Design Processes for Senior Capstone Collaborations Across Biomedical Engineering and Information Computer Science

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Abstract

Interdisciplinary senior capstone projects allow students to be able to develop real-world product design and development skills as well as practical applications of their knowledge. In order to be able to manage these projects, collaboration and efforts across students and faculty in multiple disciplines require efficient management and alignment of design processes. In this paper, we describe the implementation of an interdisciplinary senior capstone project across the Schools of Information Computer Science and Engineering. The project was hosted by the senior capstone course in the School of Information Computer Science, but mentored and implemented in the Department of Biomedical Engineering. It was found that there were significant differences and alignment between design processes utilized by these two schools. In particular, it was found that the design process associated with biomedical engineering design, namely the BioDesign process, was comparatively slower than the Agile design process utilized in the information computer science capstone course. However, both processes were able to highlight the key components of design and development, such as discovery, planning, and building. Lastly, human centered design was realized as an important strategy to teach students to ensure that diversity, equity, and inclusion are considered throughout their design.

Information Computer Science Capstone Course

- Two-quarter (6 month) program, winter and spring
- Learning Objectives:
  - Define project requirements
  - Approach and implementation
  - Testing in front of real users
  - Redesign given user feedback
  - Dissemination of project and findings to a broad audience
- Lecture Topics:
  - Project management
  - Practical applications of advanced topics in computer science (e.g. artificial intelligence, internet of things, and augmented reality)

Interdisciplinary Capstone Project

- Department of Biomedical Engineering + School of Medicine + School of Information Computer Science
- Virtual reality platform for student learning in clinical environments [1, 2]
- Provides innovation and design of medical devices used in clinical spaces
- Example Video: `https://youtu.be/hlCnx9urynE`

Figure 1. YouTube channel of the virtual reality clinical immersion videos.
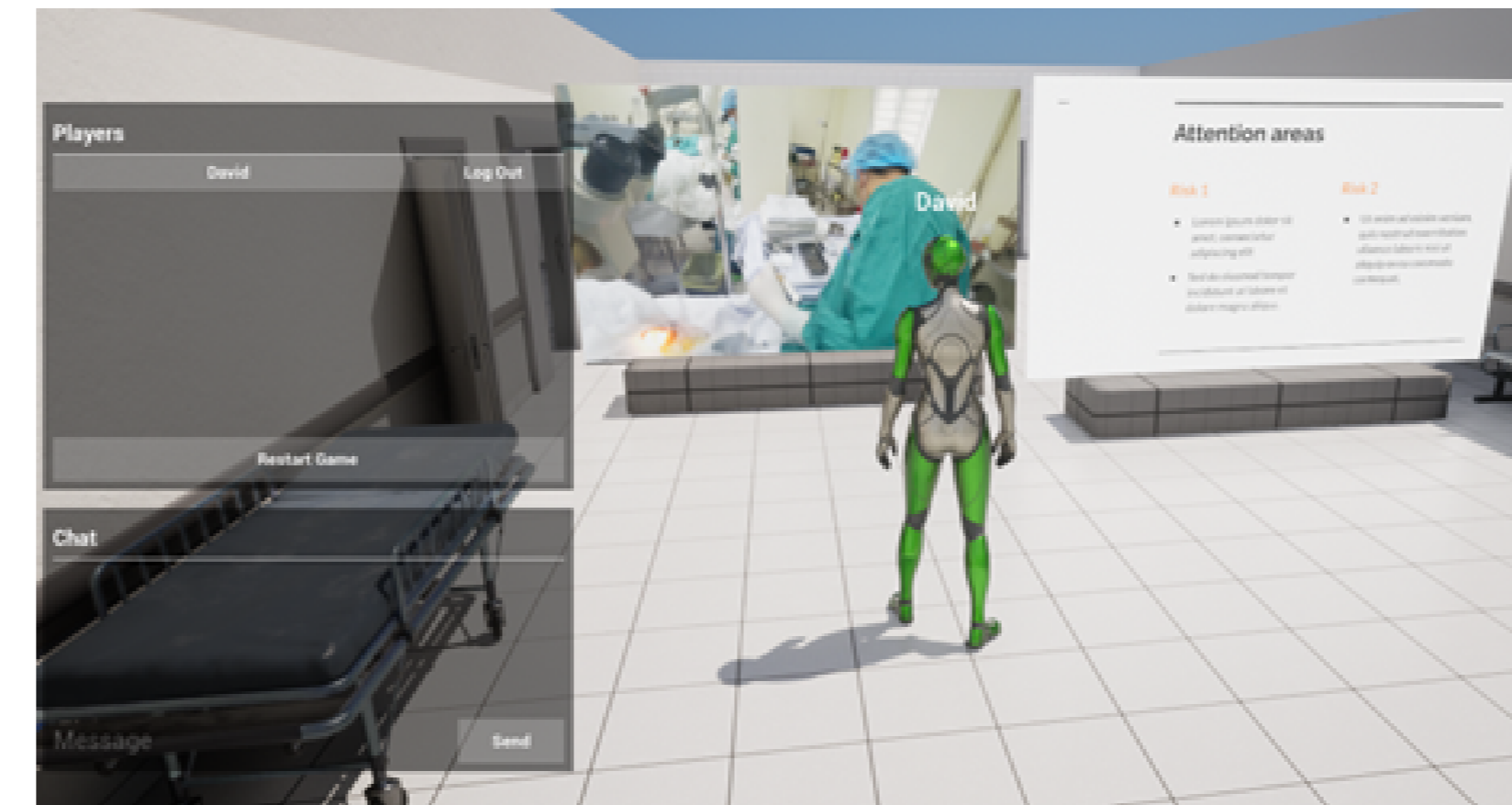
Student Project Results

Figure 2. Screenshots of the multiplayer functionality and whiteboard and chat features developed by the students within the virtual reality clinical environment.

Figure 3. Interdisciplinary student team of the English major graduate student (left), ICS capstone students (middle), and Biomedical Engineering professor (right).

Design Processes Utilized

BioDesign Process

- 3 I's of Stanford BioDesign Process [3] for medical innovation: Identify, Invent, Implement
- Identification: unmet needs finding and screening in a medical environment, stakeholder and market analyses, disease state analysis
- Invention: design specifications, ideation and concept selection based on intellectual property, regulatory affairs, reimbursement strategy, business model canvas
- Implementation: patent filing, FDA approval, business development via marketing, sales, and distribution
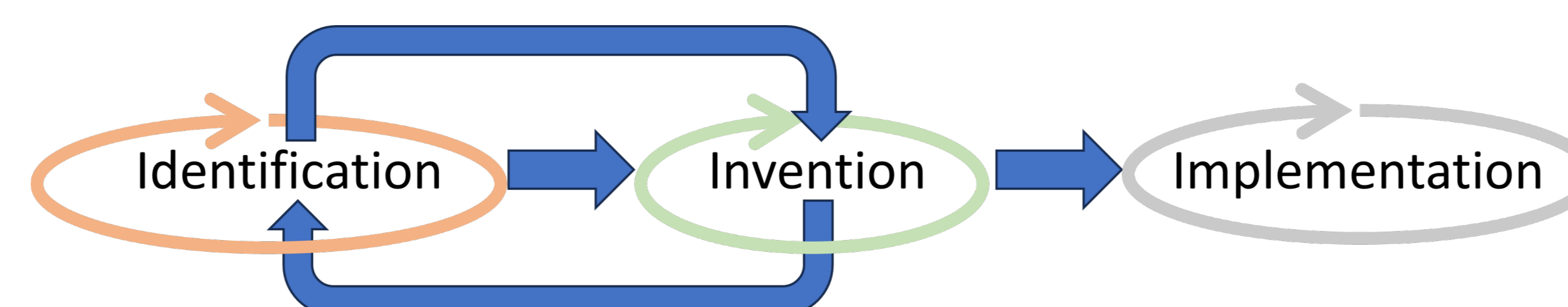- BME students utilize this method to create startup companies [4]

Figure 4. BioDesign process adapted from Yock et. al [3] used to develop the virtual reality clinical immersion environment.

Agile and SCRUM Design Process

SCRUM is the most used software-development method in practice; and the most popular implementation of Agile development. Agile is a process model that serves as an umbrella framework for SCRUM, Kanban, Lean, and other popular software process models. Agile is anchored in 4 Values and 12 Principles that summarize and incorporate the wisdom and experience of its methods. Values and Principles range from Self-organizing Teams and Deliver Software Frequently, to specific XP items such as Pair Programming, TDD, and CI/CD.

Benefits and Pitfalls of Design Approaches

- SCRUM and related methods work well for a wide variety of Agile Capstone software-development projects
- But, Agile and SCRUM need to collaborate and integrate with BioDesign Invention phase
- But, Agile and SCRUM need to compromise and integrate with the linear and sequential nature of the BioDesign process

Conclusion

It is important for instructors and mentors to train each other on the design processes utilized in different fields, and find similarities across disciplines. Understanding the differences of discipline-based design processes and how they can be better aligned can improve the education of students in interdisciplinary capstone design teams.

Future Direction

- IRB-approved study examining student perspectives on interdiscplinary design projects and design processes utilized.
- Instructor and mentor training on discipline-specific design strategies.
- Improved curriculum alignment across capstone design courses.
- Expand collaborations across schools, industry, and faculty to promote future interdisciplinary capstone design projects.

References

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