Informatics in Education, 2022, Vol. 21, No. 4, 695–731

DOI: 10.15388/infedu.2022.29

Integrating Open Challenges in the Curriculum: Lessons Learned from an Experience with NASA

Giovanni VINCENTI
The University of Baltimore, 1420 N. Charles St., Baltimore, MD 21201, USA
e-mail: gvincenti@ubalt.edu

Received: April 2022

Abstract. Preparing students for the workforce is a balancing act that involves theory, practice, and assessment. As students navigate an educational experience that is, however, often distant from real-world needs, it is imperative that academia finds a novel way to bridge the gap. As many organizations utilize open challenges to attract ideas and talent, academia can easily create such bridge, leading to greater engagement, greater student preparation, and a potential employment pipeline. This paper describes the experience of our students and faculty advisors who participated to the NASA SUITS (Spacesuit User Interface Technologies for Students) Design Challenge. In particular, we review the pedagogical value of the solution that they created and the changes that were implemented in the curriculum of an undergraduate degree program in Information Technology. This open-source, multi-year project is also a flexible platform that can be utilized for engagement in K-12 education as well as graduate research projects.

Keywords: project-based learning, open-source, student engagement.

1. Introduction

Higher education is often seen as a necessary step to complete before entering the workforce. However, it seems like many leave their undergraduate studies feeling that the material they spent years studying does not apply directly to their professional ambitions. In the case of technology education, this feeling may be supported by the ever-changing landscape of frameworks, programming languages, applications, and architectures that can be found in the professional world. This is particularly true if graduates find jobs in companies that utilize many tools that have been developed internally over the years.

A good education provides a solid foundation to modern technologies, but graduates are often left to connect the dots between what was learned in the classroom and their application on their own. In recent years, there has also been a significant increase of self-taught technologists, who acquire skills by studying independently or through bootcamps. Although there is nothing wrong with self-taught technologists, it is also of value to complete a degree and methodically go through the fundamentals.

The integration of real-world projects and contexts in a classroom, or perhaps even a whole degree program, would allow students to have the "a-ha moment" of connecting the dots while still in the classroom, and consequently should have a better preparation after graduation. In some cases, universities choose to partner with companies that shape their future workers throughout the higher education process. Although this approach is productive, students may focus too much on vendor-specific technologies, where a more generalistic approach to a subject may be preferable.

In this project we look at Open Challenges as a way to engage students by bringing contexts and projects into the classroom. In particular, we report on a multi-year effort to let our students work on real contexts through individual projects as well as classroom-based curricular activities. The outcomes include a surprising level of engagement as well as a high preparedness to enter the workforce, without tying the curriculum to one particular organization.

2. Background

2.1. *Project-Based Learning*

This learning paradigm is a subset of experiential learning, as reported by Blumenfeld *et al.* (1991), where students are required to shift their focus from memorization to the application of what they learn. A beneficial consequence of this shift is that they engage more parts of the brain, in according to Zull (2002). However, not every experience that is somewhat grounded in real-life scenarios may be a useful approach to project-based learning. Kolb and Kolb (2005) states that it is essential that the series of activities engage in a cycle of four iterative stages: Abstract Conceptualization, Active Experimentation, Concrete Experience, and Reflective Observation.

Just like picking a real-life scenario may not be enough, it is important to also consider other aspects. In particular, Larmer and Mergendoller (2010) suggest that a good project must feature the following aspects: significant content, a need to know, a driving question, student voice and choice, 21st century competencies, in-depth inquiry, critique and revision, and lastly a public audience. These experiences are particularly useful if associated with meaningful peer assessment, especially in adult learners, as reported by Surahman *et al.* (2018).

2.2. *Institutional Context*

The University of Baltimore is an institution deeply tied to the community. Its four Colleges, including the College of Arts and Science, in which this project exists, are strongly connected to the social fabric of the city. The Liberal Arts nature of the University ensures that our students not only study a domain of their choice, but also expand and connect the specific knowledge to broader topics and issues. The institution focuses on students who are already working and typically have not been able to finish their degree prior to entering the workforce. Consequently, our student population can be referred as non-traditional, as the average age for undergraduate students is currently 30 years[1]; the age of 24 years is typically considered the limit for traditional-age students, as reported by Dill and Henley (1998). Recently, the University has also been designated a Minority Serving Institution[2], or MSI, as it meets the characteristics of a Predominantly Black Institution[3], or PBI.

The faculty member primarily involved in the project, as well as the curricular context in which it exists, are part of the Applied Information Technology program. Students in the program can select from a general track or from one of two concentrations: Application Development or Cyber Security. All students in the degree are required to learn fundamentals of programming, databases, networking, cyber security, and project management. The general track allows students the freedom to customize their academic experience in a way that best suits their future plans. The concentrations instead focus on specific areas, so that students can quickly become familiar with the latest technologies within their sub-domain.

The significant presence of non-traditional-age undergraduate students in our degree program poses significant challenges, as the differences with traditional-age students are sometimes significant Remenick (2019). Much of the material, which is often theoretical in nature, is not always easily adaptable to contexts that are more in line with our students' needs. With an average age of 30, our students often have the necessity of finding a job within the field quickly, and often without going through an internship. Most of our students have responsibilities such as a family or a full-time job, usually not in technology.

The limitation of time to be dedicated to academic content leads to the necessity of optimizing the time that they have in class or working on the material. For this reason, we take the "Applied" part of our degree program very seriously, as we need to equally help students who are interested in joining the tech workforce as well as those who plan on continuing their education through graduate studies. For this reason, we decided to look into Open Challenges, and in particular NASA SUITS, as a way to enhance the curriculum, engage students, and quickly apply the theory into practice, as described in Section 5.

3. Open Challenges

An early project that extended beyond an organization's typical Research & Development department is SETI@home, which asked regular home users to install a screensaver that would process radio signal data collected from Space while their computers were inactive. The project, described by Anderson *et al.* (2002), is a great and early example of crowdsourcing, where everyday citizens could participate in some way to larger projects, as described by Estellés-Arolas and González-Ladrón-de Guevara (2012).

[1] https://www.ubalt.edu/about-ub/ataglance/
[2] https://www.doi.gov/pmb/eeo/doi-minority-serving-institutions-program
[3] https://www2.ed.gov/programs/pbihea/awards.html

The original project of SETI@home morphed into a platform, as described in Anderson (2004), that opened access of a global computational power to other projects as well. From this point, access to large projects by "amateur researchers" seemed easier, especially if the volunteers wanted to contribute through their skills rather than just computational power; this marks the start of citizen science, as reported by Silvertown (2009).

As Howe (2006) reports, in recent years there have been several initiatives dedicated to bringing real-life problems to the public through crowdsourcing. Some crowdsourcing initiatives go well beyond programming competitions, since they often require the creation of entire systems or workflows. Among the many initiatives, we can find projects sponsored by the US Government[4], data mining competitions hosted primarily by private companies and available on Kaggle[5], and ACM Student Research Competitions[6].

The inclusion of crowdsourcing projects into academic contexts is far from new. One of the earliest examples is described in Miko (2014), where an instructor utilized the Google Online Marketing Challenge to teach search marketing and pay-per-click advertising campaigns. One of the latest examples is DARPA's SubT challenge[7], reported in Ackerman (2022). The main goal was to elicit ideas for innovative technologies that would augment underground operations. Although the challenge was open to anyone, teams from 20 universities participated to this event. However, the project described in this article is different from the others as our participation to an Open Challenge sparked a series of updates to the curriculum and the way we engage current and future students through project-based learning.

3.1. *NASA SUITS*

Microgravity University[8] is based at NASA's Johnson Space Center in Houston, Texas, and is dedicated to initiatives centered around Artemis Student Challenges[9]. These Challenges are inspired by the Artemis Program, which aims at establishing a permanent human presence on the Moon, as reported by Smith *et al.* (2020), and are managed by NASA's Office of STEM Engagement[10].

Among Microgravity University's Challenges, we can find Micro-g NExT[11] (Micro-g Neutral Buoyancy Experiment Design Teams), which invites student groups to design tools that may facilitate work in Space. Another initiative is MITTIC[12] (MUREP – Minority University Research and Education Project-Innovation Tech Transfer Idea Competition), which focuses on the commercialization of ideas and research projects linked to Space exploration.

[4] `https://www.challenge.gov/`
[5] `https://www.kaggle.com/`
[6] `https://src.acm.org/`
[7] `https://www.darpa.mil/program/darpa-subterranean-challenge`
[8] `https://microgravityuniversity.jsc.nasa.gov/`
[9] `https://stem.nasa.gov/artemis/`
[10] `https://www.nasa.gov/stem`
[11] `https://microgravityuniversity.jsc.nasa.gov/about-micro-g-next`
[12] `https://microgravityuniversity.jsc.nasa.gov/nasamittic`

Table 1
Timeline for the NASA SUITS Design Challenge

Month	Primary Activity
August	Call for Proposals Announcement
September	Letter of Intent Deadline
October/November	Proposal Deadline
December	Team Selections Announcement
April/May	Test Week
June	Final Submission Deadline

Our project is based on the Artemis Student Challenge called SUITS[13], or Spacesuit User Interface Technologies for Students. The main goal of SUITS is to elicit student-designed augmented reality solutions that may be integrated into space suits to be used in the Artemis program. The focus of this Design Challenge shifts every year, and the tasks ranged from assisting astronauts with repair procedures, facilitating an astronaut's translation over the Lunar surface, and the interaction with assistive technologies, such as rovers.

As NASA SUITS is explicitly geared towards higher education participants, the works are scheduled around the academic year. The original goal of the organizers, who are educators themselves, was to allow universities to incorporate this experience into a capstone-type course. For this reason, the schedule that they have maintained since the inception of this initiative, reported in Table 1, is in line with the academic year.

Students are expected to work on their solutions throughout the year, and they will receive feedback from NASA personnel at different stages of the process. The first, main event is Team Selections, where a technical committee will choose a subset of teams based on the proposals that they have sent earlier in the year. Over the years, the process after Team Selection has changed, so we cannot generalize enough the different steps without referencing a particular year. However, after Team Selections, all teams work closely under the supervision and with the help of NASA engineers, who provide feedback as well as systems such as telemetry simulators (data that may originate from a space suit, such as oxygen levels, ambient temperature, and internal pressure), aimed at contextualizing the Design Challenge as much as possible.

Test Week is the highlight of the works, where students will collaborate directly with NASA engineers and other personnel to introduce, demonstrate, improve, and document the solutions that they proposed. This time of intense work is the highlight of the experience, giving students a true hands-on week. During the past years, COVID-related restrictions limited Test Week to virtual synchronous collaborations, however SUITS organizers already resumed in-person Test Week activities during this past edition.

[13] `https://microgravityuniversity.jsc.nasa.gov/nasasuits`

4. Student Engagement

The need to engage traditional and non-traditional students quickly and successfully, as described in Section 2.2, is a challenge that exists in all of our courses. We have tried to include a significant hands-on element, which includes the project described in this article. However, this is not the only large project that we have as part of our curriculum.

The other major project that spans over multiple courses is described in Vincenti and Pecher (2020) and aims at creating an automated indoor farm, jointly with our Environmental Sustainability program. The primary short-term goal of this project is also to help students quickly gain and apply technical skills in lieu of internships. We attempted to also incorporate this project into an Open Challenge, NASA's Deep Space Food Challenge[14], we were not successful as COVID imposed significant limitations to several aspects of the project that would have required in-person work.

4.1. *Participation to NASA SUITS*

Since 2018, students at the University of Baltimore have participated in NASA SUITS, an Artemis Student Design Challenge that asks students to design and create spacesuit information displays within Augmented Reality (AR) environments. Our students have participated in this challenge enthusiastically and have created a complex system that not only includes an AR component for the User Interface (UI), but also a series of other technologies that would support an astronaut's operations during an Extra-Vehicular Activity (EVA), informally known as a "Space Walk".

The system, named ARGOS (Augmented Reality Guidance and Operations System), described in more detail in Section 4.2, utilizes an AR headset to present a minimal and effective user interface designed to display vital information, provide instructions, and reduce the cognitive load for the user. The AR element is supported by technologies that are found in Internet-of-Things (IoT) systems, such as microcomputers, ad-hoc networks, and mobile applications for remote monitoring and control.

A first direct measure of the amount of engagement observed in students is the number, variety, and level of degree programs of student participants. The first iteration of the project included only students in Applied Information Technology, but over time it expanded to include students from 7 different programs:

- Bachelor of Science in Applied Information Technology (AIT).
    - Upper-Division Certificate in Computer Programming (CP).
- Bachelor of Science in Simulation and Game Design (SGD).
- Bachelor of Arts in Interdisciplinary Studies (IDS).
- Bachelor of Science in Business Administration, Data Analytics Specialization (BA).
- Master of Science in Interaction Design and Information Architecture (IDIA).
- Doctor of Science in Information and Interaction Design (IID).

[14] https://www.nasa.gov/feature/deep-space-food-challenge/

Given the non-traditional nature of our students and the need of some to quickly change careers, we have created an Upper-Division Certificate in Computer Programming (CP), included in the list above. This program requires students to complete 4 courses, equivalent to 12 credits, that are a subset of the degree in Applied Information Technology. Although the outcome is not a full degree, many students prefer this option as they may already have one or more degrees in different fields but wish to make a career change into technology. Since several courses that are now aligned with Open Challenges are also part of the Upper-Division Certificate, we had several students inquire about the AstroBees and some also joined the group.

As a second direct measure of engagement, we report in Table 2 the amount of students involved in the project, listed by major. The number in parentheses next to the total of AIT students reports CP students, included in the AIT count. The increment of student participation in terms of numbers and degree programs is most significant. This project is taken on by students as either their Capstone project or as an extra-curricular. In both cases, participation to the project is voluntary.

There are two elements that are worth noting. The first is the number of returning students. Most students graduate at the end of the year of participation. However, in some cases, students either had other academic requirements to fulfill after their Capstone experience, or simply participated to the project as an extra-curricular activity. All the students who did not graduate by the end of the first year of participation decided to return the following year.

The second element that we should address is the lower number of participants on Year 2021–22. The timeline of NASA SUITS requires students to submit a proposal by October, which will be reviewed by December. At that time, there will be a selection for teams that will advance to the next stage. During this academic year, our team was not selected, and consequently other students did not join in the Spring 2022 semester. However, several members continued their project throughout the year or in preparation for future semesters.

Table 2
Number of student participants by course of study by year.

Course of Study	NASA SUITS Design Challenge Year			
	2018–19	2019–20	2020–21	2021–22
AIT (CP)	5	9	10 (1)	3 (1)
SGD	2	1	3	4
IDS	0	0	1	0
BA	0	0	0	1
IDIA	0	2	2	5
IID	0	0	1	0
Total	7	12	17	13
of which returning	–	3	6	5

Although we do not report the age of the students in this work, we need to clarify that not all participants were non-traditional. All the participating students informally reported significant benefits, including receiving multiple offers within two months after graduation and/or admission to prestigious graduate schools. As this observation was true for all students, both traditional and non-traditional, we believe that the project described in this article is of interest regardless of the students' age.

4.2. *ARGOS*

The next important aspect to introduce is ARGOS itself, as it is the student-driven, faculty-supported project that is the focal element of the work reported in this article. This system is now a platform that supports educational initiatives as well as undergraduate, graduate, and faculty research. The system and the context in which it exists are characterized by the presence of many acronyms, reported in Table 3.

ARGOS, depicted in Fig. 1, allows for the interaction of multiple entities, such as IVA/MCC controllers, astronauts on EVAs, and other autonomous systems. The main communication infrastructure is provided by OCTaVIA, a series of nodes interconnected through a Wi-Fi network. The primary mode of interaction is through MAE, an augmented reality application that provides an HMD to the user. This system is a head-worn device that takes incoming data from OCTaVIA and xEMU space suits to provide information relative to the user's location, telemetry data, and hosts navigation, scientific sampling, emergency and remote-operation controls, and a warning/alert system.

Access to ARGOS and any of its features can be achieved by any device that can be connected wirelessly, such as an exploration rover or other equipment. As OCTaVIA is the backbone of ARGOS, and it consists of interconnected devices providing services, it

Table 3
Acronyms related to the project described in this paper

Acronym	Meaning
AR	Augmented Reality
ARGOS	Augmented Reality Guidance and Operations System
EVA	Extra-Vehicular Activity
HMD	Head-Mounted Display
ISaMS	Intelligent Sensing and Mapping System
IVA	Intra-Vehicular Activity
MAE	Mobile Augmented Environment
MCC	Mission Control Center
OCTaVIA	Operations Control, Translation, and Visual Interface Assistance
PAM	Passive Activity Monitor
RCA	Remote Control Application
xEMU	Exploration Extra-Vehicular Mobility Unit

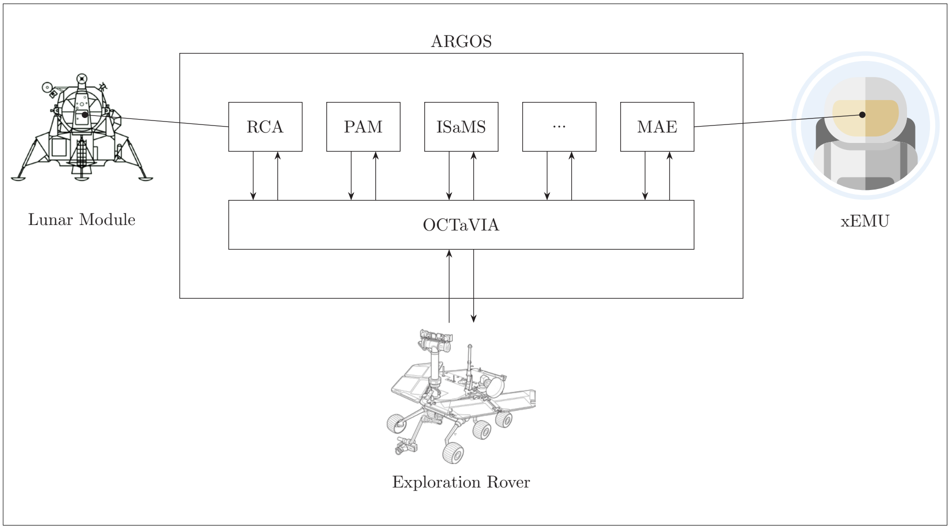

Fig. 1. ARGOS – This is the original figure from the ICES paper.

can be easily expanded to include new features that are readily available throughout the entire system by adding them as simple services.

An example use-case for ARGOS and OCTaVIA is reported in Fig. 2.

Let us consider the distance that astronauts may have to travel from their base, either a lander or a permanent structure. As line-of-sight is necessary for signals to hop from the sender to the receiver, it is necessary to have communication nodes, depicted as N_1 through N_{17} in Fig. 2, throughout the work area. As the nodes would be in place for communications purposes, we also give them the ability to process information using technologies typically used in cloud computing, such as Docker and Kubernetes. This allows astronauts the safety of a digital tether that is not only able to relay communications, but can also be used for data processing and storage, effectively augmenting the computational abilities of the xEMU.

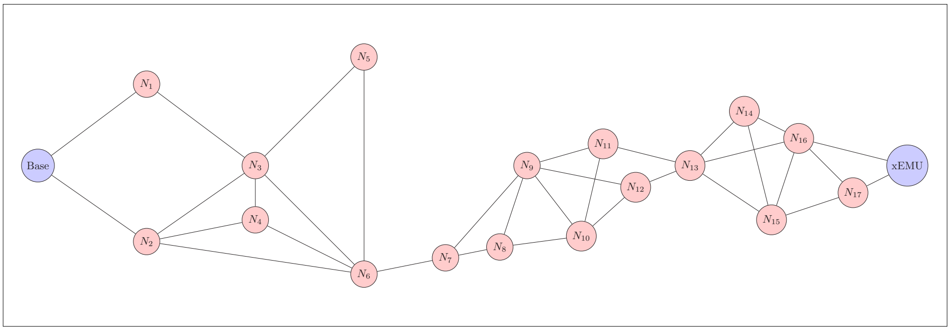

Fig. 2. OCTaVIA.

5. Integrating Open Challenges in the Curriculum

The complex structure of ARGOS offers two significant pedagogical aspects: students see a variety of technologies that are operating as one, and the system can be easily augmented given its modular architecture. Coupled with the significant level of engagement that the participation to NASA SUITS reported, we have built a tool that can grow and support meaningful learning at several levels given the technical competencies that it includes, reported in Table 4.

This list of technical competencies is just a starting point, as the system can be augmented in many ways. Currently, there are the competencies that are most relevant to our degree programs and that are associated with modules that have already been developed. We should also mention that this project requires competencies that go beyond computer programming, which include project management, documentation, collaboration, agile development, communication, and requirements elicitation. All of the hard and soft competencies reported in this section are in line with current trends in terms of workforce readiness, as reported by Karaevli *et al.* (2020).

The project generated a significant amount of engagement within the students who participated, far greater than any capstone experience that we observed. The students' commitment for this project and the social media coverage by our institution also influenced many of their peers who were not completing a capstone, but who were interested in using the same project once they would be eligible for the course. The amount of interest led to the implementation of curricular changes.

Table 4
Technical Competencies by Device

Device	Competencies
EVA Simulator	JavaScript or C# Programming User Interface Design Network Programming Multi-Threading 3D Modeling and Animation
IVA/MCC Simulator	Android Programming User Interface Design Network Programming API Calls
OCTaVIA	Node.JS Development NoSQL Database Design and Management Relational Database Design and Management Application Programming Interface (API) Development Python Programming Java Programming Artificial Intelligence Modules System Administration and Task Automation Distributed System Design and Implementation Containerization Technologies (Docker and Kubernetes)

We can identify three phases to the curricular evolution. Phase I was limited to Capstone projects, where students chose to utilize ARGOS or one of its components as their final project. In Phase II, we extended the involvement of our students by updating projects in regular courses and aligning some of the curriculum to cover the technical fundamentals required by the project. Lastly, in Phase III we created courses that are tailored around experiences that our students reported as important. Outcomes associated with Phase I and Phase II are reported in Section 6.

5.1. *Phase I – Capstone Projects*

Curricular work associated with this phase focused on individual students who chose to work on ARGOS or one of its components for a for-credit experience typically linked to their final project, or Capstone. When our students started participating in NASA SUITS in 2018–19, we adopted immediately this format as it was the easiest to meet the dynamic requirements of the Design Challenge. Since then, we continued using this format for individuals who were directly involved with the project, however the initial scope expanded from a single course, described next, to other endeavors, such as Master's Theses, discussed in Section 6.1.4.

5.1.1. *AITC 490, Capstone in Information Technology*

Capstone courses typically culminate the academic experience of students working on a degree in IT, and they are fundamental to summarize and put in context all the topics discussed through their studies Helps *et al.* (2015). The rationale behind such experiences is not only empirical, but also firmly grounded in research-based educational practices Wang and Bohn (2018). Finally, even though some students are reluctant to work in groups, such practice is most useful for a meaningful experience Börstler and Hilburn (2015), and in particular when such project is driven by external stakeholders Steghöfer *et al.* (2018).

Provides students with hands-on work experience in applied information technology. Students may arrange placement with an external organization, subject to written approval by the instructor and an official of the organization. Alternatively, students may participate in an in-house project managed by the instructor. In the latter case, students attend regular class meetings as part of their project work.

LO.490.1 Implement an IT solution relevant to your chosen track or career orientation.

LO.490.2 Demonstrate effective written and oral communications skills.

5.2. *Phase II – Course Projects*

In this second phase, we decided to expand the reach of the project from individual endeavors of students dedicated to NASA SUITS to others who may not be able to join because of other commitments or time limitations. For this reason, we revised the curriculum as well as the requirements (typically assignments) of three different courses to include aspects of ARGOS and the context of NASA SUITS.

5.2.1. *AITC 351, Object-Oriented Programming*

The topics discussed in AITC 351 are equivalent to most CS2 courses as reported in Porter *et al.* (2018), including abstract data types, generic classes and methods, complexity, and algorithms. The following Learning Outcomes specify the main goals of the course, which is currently taught using the Java programming language:

LO.351.1 Describe the concepts of encapsulation, inheritance and polymorphism.
LO.351.2 Practice problem solving skills.
LO.351.3 Implement Java programs based on object-oriented techniques.
LO.351.4 Solve a variety of problems using Java.
LO.351.5 Develop programs that are syntactically and logically correct.
LO.351.6 Apply advanced concepts of the Java language.

The assignments in this course were already structured in a way that students are exposed to a single, semester-long project that they develop incrementally. Anecdotally, we have found that our students react positively to this approach and report a higher engagement with the material, as described in the literature by others Vega *et al.* (2013). Since the assignments are sequential and build on each other, if the students do not feel comfortable with their own solutions to a previous assignment, they can utilize the one published by the instructor.

Typically we assign 5 scaffolded projects, with the intent of creating a full application by the end of the semester. The students start by creating a simple class that features encapsulation, where the setters implement validation rules. The second assignment turns the original class into an abstract one and adds inheritance as well as polymorphism to represent conceptual specialization. In the third assignment, we add interfaces as well as a basic user interface where students enter a series of objects of different type into an array. The fourth assignment builds on the third by allowing the students to edit records as well as implement searching and sorting algorithms still based on a simple array. In the fifth and last assignment, students implement a simple array-based list and substitute the array with their own data structure. The assignments also require thorough documentation with Javadoc, unit testing with JUnit, and validation rules based on one or more JSON datasets.

The basic structure that we just outlined allows for a wide customization of concepts. Each semester, the instructor chooses the types of objects that the application should manage, along with the validation rules. For example, students have created a management system for a grocery store, for a hospital, and for a bookstore. In Fall 2019, the main subject of the management system revolved around the scientific sampling of the previous year's NASA SUITS Design Challenge. In particular, students were asked to create a system that would allow astronauts to store information about scientific samples collected in space. The class diagram for the overall set of assignments is reported in Fig. 3.

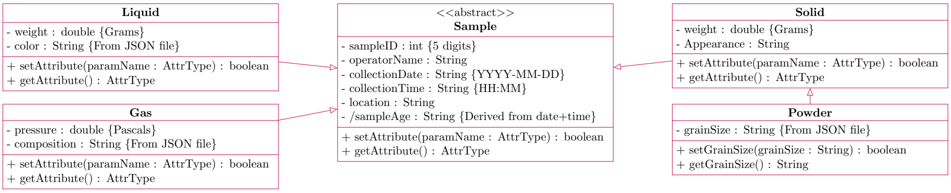

Fig. 3. OCTaVIA.

The series of assignments was designed to touch on all Learning Outcomes. In particular, however, they focus on *LO.351.1*, *LO.351.3*, *LO.351.5*, and *LO.351.6*. As the students progress through building their own equivalent to a back-end Model and Controller in the MVC pattern as described in Leff and Rayfield (2001), they become familiar with advanced programming OOP concepts such as static and dynamic polymorphism as well as language-specific elements such as lambda expressions.

The classes and data structures that were implemented for this course were contextualized to the students early on, with an introduction to the requirements of the NASA SUITS Design Challenge, as well as an introduction to ARGOS. The students were aware that their work would fit as part of the EVA as well as IVA simulator, any time the astronauts would interact with the set of geological samples. Even though the students knew where to find information regarding the challenge and any related content, they were not instructed to compare their solution to any of the documentation available through NASA.

5.2.2. *AITC 356, Database Systems*

The course covers material that is typical of Database courses that focus on relational models. We spend most of the semester on the theory and practice related to relational systems, with brief introductions to document and graph models. The implementation of the course puts much emphasis on the theoretical elements as well as coupling the implementation element with the specifications drafted when creating an ER diagram. The Learning Outcomes show the intertwining of theory and practice:

LO.356.1 Design a database to reflect business needs.
LO.356.2 Describe the principal features of the relational data model.
LO.356.3 Apply the Data Definition Language and Data Manipulation Language to interact with the Database Management System.
LO.356.4 Model an organizations data using entity-relationship modeling concepts.
LO.356.5 Illustrate relevant hardware and data structure concepts as they apply to data management.
LO.356.6 Describe the organizational issues involved in data management, especially the role of the database administrator.
LO.356.7 Explain the basic concepts of distributed databases and the advantages and disadvantages of distributing data.

The assignments throughout the semester include several individual projects as well as one group project. Most of the individual projects for this course are also organized in a scaffolded way, so that students can see how a simple concept can evolve into a larger, more complex system. For this course, we did not alter the individual projects, as there is the need to individually assess students on each of the Learning Outcomes listed above.

The group project involves activities that arch over the entire semester, from the creation of an ER diagram to the implementation of queries and any necessary basic stores procedures. Typical group projects assigned in this course appeal to the students' knowledge of common concepts, such as hospitals or retailers. In these cases, students have to observe a domain with which they are presumably familiar and create a database system that can meet the demands of what they perceive as requirements. Although these projects are useful, they rely solely on the students' understanding of the domain. Even though these are plenty of documents that students may utilize to refine the concepts associated with the context, they often rely on their observations and make 'educated' guesses, often leading to databases that depict their own understanding rather than the true nature of the domain.

The assignment that was given for the Fall 2019 semester focuses on the scientific sampling and EVA operations associated with NASA SUITS. In this case, the students were given free range in terms of the system that they were to develop. The only requirements that they had to meet were the following:

1. Keep track of astronauts and spacewalks information.
2. Keep track of telemetry.
3. Keep track of collected scientific samples.
4. Allow scientists to access information collected during spacewalks, including telemetry and scientific samples.

Although the structure of each database was up to the students, there were underlying concepts common to all database courses that had to be present in the solutions presented by the students. For that reason, the requirements above were mapped to the following technical outcomes:

1. Inventory management.
2. Timestamped data streams.
3. Geotagged and free-text data.
4. Complex queries involving three or more tables, timestamped data, geotagged data, and free-text data searches.

Since none of the students were already familiar with these operations, they could not reference anything in their experience to guess what the needs would be. For that reason, the instructions clearly directed the students to several documents that they had to review, in order to gain a firm understanding of all that is involved with space exploration. In particular, they were asked to review a sample telemetry stream (vitals and spacesuit information, provided by SUITS 2018–19), a series of Lunar sample reports[15]

[15] `https://www.lpi.usra.edu/lunar/samples/`

and tools[16], geological sampling information from the Apollo missions[17], and Space mission data related to EVAs[18]. All this material provided plenty of references for the students to understand the types of reports that may be generated using the database that they would have to create, giving context and actual documentation for them to reverse engineer the requirements of their solution.

For this course, the students were given an overview of ARGOS, its operations, and the design that this year's team created. The students worked under the direction that this system will be a candidate for implementation in the telemetry server as a way to track data. The students knew that the original solution involved Node.JS and MongoDB for speed and potential volute of transactions, and that this relational approach would be most useful as a way to aggregate the data upon completion of an EVA.

As each of the multiple individual assignments focus on all the Learning Outcomes, the group project focuses on just as subset. In particular, the assignment asks students to review official documentation to understand the needs of the organization (*LO.356.1*), which the students will have to implement using SQL (*LO.356.3*). We also ask students to describe in plain language the design as well as the queries, effectively requiring them to justify their choices in terms of entities and relationships (*LO.356.4*).

5.2.3. *AITC 457, Mobile Application Programming*

This course leverages Android to create mobile applications for devices such as smartphones and tablets, focusing on the underlying wireless architecture and infrastructure in native environments. We have chosen a platform-dependent technology so we can expose our students to the hardware as well as implementation-specific features Dalmasso *et al.* (2013). The Learning Outcomes for this course are the following:

- *LO.457.1* Explain the difference between mobile programming and programming for other platforms.
- *LO.457.2* Describe the various aspects of mobile applications.
- *LO.457.3* Create simple GUI applications.
- *LO.457.4* Program mobile applications for the Android, Windows Phone, and/or iOS platforms.
- *LO.457.5* Deploy applications to a mobile application marketplace.

The assessment strategy is primarily project-based, and students have to work independently as well as in groups to create mobile applications. For this course, the individual assignments are typically scaffolded, while group assignments require the creation of a new project every time.

In Fall 2019, students were required to work on two group projects based on SUITS. They were required to create applications that would serve as a way to keep track of an astronaut during an EVA. Students were introduced to the requirements shared by NASA for the challenge, as well as were shown the prototype that students

[16]`https://www.lpi.usra.edu/lunar/samples/apollo/tools/index.shtml`
[17]`https://www.hq.nasa.gov/office/pao/History/alsj/tools/Welcome.html`
[18]`https://www.nasa.gov/centers/johnson/news/flightdatafiles/foia_archive.html`

created for the previous year's system. Students were given the following requirements for Group Project 1:

- Remote monitoring of data (a.k.a. telemetry).
- Sending and receiving messages with the astronaut through text-based communications.
- Warning and alarm systems in case parameters of the astronaut are outside normal ranges.
- Selection of training manuals (a series of PDFs and/or images) and sharing with the astronaut.

For this first project, students were required to create an application designed for a smartphone. The students were then asked to add the following requirements for Group Project 2:

- The application will be formatted for a tablet.
- Interaction with the telemetry data stream.
- The application will have a settings panel that will let the user perform actions such as:
  - Select the IP address of remote resources.
  - Refresh rate of the stream request.
  - Connectivity information (Bluetooth and Wi-Fi).

For these assignments, the students were told that their systems would be candidates for the IVA simulator in the final implementation of ARGOS. The instructor provided the REST API system that generated the telemetry data, based on the documentation shared by NASA during the previous year. The system was customized to simulate standard as well as emergency readings in the stream. The Learning Outcomes that are directly related to these assignments are *LO.457.3* and *LO.457.4*. Even though we did not ask the students to deploy to the marketplace, they were asked to package the application into a signed APK and be able to download it and install it through the web, so most of the elements required to fully meet Learning Outcome *LO.457.5* were also included.

5.3. *Phase III – Ad-Hoc Courses*

Informal feedback that we received from students who participated in Phase II highlighted that several would be interested in carrying out projects related to Space exploration and the Artemis Program. However, many also reported that they would be unable to join the group of students participating to the NASA SUITS Design Challenge for a variety of reasons, such as family responsibilities that would limit their availability for meetings or to travel. Yet, these students still wanted to carry out projects that had their own flare and that could focus on their own interests, rather than stick to the requirements of the course assignments. For this reason, we created two brand-new courses that were inspired by the feedback.

5.3.1. *AITC 459, Open-Source Software Development*

This first course focuses entirely on open-source projects, such as ARGOS. The course allows students to learn about and practice the development of open source application, including the contribution to well-known systems as well as starting brand new projects. Introduces students to tools and practices typically utilized in the development and dissemination of open source software. Topics include licensing, versioning systems, testing, and source code documentation.

5.3.2. *AITC 481, Undergraduate Research Experience*

As many institutions offer undergraduate research experiences as part of NSF's REU program, we decided to create a course that focuses completely on research projects led by undergraduate students. This course requires the preparation of a work of original research or a substantial IT project displaying practical knowledge of relevant research. Each student is required to develop a substantial thesis project that incorporates innovative approaches to technology based problems.

6. Outcomes

We were able to collect feedback from students for initiatives that were included in phases I and II, and they are reported in this section. We were not able to collect reports about Phase III initiatives yet, because the courses were approved shortly before COVID-related restrictions were enacted, so the attendance has been too low to get any meaningful feedback. Once our instruction returns to fully in-person, which is expected starting in the Fall 2022 semester, we hope to collect feedback from these new courses as well.

6.1. *Outcomes from Phase I*

Initiatives related to Phase I, or individuals choosing to participate to NASA SUITS and have the experience count for some type of credit, started in Spring 2019, after acceptance of the proposal into the Design Challenge. In this section we report qualitative findings from each year. Some of the material for Year 1 was already reported in Vincenti (2019), but feedback from Years 2 and 3 has not been published before.

6.1.1. *Year 1, 2018–19*

Towards the end of the project, the students completed an anonymous survey about this experience. The survey was composed of 6 questions, plus an area of comments for anything that the students may wish to share that was not covered by the questions. Four of the 7 students completed the questionnaire.

The first question asked the students to describe the best part of the NASA SUITS experience. All the feedback was extremely positive towards the NASA SUITS challenge as well as the support that they received from the university. They appreciated particularly the interaction with experts who are working in the field. One student particularly appreciated the progress made through the project, as reported in the following quote:

> *Being given a space to tackle what felt like an insurmountable challenge. To take on a project that felt above my skill level and learn my way through it.*

The second question focused on negative aspects of the experience. The main issue reported by the students was that the learning management system used to communicate with the NASA SUITS team was not very intuitive. Also, the communications were spread across different areas of the site, so students had to periodically look through the entire site to find if new information was posted. Another issue that came up throughout our participation to the challenge was that students have other courses going on at the same time. The amount of time that a first-time participant to this challenge would require is significant, and students certainly felt the pressure. Thankfully the instructors of other courses worked with the main advisor of this project to help students complete all their work on an adjusted timeline.

When asked whether the students would repeat this experience, all the answers were positive. The main focus of the feedback revolved around the creation and demonstration of the product to well-known experts in the particular domain of application. Several answers mentioned how they liked seeing their project applied somewhere, hinting at the fact that most classroom projects do not go beyond the course in which they are assigned. One answer that is particularly encouraging is the following:

> *Absolutely. This is a life changing experience that will test the students capabilities and dedication in front of unknown situations.*

The fourth question focused on whether the coursework that the students completed during their degree prepared them enough for this challenge or not. Also in this case, all the answers point to the same idea: the coursework gave them the tools necessary to tackle the challenge. They were able to apply troubleshooting techniques effectively to resolve issues, and they quickly adapted their knowledge to meet the challenge. Even though an IT program is often considered less programming-intensive than CS, it was enough to prepare the students for the challenge, as reported in the following answer:

> *My coursework helped me by providing: methods of troubleshooting and good enough programming skills to figure out a new methodology.*

Related to the previous question, the students were then asked how much extra material they had to learn for this challenge. The answers ranged over the entire spectrum, as each student had a different role that may or may not have been more in line with their experience. In one particular case, the student had never worked with modeling, so there was much ground to be covered before delivering the final product. Also in this case, one of the answers is particularly reassuring for IT programs:

> *For this challenge I do not believe I had to learn anything "extra". The foundation of how a programming language worked and how*

> *data is moved across a network towards different systems were there. I merely had to adapt and learn how to work in a different environment/ language.*

The last question focused on the future of this project at our institution, which will be discussed in the next section. The students were asked if parts of this challenge should be incorporated into group projects of other courses. Most of the answers were in support except for one, which focused on the 3D modeling of the various components involved in the animations. Since this particular skill is associated with the SGD major, this answer will not influence the integration of NASA SUITS into IT-related projects. One answer was particularly supportive:

> *I believe groups projects in the future should be geared towards something that is practical and tangible. Both the IVA manager and the telemetry simulation provided a platform to build a solution which involved practical technologies that are currently used in the industry.*

Lastly, two students entered final comments, both reported here:

> *This experience is a boost in anyone's confidence. I personally saw more of the real world with this experience, helping me to feel ready for a job interview. It was all great, I can't put into words how valuable this experience has been for me.*

6.1.2. *Year 2, 2019–20*

During this second year of participation to NASA SUITS, the World also experienced COVID and significant related restrictions. For this reason, the feedback we collected from students during Year 2 was particularly important as it highlighted how much engagement they could still feel while undergoing significant personal, professional, and academic changes linked to the pandemic.

Students were asked 10 questions plus one for other comments. The survey was sent to all 11 participants to NASA SUITS, however only 7 responded. The first question asked about which was the best aspect of the experience. Six of the 7 answers included the importance of working on a real-world problem. The last answer mentioned the final product, which was a significant piece for their portfolio. One of the answers that was most striking is the following:

> *The best part of the NASA suits experience for me, is how novel the project is compared to traditional classroom work. Also, the collaboration between team members and the interdependence of system components helped to promote coordination with team members and taught me how to work in a team.*

A rather surprising yet welcome answer focused on the outreach component of the project. A significant portion of what NASA required for SUITS participants is to host outreach events. Some of these events may be done through social media, but others included working directly with schools. Below is the answer from our participant:

The best part for me was being able to visit high schools and talk to them about the incredible things we were doing with this challenge. It was very fun speaking to them and seeing them get excited about Augmented Reality, while also inspiring them to be great in their future endeavors. It was also a really great experience to be a part of such a talented team and share so many memories that we will never forget.

The second question focused on the worst part of the project. Since the Spring semester coincided with COVID-related closures, nearly all the answers focused on the missed opportunities of working together as well as going to Houston, TX for Test Week. We did get one answer that was different than the others, and focused on a lack of preparation at the beginning of the project. After this feedback, reported below, we started offering more preparation sessions for students interested in the project.

Not knowing much in the beginning and being extremely confused; not understanding what any of this project really meant. I think hosting sessions for the 'interested' students to share what the NASA SUITS project is, what the Artemis mission is and what kind of work and progress we have made would be extremely helpful in reducing and lessening this confusion that had me almost drop and leave the project in the very beginning.

The next question asked if the respondents would repeat the experience. All agreed that they would repeat the experience. The most supportive answer was the following:

Most definitely, because I know that I will only continue to learn more and more, and the possibilities are endless when it comes to this experience.

The student who found the on-boarding comment reported earlier also expressed a very positive response. Ultimately, it seems like we were able to give the context of the project even when we did not have as many early information sessions.

I would, 100%, repeat the experience! Even if I took on the same role as I did this year, I would repeat the experience and maybe try and use more software and resources to improve my strategies and work. I would also repeat the experience if I could take on and learn a different role.

The fourth question focused more on whether our degree programs are preparing the students properly for real-world experiences, such as this one. All the students reported that courses in their majors prepared them for this project. One answer in particular stood out, highlighting that this project serves its purpose, and the students are proactively engaged:

My coursework taught me to always be ready to take on a challenge and that I could always tackle the problem with a little digging and research. This allowed me to not be worried about not knowing things, although I still was at times, but my main point is that I was challenged and taught in my classes that even if you think that the assignment or task looks impossible, you can still do it. It is important to use your resources,

> *whether that be looking online, watching YouTube videos, or communicating with your peers or instructors.*

The next question asked how much extra material the students had to learn to complete their project. All the students reported that they had to learn quite a bit, but that they were not placed in an impossible situation. The following answer is one that captures most of the others as well:

> *I had to learn a lot of extra material, since I had no prior experience with implementing any solutions that I created. This was somewhat challenging, but it proved to be beneficial for me because it expanded my horizons and gave me experience beyond the classroom that I needed.*

Next, we were interested in finding out how many students had already completed a course that included a project related to NASA SUITS. Since Year 2 included the Fall semester when we added SUITS-related projects, we wanted to see how many had already some background that came from related experiences, as outlined in Phase II. Six of the 7 respondents completed courses that had related projects.

The following question asked the students if their role in the project was directly related to the SUITS-related projects they carried out during the previous semester. Also in this case, there is one answer that captures the essence of all the others:

> *Yes and No. My role in the project involved some features that we had previously done in 457 like telemetry monitoring on the IVA and pulling data from a VM. However, even though I did not work on the IVA in ARGOS, I had to implement exactly the same telemetry methods used in 457 on the [Augmented Reality device]. So platform-wise no, but feature-wise yes.*

The next question still focused on whether the SUITS-related course project was useful in preparing for their Capstone experience. The answers were split evenly between Yes and No, as several students completed Capstone projects that were not part of the courses. The following answer captures what we originally hoped to get, when introducing ARGOS to students in courses prior to their Capstone experience:

> *No, because my role did not require programming or database skills. However, I do see how they would be beneficial since I completed the coursework, and later saw the correlation with what had to be done in those roles for the project.*

Next, we asked the students if the Artemis-related context discussed in previous courses, included in Phase II, gave them enough background information about the project. The answers ranged from students whose project was a continuation of what they completed in previous courses, to students who worked on completely different aspects of ARGOS. Overall though, the answers were positive. The following answer was the most supportive:

> *I do think there was enough context because for us as a team, the challenge was not incredibly detailed, so we worked with the information*

> *we were given from the provided website and we were creative with our solution. This is an important skill to have because in the workplace you may often be tasked to do things with limited creative instruction. There was no one way to complete the projects, and the context we were given was enough to encourage this.*

We would also like to report a second answer, which shows how, at the time, students may not realize how the course material or assignments may affect them later:

> *At first i just looked at it as an assignment. But now looking back it helped me understand the challenge better.*

The last question asked if we should continue integrating projects related to NASA SUITS to future courses. The answers were all positive, which supports our motivation to include real-life projects into our courses. We report two answers that were particularly interesting.

> *I think they definitely should continue to be integrated, because it will give students an exciting way to think about the purpose of the assignment, since it has a use in the real world. It may even spark a potential career interest in some students.*

> *Yes. Even if not all students will work on NASA's ARGOS in the future, working on ARGOS inspired projects in class will introduce students to real world applications of technology. Also, this will help reflect the title of the program "APPLIED [sic] information technology".*

Lastly, even though most students did not want to add anything else, some did. The two comments reported next show the level of engagement that students demonstrate throughout the experience.

> *Just wanted to take a second and thank YOU for your dedication, effort and endless amount of time that you put in to making our program the best it can be and for making sure all your students are successful and that they find the best jobs that they can be. Helping us become ready for the "real-world" and challenging us with tasks that we think are impossible, but you always say that you know we can do it! Thank you so much!!!!!!*

> *This was an amazing experience and I'm sad it's coming to an end. It was great working with everyone, looking forward to next year's challenge!*

6.1.3. *Year 3, 2020–21*

During previous years, we collected survey responses as the semester was coming to an end. The feedback was valuable, however it often did not include any information regarding how well the project prepared them for the workforce. For this reason, in Year 3 we decided to send out a simple questionnaire once the semester was over. We asked the students only two questions: 1) How has the project improved your learning experience while at The University of Baltimore, and 2) How has the project helped you with your professional future. In this section we include responses from four alums.

The first respondent worked on the project as Project Manager, Networking & Systems Developer, and Outreach Representative. After graduation, she is a DevSecOps Engineer at a large non-profit organization that operates between high school and college. The following are her answers:

(1) *This project significantly impacted my learning experience at the University of Baltimore as I was part of something classified as "the real-world". I learned and contributed my knowledge to such a large organization and their advance goals. I was able to not only learn, but I had the privilege to apply my skills to something with such a great impact.*

(2) *Participating in this project has been one of the best decisions I have ever taken! I learned so many real world skills and tools that I still use today at work. From technical tasks to presenting to large groups of individuals (including NASA astronauts and NASA engineers!!), I built so much confidence and experience. I can proudly say this project has had a very large impact on my future and career opportunities [...].*

The second respondent completed her Capstone project as a Mobile Applications Programmer for the IVA/MCC component. After graduation, she became a Software Engineer for a services company that supports leading grocery stores. The answer to the first question focused on the technical aspects of her project, so it was omitted from this report. However, the following is the answer to the second survey question:

> *Adding this project to my resume opened professional doors that would have otherwise been closed. I get callbacks from HR departments who are excited that I have this experience on my resume and want to know how I can contribute to their companies.*

The third respondent completed a Capstone project that revolved around the user interface design and development of the augmented reality headset. After graduation, she became a web designer for a NASA contractor and is now working at Goddard Space Flight Center. Her answers are reported next.

(1) *Taking on the NASA SUITS Design Challenge project was one of the most memorable parts of studying at the University of Baltimore. While guided well-structured classes are a great way to learn about a particular subject, the NASA SUITS project brought complex concepts to life and drastically increased obtaining the new information and retaining the information learned. The project inspired me to think outside the box and provided an opportunity to create a different study experience and a different way to acquire skills. In essence, the NASA SUITS project was a one-of-a-kind opportunity that offered the potential for success and growth, both personally and professionally, as well as presented a real-life experience.*

(2) *The project pushed me to apply the skills I have learned and motivated me to develop my knowledge further. The NASA SUITS challenge presented a chance to apply what I learned to real-life experiences. Moreover, through team-based work, I developed confidence, gained insight from different perspectives, learned new concepts, and increased my communication skills. NASA SUITS challenge was a life-changing project, and now I am continuing that inspiring journey at NASA, working there as a contractor for almost a year.*

The last respondent completed his Capstone project as a software developer also focusing on the augmented reality component, as well as the API and NoSQL elements. After graduation, he became a Software Development Engineer at Amazon Web Services and Ph.D. Candidate at Carnegie Mellon University. Next is his feedback.

(1) *The project improved my learning experience by exposing me to infrastructure development and how different software components interact in the real world. Unlike the conventional "full-stack" classroom projects with just a back-end and front-end, this project features components that support a full standalone system including Kubernetes support for containerization, IP addressing, machine learning, mobile app development, web hosting, and Raspberry Pis to provide peripheral support.*

(2) *In my professional future, the project helped me discover future trends in the tech industry and what to focus on moving forward. In addition, it also helped give my resume a head start with some industry experience which many employers look for.*

The feedback from alums gives us important insight to how potential and actual employers perceived the project that these former students carried out while at our institution. The validation of the importance of a "conversation starter" supports the integration of such project into the curriculum, whether it is at the personal level through a Capstone project or an Undergraduate Research Experience, or through a more collective initiative such as contextualized course projects.

6.1.4. *Research Products*

The feedback reported in previous sections gave us significant information about the individual responses to the academic experience, however the data is very subjective. Since ARGOS became a platform that we use for student engagement but also for research projects, we started keeping track of scholarly publications associated directly with the project. The list of all publications is reported in Table 5.

It is important to note that student research projects as well as theses were primarily conducted by students, with the supervision and guidance of faculty. The educational experiences instead were reports that focused on curricular changes as well as feedback, similar to this article. It is also important to note that all of the student research projects were not submitted in the student tracks of those conferences. Instead, all the

Table 5
Publications associated directly with the project

Type	Reference	Level
Theses	Yee (2020)	Graduate (M.S.)
	Crowther (2021)	Graduate (M.S.)
Student Research Projects	Soto Medico *et al.* (2020)	Undergraduate
	Ahsan *et al.* (2021)	Undergraduate/Graduate (M.S.)
	Hunt Estevez *et al.* (2021a)	Undergraduate
	Hunt Estevez *et al.* (2021b)	Undergraduate
	Manlucu *et al.* (2022)	Undergraduate
	Baker (2022)	Undergraduate
Educational Experience	Vincenti (2019)	Faculty
	Vincenti (2020)	Faculty

works were submitted in the regular tracks and underwent the usual rigid double-blind peer evaluation, which leads us to appreciate the metric of scholarly research products even more.

6.2. *Outcomes from Phase II*

This section reports the feedback and observations related to Phase II, introduced in Section 5.2, which focuses on the update of material for three undergraduate courses. Some of these findings were previously published in Vincenti (2020).

Students in each course were asked to complete a survey at the end of the semester. The response rates for each course are reported in Table 6. It is worth noting that AITC 457 was held online, so we were expecting lower response rates Nulty (2008). Most of the students in each course were AIT majors (71% in AITC 351, 96% in AITC 356, and 90% in AITC 457).

The student population in AITC 351 was primarily composed by third-year students (8), then fourth-year (5), and one second-year. In AITC 356 instead, the majority were fourth-year students (13), followed by third-year students (10). Lastly, in AITC 457 nine of the students were fourth-year, and one was third-year.

Table 6
Number of respondents for each course.

Course	Respondents	Enrollment	Response Rate
AITC 351	12	14	85.7%
AITC 356	16	23	69.6%
AITC 457	5	10	50%
Total	33	47	70.2%

Table 7
Course-level summary of responses to Question 1

Course	SA	A	N	D	SD	NA
AITC 351	4	4	4	0	0	0
AITC 356	5	9	2	0	0	0
AITC 457	3	2	0	0	0	0
Totals	12	15	6	0	0	0

Students were asked a total of nine questions, some using a traditional Likert scale, reported below with the following abbreviations: SA (Strongly Agree), A (Agree), N (Neutral), D (Disagree), SD (Strongly Disagree), and NA (No Answer). Others were open questions and required the students to elaborate. Question eight asked if the student was involved in the NASA SUITS project directly, and question nine focused on such involvement, so not all participants answered the last question.

First, students were asked if they agreed with the statement "This project based on NASA's Lunar Exploration was more interesting than typical projects." Responses to the first statement are summarized in Table 7.

We see that the majority of students at all levels agree or strongly agree with this statement. We can notice that there are more students who are neutral towards it in AITC 351, which may be attributed to the fact that they had less freedom in designing their own solution and they were not as involved with the documentation. This is supported by one of the statements, which reads:

> *I actually forgot that was what the assignments were about.*

Several comments, however, were very positive regarding the link to a real-life application of the project:

> *Felt we were helping solve a problem like Houston space station.*
>
> *Nice to see real world projects and challenges being solved in the classroom instead of something made up.*

Then, we asked the students if they agreed with the statement "I had to learn much about the context in which the project was set in order to complete it." The responses are summarized in Table 8.

Table 8
Course-level summary of responses to Question 3

Course	SA	A	N	D	SD	NA
AITC 351	5	3	1	2	1	0
AITC 356	7	5	3	1	0	0
AITC 457	2	1	0	0	1	1
Totals	14	9	4	3	2	1

These answers reflect the diversity of the assignment, where AITC 351 students were given most of the constraints but were given the references to learn more about the context. The students who had the most material to learn in order to produce a project were those enrolled in AITC 356. One response from this group is particularly descriptive:

> *Yes, before going into the technical components, such as building an ER Diagram or script, I had to research and learn what the NASA project really is and its details.*

Students in AITC 457 were also required to learn a bit, and one comment in particular captured the spirit of the project:

> *This is not a typical college project, reading the assignment requirements alone won't help you complete. Knowing the foundations of the telemetry data helped a lot.*

Then, we presented the students with the following statement: "I discovered information that you did not know before about NASA, the Space program, and other activities related to human exploration of Space." Responses are summarized in Table 9.

Also for this question, we expected to see a pattern where most students in 356 and 457 would agree, since their projects were less structured, while students in 351 had more restrictive descriptions. Most explanations regarding the rating were in line with how many constraints students were given with the assignment description. It is particularly refreshing to see that students were able to appreciate the difficulty of timestamped data streams in AITC 356:

> *I did not expect timestamps to be such a vital and tricky aspect of data collection.*

It is also rewarding to see the honesty of a student in AITC 351 who recognized that the assignment had much potential, but they chose not to pursue it:

> *I'm lazy, but a more ambitious person could have been compelled to.*

Then, we asked the students on whether the project in the course made them develop an interest towards the NASA SUITS Design Challenge. Overall, some responses indicated that students would be interested in continuing while others said that this was

Table 9
Course-level summary of responses to Question 5

Course	SA	A	N	D	SD	NA
AITC 351	6	2	1	2	1	0
AITC 356	6	7	3	0	0	0
AITC 457	2	1	1	0	0	1
Totals	14	10	5	2	1	1

enough. There was an answer in particular from a student who did not join the project that was encouraging in terms of engagement outside of the class environment:

> *It made me want to go further explore programming opportunities I may have overlooked.*

Another response from a student who did not join the group was also encouraging, but this time regarding the inclusion of real-life projects in college courses:

> *It was very interesting and made me aware the depths that databases can go.*

All students were then asked if they were part of the group that would officially participate to the Design Challenge for our university. The responses are reported in Table 10.

The last question was reserved to those who intended to participate, and we asked how do they believe these projects affected your knowledge of the context of this year's Challenge. All students responded positively to the effect that the injection of this open challenge had on their understanding and involvement, as some of the quotes report:

> *Yes, it has given me a greater appreciation for aspects of the project that are not my own.*
>
> *It gave me an insight on how skills I'm learning apply to real world situations.*
>
> *Being in the NASA project, I am able to have an overview on all the sections, but by participating in the in-class assignment, I was able to use that knowledge and put it into technical use.*

The feedback that we received from all the students has motivated us to repeat the experience in following semesters. However, given the significant limitations that COVID-related restrictions have imposed to in-person education, we decided not to collect data and simply treat each semester as a normal instance rather than a research-oriented project. Also, the amount of administrative work required by the instructor, who is also the Program Director for the degree and certificates, placed significant limitations to the amount of time that could be dedicated to supporting the students in learning about the context beyond what was covered in the course.

Table 10
Course-level summary of responses to Question 8

Course	Yes	No	NA
AITC 351	1	11	0
AITC 356	6	10	0
AITC 457	3	1	1
Totals	10	22	1

7. Lessons Learned

The learning curve on how to incorporate this Open Challenge into the college curriculum of either individual students through Capstone experiences or to groups through regular courses has been steep. In this section we share some fo the lessons learned, in the hope that it will facilitate the work of other faculty members interested in following a similar path.

7.1. *Project Schedule*

The first and perhaps most important aspect of the integration of Open Challenges into the curriculum revolves around the scheduling of the project. When we first learned about NASA SUITS, during the Fall semester, the faculty had enough time to work with the students to draft a tentative plan, since our Capstone courses only run in Spring and Summer sessions. This lead-time was essential in the success of the initiative.

The main advantage of NASA SUITS as well as the other MicroGravity University initiatives is that the organizers are often educators themselves, so they are mindful of the academic calendar. Also, the length of the challenges is significant enough that academic institutions may adjust their operations slightly to accommodate for the near-overlap.

In our case, since our academic calendar ended prior to the conclusion of NASA SUITS, we had to issue Incomplete grades while the students continued their work and prepared their final submissions. This did not cause any issues, since the official end of the challenge happened within three weeks from when our final grades had to be submitted.

Many other challenges, especially if they are sponsored by companies, tend to have a short turn-around, they are often announced right before the submission period starts, and they do not overlap the semester in a meaningful way. The website Challenge.gov has examples of past projects, including the announcement and submission dates.

7.2. *Interactions with NASA*

The requirements for the NASA SUITS Design Challenge mandate that the institution's interface with NASA should be a student in the role of a Project Manager (PM). Faculty members should be involved, however the bulk of the interaction between the team and NASA should take place through the PM. This organization works well for relatively small team during year 1, however during years 2 and 3 the amount of students grew along with the number of projects that each student wanted to carry out. The larger group created a significant load of work for the managing student, especially since several resources were not available to students directly and had to coordinate closely with the faculty advisors.

Another problem that we experienced was attributed to the lack of document availability at the beginning of the project. This is not an aspect that could have been easily handled by NASA, as the project that they are sharing with students is part of their core mission. Consequently, they cannot divulge all documents as they are, but need to adapt them for a general audience. This process took sometimes a significant amount of time, and some of our students' projects and tests were on hold while they were waiting for documents from NASA. Several other open challenges that we discussed earlier include a full set of documents available to all from kick-off and may be preferable if students are required to outline their work early on in the project.

7.3. *Indirect Participation to the Challenge*

A solution to the potential lack of overlap between the project and the academic semester is to participate to the challenge indirectly. The works associated with Phase I in this article involved the direct participation of students to the Open Challenge. However, Phases II and III are examples of indirect participation, where our students are still exposed to the challenge, but they will not submit any work.

This approach lacks a significant component, which is the direct interaction with personnel associated with the project, however it gives the instructors the flexibility of working at their own pace. Many Open Challenges, such as the ones advertised on Challenge.gov or Kaggle, are archived but their data and documentation is retained. The instructor may download all the information as well as augment it with other documentation that contextualized the project with the curriculum, similarly to the approach described for AITC 356 in Section 5.2.2.

Some challenges, including NASA SUITS, included some documentation and resources that are strictly linked with the year's event. For example, we received a telemetry stream simulator that was hosted on a NASA account on Heroku. Only some information was shared with the teams, and the simulator was under the control of NASA SUITS administrators. This meant that the resource is no longer available once they turn off the service. In order to accommodate our needs, we created our own simulator that generates similar data with the same format, so that, once the simulation is made available again, we can switch the source of the data from our local version to theirs.

7.4. *Growth of the Project*

Some of the projects to which the students wish to partake may be limited in scope. For example, if an Open Challenge is limited to the data analysis from a single data source, the potential impact on curriculum may be limited to a single course. However, many of the more significant challenges offer plenty of room for growth. The initial system that our students created, ARGOS version 0, was significantly smaller compared to its current structure and potential.

The integration of elements of the Challenge into the curriculum in early courses will help students become familiar with the context as well as the work that has already

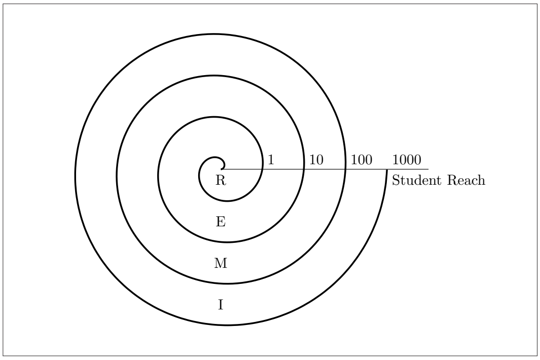

Fig. 4. REMI Spiral.

been done. Although our experience with the project is limited to a three-year run, we observed that students who were exposed to the project in earlier courses are more prone to designing and implementing their own projects once they reach later courses. This is encouraging and allows for a gradual integration of the students into the project and its associated research activities.

A brief look at some IT projects shows that they follow a relatively simple yet effective pattern, which we call the REMI spiral, reported in Fig. 4. The four phases stand for (R)esearch, (E)ngineering, (M)aintenance, and (I)nformation, and as the project evolves, each coil represents the reach to larger audiences.

7.4.1. *(R)esearch*

In order to contextualize the REMI spiral, we can take ARGOS. The project started as a research endeavor that involved a limited amount of people. Similar projects may arise in academic labs, where one or more students work with a faculty advisor on a research idea.

7.4.2. *(E)ngineering*

The next stage comes when the technology has gained enough maturity that it has proven its value, and now it is time to optimize it. This is the Engineering stage, where the solution may be introduced to graduate and upper-level courses with a limited and specific audience. In the case of ARGOS, the system has been adapted into 3^{rd} and 4^{th} year and graduate courses so students may learn the inner-workings and improve it.

7.4.3. *(M)aintenance*

As a technology evolves, improves, and affirms itself, then it can be integrated into lower-level courses for majors in the form of maintenance. In the case of ARGOS, once the system is sturdy enough to have it turn on and off with a simple switch, we plan on using it to demonstrate basic IT maintenance concepts at the 1^{st} and 2^{nd} year level, such as basic Linux system administration, logging, and remote management of devices.

7.4.4. *(I)nformation*

Once a technology reaches significant maturity, it can (and should) be included in general education courses. For ARGOS, once the system is automated enough, we will include it as a demonstration piece for networking, augmented reality, and applications development to technology courses for non-majors. At this level, the project will reach the greatest student audience, and the requirements to access the information should be limited to the context and pre-requisites of the course in which it is taught.

We also believe that the potential of this type of approach goes well beyond the coursework, as in the summer of 2022 we hosted Space Tech Camp at The University of Baltimore. The experience included several students in grades 10 and 11, meant to let them experience STEM-related activities on a college campus. Our initiative used ARGOS as a demonstration of what working in Space may look like in the future, and gave students the ability to create hypotheses and run small tests. Space Tech Camp was funded through a grant by NASA.

7.5. *Decoupling the Challenge from the Curriculum*

The choice of many universities to teach courses without using a particular vendor is linked to the fact that companies may change their technologies without forewarning, and in some cases even go out of business. The same concept applies to Open Challenges. If we were to adapt the curriculum formally to include a specific Open Challenge, then we could run into trouble if the challenge is no longer available or if it is surpassed.

As a specific example, creating a course of modifying Learning Outcomes to a tailored example, such as NASA SUITS, would inextricably link part of the curriculum to the fate of the endeavor. For this reason, even though in Phase III we created two courses that originated from feedback about NASA SUITS, those courses do not mention anything about the challenge itself. In this way, instructors can either leverage the significant infrastructure that ARGOS offers, or may customize the course to a different challenge or project.

7.6. *Workload*

The amount of work involved with integrating the challenge into the curriculum is significant. In our case, the university requires a workload of 70/20/10 for Associate professors, where 70% of our time is to be dedicated to Teaching, 20% to Research, and 10% to Service. The workload is subject to changes by rank, so the numbers may be different for others within our institution.

The fact that The University of Baltimore is considered a teaching institution allows faculty to be flexible when reporting their time for initiatives like the one described in this article. As Project-Based Learning is considered a research area, we were able to include a significant part of the work required by Phase I as Research. The fact that the group of students who participated to Phase I was not limited to Capstone students, but it was considered as an extra-curricular activity for them. Consequently, their supervision could be reported as Service since the work could be compared to being a faculty mentor to an extra-curricular student group. As we entered Phase II, the preparation of course material associated with regularly scheduled courses made it so the work could be also reported under the Teaching category.

7.7. *Funding*

Perhaps the most important part of any endeavor is finding funding to support the activities. In our case, the University was particularly supportive during the first year of the activities. This investment made it possible for our students to continue into the second year. While funding from the University was still available, we also reached out to our State's Space Grant agency, which is tasked with helping initiatives geared towards Space-related educational activities.

As the participation to these types of challenges may be considered a badge of honor (in our case it certainly is), some other institutions utilized crowdfunding as a way to sponsor the initiative. Our University Relations office also reached out to alums so they could run fundraising campaigns directly related to our project. Another potential source of funding comes from local government grants, where cities and municipalities may fund projects related to the improvement of the local environment, including education. Lastly, as our project can also be utilized as an engagement platform, we were able to obtain funding to explore ARGOS as a STEM engagement tool for high school students. Even though most of the funds went to personnel costs for running the experience, we gained knowledge related to improving our project as well as some hardware that will remain with the University.

7.8. *International Perspectives*

International students are often limited by their visa requirements in terms of the types of experiences they can carry out during their studies. For example, in the United States students cannot easily obtain permission to take an internship that is not on-campus. Projects such as this allowed international students at our institution to participate and gain the same skills that students who are citizens or permanent residents. The only restriction that was imposed by NASA SUITS was that international students could not participate to on-base activities at Johnson Space Center. Students who are in other countries can also participate to NASA SUITS by partnering with a US institution.

Another valuable experience that our students enjoyed was giving guest lectures to other institutions. The organizers of NASA SUITS put our team in communications with other institutions, some within the USA and others that were international, and our students were invited to meet with their students and introduce ARGOS. Although this is far from an exchange student opportunities, the experiences were still valuable. This is particularly true at our institution, as non-traditional students typically cannot embark in a semester-long or year-long exchange program because of other commitments, such as having a family or full-time employment. Most exchange programs at our institution are limited to one week of travel.

Lastly, this project generated several technical publications, reported in Table 5. The participation to international conferences allowed our students to broaden their perspective, which was often limited to their own schoolwork. Throughout the years, members of the group have established connections with national and international researchers. Recently, some of our alums have created a start-up that focuses on their work related to ARGOS and submitted a proposal for seed funding to transform their idea into a product to offer to NASA, ESA, and their industry partners.

8. Conclusions

The approach to integrating Open Challenges into the curriculum described in this article is just one way to enhance the experience of students while completing a college degree. We do believe that this initiative has brought significant advantages to our students and faculty, even though it does require significant amounts of work at times.

In closing, the steps, results, and observations shared in this article are just an honest approach to creating an engaging environment for students. The work of students themselves with the faculty has been instrumental in the success of this project, as we took the “Why Not” approach to getting started, growing, and now sharing ARGOS as an educational resource, research platform, and engagement tool.

Acknowledgments

ARGOS was designed and implemented primarily by students, with the direct support of faculty members. I would like to acknowledge the participants that each year have allowed the system to evolve into a complex product. The students who took part in this challenge are the following, in alphabetical order:

Poegrammers, Year 2018–19: Karl-Heinz Gilbert-Wason, William Hyland, John Manlucu, Osman Martinez, Larysa Paliashchuk, Eric Yang Ra, and Juan Pablo Soto Medico. Sujan Shrestha and Greg Walsh participated as faculty co-advisors.

AstroBees, Year 2019–20: Najya Ahsan, Michael Andersen, Peter Baldwin, Jasmine Brown, Naiya Chapman-Weems, Chantil Hunt Estevez, William Hyland, Blessing Leonard, John Manlucu, Larysa Paliashchuk, Michael Vandi, and Claudia Yee. Greg Walsh participated as faculty co-advisor.

AstroBees, Year 2020–21: Najya Ahsan, Michael Andersen, Kaitlyn Baker, Jasmine Brown, Naiya Chapman-Weems, Nathan Crowther, Avery Dixon, Shawn Forrest, Chana Goldberg, Manisha Gurung, Chantil Hunt Estevez, Joshua Jones, Brian Kelly, Ghazaleh Keshavarz, Nuam K. Lun, Stephanie Parey, and Michael Vandi. Greg Walsh participated as faculty co-advisor.

AstroBees, Year 2021–22: Kaitlyn Baker, Kristen Barbour, Avery Dixon, Shawn Forrest, Angela Jackson, Joshua Jones, Blessing Leonard, John McMahon, Marcia Marroquin, Kirstyn Miranda, Ruth Robinson, Nicholas Silva, and Trevor Wamhoff. Greg Walsh participated as faculty co-advisor.

Funding

The work reported in this manuscript was in part funded by the University of Baltimore, the Turner Student Research Awards, the University of Baltimore Foundation, and the Maryland Space Grant Consortium.

Space Tech Camp was a Precollege Summer Institute (PSI) initiative funded by a grant issued by NASA's Minority University Research and Education Project (MUREP). Grant number 80NSSC22M0146, awarded to Dr. Giovanni Vincenti (P.I.) and Dr. Greg Walsh (Co-P.I.).

References

Ackerman, E. (2022). Robots Conquer the Underground: What Darpa's Subterranean Challenge Means for the Future of Autonomous Robots. *IEEE Spectrum*, 59(5), 30–37. https://doi.org/10.1109/MSPEC.2022.9771355

Ahsan, N., Andersen, M., Baldwin, P., Brown, J., Chapman-Weems, N., Hunt Estevez, C., Hyland, W., Leonard, B., Manlucu, J., Vandi, M., Yee, C., Walsh, G., Vincenti, G. (2021). An Augmented Reality Guidance and Operations System to Support the Artemis Program and Future EVAs. In: *50th International Conference on Environmental Systems*.

Anderson, D.P. (2004). Boinc: A system for public-resource computing and storage. In: *Fifth IEEE/ACM International Workshop on Grid Computing*, pp. 4–10. IEEE. https://doi.org/10.1109/GRID.2004.14

Anderson, D.P., Cobb, J., Korpela, E., Lebofsky, M., Werthimer, D. (2002). SETI@ home: an experiment in public-resource computing. *Communications of the ACM*, 45(11), 56–61. https://doi.org/10.1145/581571.581573

Baker, K. (2022). An Overview of Augmented Reality Solutions for the Enhancement of Space Exploration and Operations. In: *51st International Conference on Environmental Systems*.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M., Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3–4), 369–398. https://doi.org/10.1080/00461520.1991.9653139

Börstler, J., Hilburn, T.B. (2015). Team projects in computing education. *ACM Transactions on Computing Education (TOCE)*, 15(4), 16. https://doi.org/10.1145/2808079

Crowther, N. (2021). *Remote Testing of AR HUDs for Lunar Exploration*. Master's thesis, The University of Baltimore.

Dalmasso, I., Datta, S.K., Bonnet, C., Nikaein, N. (2013). Survey, comparison and evaluation of cross platform mobile application development tools. In: *2013 9th International Wireless Communications and Mobile Computing Conference (IWCMC)*, pp. 323–328. IEEE. https://doi.org/10.1109/IWCMC.2013.6583580

Dill, P.L., Henley, T.B. (1998). Stressors of college: A comparison of traditional and nontraditional students. *The Journal of Psychology*, 132(1), 25–32. https://doi.org/10.1080/00223989809599261

Estellés-Arolas, E., González-Ladrón-de-Guevara, F. (2012). Towards an integrated crowdsourcing definition. *Journal of Information science*, 38(2), 189–200. https://doi.org/10.1177/0165551512437638

Helps, R.G., Ekstrom, J.J., Lunt, B.M. (2015). IT capstone course structure for success. In: *Proceedings of the 16th Annual Conference on Information Technology Education*, pp. 27–32. ACM. https://doi.org/10.1145/2808006.2808024

Howe, J. (2006). The rise of crowdsourcing. *Wired Magazine*, 14(6), 1–4.
Hunt Estevez, C., Jones, J., Shrestha, S., Vincenti, G. (2021a). A Lunar Spacewalk Simulation to Support the Artemis Outreach Program and Promote Remote Public Engagement. In: *50th International Conference on Environmental Systems*.
Hunt Estevez, C., Jones, J., Shrestha, S., Vincenti, G. (2021b). Serious Games in STEM: Online Collaborative Design of a Lunar Simulator. In: *International Conference on Human-Computer Interaction*, pp. 223–235. Springer. https://doi.org/10.1007/978-3-030-77685-5_18
Karaevli, A., Özcan, S., Wintermeyer, A. (2020). The four competencies every it workforce needs. *MIT Sloan Management Review*, 62(1), 1–6.
Kolb, A.Y., Kolb, D.A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, 4(2), 193–212. https://doi.org/10.5465/amle.2005.17268566
Larmer, J., Mergendoller, J.R. (2010). Seven essentials for project-based learning. *Educational Leadership*, 68(1), 34–37.
Leff, A., Rayfield, J.T. (2001). Web-application development using the model/view/controller design pattern. In: *Proceedings fifth IEEE International Enterprise Distributed Object Computing Conference*, pp. 118–127. IEEE. https://doi.org/10.1109/EDOC.2001.950428
Manlucu, J., Ahsan, N., Robinson, R., Vandi, M., Baker, K., Vincenti, G. (2022). A Cloud Computing Infrastructure to Support xEMUs and Future EVAs. In: *51st International Conference on Environmental Systems*.
Miko, J. (2014). The Google Online Marketing Challenge: Real Clients, Real Money, Real Ads and Authentic Learning. *Information Systems Education Journal*, 12(6), 45.
Nulty, D.D. (2008). The adequacy of response rates to online and paper surveys: what can be done? *Assessment & Evaluation in Higher Education*, 33(3), 301–314. https://doi.org/10.1080/02602930701293231
Porter, L., Zingaro, D., Lee, C., Taylor, C., Webb, K.C., Clancy, M. (2018). Developing course-level learning goals for basic data structures in CS2. In: *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, pp. 858–863. https://doi.org/10.1145/3159450.3159457
Remenick, L. (2019). Services and support for nontraditional students in higher education: A historical literature review. *Journal of Adult and Continuing Education*, 25(1), 113–130. https://doi.org/10.1177/1477971419842880
Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, 24(9), 467–471. https://doi.org/10.1016/j.tree.2009.03.017
Smith, M., Craig, D., Herrmann, N., Mahoney, E., Krezel, J., McIntyre, N., Goodliff, K. (2020). The Artemis program: an overview of NASA's activities to return humans to the moon. In: *2020 IEEE Aerospace Conference*, pp. 1–10. IEEE. https://doi.org/10.1109/AERO47225.2020.9172323
Soto Medico, J.P., Gilbert-Wason, K.-H., Hyland, W., Manlucu, J., Martinez, O., Paliashchuk, L., Ra, E., Vincenti, G. (2020). ARGOS: A platform for student engagement. In: *Proceedings of the 21st Annual Conference on Information Technology Education*, pp. 298–298. https://doi.org/10.1145/3368308.3415430
Steghöfer, J.-P., Burden, H., Hebig, R., Calikli, G., Feldt, R., Hammouda, I., Horkoff, J., Knauss, E., Liebel, G. (2018). Involving External Stakeholders in Project Courses. *ACM Transactions on Computing Education (TOCE)*, 18(2), 8. https://doi.org/10.1145/3152098
Surahman, E., Wedi, A., Soepriyanto, Y., Setyosari, P., et al.(2018). Design of Peer Collaborative Authentic Assessment Model Based on Group Project Based Learning to Train Higher Order Thinking Skills of Students. In: *International Conference on Education and Technology (ICET 2018)*. Atlantis Press.
Vega, C., Jiménez, C., Villalobos, J. (2013). A scalable and incremental project-based learning approach for CS1/CS2 courses. *Education and Information Technologies*, 18(2), 309–329. https://doi.org/10.1007/s10639-012-9242-8
Vincenti, G. (2019). Engaging IT students through the NASA suits design challenge: An experience report. In: *Proceedings of the 20th Annual SIG Conference on Information Technology Education*, pp. 22–27. https://doi.org/10.1145/3349266.3351400
Vincenti, G. (2020). Open challenges as a way to engage students: An experience report from three undergraduate courses. In: *Proceedings of the 21st Annual Conference on Information Technology Education*, pp. 200–205. https://doi.org/10.1145/3368308.3415407
Vincenti, G., Pecher, W.T. (2020). Merging Sustainability and Technology in the Classroom: An Experience Report. In: *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, pp. 448–453. https://doi.org/10.1145/3328778.3366899

Wang, M., Bohn, D.M. (2018). Charging to the End: Course Activities for Semester-Long Student Engagement in an Undergraduate Product Development Capstone Course. *Journal of Food Science Education*, 17(3), 85–93. https://doi.org/10.1111/1541-4329.12138

Yee, C. (2020). *Wearable Augmented Reality in Procedural Tasks: Designing an Interface Used to Deliver Step-by-step Instructions to Support Novice Users in Unfamiliar Tasks*. Master's thesis, The University of Baltimore.

Zull, J.E. (2002). *The Art of Changing the Brain: Enriching Teaching by Exploring the Biology of Learning*. Stylus Publishing, LLC., Sterling, Virginia.

G. Vincenti earned his D.Sc. degree in Applied Information Technology from Towson University in 2007, where he also worked as Lecturer for several years. He is an Associate Professor in the Yale Gordon College of Arts and Sciences at The University of Baltimore, which he joined in 2013. He serves as Program Director for the degree in Applied Information Technology since 2014. He primarily teaches courses in computer programming and database systems using a hands-on, project-based learning approach. He supervises extra-and co-curricular groups such as the ARGOS development team and the indoor farming initiative.