them. They become your mentors. They meet your parents. . . I think that helped me a lot as well, because you get this one person and they will take time out of their day to tutor you at lunchtime. • Most kids in India have tutors. It's not a very rich person kind of thing. It's very reasonably priced. • In Singapore. . . after school, if you have any issues or questions about anything in the classroom, you can just stay behind and ask your teacher, and then she'll explain it to you. . . It's like quite easy to catch them or get hold of them and then ask them to explain something.

3.2. Self-Paced Online Numeracy Modules Have Potential to Support Student Enjoyment of and Engagement with Tertiary Math Learning

Alongside questions about attitudes to mathematics, participants in our semi-structured interviews were asked questions about module design and engagement, and about diversity content. Although participants were free to comment on any aspect of the modules they wished, student responses were highly positive overall (comments identified 91 strengths, 32 areas for development) and broadly aligned with major features of module design. To assist readers in considering implications for online math module design, we organize the Results around the features most salient in student accounts—elements that promote active learning, contextualization to course content, and Universal Design for Learning (UDL). However, we do not claim single-principal attribution; rather, we acknowledge the conceptual overlap among these features, reflected in individual comments that traversed multiple categories. For example, the quote "you can retry as much as you like, so I find that it would really help students who have that kind of anxiety" foregrounds

iterative and formative practice and feedback (active learning) while emphasizing a safe-to-fail, supportive learning climate (safety and representation) that accommodates additional learning needs (UDL). While detailed comments are presented in Table 4 and mapped to the most relevant feature in that comment for clarity, readers are encouraged to note the intersection of features (brackets in Table 4) and interrogate this overlap as it applies in their own contexts.

Table 4. Self-paced online modules can support tertiary math learning, confidence, and engagement. Key to attributions (used only for additional themes beyond the section heading): AL = Active Learning, UDL = Universal Design for Learning, S&R = Safety and Representation, CTX = Contextualization.

Design Feature	Feedback from Student Interviews
1. ACTIVE LEARNING	
1.1 Interactive Elements	
	• I just go straight to the interactive things, [they] are fun and challenging and I enjoy challenging myself.
	• The drag and click one I really enjoyed. . . it kind of gave you [a]. . . break from the wordiness. (UDL)
	• The interactive bits were really well put together, and so that's why I enjoyed it a lot.
	• [I liked]. . . not just having multiple choice, after multiple choice.
	• [The concept will]. . . click if I do it rather than if I read about it. (UDL)
	• I really like the practical aspect of dropping things in order from smallest to largest. . . It seems kind of childish, I suppose, but it works brilliantly, especially for someone with. . . ADHD. . . I need that time. . . for things to sink in. . . yeah, I really liked that. (UDL)
	• Box checking is great, and it's a good way to get people to do and learn what they should. Even if they probably don't want to.
	• The drag and drop feature worked really well.
	• I really loved the [Kahoot!®] part. That was cool.
	• To be able to visualize it. . . there's a diagram and you have to sort of direct click and drag and label it yourself. I just find it so much more. . . efficient and brilliant than books and stuff. (UDL)
	• Just the interactiveness of that, I love something that I can play around with and move to actually see what I'm completing.
	• I really liked the click and drag. That's my favorite. I find that that is really helpful in. . . the way that I learn. Personally, I really, really enjoyed that because you were able to sort of visualize it before actually going to do the questions, which I found really, really helpful. (UDL)
	• The drag and drop and then click options were really good.
	• *Not everyone's gonna [sic] find it very engaging, and people are gonna [sic] be struggling.*
1.2 Practice & Feedback	
	• Practice is everything.
	• They would show you how to do something, and then you'd have an opportunity to practice doing it.
	• There was plenty of opportunities to practice and see how to do the questions [sic].
	• [Modules have] practical examples and opportunities to practice doing *t*-tests. . . correlation or unit conversions with feedback. (CTX)
	• You click, it tells you if you're right, and then it swipes over, and the next question comes. I like those as well.
	• It gives you exactly what you've got wrong.
	• It's more helpful for my learning to attempt a question. . . a few times for it to click rather than reading something about it. (UDL)
	• It's kind of just extra practice for hard things, and so if you're struggling with something in specifics [sic], you can go to that and there will probably be a bit on it that you can. . . practice, and that's very helpful.

Table 4. *Cont.*

Design Feature	Feedback from Student Interviews
	• It can be very much the same thing, sort of reiterated, again and again. Which I find very helpful. You know, it's not just said once and then you go and do it, and then it moves on. It actually gives you a few different activities on the same kind of topic. Yeah, I find it really helpful. • I do like the "show answer" thing. Once you get it wrong, you can either choose to attempt it again by yourself or see the answer. I think that's good because I think if it just showed you the answer, you wouldn't get a chance to work through it again on your own if you wanted to. I really like that feature. • I enjoyed getting feedback on the responses simultaneously. • I like that it gives you feedback when you make mistakes. • They were based on the articles. There was a little bit of assumed knowledge when answering the questions, which was then explained after the questions were answered, rather than explained before, and then you had an opportunity to apply what you learnt in the questions. (CTX) • If you didn't understand, you could see what the right answer was, and instead of just showing, "oh this is the answer", there was a nice little explanation as to why that was the answer. Which was really good. • If you get something wrong. . . it comes up with a little comment saying what you may have done and what you should potentially do next, which is good. It gives you a sort of idea of the direction you need to head if you get something wrong. • You can retry as much as you like, so I find that it would really help students who have that kind of anxiety. (S&R, UDL) • *I did not really appreciate the language [of feedback]. . . at times. . . "No, this is wrong." Which can be a little bit, "Oh, okay." It can take you back a little bit, especially if you have issues with math already. It can be discouraging seeing that.* (S&R) • *I would say probably more exercises would be helpful.* • *Maybe in providing a bit more. . . examples and. . . getting harder when. . . doing the practice questions because the practice questions are very easy.* (CTX) • *Yeah, it's really easy. It it's quite simple. That's why I would say. . . to maybe make it a bit. . . harder as you go along.*
2. UNIVERSAL DESIGN FOR LEARNING	
2.1 Scaffolding	• It just lays it all out very clearly. • I liked how it jumped from something easy and then just kept getting a little bit harder until you got to the end. • I certainly felt "well, I might just need to spend some more time going back through all this.", but if I do that, it seems like everything's there for me to be able to, you know, get the concept. (AL) • It lays things out really clearly, and it sort of dumbs it down into like layman's terms. • It sort of explains the reasoning behind it. • I really liked [the module] because it. . . gave you a background, and I think that's something that's missing, like when you do [a statistics unit]. . . it's very, very quick. (CTX) • I thought it was easy to understand. • It explained everything quite. . . clearly and concisely, and that builded [sic] well on each other. • It's well explained and spelled out to you, which is really good. • It starts. . . very simple, and then gradually moves on. . . I think the difficulty level is manageable. • I think, like, they explained it well, just took it step by step. • *They didn't really explain how to figure the thing out with the standard deviation. I thought they were just referring to this one part, which was 34%, but they actually wanted you to plus [sic] those two together to get the 68%, and I didn't actually understand that until I got it wrong.* (AL) • *[If it's for]. . . very beginners, it could be more simple than this, because it started very simple. It was nice, but the transition to harder things was a bit. . . big. . . not [a]. . . smooth transition.* • *In the other module, when I had no idea what they were talking about, that was challenging.*

Table 4. *Cont.*

Design Feature	Feedback from Student Interviews
	• *Potentially the two second year [modules], because they were based off the articles, there was a little bit of assumed knowledge when answering the questions, which then was explained after the questions were answered, rather than explained before. . . I think it might have been more useful the other way around.* (CTX) • *The graph was not very interesting because I don't [sic] have the knowledge to answer those questions.* (CTX)
2.2 Easy, Flexible Navigation	• They were easy to navigate back and forth between different slides. • The flow of it was quite easy. . . Flow with the tabs and stuff is quite good, and the fact that you can go back as well.
2.3 Explicit Instruction	• The learning objectives are very clear and there's not many. . . that's good. • At the beginning of the module, the prefixes and everything are sort of laid out. . . If you get stuck on a question you can refer back to that page and then see exactly where you went wrong or what you should do. So, I think it will definitely relieve math anxiety. In my case it would relieve it. (AL) • You got these. . . question marks where you could click and it tells you the information. (AL) • It gave you a nice little summary at the end. . . it was a good way to see. . . "I've done really well with this" or "I probably should focus a little bit more on this kind of content". (S&R) • *Instruction and then background information is like one big chunk. . . it just puts you off when you see so many words.* • *The [journal-article linked module]. . . was a bit difficult. [It had]. . . so many words, then you need to read through. . . find. . . information. Then you've got to answer the questions. So, it's a bit tough.* (CTX) • *I got a bit nervous. . . It's a lot of numbers, and I needed to interpret that to answer the questions, and some of them I just couldn't. . . I guessed the answers because I just wasn't able to look at them. It was too much information.* (S&R) • *I wouldlike for it to say at the beginning, "please grab a calculator," or "have a calculator near".*
2.4 Multimodal Engagement	• Videos were helpful. • They have pictures in the. . . questions. It makes things so much better. • It gives you diagrams, tables, videos, information on everything, and it's. . . nicely laid out and it has interactive little games. I love that about it. • The pictures they use are very. . . attractive, so, I kind of want to know what the text is about. . . It made me. . . want to read. • One of the modules had an option for the audio version of the text. Which was really cool because I know a lot of people prefer that. • There was a person reading, that also helped me. • I think the video itself is quite good, with math aside. . . it wasn't boring. Not necessarily entertaining, but yeah, I was able to focus at least. • The videos, when they actually gave you examples. Especially, the [light board video] with the texts and stuff. I love actually seeing the examples being done and then being able to do it. (AL) • I liked the way that. . . [the module] incorporated other videos. . . I think sometimes it's useful to have the more visual audio aspect for students who prefer not to just read content. A lot of people learn differently, and it's good to have those different options. • I like that it was plainly written out, like [the video presenter] was writing and going through it. I find that easier than just having like a spreadsheet or whatever. • [The modules] could. . . help people that have some sort of disability. Like. . . anxiety, or a hearing problem, because you could read and you could also hear. . . You got the options. Or even if somebody is not able to read properly, you could hear, and then you probably will be able to answer the question. So, I thought that those two things combined, that was very good.

Table 4. *Cont.*

Design Feature	Feedback from Student Interviews
	• *I think it would be good if the videos had captions* • *I'm also hard of hearing, and I was. . . struggling with not having the captions there. . . I do struggle to read wordy things. . . I find that very useful, because there were quite a few words.* • *The other [journal-article based] module. . . had pictures, but they were black and white if they had them. Even the tables were, like, a bit darker, like blurry.* (CTX) • *There was so many words that I had to read slowly, and it took me some time.* • *I did find the terminology a little bit daunting.* • *There was a lot of information. It could've been divided more.* • *If there's a large block of text, you'd usually skip over it.* • *I just skip over them [blocks of text].* • *I'm struggling a bit, because it was just words on words on words and I kept getting lost. . . It did have a flow, but there was nothing really breaking it up. You go from words, words, question, to big paragraphs again.* • *Some of the slides [in the journal article based module had]. . . a lot of content on a single slide, especially with the quotes. It was just a lot to read and could potentially be a little bit confusing or overwhelming for students.* (CTX)
2.5 Accessibility Features	
	• There was not a lot of typing, which I think was really good because I know a lot of students really struggle with typing, students that have dyslexia and things particularly. • I found. . . the voice notes that were describing it was very inclusive. . . That's a nice aspect of it. • The colors are very gentle and they don't affect me. . . when they use colors like red, it distracts me a lot and makes me even more nervous when I'm taking a quiz. . . It didn't distract me. It didn't make me nervous at all. • I think having the different colors made it easier though, especially on the video. . . He used about three different colors when he was writing the equations. . . It's sort of just easier to distinguish steps. • I liked, you know, the images, the fact that it was colorful. • *Maybe like less numbers together.* • *[The module is] also not the most accessible.*
3. CONTEXTUALIZED INSTRUCTION	
3.1 Relevance & Context	
	• Talking about ratios, and you've got. . . half a pizza, quarter of a pizza. Things that relate back to human experience are really helpful. • I think context is the most important part. [For example, one module covers] the relationship between hand length, foot length and stature. . . and that was really helpful. • You're given a real-world scenario, you're given a context and the background. • Context is everything, and if you can see and practically apply something, then it's just. . . It's going to make sense. • I get it. . . as long as context is given. • I'm studying chiropractic. . . when I was reading about the bone, and because it was related, I thought, "oh, that was interesting", and I put more attention into it [sic]. • The inclusion of the example articles and not just boring math content. . . made it a little bit more interesting and engaging. • Using. . . a case study actually helped me apply it to a real-life scenario that I would be doing with my research. • I think it's more relatable for people that aren't very strong in mathematics [sic]. • *I would recommend maybe adding different case studies so that we can sort of see it in different applications.*

Table 4. *Cont.*

Design Feature	Feedback from Student Interviews
3.2 Transferable	
	• If you're struggling with something... specific, you can go to that [module]... and there will probably be a bit on it that you can... practice, and that's very helpful. (AL) • I'm doing biochemistry at the moment, and I've been struggling with the unit conversion rate, just remembering [the modules]... it clicked. I was like, "Oh, that's right." It's helped me already. • I'm doing [a forensics unit] at the moment. And I find I need... calculations and conversions. I need so much math for these units, and if we had... these modules for all units, just to give you that refresher... I reckon it would improve learning outcomes dramatically. (AL) • [Referring to a previously failed unit] If I had a module like this, then I'm pretty sure the outcome would have been a lot different. • I did well in [statistics], but that was years ago now... I found that, having these modules just to refresh your memory on it was really helpful. (AL) • Having these for other units would be fantastic. • The unit conversion module, especially if you provided it in first year for science students... We use that every single day, in almost all of our labs and classes... That'll help, and save them so much time throughout their whole degree, and help prevent mistakes. • In the first-year units... there's so many students doing so many different things that use math covered in these modules. • I would love if there were modules like this available across the board. Like in biochemistry, it would be really awesome if there was something like this. • I would probably say it'd be helpful because... having that module there... if you don't understand something, you can always go back to that module and have a look at it and refresh... your brain. (AL) • Would have been really helpful to have them when I was doing [an anatomy unit].
4 SAFETY & REPRESENTATION	
4.1 Low-Stakes & Encouraging	
	• You're not... penalized for getting something wrong. • You know you've got nothing to lose, and it's only going to help your learning rather than hinder. • You're allowed to get things wrong. • You know you can redo. So if you get something wrong, you can press "retry" and it'll give you the opportunity to go and do it again, without penalties or anything like that. You can actually retry each individual question of that entire module... I found that really helpful. (AL) • I think the thing at the start about the anxiety around numeracy and everything was really awesome. When it says "Take a few moments to write as openly as possible about your thoughts and feelings". That's great, you know. Yeah, it gives people a push, doesn't it? To... analyze how they feel about it... realize that it's not that scary. You can do it. It's all about those little moments of praise. (AL, UDL) • [The module] was a lot less pressured, I guess. It was more of an opportunity to learn rather than feeling like you were being assessed. • With an online module you can sort of do that at your own pace. You don't feel pressured to get it all within the setting of... 30 min to an hour. So, you've got that chance to just go at it... all day if you have to, without that constant pressure. • *I just felt so stupid doing this even [though]... it was so simple.*
4.2 Staff Presence	
	• Another thing I like is the congratulations and the praise... you don't have people holding your hand... they give you that feedback and they give you that praise and that push to actually learn. (AL) • I clicked the [voice]... recording, it really calmed me down, and I was able to read through. (UDL) • I get very distracted with everything I have around, especially when I'm on the computer... Having somebody there, reading... helped me to concentrate. (UDL)

Table 4. *Cont.*

Design Feature	Feedback from Student Interviews
4.3 Representation & Inclusivity	• I don't think people quite realize how important representation is. . . to be able to see someone like you. . . or someone that resembles you. . . in what you're learning. • I did notice the differentiation of sex and gender in the [module]. • "Today we're analyzing a skeleton from Saudi Arabia". "Now, we're analyzing a skeleton from Brazil." There's a lot of different things in there. (CTX) • One study was from Türkiye, I think. There was another one. . . from Asia, so I think it's got a good blend of not just centered around Australian things. (CTX) • *I didn't enjoy how they made it very racially—"this is Korean women". . . "Japanese men". . .* (CTX) • *It's not very inclusive.* • *Well, I mean the only thing I can really think of is it's just that it's only in English. But at the same time, it's, you know, university in Australia.*

3.2.1. Incorporation of Active Learning Benefits Student Engagement and Practice

Active learning elements were consistently highly praised in student interviews and identified as particularly valuable for learners who found maintaining prolonged concentration challenging (Section 1, Table 4). The range of different active learning elements appealed to diverse students (individual students expressed preferences for different question types) and helped to challenge students while providing a sense of fun (Section 1.1, Table 4). Student participants also describe the learning-by-doing benefits of active learning elements; manipulating items or working with visual representations of concepts made concepts "click" and served as a welcome break from the "wordiness" of other learning materials.

Students also valued the opportunity to apply concepts to solve problems and receive immediate, detailed feedback (Section 1.2, Table 4). They recognized the benefit of iterative practice for their learning, particularly if that practice incorporated a range of different ways to apply their learning. Interestingly, students were broadly positive about the extensive feedback provided in the modules. Most respondents seemed open to receiving corrective feedback in this form, suggesting modules were helping to frame errors as a normal part of the learning process rather than an implication of deficit.

3.2.2. Students Recognise and Value Universal Design for Learning in Online Modules

It is perhaps not surprising that active learning elements, with their gamification properties, were highly popular among students. More unexpected was students' explicit recognition of and appreciation for UDL features. The most frequently and deeply valued UDL feature was stepwise scaffolding of content. Learners valued materials that began at a basic level and gradually increased in complexity, with reasoning explained and the opportunity to revisit concepts incorporated (Sections 2.1 and 2.3, Table 4). Many participants in our interviews had expressed experiences of falling behind in pre-university mathematics education (Section 2, Table 3), which could explain why learning materials that do not assume prior learning were particularly highly valued. Indeed, most of the constructive criticism voiced by students called for more, or improved scaffolding (e.g., breaking up blocks of text, reducing the complexity of tables; italicized text, Section 2.1, Table 4).

Multimodal options for engaging with content (e.g., diagrams, text, video, audio) were praised by students, both as a source of personal engagement and as a support for peers with different learning needs (e.g., concentration and reading support via audio; reduced typing load for dyslexia; Sections 2.4 and 2.5, Table 4). Even the inclusion of relatively

standard UDL features, such as clear learning outcomes and flexible, easy navigation were appreciated by students (Sections 2.2 and 2.3, Table 4). Our findings suggest that in the context of math education, where a significant proportion of students approach learning from a position of anxiety and low confidence, clear learning goals and the ability to easily move back and forth through material are important to help students check their learning without losing momentum.

3.2.3. Online Math Modules Have the Potential to Contribute to a Safe and Inclusive Curriculum

The potential of online learning modules to provide a safe, low-stakes, low-pressure learning environment emerged as a dominant theme in student interviews (Section 4.1, Table 4). In particular, students placed importance on being able to retry problems without penalty and work at their own pace, to reduce numeracy anxiety and encourage persistence. Creation of a safe learning environment was enhanced by the incorporation of staff presence (narration, encouraging feedback, Section 4.2, Table 4), which students perceived as supportive, mitigating the potential isolation of self-paced online study (Tse et al., 2022; Whiteside et al., 2023).

Deliberate inclusion of diverse perspectives (gender, global, indigenous) in modules showed some promise as a means of creating a sense of belonging in a mathematics digital learning environment—in the words of one student, "I don't think people quite realize how important representation is... to be able to see someone like you... or someone that resembles you... in what you're learning" (Section 4.3, Table 4). Six out of nine student respondents gave the diversity portrayed in modules a rating of 8 out of 10 or more (mean rating 7.3/10, n = 9; 1 = not diverse, 10 = extremely diverse). However, the potential challenges of this approach were also evident—one student disliked the explicit reference to different populations (e.g., 'Korean women') in the modules, and another student commented that this content was exclusive, rather than inclusive (Section 4.3, Table 4, italicized text).

3.2.4. Contextualization of Math Content in Online Modules Supports Comprehension and Engagement

The benefit of incorporating contextualized instruction into modules (e.g., providing examples related to microbes in a module in a biology course) was reflected in students' comments that concepts made more sense when framed in real-world or discipline-specific contexts (Section 3.1, Table 4). Students reported that context increased attention and made abstract numeracy feel applicable and worth engaging with. Excitingly, from a course-design perspective, learners expressed a desire for modules to be utilized as on-demand refreshers that they could revisit when confused or when knowledge had faded and wanted modules to be available across units and early in science programs. Several students believed that previously challenging or unsuccessful course attempts could have had a different outcome if modules were available (Section 3.2, Table 4).

3.2.5. Overall Student Satisfaction with Online-Self Paced Math Modules Was High

Relative to students' strong, negative, and often fixed perceptions of mathematics (see Section 3.1.1), overall student satisfaction with numeracy modules was unexpectedly high. When students were asked to rate modules overall quality on a 10 point scale, 6 of the 10 student respondents gave numeracy modules a rating of 8 out of 10 or higher (mean rating 7.9, 1 = lowest rating, 10 = highest rating), expressing confidence that modules would benefit their learning and the learning of others ("a nice way to learn"; "I think a lot of students would benefit from [the modules]; "I was very surprised... how much I enjoyed it, actually... they're honestly really, really helpful").

3.3. Staff Perceptions of Numeracy Modules

While staff acknowledged many of the same strengths identified by students (Sections 1–4, Table 5), they were more likely to identify deficiencies or opportunities for enhancement (53% of staff comments vs. 24% of student comments), noting 21 strengths and 24 areas for development (Table 5, italicized text). One unique theme among staff, not apparent in student feedback, was concern that references to mathematics anxiety within modules might inadvertently trigger or exacerbate anxiety (Table 5, row 5). These themes are considered in more detail below.

Table 5. Educators tend to view online, self-paced math modules with caution, often focusing on opportunities for enhancement. Note: Tags indicate additional overlaps beyond the section heading, making visible where staff comments traverse Universal Design for Learning (UDL), Safely and Representation (S&R), and Contextualization (CTX). This mirrors the synthesis approach used in Table 4 for student quotes.

Design Feature	Feedback from Staff Interviews
1. ACTIVE LEARNING	
1.1 Interactive Elements	• There's some just straight up writing short answers, but lots of drag and drop and lots of... interactive images and things that you know are a bit more exciting. • I think they're really engaging... just the way that they're put together with all of that variation of different interactive sort of formats. For something that's intended to be self-paced, standalone... really well done, I reckon, and engaging. (UDL) • I think they're really engaging, and I think that's really important. • *We talk a lot about a hook... hooking engagement right at the start. Your ULOs are not a hook... They're [an educator's]... thing, that's not an engagement hook... a hook in my mind would be a really dynamic kind of video, or a really engaging little story from real life or something that's gonna [sic] capture them right from the beginning.* (UDL)
1.2 Practice & Feedback	• I liked the way you got people to read tables and actually answer questions about the table straight away. (UDL)
2. UNIVERSAL DESIGN FOR LEARNING	
2.1 Explicit Instruction	• *If I were a student, I would feel that I need a bit more explicit direction... It's really challenging, and I could see a lot of students just saying... "This is too hard."* • *I didn't totally love the learning outcomes. They're a little bit unobservable... "engage," what's that? "Demonstrate understanding"?* • *There's a lot of content... you're kind of pulling all this in and thinking, "Why am I needing this? Is this gonna [sic] be helpful?"*
2.2 Easy, Flexible Navigation	• I think they're really accessible. • I also liked how you can actually see where you're up to down the left-hand side. • [Responding to comment above] I like that too, because I think that it really helps you to not feel so rushed. Like, you know where you're at, and you feel like you've got good control over getting through it... that kind of felt like a bit of a reduction of anxiety... using that tool. • Very clear and self-paced. • They've got a nice ease for the user, and they're very friendly... the actual overall look of them is really engaging.

Table 5. *Cont.*

Design Feature	Feedback from Staff Interviews
2.3 Scaffolding	• We are all aware that students aren't reading… So by chopping [the journal article]… up and explicitly taking all of those parts into [module]… components, I feel that you've kind of forced them into reading the constructs around the math… the stats… getting them to interact. (CTX) • There's enough scaffolding, enough kind of support as you go through that, you feel well, "Yeah, I just need to just work through this," and you know, I think that, it sort of gives you confidence in… working with those concepts. • *I'm just gonna [sic] say [a specific module] was frustrating, because I didn't find the content was well scaffolded, it would speed up and slow down, and things would be assumed.* • *I think that [specific pages of this module need] much more scaffolding. That's one of the spots where it… just assumes that they know this and they know that, and now we're going to jump to the next thing.* • *I did have the thought that* t*-tests themselves could have perhaps been introduced more directly… it sort of comes right towards the end.* • *Suddenly, there's a jump to the abbreviation SI… but it hadn't been introduced… if there's [sic] students who are worried about their math and they're feeling like, "Aww, I never understand anything. I get confused," and then they do get confused, that doesn't help them very much.* • *There seems to be an assumption that students will just run a* t*-test. Not enough up front about why they would choose to run a* t*-test, or what other options there might be.*
2.4 Multimodal Engagement	• In terms of the display, where there's audio, there's still… moving images, and it's presented in a way that's easy to view. • Diversity, the more we can diversify the way in which we're actually conveying information, the better. • I thought the audio was actually pretty good with the moving images on some of the pages. • *I did find them a little bit wordy. I found that there's a lot of reading and sometimes I wasn't sure if I absolutely had to read all of this stuff or if I could just cut to the numbers… If I'm time-poor student, I'd like to know what I absolutely have to read, versus what's interesting… I wonder if it's possible to do a big highlight for, 'You absolutely have to read this text,' in order to… just to make certain parts of it stand out.* • *I just kind of got a bit bogged down in some of the complex vocab and I lost the math a little bit.*
3. SAFETY & REPRESENTATION	
3.1 Low-Stakes & Encouraging	• *I'd probably even give it a grade… If it's a threshold concept for the unit, then… absolutely giving it 5% [assessment weighting]… and then I think the whole dynamic changes.*
3.2 Staff Presence	• In particular, I like [the lightboard] videos because… it was like [the instructor] was actually talking to them. He was making mistakes along the way… speaking through his mental process in a way that made sense, and you could visualize it. (UDL) • It really felt like somebody cared about how good I was at doing math. I thought that really came through very strongly. • *Instead of having a… mug shot at the beginning, I think it would be fantastic if it's possible to have a welcome video where someone is speaking, also to include much more audio or video in all of them.* (UDL)
3.3 Representation & Inclusivity	• The examples are clearly from non-Caucasian studies, right? But the focus is about math. (CTX) • *I saw the word diversity in there a few times, like "diversity in measurement", but I didn't really understand. If I was a student, I would just not get that. It wasn't explicit what they meant. It kind of felt like the word diversity was thrown in there a few times, but I didn't understand.*

Table 5. *Cont.*

Design Feature	Feedback from Staff Interviews
	• *I wouldn't have picked up diversity as a theme.* • *I'm not sure about the intent. If it was to represent sociocultural diversity and other diversities then I would expect to see people, diverse peoples, represented very visibly. Perhaps in videos speaking, like actually representing, for instance, an experience they've had.*
4. CONTEXTUALIZED INSTRUCTION	
4.1 Relevance & Context	• I quite like. . . having references at the end. . . I thought that was quite useful. • I found that the use of articles was really interesting. I liked it because it showed. . . what's going on in. . . research at the moment. • It's a nice, warm, friendly introduction to the topic in a contextualized way. (S&R) • I'd say that it's an opportunity to engage with critical numeracy in the context of your discipline. • *The math got a bit lost in the science. and so, it was like, "Yes, I see, math and science are inherently tied, but I'm not sure what that means about my math anxiety".* • *People assume that learning objects from their field. . . are immediately enticing, but they're actually not to students.*
5. UNDER-SUPPORTED AND SUGGESTIVE MATH ANXIETY	• *I would like to maybe see a little bit more explicit direction or instruction around the reduction of anxiety. . . In the beginning, we ask students, "Are you feeling anxious?" So, my question is, what if they say yes? And then what at the end, if they say, "I'm still feeling anxious?". . . What if that hasn't reduced the anxiety by completing the [module]. What if they can't get through it?* • *It's quite possible you've got people who are not anxious. They're actually feeling very excited about [math]. . . and they're being told, "You should be anxious. Are you feeling anxious yet? Tell us about it". . . I'm reading it like a psychologist and going, "Oh my goodness, why isn't there a Likert scale there, to rate. . . how you're feeling?"* • *I think a [Likert]. . . scale, and then some kind of correlatory [anxiety] resources that could help them.* • *Maybe you're not anxious at all, and it just says, "Good on you, get going," you know, "Crack on. You've done a great job."* • *Later in the modules, there's no return to [math anxiety]. . . and there's no kind of follow-up with the participant/student, like, "Let's check in. How are you feeling now? Are you feeling more confident about whatever it is?" [The math anxiety reflection] it's a little bit like a bolt-on.* • *They haven't really addressed math anxiety in any real way. There's a mindful moment at the beginning, and at the end. . . but there's nothing kind of in between.*

3.3.1. Active Learning & Interactivity

Similar to students, staff consistently described the active learning formats as engaging and varied (e.g., "I think they're really engaging. . . just the way that they're put together with all of that variation of different interactive sort of formats"; Section 1.1, Table 5). For something that's intended to be self-paced, standalone. . . really well done, I reckon, and engaging"). Staff suggestions for improvement included a stronger initial 'hook' to strengthen engagement (e.g., "ULOs are not a hook. . . a dynamic video or engaging real-life story would capture [students]) and more explicit explanations of more complex mathematical concepts (e.g., "If I were a student, I would feel that I need a bit more explicit direction. . . it's really challenging").

3.3.2. Universal Design for Learning (UDL)

Educators broadly endorsed the navigation and pacing of modules (e.g., "very clear and self-paced"; seeing progress "I think that it really helps you to not feel so rushed. . . you know where you're at and you feel like you've got good control over getting through it"), and shared students' appreciation of multimodality ("where there's audio, there's

still. . . moving images, and it's presented in a way that's easy to view"; Sections 2.1–2.4, Table 5). The main UDL-related concern voiced by staff participants related to sections where wordiness and/or complex vocabulary were perceived to be challenging for students. Educators suggested distinguishing between essential and nonessential text in modules (e.g.," I did find them a little bit wordy. I found that there's a lot of reading and sometimes I wasn't sure if I absolutely had to read all of this stuff or if I could just cut to the numbers", "I. . . got a bit bogged down in some of the complex vocab and I lost the math") and addressing some gaps in captioning as potential improvements (captions were present in some videos but not consistently in all videos in each module).

3.3.3. Contextualization

Educators had mixed reactions to modules that framed mathematical content in scientific articles. Some participants found the context and scholarly framing valuable (e.g., "I found that the use of articles was really interesting. . . it showed. . . what's going on in. . . research at the moment"), while others cautioned that mathematical concepts might be obscured by their framing in a scientific context (e.g., "the math got a bit lost in the science"; Section 4.1, Table 5). Both educator and student comments reflect varied opinions on the implementation and level of contextualization, the implications of which will be considered in the discussion.

3.3.4. Safety & Representation

Similar to student cohorts, educator comments (Sections 3.1–3.3, Table 5) praised the visible instructor presence in modules (e.g., "[in lightboard videos] it was like [the instructor] was actually talking to them. He was making mistakes along the way. . . speaking through his mental process in a way that made sense, and you could visualize it.") and highlighted its role in providing a sense of support during module completion (e.g., "It really felt like somebody cared about how good I was at doing math"). Similar to other themes, educators suggested expanding instructor presence, for example, through the use of welcome videos to support engagement. Educator perceptions of representation and inclusivity were mixed. They noted the global diversity of examples, but concerns were raised that diversity did not emerge as a clear theme, and they recommended incorporating additional visible representation (e.g., more examples of diverse people speaking in videos).

3.3.5. Anxiety Framing and Support

Some staff raised the concern that anxiety prompts in modules (e.g., through reflective prompts at the start of each module) could trigger or exacerbate student anxiety (Section 5, Table 5). A number of suggestions were provided to mitigate this risk, including follow-up activities such as post-module check-ins (e.g., via Likert scales), mid-module anxiety touch points and links to anxiety support resources ("close the loop").

While not directly relevant to the module design focus of the present work, where modules were designed for but not presented within a course context, it is worth noting that several staff remarks implicitly called for clearer integration with course aims. Suggested improvements included providing an upfront rationale for specific techniques (e.g., when, and why to choose a *t*-test) and ensuring scaffolding that avoids assumed knowledge jumps (e.g., SI abbreviations) and assigning a light marks weighting for module completion to signal importance and foster engagement across a cohort.

4. Discussion

Our findings echo a substantial body of STEM education research: most tertiary STEM students arrive with negative perceptions of and anxiety around mathematics, commonly rooted in prior experiences of math learning (Daker et al., 2021; Khasawneh

et al., 2021; O'Leary et al., 2017). These affective barriers matter because they predict macro (course-level) and micro (activity-level) avoidance and under-performance in university STEM—even when math aptitude is accounted for (Canning et al., 2019; Khasawneh et al., 2021; Muenks et al., 2020). In our work, these negative feelings towards mathematics were frequently accompanied by a lack of self-efficacy—students commonly voiced beliefs that mathematical skills are fixed and determined by factors outside of their control. How can educators best support their students to overcome an aversion to mathematics and engage successfully with the challenge of tertiary learning?

Here, we explored the potential for bespoke, contextualized, inclusively designed numeracy modules to support tertiary students to (re)engage with math learning. Module design was informed by constructivist theory, emphasizing active learning, and by principles of universal and inclusive curriculum design, to explore whether established mechanisms for supporting learning would translate in a self-paced online context. Unexpectedly, students in our interviews were consistently, enthusiastically positive about the numeracy modules, despite those students holding generally negative attitudes towards math.

Active learning, including iterative practice and timely formative feedback, improves achievement and persistence in mathematics (Butler & Winne, 1995; Freeman et al., 2014). Online numeracy modules provide a mechanism to deliver active learning elements flexibly and at scale by embedding detailed feedback into active learning elements in modules. Active learning elements, and their associated feedback, were consistently and highly praised in our student interviews—students recognized the potential learning benefits of practice-feedback cycles and valued online resources that provide more exposure to these tools. Importantly, our data suggests that the incorporation of active learning activities into online modules had affective benefits beyond cognitive gains. The online, self-paced active learning elements, with their gamification qualities, seemed to create a low stakes learning environment that reduced anxiety and increased persistence, helping students to view errors as information rather than as evidence of personal deficiency. This change in framing is not trivial in cohorts where fixed beliefs about mathematical ability are common (Section 3.1.1, see also Boaler, 2015; Dweck, 2006).

In our hands, online numeracy modules also emerged as a scalable way to incorporate universal design into tertiary mathematics education. The rationale for implementing UDL is that inclusive, flexible learning environments providing multiple means of engagement, representation, and expression can accommodate and promote success among diverse learners (Dewi & Dalimunthe, 2019; Gaunt et al., 2025). Our student participants explicitly recognized and valued UDL features in numeracy modules, particularly stepwise scaffolding and multimodal content delivery. Students also appreciated explicit instruction elements in modules (e.g., structured progression and flexible navigation) and multimodal content delivery. This aligns with evidence from face-to-face (F2F) learning contexts that scaffolding reduces extraneous cognitive load and supports problem-solving in mathematics (Gupta & Zheng, 2020; Karabay & Meşe, 2025), while multimodal approaches enhance engagement and accessibility in online learning (Banihashem et al., 2025; Ruamba et al., 2025).

Educator opinions were broadly aligned with students in recognizing the benefits of active learning and UDL elements of modules. Indeed, a sizable proportion of educator sentiment around these themes was in support of expanding and/or strengthening these elements in the online modules, suggesting that the educators recognize their value for student learning and/or experience in an online, self-paced context.

Our approach differed from previous studies of online mathematics modules in a tertiary context in two important respects. First, we designed bespoke, contextualized mod-

ules to address a specific numeracy concept within a particular course. Second, we explored using online modules to support inclusion by making diversity visibly present in the learning materials (e.g., through global examples and inclusion of underrepresented perspectives).

Our design deliberately foregrounded contextualization—examples, datasets and practice questions were directly aligned with the broader course curriculum, as opposed to the more widespread use of commercially available math modules to support generalized math learning (Bowers & Kumar, 2015; Wang, 2023). Students repeatedly pointed to this contextualization as a reason the content "made sense," suggesting that familiar contexts and direct relevance to course content made math concepts more approachable and helped students to see immediate relevance to assessment and broader learning goals. For higher-level contextualization, two of the three numeracy modules in this study were embedded within scientific journal articles to provide context and promote parallel development of numeracy and scientific literacy skills. While this approach was engaging for some students, it also increased the complexity of the modules, creating a barrier for others. These concerns were echoed by some educators reviewing the modules, who felt that framing math content in a scientific article obscured the central math learning outcomes and or added unnecessary challenge for students who would already feel challenged by mathematical concepts. These results suggest that educators considering implementing modules in their own context think carefully about the level of contextualization in the module. Lower-level contextualization (e.g., using biological examples of mathematical concepts) seemed broadly well received by educators and students, but higher-level contextualization (e.g., framing a mathematical concept within a published article) was overly challenging for some students and might be approached with caution, depending on the educational goals of the course and the level and mathematical confidence of the student cohort.

An exciting theme to emerge from this work was the potential for online modules to contribute to a supportive, representative learning environment. Both staff and students described the supportive atmosphere created by instructor presence in the modules (narration, lightboard demonstrations, encouraging tone in text feedback) and suggested a role for these elements in mitigating the isolation of self-paced study. Students also noted that hearing an instructor think aloud helped them to persist (Sections 4.1 and 4.2, Table 4). Although modules were presented outside a full course frame in this pilot, these findings suggest that a visible educator's voice within online materials can help to support students to engage with challenging math content.

Responses to diversity and representation features were also broadly positive in both groups, with some caveats. Educators typically endorsed the intent but asked for more visible and explicit representation (e.g., diverse people speaking in videos) and clearer signaling of inclusivity across modules. Students generally recognized and valued the diversity elements as supporting belonging and relevance; however, their reactions were not uniform—some cautioned that specific population labels felt intrusive or exclusionary, and one noted that the English-only format limits accessibility. Our preliminary data suggest that intentional use of online modules has the potential to augment diversity and inclusion goals in a math learning context; however, on their own, such features are unlikely to be sufficient to develop a shared awareness of diversity and inclusion across a cohort.

Interestingly, educator concerns that attempts to normalize math anxiety in modules (e.g., through reflective exercises, based on the work of Ramirez and Beilock (2011) might prime or escalate student anxiety were not reflected in student responses; there was only a single student comment directly related to the anxiety reflection, which described the activity in positive terms. It is possible that staff concerns might have emerged in a larger student sample, but the anxiety normalization exercises appeared acceptable to the student cohort in our study. In either case, staff suggestions of strategies to mitigate the risk were

constructive and feasible (e.g., providing links to support services, post-module check-ins) and could be implemented by educators looking to explore this approach.

This is a small, single-institution pilot with a modest sample (11 students; 7 educators). The intent was to gain insight into user experience and perception of the online modules for the purpose of design refinement and to guide the development of potential evaluation studies in the future. As an interpretivist pilot study, the dataset is not suitable for statistical generalization; the sample size and recruitment constraints mean findings are not representative of the broader cohort intended for the modules and are susceptible to sampling bias. We did not measure learning gains directly, nor did we examine longer-term impacts on engagement or math anxiety. Quantitative evaluations of module-supported instruction relative to F2F-only instruction, informed by student participant demographics (not collected here), would be needed to provide assurance of positive learning outcomes and to explore the relative contributions of different module design features (e.g., staff presence, contextualization) to outcomes for particular cohorts of learners.

Notwithstanding these limitations, consistent themes emerged in the data that may be informative for fellow educators considering the implementation of online, self-paced math learning in their own context. Incorporation of active learning and UDL elements into modules received widespread support from both student and educator participants. More unexpectedly, students in particular spoke about a sense of connection (with educators) and support when completing online modules. Light contextualization of math examples in course contexts also provided a point of connection for students, provided it was not at a level that interfered with the math focus of the module (see above).

Our data and discussion have been organized by themes aligned with design principles, to enable educators with an interest in incorporating a particular design principle (e.g., UDL) into their online teaching materials to easily identify specific strategies they could adopt in their own context. However, both our data (see theme cross-referencing in Tables 4 and 5) and our personal experience when designing modules is that the four design features are highly interrelated and generate complementary positive outcomes for student learning and experience. For example, UDL content builds both accessibility and a sense of connection with students.

Taken together, our findings suggest a role for bespoke, contextualized modules as a complement to face-to-face math teaching. We propose that well-designed, contextualized math modules may support the scalable delivery of more consistent, accessible, feedback-rich math content in a tertiary STEM context.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci16020203/s1, Figure S1: Example of module construction: Linear regression using forensic anthropology data. Images and data reproduced with permission from (Sanli et al., 2005); Table S1: Discussion prompts for interview moderators.

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Abbreviations

The following abbreviations are used in this manuscript:

STEM	Science, Technology, Engineering, and Mathematics
UDL	Universal Design for Learning
LGBTIQA+	Lesbian, gay, bisexual, transgender and gender diverse, intersex, queer, asexual/agender, plus other identities of diverse sexual orientations, gender identities, and sex characteristics
F2F	Face-to-face
PISA	Programme for International Student Assessment,
TIMSS	Trends in International Mathematics and Science Study

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