**Teaching Innovation Grants 2024**

Application for Course and Program Projects

Please list all applicants, with PI listed first. The PI will be the primary contact and will be responsible for budget oversight if the grant is awarded.

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| **Name** | **Job Title** | **Department/Program/Office** |
| PI: Rose Bohrer | Assistant Professor | Computer Science |
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**Title of Proposal:** Pedagogical Comics for Programming Language Design Instruction

**Brief Proposal Description (maximum of 80 words, for publicity purposes).** This project funds production of a series of one-page comics, each illustrating a key concept from respective lessons of the PI’s courses on programming language design. Not only do comics serve as mnemonics for key concepts, but the diverse cast of characters promotes a subtle message of belonging in the classroom.

**Course(s) or Projects Affected:** CS 4536, CS 536

**Approximate Number of Students Affected Annually:** 85

**TOTAL BUDGET REQUEST: $6,240**

**Start Date:** July 2024

**End Date (when final report will be submitted):** July 2025

**CERTIFICATION**

I agree to abide by the grant conditions in the program guidelines if an award is made.

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| **Signature(s) of Applicant(s):** (typed signature is acceptable) | **Date** |
| Rose Bohrer | 1/31/2024 |
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**DEPARTMENT HEAD / PROGRAM DIRECTOR ENDORSEMENT** is required. Please ask them to send it as an email message to [morgan-center@wpi.edu](mailto:morgan-center@wpi.edu) by February 8, 2024.

Budget Details and Justification

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| **Student support** (specify hourly wage, estimated hours, time period, and activities). Consider $15/hr for undergraduates and $15-20/hr for graduate students, depending on required skill set and time of year. | $6240 |
| *Explanation and justification:* The course materials consist of 21 lessons, each which will receive a 1-page comic illustration. These comics feature five characters, which will each receive a character sheet as part of the design process. Commissioned comic illustration is typically billed by page, not by hour. I budgeted based on mean market rate for indie illustration according to fairpagerates.com. For line art, color, and lettering combined, this rate is $240/page. For an experienced illustrator, this page rate averages to $15-20/hour. For 26 pages, this yields (21+5)\*240 = $6240 for illustrating the entire project.  This work is expected to be completed by one undergraduate student with specialized art skills over (e.g.) the period July 2024-July 2025. This budget includes intermediate products such as four iterations of the illustrations as well as planning meetings. | |
| **Faculty compensation** (specify individuals, time period, and activities) | **$ 0** |
| *Explanation and justification:* The PI’s time commitment is at a level which does not necessitate additional compensation. The PI’s activities include scriptwriting, storyboarding, meeting with the commissioned artist, and providing feedback on works-in-progress, taking place from July to July. Though these activities are in addition to the PI’s typical course development workload, no additional compensation is sought, due to the intrinsic satisfaction provided by the work and alignment with other work responsibilities. | |
| **Travel and/or professional development activities** | **$0** |
| *Explanation and justification: N/A* | |
| **Supplies, software, equipment** (itemize and explain why department capital or IT budgets are not an appropriate source of funding) | **$0** |
| *Explanation and justification:* The PI has consulted with her top candidate for the art commission, who has confirmed they already have access to all necessary supplies and software. | |
| **Assessment/evaluation support** | **$0** |
| *Explanation and justification: N/A. Evaluation is expected to entail no added costs.* | |
| **Other costs (itemize)** | **$0** |
| *Explanation and justification: N/A* | |
| **TOTAL =** | **$6240** |

**Project Description:**

***Need for the project***

The field of programming language foundations has not only a diversity problem, but a belonging problem. This field often presents itself to the outside world as a “prestige” subfield of computer science, where the need for rigorous mathematical proof is reflective of deep intellectual prowess. For marginalized scholars in this field, no amount of rigorous mathematics is enough to “prove” that we belong. Though rarely formalized through the academic literature, this is pervasive in our daily lived experience. Whenever a group of marginalized scholars in programming languages connect at an academic conference, conversation quickly turns to feelings of exclusion and non-belonging. All too often, these fears prove true: restricting my attention even to my own intersectional identity of transgender women, I can name multiple PhD graduates in this subfield whose academic careers were derailed by interpersonal transmisogyny from their direct supervisors, a fate I narrowly avoided myself. This is equally true for other marginalized groups.

Perceptions of oneself as not belonging are known to start early in one’s educational journey, and thus students’ first exposure to a given topic is a key moment at which messages of belonging (or non-belonging) can be sent. Perhaps without thinking, contemporary course materials for programming language foundations passively tell marginalized students that they are the Other. Such courses frequently employ identitarian language telling students they must “be Computer Scientists” – for students whose status as “a real computer scientist” has already been questioned in other environments, this reads as an announcement that their courses are not for them. Exacerbating this problem, traditional course materials rely heavily on prerequisites in higher mathematics, a field with similar belonging problems, and rely heavily on formal mathematical notations, to the point it may impact the self-efficacy of students whose prior opportunities to take higher mathematics courses were limited. On a different front, it is also common to emphasize the idea of doing theoretical work for theory’s sake, yet the academic consensus is that engagement of diverse student bodies improves when applied motivations are included in the narrative.

“Human Centered Programming Languages” (HCPL) is my long-term project to address this issue through the development of an entirely new introductory PL curriculum. Deliverables thus far have included an open-access textbook, assignments, slides, autograders, and two full-length research papers. ***The proposed project is a series of pedagogical comics with diverse characters, one to accompany each lesson of the HCPL curriculum.***

The proposed project is important because ***course materials are media***, and as media, they implicitly communicate social messages such as who belongs and who does not. In this light, the use of comics is intentional. For many of today’s students, the mere use of advanced mathematical notation can recall memories of math anxiety, whereas the use of visual art is more likely to evoke positive memories, perhaps moments of self-expression or recreation. These memories serve to communicate the first key message: there is no need for math anxiety. The characters then serve to communicate the second key message, one of belonging. In addition to being diverse in terms of their gender, race, and disability status, these characters are also diverse in the intellectual traditions they use to approach the study of programming languages. These traditions range include both applied and theoretical perspectives within computer science as well as both social-scientific and humanistic methods from outside computer science. Intellectual diversity goes hand-in-hand with demographic diversity because it reinforces a message that students are welcome in the classroom regardless of their academic background. This message is complementary because diversity of the student body varies greatly by discipline.

***Goals and objectives***

The project has two high-level goals:

* Communicate a sense of belonging to students through an accessible medium (comics) with a diverse cast of characters
* Reinforce understanding of core course concepts by attaching narratives and mnemonics to them

We pursue the high-level goals through these low-level objectives:

* Develop character sheets (drawn and written) to support consistent artistic style and solidify world-building
* Identify compelling narratives and mnemonics for the core concepts of each lesson
* Develop the narratives and mnemonics into complete scripts
* Build upon the scripts to deliver the series of 21 comics
* Integrate the finished comics in the delivery of courses CS 536 and 4536.

***Approach***

I outline my approach to both the development of the comics and the assessment of their effectiveness.

The development approach is based on the PI’s experience advising multiple 2D art-intensive MQPs, one of which won a Provost MQP award. The top candidate for artist has extensive prior experience working with the PI on the award-winning project as an independent-study artist. A second candidate is available who currently collaborates on an MQP project with the PI. This approach is fundamentally iterative, but starts with specifications provided by the PI consisting of reference images, character descriptions, scripts, and storyboards. Weekly meetings are held to guide iteration and track progress. Standard organizational tools such as asset tracking sheets are used.

The assessment approach combines both quantitative and qualitative methods. Desired outcomes will be assessed with preexisting scales, e.g., the mathematics anxiety rating scale [1], sense of belonging to school scale [2], or the appreciative joy scale [3]. Shortened versions of scales may be used to manage effort burden on students. Learning outcomes will be assessed through scores on relevant exam questions. Open-ended written responses pertaining to each outcome will be collected and interpreted through thematic analysis.

***Deliverables and Impact***

Many but not all of the deliverables closely follow the low-level objectives:

* Initial specifications for characters and art styles, including written descriptions of characters’ demographics, personal body type, and typical dress/presentation. These specifications also include reference images.
* A list, for each chapter, of the core concept to be communicated, along with mnemonics or narratives associated to it, to serve as the core of the comic
* Scripts for each comic (consisting only of text)
* Storyboards for each comic (including blocking/layout information)
* Five character sheets consisting of drawings of each character from multiple angles and poses along with any costumes or objects associated with the character. Character sheets include written information about the character, e.g., drawn from the initial written specification
* Twenty-one pages of comics at standard dimensions (6.875” x 10.438”) and print resolution (at least 300DPI) in digital format. Delivered digital files should include originals in a format intended for editing such as PSD or CLIP.
* Intermediate work such as four iterations of all digital art.
* A survey of student reactions to the use of these comics
* A written report detailing results.

A survey will be used to assess the immediate impact in the classroom. The use of the comics by students will be made optional in the next course iteration in order to provide a natural control group for the survey. The survey will assess impacts along the following dimensions:

* Learning outcomes: On the final exam, do students who engaged with the comics correctly answer questions related to the core concepts illustrated? Are their outcomes on the exam different from students who chose not to engage with the comics in a statistically significant way?
* Math anxiety: Did students perceive the course material as anxiety-provoking? Did these perceptions change between students who did or did not engage with the comics?
* Sense of belonging: Did self-reported sense of belonging in the discipline of programming languages as a whole differ between students who did or did not engage with the comics?
* Sense of joy: Were the students happy to read the comics?

If successful in improving these measures, potential outcomes include both improved learning outcomes in general and improved retention of diverse students within the field.

The long-term professional impacts for the PI are substantial. The survey results are expected to be the basis of a peer-reviewed research paper. The HCPL project is expected to be the basis of an upcoming grant proposal (e.g. NSF CAREER). The project and resulting paper would bolster that proposal, potentially yielding $600,000 of grant funding. Because I also intend to submit the HCPL textbook to academic publishers, this project would serve to bolster the book submission and lead to a successful textbook publication.

***Project Timeline***

The project will be 12 months, from July 2024 to July 2025. It consists of three phases:

**Phase 1, Preparation (July-August 2024):**

* PI delivers specifications of the five characters and the first 1-3 storyboards
* Artist delivers five character sheets
* Weekly meetings are used to refine collaboration dynamic and handle logistics

**Phase 2, Production (August 2024 – June 2025):**

* Artist delivers approximately 2 comics per month. If this throughput is not met, work may be divided between two or more artists
* PI delivers 2 storyboards per month
* Production proceeds in pipeline fashion, storyboard to initial art to revised art
* Weekly meetings are used to track progress and refine comic style

**Phase 3, Finalization (June 2025 – July 2025):**

* PI delivers written report with consultation from artist

References:

[1] <https://psycnet.apa.org/record/1973-05788-001>

[2] <https://files.eric.ed.gov/fulltext/EJ1060376.pdf>

[3]<https://idp.springer.com/authorize/casa?redirect_uri=https://link.springer.com/article/10.1007/s12671-016-0599-4&casa_token=SuhZOrZCACoAAAAA:c0M5iciEv6oLyxlFoY_mxg2BoDxobsfaPAWJkPIBp7SY7L47WWA-V7T-G4j5O5nuOJ6fqkq1wVqBrvq_Ag>