education sciences

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# An Integrated Achievement and Mentoring (iAM) Model to Promote STEM Student Retention and Success

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**Abstract:** The Integrated Achievement and Mentoring (iAM) Program responds to the challenge of STEM student retention. The iAM Program provides access to the hidden curriculum (the unwritten, implicit skills critical for academic success) and uses legitimate peripheral participation to structure resources. Three essential (integrated support services, mentoring, and responsive program structure) and two adaptable components (STEM writing and metacognition seminar, and scholarships) are intended as mechanisms of inclusivity that build community and promote belonging. Retention of iAM Scholars was 18.3% higher relative to peers who were eligible but did not join the program. The Scholars' four-year graduation rate was 26% higher than that of their STEM peers. A cost/benefit analysis revealed a net revenue benefit and suggests less-quantifiable benefits to the institution such as increased reputation. While the essential components of an iAM-based program should be consistent across institutions, the adaptable components can be implemented in ways that address local challenges and opportunities across international contexts.

**Keywords:** retention; STEM; iAM Program; diverse; legitimate peripheral participation; inclusivity; belonging; community

**Citation:** Santangelo, J.; Elijah, R.; Filippi, L.; Mammo, B.; Mundorff, E.; Weingartner, K. An Integrated Achievement and Mentoring (iAM) Model to Promote STEM Student Retention and Success. *Educ. Sci.* **2022**, *12*, 843. https://doi.org/10.3390/educsci12120843

Academic Editor: Billy Wong

Received: 13 October 2022
Accepted: 18 November 2022
Published: 22 November 2022



## 1. Introduction

Recruitment and retention of Science, Technology, Engineering, and Mathematics (STEM) students is critical to meeting global workforce demands [1,2]. However, disparities in STEM degree and job attainment exist with respect to gender, socioeconomic, rural-urban, and race/ethnicity characteristics [3–5].

Within the context of the United States, only 62% of all first-time, full-time undergraduate students entering college complete a bachelor's degree in six years [6]. For historically minoritized groups of students, graduation rates are even lower with only 42% of Black and 57% of Hispanic students earning a bachelor's degree in six years [6]. The disparity is even more pronounced in STEM disciplines. Only 52% of students, regardless of race or ethnicity, who begin a STEM bachelor's degree ultimately earn that degree [7]. Again, fewer historically minoritized students, such as Black and Hispanic students, earn STEM degrees relative to White or Asian peers [7]. Combined, these statistics indicate that current practices in the United States are insufficient to support a diverse population of students in earning bachelor's degrees, particularly in STEM disciplines.

Here we describe an integrated achievement and mentoring (iAM) model that addresses multiple factors to support STEM degree attainment. Developed in the United States, the iAM model was designed to be adaptable across higher education contexts with the goal of increasing STEM degree attainment and job entry. The model features three essential (integrated support services, mentoring, responsive program structure) and two adaptable components (STEM writing and metacognition seminar, scholarships). As applied to our context, the iAM model focuses on factors that include the transition from and differences in academic culture between high school and college and the implicit skills and expectations related to collegiate academic success. The iAM model addresses these factors via seamless integration of existing support services, addressing metacognitive and writing skills, mentoring, financial support, and a responsive program structure.

The transition from high school to college is challenging for many students. Students entering college directly from high school, in particular, may simultaneously navigate academic challenges, the transition to adulthood, moving away from home, new roles, and increased responsibility [8,9]. The academic challenges students face are not limited to discipline-related knowledge and skills. College presents a fundamentally different learning experience relative to high school [10]. While high school learning often focuses on reproduction of information or replication of a process, optimized for standardized test performance [11], college learning requires deep mastery, analysis and critical thinking skills [12–16]. Both students and faculty report that the difference in academic culture presents a barrier to student success in college [17].

The difference in academic culture is due, in part, to an implicit set of expectations for college student behavior that includes academic skills, use of resources, and communication with faculty. This set of expectations is variously referred to as the hidden curriculum [18,19], academic discourse [20], academic literacy [21], academic ways of being [22], language of the academy [20], discourse of the discipline [23], access to the 'unthinkable' [24], and epistemological access [25]. Here we use the term hidden curriculum to refer to these unwritten, implicit expectations and skills. These skills are not traditionally made explicit to students but are critical for collegiate academic success.

Students without access to the hidden curriculum may continue using previously successful learning strategies in a new, more challenging environment. These previously successful strategies are often insufficient to yield the same level of success in college as they provided in high school [26,27]. Students who are unaware of the hidden curriculum may not know that they could or should adjust their strategies or ask for support [21].

Access to the hidden curriculum is one of many interrelated factors contributing to student academic success and retention. Student psychological well-being [28], adjustment to college life [29], and feelings of connection and belonging to the university community [30] are also related to academic success and retention. Ideally, when students enter college, they are able to utilize skills and develop a support network that helps them feel like they belong and can successfully meet the expectations of college [31]. Unfortunately, for many students, feelings of connection and belonging decline in the first semester of college and do not recover in the second semester [3]. This coincides with a drop in grade point average (GPA) as they transition from high school to college [26,32], even for students who were academically high performing in high school [33,34]. The combined impact of lower academic performance, the stress of transitioning to a new academic culture, and decreases in connection and belonging can be overwhelming.

While students majoring in all disciplines may experience challenges in the transition to college, early access to the hidden curriculum may be particularly important in STEM disciplines. The first two years of college are critical for retention of STEM majors [35]. Academic underperformance in introductory STEM courses can push students out of STEM majors [36]. Students may also be pulled away from STEM majors by higher grades in non-STEM courses [37]. First-generation and historically minoritized students are disproportionately affected by the challenging transition to college [38–42]. In particular, they are less likely than non-minoritized peers to have access to the hidden curriculum [21]. However, if students are supported in gaining access to the hidden curriculum, their likelihood of success increases [21]. Given the need for a large, diverse STEM workforce [35], addressing the hidden curriculum early is critical to increasing both the number and diversity of students entering STEM careers.

The motivation for the Integrated Achievement and Mentoring (iAM) Program was to leverage existing institutional resources to provide access to the hidden curriculum in ways intended to support inclusivity, community, and belonging (Figure 1). We use legitimate peripheral participation (LPP) [43] both as a theoretical framework to organize program components and as an analytical lens to assess the program's success. In assessing the iAM Program's success, we focus on three interrelated concepts: inclusivity, belonging, and community. Inclusivity coincides, at least in part, with the access and transparency characteristics of LPP. Community and belonging should emerge from a successful implementation of the program given the underlying LPP framework.

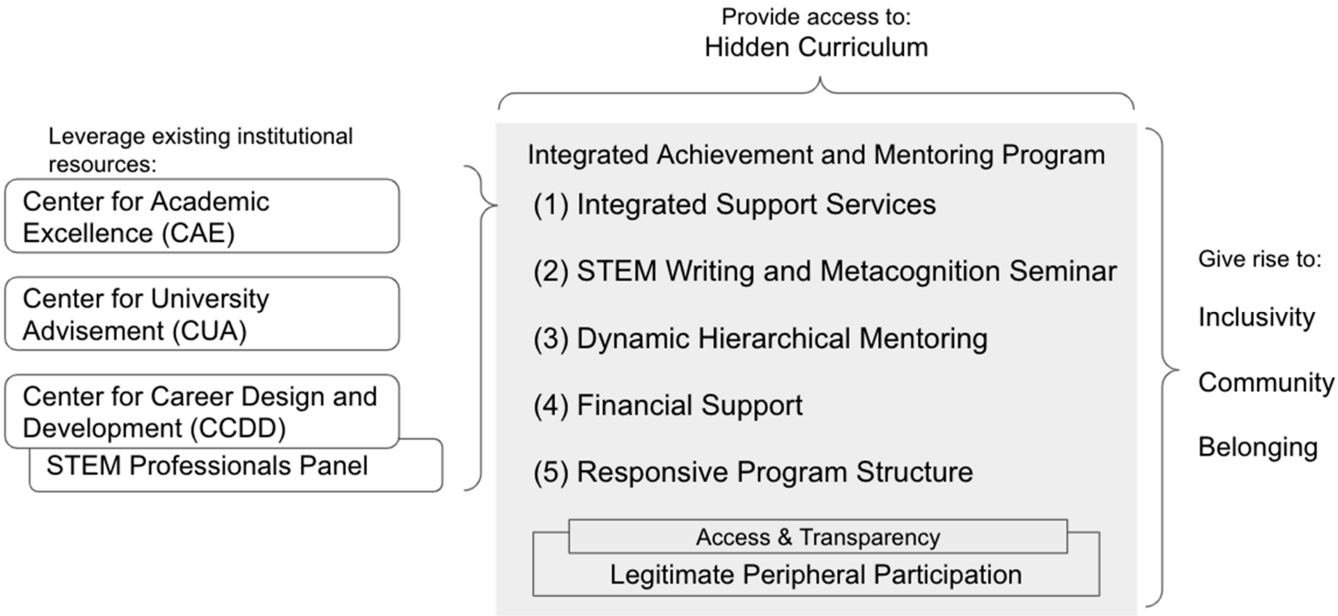


**Figure 1.** The theoretical framework of legitimate peripheral participation [43] guides arrangement of iAM Program components and serves as an analytic tool to understand Scholars' experiences. The program components leverage existing institutional resources to provide access to the hidden curriculum in ways intended to support inclusivity, community, and belonging.

Here we outline the social constructivist LPP framework [43] that undergirds the iAM Program and define the overlapping constructs of inclusivity, community, and belonging that we identified in the literature as critical for iAM Program Scholars. We discuss the socio-historical context within which the model was developed and describe the five core program components. The iAM model suggests promise as indicated by qualitative analyses of Scholar focus groups as well as quantitative institutional data. Here we present a description of the structure and components of the program and a cost/benefit analysis as we posit that the iAM Program model is transferable to other disciplines, institutions, and international higher education contexts. We used institutional data and a cost/benefit analysis to test the hypotheses that: (1) the iAM Program influences student retention, and (2) investing in the iAM Program results in a net benefit to the institution. Finally, we discuss how the essential and adaptable components of the iAM model can be used to leverage opportunities across institutional settings and contexts.

## 2. Theoretical Frameworks

### *2.1. Legitimate Peripheral Participation*

The iAM Program is premised on a social constructivist framework of legitimate peripheral participation (LPP; [43]). Based in Marxist theory, LPP focuses on identity construction through participation in a community of practice. LPP highlights the knowledge that emerges from participation, curriculum, and the community of practice. It focuses a lens on analyzing the structure of resources, both human and material, to determine the extent participants have access and transparency. The LPP framework posits that increasing access and transparency are some of the ways to support motivation and increase participation, engagement, and learning. If participants become increasingly engaged in a community of practice, they are more likely to identify with the community's values, norms, attitudes, and behaviors. That is, participants' identities are constructed through meaningful participation as they become legitimate peripheral participants.

Lave and Wenger [43] use LPP as an analytical tool to unpack and understand how the structuring of resources and curricula (for example, access and transparency, discourse and practice, motivation and identity, contradiction and change within the community) influence newcomers' participation and engagement in the community. For example, if newcomers are given access and provided transparency to the workings and ways of a community, it is more likely that newcomers will move towards full participation in that community. The success of a newcomer in adopting the values, norms, and behaviors of a community depends in part on the access the newcomer has to the human and material resources in the community. Transparency is critical to access, involving both visibility and invisibility. That is, transparency requires knowledge of the resource (visibility) and ease of operation and use (invisibility) in order to learn how to use the resource in contextually responsive ways. In this way, access and transparency are interconnected.

We designed the iAM Program to provide Scholars with access and transparency to human and material resources (we define this as inclusivity below). The iAM Program provides transparency in two ways: visibly, by engaging Scholars with people and support services within the context of the iAM Program, and invisibly, by seamlessly integrating those people and services into Scholars' college experience. This design was influenced by literature that highlights the problems of transition from high school to college [8,9,28,31,44,45] including the lack of appropriate study skills [10] and lack of knowledge of academic discourse and support [17]. While Scholars may technically have access to support services, without the iAM Program, many do not capitalize on that access. The iAM Program ensures Scholars access people and resources, engage with the hidden curriculum, and use tools to promote academic success.

The LPP framework has been utilized across multiple contexts (e.g., literacy education [46], music education [47], nursing [48], engineering [49], online learning environments [50]) and populations (e.g., adult learners transitioning to higher education [51], part-time doctoral students [52], students engaged in social movement organizations [53]). Within these contexts and populations, the lens of LPP supports an understanding of how newcomers access people in a group [53] and are enculturated into a community, assume communication norms, and gain a sense of belonging [49]. LPP further offers insights for community members to structure a community to best support newcomers [47,50] and can reveal practices that either include or exclude newcomers from full participation in a community [51].

Unlike a behaviorist framework that assumes a response to a stimulus [54], the social constructivist framework underlying LPP assumes that individuals mediate [55] a response to the stimulus based in the cultural knowledge, tools, experiences and perceptions individuals bring to the stimulus. In other words, individuals give the stimulus cultural meaning in order to respond to it. Individuals acquire cultural tools (e.g., academic discourse, norms and understandings of success and failure, etc.) by participating in a larger community (e.g., society). These cultural tools are further redefined by participation in subsets of intersecting communities (e.g., schools, communities defined by race and ethnicity, socioeconomics, geographic location, etc.).

We use the responsive program structure to understand how Scholars mediate the mechanisms of access and transparency in the iAM program. Based on this feedback, we revise program mechanisms to better meet Scholar needs. We further utilize the responsive program structure to assess the value of the mechanisms of access and transparency to Scholars by exploring belonging and community (defined below).

### *2.2. Inclusivity, Community, and Belonging*

Using the LPP framework to organize resources for iAM Scholars is intended as a mechanism of inclusivity that builds community and promotes belonging. The terms "inclusivity", "community", "belonging", and similar terms (e.g., inclusive, inclusive excellence, sense of community, sense of belonging) appear throughout the literature on higher education [30,31,56–63], often without explicit definitions (but see [30,64,65]). This is due in part to the overlapping nature of the concepts underlying each term and because the concepts often rely on perceptions of experiences, and feelings of connectedness. We therefore operationalized definitions for inclusivity, community, and belonging such that we could look for evidence of each in our exploration of the impacts of the iAM Program on students.

### *2.3. Inclusivity*

We operationalized the definition of inclusivity as: the institutional structures, practices, processes, or mechanisms intentionally created to achieve equity for all students to engage in the curriculum, co-curriculum, or communities (e.g., intellectual, social, cultural, geographical) that may promote retention, graduation, and STEM career entry. This definition is based on the American Association of Colleges and Universities' *Making Excellence Inclusive* core principles [59,66]. Our goal is to organize mechanisms of inclusivity within the iAM Program so that Scholars are able to negotiate their success in their majors, the university, and STEM professional communities. This definition aligns with the concepts of access and transparency that are central to the LPP framework.

### *2.4. Community*

Using Boyer's [67] explanation that communities are often described by characteristics they should have, we operationalized the definition of community as: a group of people who share or come to share characteristics that are definable, identifiable, and sufficiently distinct from other such groups. The characteristics could include: shared purpose, behaviors, values, norms, expectations (those placed on them and those they place on others), attitudes, or other characteristics such as being a first-generation or commuter student. Our goal is to engage Scholars with three communities we identify as relevant to Scholars' success: the iAM Program, the university, and STEM professionals. This definition aligns with the idea of community articulated within the LPP framework that includes common goals, values, beliefs, practices, norms, and behaviors.

### *2.5. Belonging*

We adopted Strayhorn's [30] definition of belonging: "In terms of college, sense of belonging refers to students' perceived social support on campus, a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to, the campus community or others on campus such as faculty, staff, and peers." We added "feeling validated" to the definition as the idea of validation arose during our analysis of Scholar reflections. Our goal is to provide the social and emotional support to students, through the program design and the interactions with peers and faculty, that encourage Scholars' sense of belonging to STEM majors, the iAM Program, the university, and the STEM professional community. This definition aligns with the notion within LPP that participants feel invested in by the community and in turn reciprocate that investment.

## 3. The iAM Program

We adapted elements of an existing program, the HHMI Professors Program at Louisiana State University [68], to address our institution's contextual needs. Five core components were developed into the iAM Program to address the complexities of the transition to college and integrate the frameworks described above. The goal was to be responsive to the context of STEM at our institution by including analyses of historical data, discussions with STEM faculty, and an exploration of existing university services.

Hofstra University is a nonsectarian, private university located in Hempstead, NY, 25 miles east of New York City. Enrollment in Hofstra's undergraduate STEM programs has increased 35% since 2011, catalyzed by the addition of a medical school, physician's assistant program, graduate and undergraduate nursing schools, and the creation of the School of Engineering and Applied Science. Relative to non-STEM majors, Hofstra's STEM majors are more likely to be from historically minoritized populations in the sciences (Hispanic, Black, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native) and to be Pell-eligible (Table 1). Consistent with national trends [6,69], STEM students historically minoritized in the sciences and Pell-eligible students are less likely to retain from year one to year two or graduate in four or six years relative to White or Asian STEM and non-STEM peers (Table 2).

**Table 1.** Institutional demographic data of entering first-time, full-time students from 2011–2020.

| | All N = 18,492 | Non-STEM N = 14,052 | STEM N = 4440 |
|---|---|---|---|
| **Pell-eligible** | **27%** | **25%** | **33%** |
| White | 57% | 60% | 46% |
| Asian | 10% | 8% | 17% |
| **Hispanic** | **15%** | **14%** | **16%** |
| **Black** | **10%** | **9%** | **12%** |
| **Native Hawaiian/ Pacific Islander** | **0.6%** | **0.5%** | **1%** |
| **American Indian/Alaskan Native** | **0.4%** | **0.3%** | **0.6%** |
| Two or More | 3% | 3% | 3% |
| Not Reported | 5% | 5% | 4% |

Numbers are percent of all, non-STEM, and STEM majors. STEM majors are enriched for Pell-eligible, Hispanic, Black, Asian, Native Hawaiian/Pacific Islander, and American Indian/Alaskan Native students relative to non-STEM majors, indicated with bold.

**Table 2.** Institutional retention and graduation rates for White/Asian, historically minoritized in the sciences, and Pell-eligible students.

| | Retention to Year 2 (2011–2020) | | 4 Year Grad (2011–2017) | | 6 Year Grad (2011–2015) | |
|---|---|---|---|---|---|---|
| | **Non-STEM** | **STEM** | **Non-STEM** | **STEM** | **Non-STEM** | **STEM** |
| Total | 79% | 76% | 57% | 47% | 63% | 57% |
| White/ Asian | 81% | 80% | 61% | 52% | 68% | 63% |
| Minoritized | 74% | 68% | 46% | 37% | 54% | 47% |
| Pell | 74% | 71% | 49% | 39% | 55% | 48% |

Within STEM majors, we initially focused on Biology and Chemistry to develop a program that was a manageable size. Biology is the largest STEM major on campus and there is significant overlap between the introductory courses taken by Biology and Chemistry majors. The goal is to gradually expand the iAM Program to include all STEM majors, and possibly non-STEM majors, through time.

We analyzed institutional data to understand the pathways students followed to a biology or chemistry degree. The analysis revealed a critical attrition point at the end of the first two semesters of college for biology and chemistry majors who were academically successful in high school (GPA $\geq$ 3.3 and/or scored $\geq$ 85th percentile on a standardized college entrance exam and/or were awarded institutional merit-based financial support) and who initially underperformed in college (first term college GPA 2.0–2.74). Over five years, 20.7% (302 of 1459) declared biology or chemistry majors met the criteria to be eligible for the iAM Program. Most students (81.8%) were unable to achieve a 3.0 cumulative GPA by the end of their second term. Retention of these students to year 2 was only 75.7%, 10% lower than peers who were able to achieve a 3.0 cumulative GPA by the end of their second term. The 3.0 cumulative GPA is particularly relevant to Pell-eligible students as it is the cut off for continuation of institutional merit-based financial support.

Our findings are consistent with others [70,71] that students who underperform early in their college career are less likely to remain in college relative to peers who do not experience initial underperformance. We therefore chose to recruit students at the end of their first term who, while high performing in high school, underperformed in the first term of college. This allowed us to target finite resources to a student population most likely to benefit from those resources.

We discussed our findings with colleagues in the sciences who identified several skills important for STEM student success (e.g., data representation, data interpretation, computer literacy, knowing how to learn, and how to write in the sciences). They acknowledged that while several of these skills were explicitly taught, how to learn in college and how to write in the sciences were rarely explicitly taught to students. In other words, at our institution, how to learn in college and how to write in the sciences are part of the hidden curriculum. Identifying that struggling students tended to lack these skills was confirmation that they lack access to the hidden curriculum.

We therefore developed an integrated achievement and mentoring (iAM) model that provides access to the hidden curriculum via seamless integration of support services and uses mentoring to position students within relevant peer, faculty and STEM professional communities. The iAM model reframes the existing deficit model focused on fixing student inadequacies [22] into an achievement model that arranges program elements around the LPP framework of access and transparency.

The iAM Program consists of five core components: (1) integrated support services, (2) dynamic hierarchical mentoring, (3) a STEM writing and metacognition seminar, (4) financial support for Pell-eligible students, and (5) responsive program structure. In addition, the iAM Program hosts three All Program events each academic year, typically as lunches on campus. Eligible students are invited to apply via email and letters in the January between their first and second semester on campus. Students complete an online application and are interviewed by iAM Program faculty. Here we describe each iAM Program component, emphasizing how each leverages or reframes existing university services to provide access and transparency for Scholars.

### *3.1. Integrated Support Services*

The university offers a variety of support services (Table 3) staffed with dedicated professionals with expertise in their respective areas. Any student may utilize any Center at any time. While intended to be accessible to all students, the existing model relies on students utilizing skills inherent to the hidden curriculum. Those students without access to the hidden curriculum, particularly those in their first year of college and/or who never previously had to ask for support, (1) may not know that the services exist, (2) may not self-identify a need for support in timely ways, (3) must figure out how to access each service (e.g., location on campus, how to schedule an appointment), and (4) may have to overcome the psychological stigma of reaching out for support.

**Table 3.** Existing university support services integrated into the iAM Program.

| Support Service | Description of Service |
|---|---|
| Center for Academic Excellence (CAE) | Supports student academic and personal success through one-on-one advising, tutoring, and workshops |
| Center for University Advising (CUA) | Provides academic advising regarding campus policies, academic planning, and major exploration. |
| Center for Career Design and Development (CCDD) | Offers career counseling and programming to empower students to find, apply for, and be hired into professional careers |

To address the limitations of the existing model, the iAM Program: (1) ensures students know what services exist by integrating services into the iAM Program; (2) helps students identify their goals, challenges, and needs; (3) removes logistical barriers to access, and (4) removes the stigma of asking for help by highlighting support as integral to success of all students rather than support as remediation of deficiencies. This model allows students to assess the value of each service and create personal connections with service providers, increasing the probability that students will continue to utilize these services.

Our intention in integrating support services into the iAM Program is to ensure inclusivity by providing access. Scholars engage with these services as a cohort with the implicit goal of developing their identities as part of the iAM Program and the university community. Ideally through these experiences, Scholars develop community and a sense of belonging.

We utilize Success Workshops and a STEM Professionals panel, described here, and a STEM Writing and Metacognition Seminar, described below, to integrate academic and career support services into the iAM Program.

#### 3.1.1. Success Workshops

One workshop is held each semester. Each workshop includes a pre-workshop reflection, individual and group work during the workshop, and a post-workshop product to be refined during mentoring sessions. This integration between workshops and mentoring (described in 3 below) ensures that workshops are not standalone information-delivery sessions but are catalysts for ongoing growth and achievement.

#### 3.1.2. STEM Professionals Panel

Each fall the iAM Program collaborates with the CCDD to bring to campus a panel of alumni working in STEM careers to share first hand experiences. The panel is composed of STEM professionals primarily outside the medical field, providing Scholars access to a diverse view of available careers. The panel is open to the entire Hofstra community. An iAM Program-only lunch follows the panel, allowing iAM Scholars to ask specific questions (encouraged and honed in squads) and network with the panelists.

### *3.2. STEM Writing and Metacognition Seminar*

The iAM Program utilizes a zero-credit, pass-fail seminar course taken in the first semester in the iAM program (second semester at the institution). The course name and grade appear on the students' transcripts although the grade does not affect GPA calculations. The goals of the seminar are to (1) develop Scholars' science writing skills, (2) develop Scholars' metacognitive skills, (3) assist Scholars in identifying and addressing barriers to academic success, and (4) seamlessly engage Scholars with existing support services and STEM faculty. It provides a small group setting to provide individualized support to meet the specific needs of each Scholar. We include an upper division Scholar, trained as a peer mentor, as a teaching assistant for the seminar. This is possible via an existing institutional program, the Peer Teacher program. This upper division Scholar is well-positioned to offer encouragement and advice given that they were in a similar position a few semesters prior. The small class size is intended to encourage development of a community within the cohort and to increase academic and social integration.

We intentionally chose writing as an element of the seminar given that most college STEM majors require at least some writing, usually in labs, and our science colleagues identified writing as a challenge for struggling students. Scientific writing is fundamentally different from other types of writing [72]. While written communication is important to STEM faculty, they report that they do not adequately address those skills within the context of the courses they teach [73]. Therefore, students entering college are expected to write like scientists without being explicitly taught those skills.

Metacognitive skills are those skills related to reflection on and adjustment of learning strategies that support academic success. Students enter college with a range of metacognitive skills [32,74]. Most are willing to reflect on and adjust their learning strategies. However, without explicit support, most students do not know what else to do other than to continue to use strategies used with success in high school. Even a single class session workshop on metacognitive skills increases academic performance [75]. A one-semester course that includes explicit instruction and practice increases student metacognitive skills [32]. Stronger skills are associated with higher academic performance and retention at the university [32].

We utilize the Four Domains of Learning [76] to address barriers to academic success in college. Osterholt and Dennis [76] identified four key domains: academic skills, social-emotional, motivation, and self-regulation. Seminar students engage with the Four Domains of Learning by working in pairs to align each domain with its relevant characteristics and examples. Scholars then complete weekly reflections during seminar using each domain as a lens through which to review the previous week. Not only does this help students be aware of all domains required for learning, it supports development of metacognitive monitoring, planning, and regulating.

The seminar is structured such that each week, Scholars spend the first 10–15 min checking in with each other and the instructor and writing reflections. We found it most valuable to have the students complete reflections during the seminar rather than outside it. The instructor provides written comments, advice, and feedback on reflections each week. The reflections provide an important opportunity for the instructor to continually gauge how each student is managing and to respond to their concerns. The remainder of the seminar time is used to provide access to the hidden curriculum through a series of workshops featuring guests from academic and student support units on campus, a metacognition workshop and a writing workshop led by STEM faculty. Students also initiate a portfolio of their work, which they continue to contribute to as they move through the iAM Program.

The intention is that the seminar engages Scholars as participants in the STEM learning community by providing access to skills required to successfully participate—that is, by providing access to the hidden curriculum. The seminar provides Scholars with access to faculty, upper division peers, support services, and the ways of learning and doing science that Scholars may not otherwise experience. The seminar provides transparency by explicitly focusing on the hidden curriculum so that Scholars gain and utilize skills that enable them to be full participants in the STEM learning community. Without these skills, Scholars may be pushed out of the STEM community due to academic underperformance [36].

### 3.3. Dynamic Hierarchical Mentoring

In the first year of college, students and STEM faculty at our institution primarily interact in the classroom. It is not until the third year that a subset of students interacts with faculty in a research mentor–mentee capacity. Both the classroom and research interactions depend on student initiative through active participation in the classroom, attending office hours, and/or contacting faculty to begin research projects. With respect to interactions with peers, formal mechanisms for STEM-related interactions exist via peer tutoring, STEM-related clubs, and discipline- or population-specific peer mentoring programs (e.g., through the Biology Club, Honors College, and Commuter Students Organization). As with student support services, a student must (1) know that these opportunities exist, (2) know how to access them, (3) self-identify that they could benefit from them, and (4) proactively seek them out.

In developing the iAM Program, we emphasize mentoring given its potential to address attitudinal factors such as mindset, motivation, confidence, and belief about one's capacity to learn STEM [77,78]. Students mentored by faculty tend to have higher GPAs, more rapid progress toward degree, and greater retention than non-mentored students [79]. Peer mentoring programs positively affect both mentees and mentors, and increase self-esteem, academic self-efficacy and perseverance in achieving educational and career goals [80–83]. Peer mentoring further addresses feelings of academic and social isolation, particularly among low income and minoritized students in STEM disciplines [84–86].

The iAM Program reframes student–faculty and student–student interactions within a dynamic hierarchical mentoring framework. The model is composed of faculty mentors, more experienced iAM Scholars, and new or less experienced Scholars. This comprises the hierarchical component of the model in which mentoring occurs at three or more levels [68,87,88]. We further include in the model a dynamic structure in which Scholars enter as mentees and, as they progress through the iAM Program, become mentors to subsequent Scholar cohorts. The dynamic structure allows every Scholar an opportunity to be mentored by more experienced peers and to mentor subsequent cohorts of Scholars.

All mentors, both faculty and student Scholars, receive initial mentor training [89,90] focused on implicit bias, communication styles, time management, and resources available on campus. All mentors receive on-going training each academic year to engage in iterative reflection about the mentor–mentee relationship. This model leverages existing university resources and increases awareness of these units and resources on campus. Our goal is for mentors to utilize the skills learned in the training to foster strong mentor–mentee relationships, both within and beyond the scope of the iAM Program.

The iAM Program utilizes a group mentoring model that we refer to as mentoring squads. Two faculty mentors, one each from biology and chemistry, co-mentor a group of 4–7 Scholars. The Scholars in the group include new Scholars as well as more senior peer mentor Scholars. Group mentoring provides opportunities for both "vertical" mentor–mentee as well as "horizontal" mentee–mentee interactions [91]. Vertical interactions are those between individuals with different levels of knowledge and social power [86]. In this case, faculty mentors and more senior peer mentors have greater knowledge and social power relative to mentees. Horizontal interactions occur between individuals with similar levels of knowledge and social power [91]. These interactions, for example, occur between newer Scholars who recently joined the iAM Program. It provides opportunities for support through both mentor–mentee dyads and at a group level [92].

A cohort of Mentoring Scholars, academically high achieving and socially engaged juniors (e.g., active in student clubs, conducting research with a faculty mentor, and/or serving as peer tutors or peer mentors in other contexts), was selected to serve as mentors to the first cohort of iAM Program Scholars. This was necessary given that the dynamic nature of the mentoring framework is dependent on more experienced Scholars mentoring newer cohorts of Scholars. At the program's inception, there was not a pool of more experienced Scholars to serve as mentors, hence the selection of Mentoring Scholars.

The combination of faculty and peer mentoring in a dynamic hierarchical mentoring model aligns with the LPP framework. The intent is to ensure that Scholars have access to and engage with a diversity of perspectives and levels of expertise and experience within the institution (including peers, faculty, and staff) and the STEM professional community (including faculty and alumni panelists invited to the STEM Professionals Panel). Mentoring is further intended to encourage development of Scholars' own STEM identities and foster a sense of belonging as Scholars contribute to the community.

We use faculty mentoring as a mechanism for Scholars to observe and participate with faculty outside the traditional faculty–student classroom power structure. Faculty mentors provide a level of expertise and knowledge that peer mentors alone cannot provide (e.g., guidance regarding university policies and practices, internships, research opportunities, professional advice, and references). Peer mentoring allows Scholars to interact with peers who may have stronger identities as STEM majors and who can provide support in a context less burdened with power dynamics. Peers provide a student perspective on human and material resources of the major and university, providing an empathetic perspective on overcoming challenges to become successful students and STEM professionals.

To date, the mentoring component of the program has been sustainable with room to scale. Most Scholars show interest in serving as mentors. We typically have at least two mentor-trained Scholars in each mentoring squad. With respect to faculty, we have more faculty interested in being mentors than we have available squads. We compensate faculty mentors with a $300 stipend paid as summer salary. This nominal financial compensation is not the motivating factor for faculty involvement. The stipend is also small enough that the institution could compensate the faculty mentors when external funding ends.

The situation may be different at other institutions where it may be more challenging to recruit faculty mentors and/or faculty mentors seek greater compensation for their time and effort. In that instance, it may be feasible to rely more heavily on more senior Scholars as peer mentors, perhaps having multiple Scholar squads interact with a single faculty mentor rather than having a faculty mentor embedded within each individual squad.

### 3.4. Financial Support for Pell-Eligible Students

At our institution, 1-year retention and 4- and 6-year graduation rates are consistently 7% and 10% lower, respectively, for Pell-eligible biology and chemistry majors compared with their non-Pell-eligible peers. Financial concerns may drive at least part of this disparity. Pell-eligible students average $19,000 more per year in unmet financial need relative to non-Pell-eligible peers. Among students who report a reason for leaving Hofstra, 62% of Pell-eligible students report leaving for financial reasons versus 38% of non-Pell-eligible students. Continuation of institutionally-awarded merit-based aid is contingent upon maintaining at least a 3.0 cumulative GPA. Thus, the financial implications of underperformance are greater for Pell-eligible students relative to non-Pell-eligible peers.

Funding provided by an NSF Scholarships in Science, Technology, Engineering, and Mathematics award provides $10,000/year in scholarship support to Pell-eligible Scholars for up to four years. The scholarships help mitigate the disparity in unmet need between Pell-eligible and non-Pell-eligible peers. Many students, including Pell-eligible students, work to help pay tuition. Time spent at work may reduce the amount of time available to study, access resources on campus, integrate into campus communities, and network with the STEM community. The intent of scholarship support is to ease the financial burden on Scholars to provide them the opportunity to engage within the university and STEM communities. Scholarship support aligns with the LPP framework as it provides access to the institution and, ultimately, STEM professions.

### 3.5. Responsive Program Structure

The university distributes 14 surveys across multiple populations of students at various time points from entry to graduation. These include surveys regarding new student programs and the transition to college, health and wellness, residence life, and student satisfaction with support services. While the university uses student feedback to continuously improve the services offered, it is challenging to make major adjustments within a large institution. In contrast, the limited size of the iAM Program provides opportunities to solicit and respond to Scholar feedback in meaningful ways in near real time. We conduct focus groups with each Scholar cohort at the end of every semester. Scholar feedback allows us to understand if and how various iAM Program and institution mechanisms support inclusivity, formation of community, and sense of belonging. The intent of a responsive program structure is to ensure that program components are revised in near real time to meet the needs of iAM Scholars.

### 3.6. All Program Events

While not an official component of the iAM Program structure, All Program events provide an opportunity for community building, allowing Scholars, faculty mentors, and program leadership to interact. These events provide a structured time to address program logistics, updates, and paperwork. Typically, All Program events are catered lunches hosted during the university's Common Hour, a time slot during which no classes are scheduled. We host All Program events at the beginning of the fall and spring semester and again at the end of the spring semester.

### 3.7. Integration of Theoretical Frameworks with Program Implementation

Each program component is designed to support Scholars' participation by providing (1) access to people and resources important for STEM student success, and (2) transparency regarding how to access and best utilize those people and resources (Table 4). The exception is financial support, which is primarily intended to provide access. The program structure is a mechanism for inclusivity and an opportunity to build community and belonging.

**Table 4.** Alignment of iAM Program components with theoretical frameworks underlying the program.

| iAM Program Component | LPP | | Community | Inclusivity | Belonging |
|---|---|---|---|---|---|
| | Access | Transparency | | | |
| Integrated Support Services | | | | | |
| Success workshops | X | X | | X | |
| | The iAM Program ensures ease of operation and use as existing institutional support services are integrated into Scholars' college experience rather than Scholars seeking them out. In integrating success workshops into the iAM Program, the tools for academic and career success become visible to Scholars. | | Success Workshops ensure consistent engagement with institutional support services. As such, they serve as a mechanism to promote retention, graduation, and STEM career entry. | | |
| STEM Professionals Panel | X | X | X | X | X |
| | The STEM Professionals Panel provides Scholars access to STEM professionals. Rather than requiring Scholars to seek out STEM professionals themselves, the iAM Program integrates engagement with professionals seamlessly into Scholars' experience. In doing so, it makes visible to Scholars the breadth of potential STEM careers and exposes Scholars to established and emerging fields. | | The STEM Professionals Panel promotes STEM career entry by exposing Scholars to the breadth of potential careers and offering networking opportunities through which Scholars begin to identify with the profession and the professionals. | | |
| STEM Writing and Metacognition Seminar | X | X | X | X | X |
| | The Seminar provides Scholars access to the hidden curriculum: the implicit expectations (e.g., go in office hours, talk to faculty, talk to upper division peers) and skills (e.g., how to write, how to study, how to communicate with faculty) for college success. Transparency is achieved both by making the hidden curriculum visible and via seamless integration into Scholars' experiences. | | The Seminar brings newcomers of the iAM community together in purposeful ways to provide equity for Scholars to connect, build relationships, and engage in the undergraduate STEM community. | | |
| Dynamic Hierarchical Mentoring | X | X | X | X | X |
| | DHM provides access to people and resources. Explicit inclusion of mentoring, as opposed to Scholars connecting with peers or faculty serendipitously, provides a pathway for Scholars to engage with the iAM Program, first as newcomers (mentees) and eventually as experts (mentors). Mentoring is, therefore, both visible as it is integrated into the iAM Program and invisible since Scholars are not required to *seek out* mentors. | | DHM provides equitable opportunities to build relationships across the iAM community (upper-level students, faculty), develop identity related to STEM professions and professionals. | | |
| Scholarships | X | | | X | |
| | Scholarships provide Pell-eligible students access to the institution. | | Scholarships provide more equitable access to the university and a STEM degree. | | |
| Responsive Program Structure | X | X | X | X | X |
| | The responsive program structure provides Scholars voice to shape the iAM Program to meet their needs and claim ownership in the program. It provides a window into the program's goals and structure. | | The intent of the responsive program structure is to make the program more equitable through time, increase belonging and enhance community as Scholars provide actionable feedback to the program. | | |

## 4. Materials & Methods

### *4.1. Scholar Selection*

Students majoring in degrees within the Biology and Chemistry Departments (Biology, Urban Ecology, Neuroscience, Chemistry, Biochemistry, Forensics) with a first term GPA of 2.0–2.74 and at least one of the following characteristics were invited to apply for the iAM Program the January between their first and second semester at the institution: high school GPA $\geq$ 3.3, $\geq$85th percentile on a standardized college entrance exam, and/or received merit-based financial support from Hofstra.

Students completed an online application requesting information about their high school and college activities and responded to prompts about:

(1) Career goals: "State your career goals (50 words). Then make a bulleted list of the strategies you are using to meet these goals with a 10–25 word explanation for why you are employing each strategy."
(2) Academic success "How do you define academic success? (50 words) How well did you meet your definition of academic success before Hofstra? At Hofstra? Why? (100–200 words)."

Responses to the prompts were used by the program leadership team to gauge each student's level of self-reflection, motivation, and access to the hidden curriculum.

Students were subsequently interviewed by pairs of faculty on the leadership team. We asked questions such as:

- Tell us about your transition from high school to college—what was it like?
- What was your approach to your classes in the fall?
- What campus resources were you able to use on campus; tell us about your experiences with them?
- What is your plan for the upcoming semester to achieve academic success?

Responses allowed us to identify motivated, self-reflective students open to altering their approaches to college who we felt would benefit from the components of the iAM Program.

### *4.2. Program Outcomes*

We used retention of iAM Scholars relative to peers who were not eligible to join the program, and peers who were eligible but chose not to join the program to answer the research question: Does the iAM Program influence student retention? Institutional data regarding retention were analyzed to compare relative retention rates across the three groups. We limit the analysis to descriptive statistics given the relatively small cohort sizes to date.

### *4.3. Program Cost/Benefit Analysis*

We calculated institutional revenue benefits by comparing Scholar retention to retention of a comparison group of students who were eligible but did not join the iAM Program. This allowed us to answer the research question: Does investing in the iAM Program result in a net benefit to the institution? We first calculated retention rates in the comparison group and in the Scholar population, then applied each rate to the Scholar population. We did this for the transition to each term (i.e., from 2nd term to 3rd term at the institution, from 3rd term to 4th term, etc.) as retention rates vary by term and the amount of revenue lost depends upon the term in which a student leaves the institution. Those leaving in terms 3 or 4 result in a larger revenue loss relative to those leaving in terms 6 or 7, for example. In calculating the term-to-term retention rate, we used, to the extent possible, an average rate across cohorts. We did not consider retention from term 1 to term 2 since Scholars are only eligible to join the iAM Program in term 2. Students who do not retain to term 2 cannot join the program.

Applying the comparison group term-to-term retention rates to the Scholar population allowed us to predict the number of Scholars we would have lost in the absence of the iAM

Program. We then compared that with the actual number of Scholars lost in the presence of the iAM Program. With this information, we calculated the tuition revenue the institution loses in each instance. We also include the cost of recruitment for each student, as the institution expends money to recruit students that ultimately do not graduate. Using these values, we calculated projected revenue lost with and without the iAM Program.

## 5. Results

### *5.1. Program Outcomes*

To date, four cohorts of students have participated in the iAM Program (N = 35 Scholars). Data from three cohorts (those completing at least four semesters at the institution) are included in retention and revenue calculations (N = 23 Scholars). Scholar retention across all terms was higher relative to peers who were eligible but did not join the program (by 18.3%) and peers who were not eligible to join (by 10.4%). The four-year graduation rate of the first cohort of Scholars was 83%, much higher than that of both STEM and non-STEM majors (Table 2). Controlling for the effects of motivation for joining or not joining the iAM Program was not feasible given that students who chose not to join were typically not responsive to outreach. Therefore, program outcomes should be interpreted with this caveat in mind.

### *5.2. Program Cost/Benefit Analysis*

A cost/benefit analysis revealed that the institution has benefitted both financially and in other less-quantifiable ways from the iAM Program. The primary cost of running the program is time, with approximately 300 total hours of time dedicated to the program each year by a six-member leadership team (accounting for 235 h) and five faculty mentors (accounting for 65 h). This time was spent recruiting students, running the program, administrative duties (e.g., managing scholarships, budget, staffing), teaching the STEM Writing and Metacognition Seminar, mentor training for faculty and students, meeting with mentoring groups, planning and attending program events (e.g., success workshops, All Program Lunches, STEM Professionals Panel), conducting focus groups, and altering program structure in response to student input. Converting time into dollars using an average salary at our institution, the program costs the university $45,000/year, including the cost of course-release time provided by the university to the leadership team.

The university experiences a revenue benefit in the presence of the iAM Program as retention of Scholars in the program is higher than that of the comparison group (Table 5). With respect to actual costs and benefits, to date, with 23 students in three cohorts over four years, the university and a grant invested USD 317 K with a revenue benefit of USD 433 K for a net revenue benefit of USD 116 K and an overall return on investment of 36.6%. Note that gross revenue benefit to the institution is less than that projected in Table 5 since two cohorts have not yet completed all eight semesters. Even with small cohort sizes, the net benefit to the institution is positive. We are currently scaling the program with 12 biology and chemistry students in the most recent cohort and plan to expand to 22 students across all 24 STEM majors at the institution.

In addition to revenue benefits, the university experiences less-quantifiable benefits from the iAM Program. For example, higher retention and graduation rates and entry to STEM graduate schools or jobs contribute to national rankings, reputation, and alumni contributions. Within the institution, interdisciplinary collaborations and collaborations across academic and student services units contribute to increased efficiency and use of existing resources. In our case, the prestige of an NSF-funded program supported the institution's reputation and helped reframe conversations around retention and delivery of student support services. Beyond the university, societal benefits include placement of students into STEM careers, addressing the national need for STEM professionals.

**Table 5.** Retention rate from term to term of a comparison group (students eligible to join the iAM Program who did not join) and Scholars. Retention rates were calculated using the first three cohorts in the iAM Program. Actual retention rates were subsequently applied to a hypothetical situation of three cohorts of eight students assuming seven years of support for the program (i.e., until the third cohort had completed eight terms) to calculate projected revenue losses based on actual retention data. Retention is calculated using term 2 as a baseline since students who do not retain to term 2 cannot join the program. Rates > 100% are due to students returning following leave of one or more terms.

| Term | Comparison Retention Rate | Scholar Retention Rate | Number of Cohorts Used to Calculate Rates |
|---|---|---|---|
| 2 to 3 | 73.2% | 100% | 3 |
| 3 to 4 | 100% | 91.3% | 3 |
| 4 to 5 | 91.4% | 76.9% | 2 |
| 5 to 6 | 93.8% | 110% | 2 |
| 6 to 7 | 105% | 100% | 1 |
| 7 to 8 | 90.0% | 100% | 1 |
| Projected Scholars lost | 9.73 | 5.46 | |
| Projected Revenue lost * | $1.27 M | $687 K | |
| Projected gross revenue benefit | $588 K | | |
| Projected university and grant investment | $476 K | | |
| Projected net revenue benefit | $112 K | | |

* Unrealized tuition revenue + per student cost of recruitment.

## 6. Conclusions

We developed the iAM Program to be responsive to the existing context and situation at our institution. To date, the impacts on retention, graduation, and career entry have been large. As the iAM Program continues to grow and becomes institutionalized, we predict that the benefits to the institution will grow faster relative to costs required to maintain the program.

We adapted components of an existing program, the HHMI Professors Program at Louisiana State University [68], to create a model that addresses the contextual needs of our institution. We suggest that there are both essential and adaptable components underlying the model we developed (Table 6). We posit that for institutions to successfully replicate the iAM model, the essential components must be included and the adaptable components must be developed based on an analysis of each institutional context. Given diverse landscapes of higher education across countries, this analysis can and should include broader consideration of the cultural and societal contexts within which institutions exist.

The details of an iAM Program at other institutions should, therefore, vary from our program as the local context and needs will differ from that at our institution. For example, at our institution, the 2.0–2.74 first term GPA range served as a critical predictor of attrition. At other institutions, that GPA range or some other metric may serve as a better predictor within that institution's context. However, utilizing the following practices that underlie the iAM Program at our institution should help guide other institutions to create a program that is responsive to their local context, challenges, and opportunities:

**Table 6.** Theoretical foundations of the iAM model guide essential and adaptable program components. Developed within the context of higher education in the United States, the model is intended to be adaptable across international higher education contexts.

<table>
<tr><th colspan="2">Theoretical Foundations</th></tr>
<tr><td colspan="2"><u>Frameworks</u><br>
Legitimate Peripheral Participation<br>
Shifts planning and implementation of program components away from a program-centered focus of resources offered and towards a student-centered focus on how students experience resources.<br>
Inclusivity, Belonging, Community<br>
Guide adjustments made to the program by maintaining a focus on Scholars' experiences of these constructs.<br>
Frame program components within an achievement model<br>
Shifts the program focus away from "fixing" students and towards a focus on developing Scholar agency with the goal that student perception of interventions shifts from punitive to supportive.<br>
<u>Approach</u><br>
Ground in an understanding of the institutional context<br>
Ensures that program components and structure are relevant to and appropriate for the institutional context and target population(s).</td></tr>
<tr><th colspan="2">Program Components</th></tr>
<tr><td><u>Essential</u><br>
Each of the essential program components directly aligns with LPP in that each offers access and transparency to resources.<br>
• Integrate student support services into the student experience<br>
o Ensures students engage with existing support services rather than having to seek out services that they may not know exist, may not realize they could benefit from, and/or may not know how to access.<br>
• Dynamic hierarchical mentoring<br>
o Ensures newcomers have access to upper-level students and faculty who can guide newcomers to resources and the breadth of STEM professions; gives newcomers the opportunity to be engaged in a community and transition from a mentee to a mentor role.<br>
• Responsive program structure<br>
o Allows program changes to happen in near real time in direct response to Scholar feedback regarding challenges they articulate related to their success.</td>
<td><u>Adaptable</u><br>
Each adaptable component is dependent on (1) an analysis of the institutional context, and (2) clearly articulated goals for the target population(s).<br>
• Target student population(s)<br>
• Scholar selection criteria<br>
• Which student services to incorporate<br>
• Whether and in what form to incorporate metacognition and writing (e.g., via a seminar course, a student club)<br>
• Whether and in what form to incorporate exposure to the breadth of STEM professions (e.g., discipline-based professionals panel, in-class speakers)<br>
• Scholarship support</td></tr>
</table>

- Avoid *predicting* who will succeed versus who will struggle in the first semester of college. Rather, identify students who *actually* struggle in that first semester. This provides better use of resources as it targets intervention to students who would most benefit.
- Look closely at the historical and current context of the institution to determine:
    - Where critical attrition points exist;
    - What skills might best support students in your context;
    - What resources currently exist;
    - How existing resources are organized.
- Utilize the LPP, inclusivity, belonging, and community frameworks to guide decisions about program structure:
    - Ensure access;
    - Provide transparency (visibility and invisibility);
    - Recognize that access and transparency are necessary but not sufficient.

- Restructure existing resources as necessary (e.g., integrating support services).
- Provide a mechanism early in each student's engagement with the iAM Program in which to provide access to resources and address the skills identified as important (e.g., the STEM Writing and Metacognition Seminar).
- Encourage relationship building among peers and faculty with structured opportunities for students to become invested in the community (e.g., dynamic hierarchical mentoring).
- Create a program structure that is responsive to the needs of students. This could be part of a formal knowledge generation component as we have at our institution or it could be more informal.

If possible, find ways to support students financially.

While external funding was an important catalyst to generate ideas, secure university commitment, develop the program, and in particular, to offer Pell-eligible students scholarship support, all other components of the program either already existed within or were capable of existing within the university context. Therefore, the main costs in implementing the iAM model are those associated with commitment and time, both of which have financial analogues. Each institution must resolve the challenge of allocating resources, financial or otherwise, based on their respective context.

Given the need to support a larger, more diverse STEM workforce, institutions of higher education have a responsibility to support more students in earning STEM degrees. The iAM Program model is one response to this challenge.

**Author Contributions:** Conceptualization, J.S., R.E., L.F., B.M., E.M. and K.W.; Funding acquisition, J.S., R.E., L.F., B.M., E.M. and K.W.; Investigation, J.S., R.E., L.F. and K.W.; Methodology, J.S. and R.E.; Project administration, J.S., R.E., L.F., B.M., E.M. and K.W.; Supervision, J.S. and R.E.; Writing—original draft, J.S. and R.E.; Writing—review & editing, J.S., R.E., L.F., B.M., E.M. and K.W. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the National Science Foundation grant number 1742183.

**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Hofstra University (20190510-BIO-HCLAS-SAN-1 15 November 2017).

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Acknowledgments:** We thank our iAM Scholars and iAM faculty mentors, Hofstra University's Institutional Research team and Registrar, the Centers for University Advising, Academic Excellence, and Career Design and Development, Student Financial Services, the Hofstra University administration, and Amanda Turner and Kate Winter of Kate Winter Evaluation.

**Conflicts of Interest:** The authors declare no conflict of interest.

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