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From Barriers to Breakthroughs

Leveraging Undergraduate Teams for Inclusive Open Courses

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Abstract

Amid rising demand for non-formal, skill-oriented education, faculty in Georgia Tech's School of Mathematics are collaborating with undergraduate students to develop open-access mathematics courses that address this need. The initiative positions undergraduates as co-creators in course design, enhancing both the accessibility of educational materials and the students' professional and academic development. Now, two years into the project, preliminary survey data suggest that the courses support underrepresented groups on campus and attract learners for non-formal learning settings, such as placement exam preparation and reinforcement of future coursework. The project has produced free, high-quality mathematics content, with ongoing development guided by principles of accessibility and academic rigor.

Introduction

What roles do students hold in higher education institutions? More than recipients of predefined knowledge needed for future employment, some argue that college students must cultivate their ability to become agile, critical, independent actors who collaborate in communities that solve the complex problems of tomorrow (Thompson et al., 2021; Fitzsimons & Fhloinn, 2023). Institutions can cultivate these abilities through opportunities to engage in projects outside of formal learning experiences in credit-bearing courses via partnerships with faculty. These initiatives can enhance the learning experiences students have at higher-education institutions in ways that can strengthen bridges between academia and society because they can prepare students for their eventual careers after they graduate.

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When students participate in partnerships and projects beyond the classroom, they are engaging in what is often referred to as non-formal learning. Non-formal learning is defined as an organized and systematic educational activity that occurs outside of a formal, accredited course (Johnson & Majewska, 2022). Non-formal learning environments often offer structured and unaccredited opportunities for students to build skills outside the traditional classroom (Misko, 2008). Examples include community education, workplace training, and adult literacy programs. In our work, we include placement exam preparation and studying for an upcoming course as non-formal learning, because the individuals in those settings are engaging in learning outside of a formal, accredited course and without the support of an instructor of record.

Non-formal learning can be supported by open and online courses because they offer flexible, accessible, and self-paced educational opportunities outside traditional classroom settings. But developing and maintaining open courses requires significant effort, including careful instructional design and ongoing learner engagement strategies (Pike & Gore, 2018). On the other hand, involving students in the development and maintenance processes of open course materials not only helps address these challenges but also offers another pathway into non-formal learning in higher education. Involving students in curriculum development and instructional design is an example of a non-formal learning "students as partners" model, a well-established and widely studied approach that involves collaborations between students and faculty to enhance learning and teaching practices (Mercer-Mapstone & Bovill, 2017).

This paper provides an overview of a project that designed non-formal learning pathways through creating a set of open-access online mathematics courses with support from student assistants. The work implemented a collaborative model that positions undergraduate students as partners in curriculum development. This project is part of a broader institutional commitment to promote engagement in STEM. These partnerships enable faculty and students to co-create content that is both academically rigorous and relevant to learners' diverse situations and professional aspirations. Our work highlights both the transformative potential and practical challenges of integrating students into open course design.

Review of Related Literature

Higher education institutions are increasingly recognized as vital contributors to the United Nations Sustainable Development Goals (SDGs), and the integration of the SDGs into higher education extends beyond curriculum development to encompass institutional transformation and community engagement (Chankseliani & McCowan, 2021). A component of this shift is the redefinition of students' roles, not merely as passive recipients of knowledge, but as active participants in shaping sustainable futures (Leal Filho et al., 2018). Education for sustainable development emphasizes the cultivation of critical thinking, interdisciplinary collaboration, and civic responsibility, empowering students to engage with complex global issues and contribute to meaningful change (Kioupi & Voulvoulis, 2020). As such, students must be agents of transformation who can influence institutional practices, drive innovation, and foster inclusive learning environments. By involving students in curriculum development, research,

governance, and outreach, colleges can harness their energy and insight to advance the SDGs and build more resilient societies (Kioupi & Voulvoulis, 2020).

But how can higher education institutions expand their understanding of learning—both in terms of their educational mission and their conception of who the learners should be? Wals et al. (2017) argue that higher education institutions can approach these challenges by recognizing that learning does not only happen in classrooms. Non-formal and collaborative learning opportunities are essential for everyone in the academic community and should be part of the institution's culture. Sterling and Maxey (2013) describe this as building a "culture of critical commitment." Essentially, institutional efforts to create spaces where non-formal and collaborative learning is fostered offers solutions to the demands presented by the SDGs.

Open Courses

Open courses can support non-formal learning. The literature on Massive Open Online Courses (MOOCs) highlights their transformative role in reshaping education by offering scalable, flexible, and accessible learning opportunities. Studies emphasize their potential to democratize education by removing barriers related to cost, geography, and infrastructure (Goundar, 2025). Research also shows that MOOCs support lifelong learning and skill development, making them valuable for both academic and professional growth (Anson, 2024). Open courses can also serve as a bridge between formal and informal learning, offering flexible, learner-centred environments that support self-paced study, peer interaction, and practical application of knowledge (Cha & So, 2020).

Students as Partners

Another pathway into non-formal and collaborative learning opportunities is presented by students as partner frameworks. Working with students as partners offers numerous benefits for both learners and faculty. By drawing on complementary expertise (Lubicz-Nawrocka & Bovill, 2021; Cabral et al., 2023), the diverse backgrounds and perspectives of students can bring fresh insight and innovation to academic projects. This collaboration fosters authentic learning for students (Lubicz-Nawrocka & Bovill, 2021), giving them relevant, hands-on experiences that deepen their own understanding and engagement. Moreover, it supports career development (Cabral et al., 2023) by helping students build valuable skills in communication, teamwork, and problem-solving that are highly sought after by employers. Additionally, involving students in faculty-led initiatives allows for the formation of larger, more effective teams, enhancing productivity and the scope of what can be accomplished.

Although partnering with students offers significant benefits, it also presents challenges that must be addressed to ensure a successful collaboration. A primary concern involves defining roles clearly and specifying the extent of student decision-making in course development (Barrineau & Anderson, 2018). Establishing these boundaries is essential to prevent confusion and promote meaningful engagement in the course design process. Another challenge lies in designing support structures (Cabral et al., 2023) in which faculty must determine how to effectively supervise or mentor students without undermining their capabilities. Proper mentoring requires time, resources, and thoughtful planning. Lastly, scalability (Matthews, 2020) remains a concern, as student-as-partner projects often involve a limited number of

high-achieving students. This raises questions about how to expand these opportunities to a larger student population.

Course Features

The three courses, College Algebra, Precalculus, and Multivariable Calculus, are designed to share a range of features to support flexible, self-paced learning through the learning management site Canvas. The courses are open and do not require a textbook to complete. They are organized into units by topic and include pre-recorded lecture videos, downloadable notes, and worksheets with additional practice exercises. To support comprehension and mastery, auto-graded quizzes and exams are administered using the Canvas Quizzes tool. All site content can be exported as Question and Test Interoperability (QTI) files for use in other systems. In addition, user tracking through the Canvas grade book and analytics allows for monitoring engagement and progress.

The open courses were developed using a range of technologies that support collaboration and consistency amongst the team of creators. Overleaf (https://www.overleaf.com), an online LaTeX editor, played a key role in creating high-quality, professional-looking course documents such as lecture notes and worksheets. Its real-time collaboration features allowed multiple team members to work simultaneously on shared documents, streamlining the editing process and reducing errors. This collaboration was especially valuable when developing complex mathematical content, enabling contributors to efficiently coordinate and maintain a unified design.

An open-source tool was also used to convert text files written in LaTeX into Canvas Quizzes, streamlining the process of integrating assessments into the learning management system. Undergraduate students contribute from drafting lecture notes in Overleaf and generating quizzes via the text2QTI tool (Poore, 2020), to recording videos and organizing content within the Canvas learning management system. The text2QTI tool allowed for the efficient transformation of structured, LaTeX-based questions into Canvas-compatible quizzes, preserving mathematical formatting and enabling bulk upload of content. The use of these two technologies made it easy for teams to co-develop content and maintain consistency across the course, while saving significant time on manual formatting and entry.

An early challenge in the curriculum development process involved user tracking. The initial plan was to host publicly accessible courses on Canvas, the institution's centrally supported learning management system, which incurs no additional cost. However, public Canvas sites do not support user authentication, making it impossible to collect user data. Such data are essential for assessing progress toward grant-defined goals and identifying areas for curricular improvement. To address this limitation, the team developed two versions of each course: a public version open to all users and an institution-specific version requiring authentication. When promoting the courses within the campus community, the authenticated version is prioritized.

Data

The Georgia Tech community sites restricted access to its members by requiring authentication to view course materials. This authentication enables the tracking of enrollments and user engagement. Enrollments as of May 22, 2025, across our three course sites are listed in Table 1.

Table 1
Open Course Enrollment as of May 22, 2025

Course	Enrollment
College Algebra	201
Precalculus	23
Multivariable Calculus	522

Differences in enrollments across the three open courses can be a result of several factors, including how long our courses have been available and how our courses have been advertised. The lower enrollment in Precalculus is due to it being the last course released.

Demographic data were collected in the course pre-survey (Appendix A). Most users completed the pre-survey because course content was only released after the survey was completed. Gender data collected from our pre-course surveys is presented in Table 2 below.

Table 2
Gender data for open courses and Georgia Institute of Technology undergraduate population

	College Algebra	Precalculus	Multivariable Calculus	Institute Undergraduate
Number of Respondents	89	12	520	20,592
% Male	36%	33%	50%	61%
% Female	56%	58%	42%	39%
% Other	7%	8%	8%	0%

Georgia Institute of Technology Undergraduate enrollment is included for comparative purposes, is based on all students registered in undergraduate degree programs across the institute, and is taken from the fall 2024 Institutional Research & Planning fact book (Georgia Institute of Technology, 2024). Note that institute gender data does not include a category for those whose gender is not exclusively male or female. Data in Table 2 suggest that a higher proportion of students who identify as female enrolled in our open courses than what we see in the undergraduate population.

Our surveys also collected ethnicity data (Table 3). Institute data (Georgia Institute of Technology, 2024) includes an *international* ethnicity. Our surveys did not include this category. The institute *international* ethnicity was combined with the *other* for the purposes of our table below.

Table 3

Ethnicity data for open courses as of May 22, 2025

	College Algebra	Precalculus	Multivariable Calculus	Institute Undergraduate
Number of respondents	89	12	520	20,592
% White/Caucasian	35%	25%	31%	33%
% Asian/Pacific Islander	26%	33%	38%	36%
% Black/African American	13%	8%	10%	8%
% Hispanic	13%	25%	9%	8%
% Multiple Ethnicity	6%	0%	3%	5%
% Other	7%	9%	8%	9%

The Asian/Pacific Islander and White/Caucasian groups are the most represented across all three open courses. Black/African American students are slightly more represented in College Algebra (13%) than in other courses and the general population (8%). Hispanic students are also notably more represented in Precalculus (25%) and College Algebra (13%) than in Multivariable Calculus (9%) and the institutional average (8%). This may reflect differing access or readiness for higher-level mathematics.

Table 4 presents survey responses from students who enrolled in the College Algebra and Multivariable Calculus open courses, which had the highest enrollment rates. A total of 87 College

Algebra students and 505 Multivariable Calculus students responded to this question. Respondents were allowed to select multiple reasons for enrolling.

Table 4
Reasons for student enrollment as of May 22, 2025.

	College Algebra	Multivariable Calculus
Help with a course currently enrolled	80%	80%
Extra resource and problems	45%	30%
Practice for a placement exam	0%	7%
Course taking in future	16%	12%
Curiosity	18%	5%
For a research project	1%	1%
Other	4%	8%

Students enrolled in these open courses for various reasons. The most reported motivations were seeking support for a concurrent course and accessing additional practice problems. Some students also used the course to prepare for the Multivariable Calculus placement exam, which has higher demand at our institution than the College Algebra exam. Our findings suggest that motivations for enrolling in open courses can reflect the academic structures and institutional needs of individual campuses. In our context, placement exams play a significant role in driving engagement with open course materials.

Discussion

The Open Course project at our institution began approximately two years prior to this paper's submission. Although data collection remains preliminary, particularly for the Precalculus course, initial findings reveal two key outcomes. First, open courses reach a diverse student population, especially groups that are underrepresented within our institution. Second, while motivations for enrollment reflect institutional structures, engagement with our open course materials was most influenced by placement exams and academic needs in current and future coursework.

Gender and ethnicity data in Tables 2 and 3 indicate that certain underrepresented groups on campus are more prominently represented in the open courses, especially in College Algebra and Precalculus, and most notably for female, Black/African American, and Hispanic students. These differences could be present because the demographics among students who enrol in their corresponding credit bearing courses on campus include a higher proportion of these underrepresented groups. But in

either case, the open courses are offering non-formal learning support to underrepresented groups, which motivates the need for them. Indeed, open courses hold the potential to promote equality in educational resources and eliminate boundaries that disadvantage learning access among underserved communities (van de Oudeweetering & Agirdag, 2018).

Motivations for enrolling in open courses vary and often align with institutional structures and academic objectives. In our context, engagement with open course materials was primarily driven by their relevance to current or future coursework and placement examinations. In contrast, motivations such as research, independent projects, and general curiosity played a minimal role. These findings align with recent research on MOOCs, which indicates that academic motivations typically outweigh interest-based factors (Badali et al., 2022).

Future work on our Open Courses could explore several directions. We could, for example, explore how users engage with course materials depending on their initial intentions for enrolling, what courses they are enrolled in, or other factors. Further research could also explore the perspectives and experiences of the student assistants in the curriculum development process in terms of career development and non-formal learning. The Canvas Quiz tool accommodates learner interactive elements but does not allow for more complex and multi-step scaffolded assessments. The use of more flexible and open learning technologies, such as WeBWorK (Roth et al., 2008) or H5P (Jacob & Centofanti, 2024) may offer a higher level of learner engagement.

This study has several limitations. Data were collected from a single institution, which may limit the generalizability of the findings to other contexts. The use of an open-access site on the Canvas learning management system restricted data collection from public users. Although optional surveys were available on the public sites, response rates for those surveys were, perhaps unsurprisingly, relatively low. Additionally, Canvas imposes constraints on open course functionality, including limited access to certain tools and the inability to track enrollment engagement or utilize the gradebook feature for public-facing courses.

Conclusions

Our study found that enrollment in open courses included a diverse cross-section of students from across the campus. Most notably, we found that participation from certain visible minorities including women, Hispanic, and Black/African American students, was higher in our courses relative to the Georgia Institute of Technology undergraduate profile. Moreover, we found that students enrolled for various reasons, mostly for preparation for placement exams, and support for current or future coursework. These findings may help guide future initiatives at other institutions.

Finally, the partnerships between faculty and student assistants facilitated authentic learning experiences. Our team has observed that involving students in these initiatives not only enhances the quality and relevance of open educational resources we were building but also builds an institutional awareness of open-access tools and practices. Overall, the result of our efforts is a growing library of

free, high-quality mathematics courses available to both students at our institute and the public (Appendix B), designed to improve engagement and accessibility in STEM education.

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Appendix

Appendix A: Pre-Course Survey

The Pre-Course Survey included seven questions to collect data on the users who enrolled in our open courses. The questions and answer choices are listed below.

- What level of study are you currently in?
  - High School
  - College Undergraduate Program
  - College Graduate Program
  - Other (i.e., medical, business, or trade school)
  - None (not enrolled in any type of school or program)
- Are you a Georgia Tech student?
  - Yes, I am currently a Georgia Tech student.
  - No, I am not currently a Georgia Tech student.
- Why are you using this "Open Course"?
  - Help me with a course I am taking now
  - Help me with a course I am going to take in the future
  - Help me with a project I am working on
  - Practice for a placement exam
  - Help me with a research project I am working on
  - Taking this course for fun
  - Extra resource and problems
  - General Curiosity
  - Other
- What is your gender identity?
  - Female
  - Male
  - Non-Binary
  - Cisgender
  - Transgender
  - Genderqueer or genderfluid
  - Agender/I don't identify with any gender
  - Gender not listed

    - Prefer not to state
- Which race or ethnicity best describes you?
    - American Indian or Alaskan Native
    - Asian/Pacific Islander
    - Black or African American
    - Hispanic
    - White/Caucasian
    - Multiple Ethnicity
    - Prefer not to state
- Please select any to the following that apply to you
    - I am a transfer student
    - I entered college with AP credits
    - I entered college with dual enrolment credit
    - I am a first-generation student
- How old are you?

Appendix B: Where to Find Our Work

Public websites:

- College Algebra
- Precalculus
- Multivariable Calculus