BOARD # 35: Work-in-progress: Approaching Bioimaging Challenge Projects through Scaffolding and Improved Time Management

Dr. Travis Carrell, Texas A&M University

Dr. Travis Carrell joined the Biomedical Engineering faculty at Texas A&M University as an Instructional Assistant Professor in Fall of 2022. He had the privilege of participating in the curriculum redesign process, which enabled him to co-develop two of the common courses. The integration of engineering education projects within these courses has been a source of evaluation and improvement for the courses, as he and the other faculty within the department strive to continually improve the learning process for their students.

Anne-Marie Ginn-Hedman, Texas A&M University

Dr. Anne-Marie Ginn-Hedman (Annie Hedman) is an instructional assistant professor at Texas A&M University with the Department of Biomedical Engineering. Dr. Hedman specializes in the Biomechanics and Engineering Education tracks.

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Introduction & Motivation

Undergraduate engineering students often struggle when presented with complex course projects that require critical thinking and integration of knowledge from past classes. In our junior level bioimaging course, we observed that students found it difficult to approach projects that demanded the application of coding skills learned in previous courses to solve image processing and analysis problems. This issue often leads to last-minute efforts and undue stress, which prevents students from truly understanding course material and gaining deeper insights into its content. To address this challenge, we introduce a scaffolded approach aimed at promoting self-directed learning and building productive work habits to help students solve large problems.

This work-in-progress research is being conducted at Texas A&M University within the department of biomedical engineering to evaluate a scaffolded teaching intervention, exempt under IRB STUDY2025-0029. The teaching practice is being applied to coding projects in a bioimaging course where students were tasked with image processing problems designed to expose our students to various image analysis techniques and their shortcomings. Projects included pre-processing and masking lung data, automating cell counting for histology slides, calculating ejection fraction from lung CT scans, and co-registering MRI and PET data. Each project was originally designed to be completed within a two-week period. To enable this short turnaround time, the deliverables of each project report were created so that the students would first research the topic, apply techniques from the literature, recognize shortcomings of the methods, and provide a metric for the result with any relevant statistics and conclusions. The intent was not for the students to fully solve the problem within the two-week period. Rather, students' abilities to approach large problems through applying their coding and statistics skills from prior classes, researching relevant coding tools, and discussing what could be done to improve shortcomings if given more time were the intended points of evaluation.

Methods

Intervention: The intervention addresses study productivity, time management, and engagement when navigating complex image processing coding projects by breaking tasks into manageable deliverables, tracking productive work time, and documenting resource utilization [1,2]. Specifically, the scaffolding of projects with sub-deadlines for reporting on achievement of specific deliverables are utilized to engage students sooner and feed into beginning of class discussions concerning "pain points" and methods to ameliorate them. This also serves to identify struggling students and provide additional guidance, whether through the discussion of methods utilized by peers or through instructor-led discussion. Maintenance of a Google Doc by students will be utilized to document their ongoing progress and for reporting of time spent working on the individual projects and project reflection for productivity. These activities help promote steady progress and foster self-directed learning [1-4]. Grounded in Vygotsky's Zone of

Proximal Development [5,6] and Dweck's growth mindset theory [7,8], this approach encourages autonomy and reframes challenges as opportunities for growth. Furthermore, learning modules are employed to guide students in finding resources and for troubleshooting [1-4], aiming to build confidence and skills for managing intimidating, multi-step projects. These learning modules are accessible through the first two projects and include instructor and university-compiled resources on topics of GRIT, debugging, library searching, how to read academic articles, utilizing AI tools for literature searches and as coding assistants, and making use of coding repositories for inspiration. For the final two projects, students will still be required to track their work time and maintain documentation of their work without additional learning modules to see if they continue the practices learned from the first two projects.

Assessments and Data Analysis: A beginning and ending of semester five-point Likert survey will assess student confidence changes in areas of approaching large projects, coding, time management, and utilization of resources. Questions within the survey include:

1. I am confident in my ability to successfully complete large coding projects that involve image processing.
2. I am confident in my Python coding skills.
3. I effectively manage my time.
4. When faced with challenges and obstacles, I am able to persevere and find solutions.
5. I am self-aware of my strengths and weaknesses, I set realistic goals, and I consistently strive to improve.
6. I effectively utilize available resources (e.g., documentation, tutorials, online communities) when working on coding projects.

Student-reported time spent on each project will be assessed for similarities with changes in confidence reported from the Likert surveys and overall trends for duration as the projects progress. Open-ended reflections will be collected from students after the completion of each coding project. These reflections will include the following questions:

1. Describe your overall experience working on this project. What were your most significant challenges and how did you overcome them?
2. Did you encounter any instances where you felt your work was unproductive? If so, what were the signs and how did you address them?
3. Estimate the total time spent on the project. Were there any periods where you felt your time was not being used effectively? Why?
4. What resources (people, tools, information) proved most helpful during the project? Were there any resources you wish you had utilized?
5. Looking back, is there anything you would do differently to improve your project workflow or productivity?

The survey responses will be analyzed using MAXQDA to identify frequently repeated words and code them into emergent themes such as "challenges," "productivity," "resource use," and "workflow improvement." Patterns in student reflections, such as the connections between productivity and resource utilization, will also be explored. Accordingly, this approach will follow established qualitative research methods via grounded theory [9-11] to gain insight into

how students navigate and overcome challenging multi-step, complex engineering projects.

A total of up to 540 students will be assessed over three semesters from Spring 2025 through Spring 2027 with the intervention. Average project grades will be statistically compared using ANOVA tests to those of students who took the class before the intervention was applied. Qualitative instructor observations will also be presented.

Preliminary Results

Instructor Observations: Through the first rollout of these projects, both instructors observed that students appeared to flounder with the size of the project, and as a result, they procrastinated working on the project until only a day or two before it was due. Initial check-ins regarding progress were met with little student enthusiasm or understanding. Much to the dismay of the instructors, initial polling of students about time spent on the projects was also far greater than desired, even with the delay in starting. This, along with the level of detail in the reports, indicated that students were not being productive and/or effectively utilizing their resources. Utilization of the first five minutes of each of the six class periods to discuss the "pain points" appeared to benefit the few who had started on the remaining projects, but this did not appear to improve early student involvement on the project for the bulk of the class. As these discussions involved issues that were encountered on the projects, the instructor could utilize student-identified solutions or posit guiding questions to students. These likely benefited students who had not reached the "pain point" yet but did alert them to the level of difficulty when several "pain points" were identified for the projects. The use of a scaffolded approach with an initial deliverable nine days into the last project by one of the classes resulted in 93% of the students having initial quantifiable metrics, suggesting that having sub-deliverables encourages earlier involvement and results in increased student involvement during "pain points" discussions.

Conclusions and Continuing Work

Data collection and rollout of the scaffolded support and student reflections is ongoing. Utilization of this approach enables two feedback mechanisms; one mechanism is for assessing and guiding student progress during the two-week project and the other feeds back into further development of the learning modules for future students. The first mechanism has already been utilized to guide formative class discussions mid-way through the projects to aid students struggling with their approach to the first project and to affirm students who were on track with the project. Identifying resources that current students utilize can inform instructors about methods to provide additional guidance for improving student workflows and time utilization. Collection and analysis of results from the current and upcoming semesters are expected to provide insight into how students approach these large projects and how changes over the course of scaffolding assignments, instruction from learning modules, and reflections influences student time management and productivity as the class progresses. A portion of the structure of this study does depend upon self-reported data from students as a part of their reflection and could provide variability upon student engagement and honesty in reporting.

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