Immersive Learning Research Network

Extended Abstract—MESH Model: An Analysis of Roles, Responsibilities, and Dependencies in Student-Powered XR Production

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Abstract. Immersive learning experiences are often discussed in the context of their interdisciplinary nature—from topics to learners, they cross boundaries between fields. Less research, however, is available on the interdisciplinary nature of their production. Higher education institutions are uniquely positioned to streamline production pipelines and train the workforce of the future by engaging students as design partners. Students can serve as project managers, narrative writers, user experience designers, 3D modelers, audio designers, developers, and quality assurance testers. Our contribution to support future efforts is the MESH Model, a holistic shared mental model composed of a MESH Labs guild-to-project system and a MESH Weave of roles, responsibilities, and dependencies. The model is grounded in project-based learning and collaborative guidance from the literature and defined by practice. This extended abstract focuses on data gathered during a brainstorming activity where students worked within role groups, or guilds, to identify primary contributions and reliances in their respective project groups. Findings underscore the complex and interconnected nature of responsibilities and dependencies between roles. The MESH Model clarifies knowledge sharing to help support sustainable production and learning in the dynamic team environment inherent to higher education.

Keywords: Immersive Production, Project-Based Learning, Collaboration, Dependency Analysis.

1 Introduction

Getting teams to mesh can be a challenge in any industry, from the office to emergency response to space flight. Immersive learning tools have gained popularity in recent years to train and prepare teammates for collaboration in the field [1], but less research has been done on the teams *creating* those learning tools than on the tools themselves. Immersive learning and extended reality (XR) production requires understanding and collaboration between subject matter experts, instructional designers, storytellers, artists, and developers, all of whom speak different languages in their work. This paper takes a closer look at roles filled by students and dependencies between those roles using teams at MESH Labs (Media Experience Service Hub) as a case study and inspiration.

MESH Labs operates with a small administrative staff and—at the time of this study—42 student workers. As a university lab, it serves two primary objectives: 1) to streamline access to XR projects across the university, and 2) to empower students who are the creative workforce of the future. Projects are often created *by* students*, for* students, as the finished products are used in educational settings. Several projects have been shown to improve learning outcomes and are the source of independent studies and publications [2, 3]. This paper reviews collaborative production workflows across all projects from the perspective of the student workers.

While their energy, enthusiasm, and creativity can be a wealthy resource, student workers are learning on the job, and turnover rates can be high [4]. This makes it all the more important for teams to blend with awareness and flexibility. Our research goal, therefore, is to provide a shared mental model of student teamwork in XR production for increased clarity. Our resulting contribution is the MESH Model—consisting of the MESH Labs structure (Fig. 1) and a MESH Weave of dependencies (Fig. 2). The lab structure integrates production work with a student-to-student learning guild system. All student workers elect one or more guilds related to their major, interest or skill set: Product/Project Management (PM), Narrative Learning Design, User Interface / User Experience (UI/UX), 3D Modeling (3DM), Spatial Audio, Spatial Game Engine Integration (also referred to as Dev), and Quality Assurance (QA). The weave guides interdisciplinary groups of students with representatives from each guild engaging in collaborative XR project-based learning.

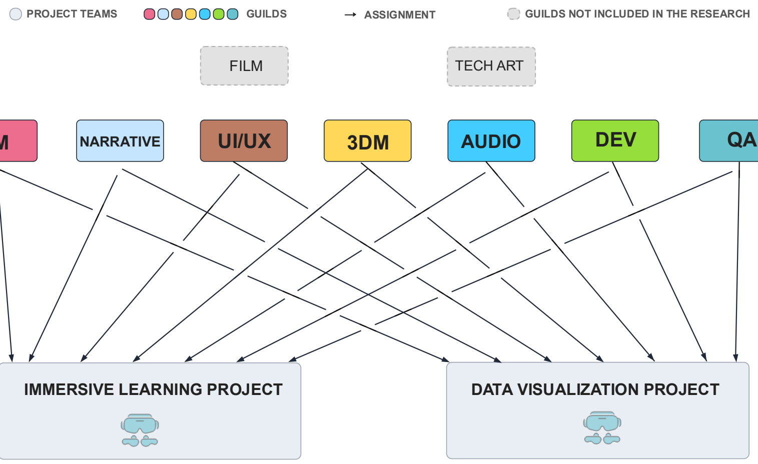

Fig. 1. The MESH Labs structure, an interwoven relationship between guilds and projects. Film is a secondary guild not tied to every project; Technical Artistry is a former guild with remaining presence.

The sections that follow review related work, summarize our methods and findings from a team brainstorming activity and document analysis with MESH Labs students, and outline the MESH Model with illustrative examples of complex dependencies between roles. The shared mental model can apply to diverse contexts including labs, courses, campus clubs, and project grants. Our hope is to support effective project pipelines and make narrative XR production more widely approachable by student teams at other universities.

2 Related Work

Twenty-first-century trends in education emphasize greater learner agency, preparing students for teamwork and creativity in the workplace. Despite significant research on collaboration, however, there remains a lack of models for student groups creating immersive learning products. This section reviews existing literature most inspirational to our own solution, including collaborative learning, production workflows, and student worker practices.

2.1 Collaborative Learning

Collaborative learning is a broad educational approach that involves students working together in groups to "solve a problem, complete a task, or create a product" [5]. Learning together has been shown throughout the literature to increase achievement and productivity [6]. Students construct shared knowledge, and reflections (including group processing [6]) can help hold every member of the group accountable [7]. A supportive and cooperative environment can benefit students academically, socially, and psychologically [6].

Building on collaborative learning, the pedagogical model of Project-Based Learning (PBL) is centered on learner-led prototyping and making [8]. PBL engages students in authentic problem-solving where solutions have potential to be used in real life. Positioning students as designers of XR has inspired gains in content knowledge for novices and motivation for experienced students [9]. MESH's objectives are directly in line with this model.

There are, however, challenges inherent to student collaboration that need to be taken into consideration. Hussein [10] concisely groups these challenges into three root causes: 1) schedules, 2) priorities, and 3) uncertainty. Uncertainty falls into subcategories regarding the end product, its value, and team organization. In response, Hussein makes recommendations to address the challenges, including to structure "knowledge information and sharing within the group." This validates the need for shared mental models such as MESH.

2.2 Production Workflows

XR production workflows are often compared to the film industry, with stages for development, pre-production, production, post-production, and exposure [11]. Considering educational outcomes for both designers *and* users impacts the collaboration at each stage. Successful software development methodologies like Agile [12] embed cycles of reflection and support according to PBL best practices [10]. Stand-ups and "sprint" retrospectives serve as crucial opportunities for communication and mentorship [13]. These feedback mechanisms are used professionally and mirror practices like design critiques and peer code reviews.

While several studies outline steps or provide recommendations specifically for educational game design [14], few detail teammates' tasks and coordination throughout the process. Our previous contribution provides a workflow for team leadership to ensure content, instruction, storytelling, and development are all represented in each stage of the immersive narrative production process: Assess, Design, Reflect, Assemble, Review, Implement, and Evaluate [15]. The Career XArcade framework more specifically details which stakeholders—including students as design partners—are involved at which stage of the design cycle [3]. A cycle starts with ideation, continues to user flow, and then to modeling of the preliminary virtual environment. When prototypes are ready, the product is tested and iterated upon within the bounds of requirements set by industry experts and curriculum integration. Our new MESH Model fills a dependency gap in the student-powered stages of these previous studies.

2.3 Student Workers

MESH engages students outside the classroom as paid workers within an XR design lab. A student worker has been defined by the United States government as a full-time student at an educational institution who is employed by said institution [16]. Arizona State University, the site of this study, specifically defines student workers as students in part-time hourly positions with the university not to exceed 25 hours per week [17].

Past research suggests a strong positive correlation between learner-focused student worker programs and retention [18]. In the context of a future career, the student is positioned as a junior professional taking on increasing responsibility within a community of practice [19]. Programs that support this style of active learning can help students to think critically and creatively about their work, a skill that translates to the workplace [18]. Across all job postings in the United States, Creativity and Collaboration are two of 10 major competencies in durable skills (or soft skills) [20]. Number one is Leadership—often gained as a byproduct of collaboration among student workers [18]. The technology industry in particular calls for higher education institutions to better prepare students for the job market [21], which programs like MESH are structured to do.

Effective functioning of student-worker teams, however, requires clear articulation of roles and responsibilities. In a typical XR project, members take on specialized roles [22] similar to those defined by MESH's guilds in the Introduction. Specialization in turn creates a network of critical dependencies [23]. While challenging, dependencies can also be sources of deep, cross-disciplinary learning. They are the threads of connection between roles in the MESH Weave, transcending individual responsibilities. An understanding of dependencies can help project managers assign tasks appropriately, which is shown to minimize stress and improve confidence [9].

3 Methods

To better understand the unique MESH Labs structure and weave between roles, we collected data during an all-hands event in August 2025. Our full methodology includes a presentation, teamwork quality survey, brainstorming activity, and interviews with project managers. With our goal to *provide a shared mental model for increased clarity* in mind, this paper focuses on the brainstorming activity and resulting document analysis.

For the brainstorming activity, students were organized by guild and prompted as follows: *With your guilds, brainstorm the core responsibilities of your role on project teams. In other words, what are the building blocks of your contributions? Then, brainstorm what dependencies, or 'reliances,' you have on other team members / roles.* Students had already defined their roles through guild charters and lived experiences; the purpose of this activity was for them to think critically about their observable connections to others.

To complete the activity, we provided guilds with whiteboards or large notepads and colored markers. We instructed them to list everything that came to mind in an approximately 15-minute timeframe. Then, we asked them to agree amongst themselves and highlight three to five of the most important or representative elements. Each guild approached the task in a slightly different manner; full documentation can be requested from the authors. After completing the brainstorming activity, guilds shared their responses with the rest of the lab. This part of the activity was not documented as there was no video or audio recording. Some guilds added written notes to match their verbal explanations. The lead researcher took photographs and documented the guilds' written responses, including which items were highlighted by the groups.

4 Findings in Brief

Twenty-one of MESH Labs' 42 student workers (50%) attended the all-hands event; all 21 opted to participate in the study. Since each guild approached the brainstorming activity in a different way, the quantity and depth of their lists varied. The priorities they highlighted are summarized in Table 1. Not all groups selected three priorities from each list. Every guild had at least one dependency referenced toward it, but some roles had more than others. Four guilds prioritized a dependency on Development, which refers to the Spatial Game Engine Integration guild. Project Management was not directly prioritized but was alluded to through terms like direction and requirements.

Drawing on over six years of combined experience as researchers and project managers, the first and second author discussed and interpreted the roles and dependencies identified in Table 1 to inform the final MESH Weave presented in Section 5.2 (selecting three per guild/category). Using 3DM as an example, the guild highlighted three responsibilities: model, optimize, and visual design/style. For our weave, we retained the first two but took inspiration from items on their larger list to round out the third. Environments (terrain, landscaping, skyboxes) and lighting are often the first steps in creating a new scene—before additional assets and interactions are added by teammates. In this way, the responsibilities presented in the weave represent the guild's intentions while considering the larger context of team production.

For the Narrative guild, "following objectives" was listed as a responsibility (but not highlighted as a priority, and therefore not included in Table 1). Objectives, however, come *from* managers—typically originating with clients—which underscores the interconnected nature of responsibilities and dependencies. For our final weave, we included objectives as a dependency rather than a responsibility.

Table 1. Primary responsibilities and dependencies identified in the brainstorming activity by each guild. UI/UX and Narrative had one member each and brainstormed together.

Guild (n)	Primary Responsibilities	Dependencies
PM (3)	Project direction (scope); Client relationship; Organization & accountability	Subject matter experts and client knowledge; Devs, artists, and team to execute; Git/plastic
Narrative (1)	Storytelling; Character	Dev interactions; 3D models and environment; UI accessibility; Project direction, QA testing; audio delivery
UI / UX (1)	Interaction design; Accessibility; User-driven	Audio experience; Development and technical art implementation; QA testing
3DM (4)	Model; Optimize; Visual design/style	Narrative for scene layout and look; Developers for a working scene and troubleshooting
Audio (4)	Sonic environments; Voiceover recording; Music composition; Field recording	Script lock from Narrative; Visuals; Direction; References; Timelines & client deliverables
Dev (5)	System design; Debugging; Integration; Version control; Cross-guild coordination	Art and UI assets; Narration to guide integration; Hardware
QA (3)	Review; Communicate	Project requirements; A build to test; Team needs to listen

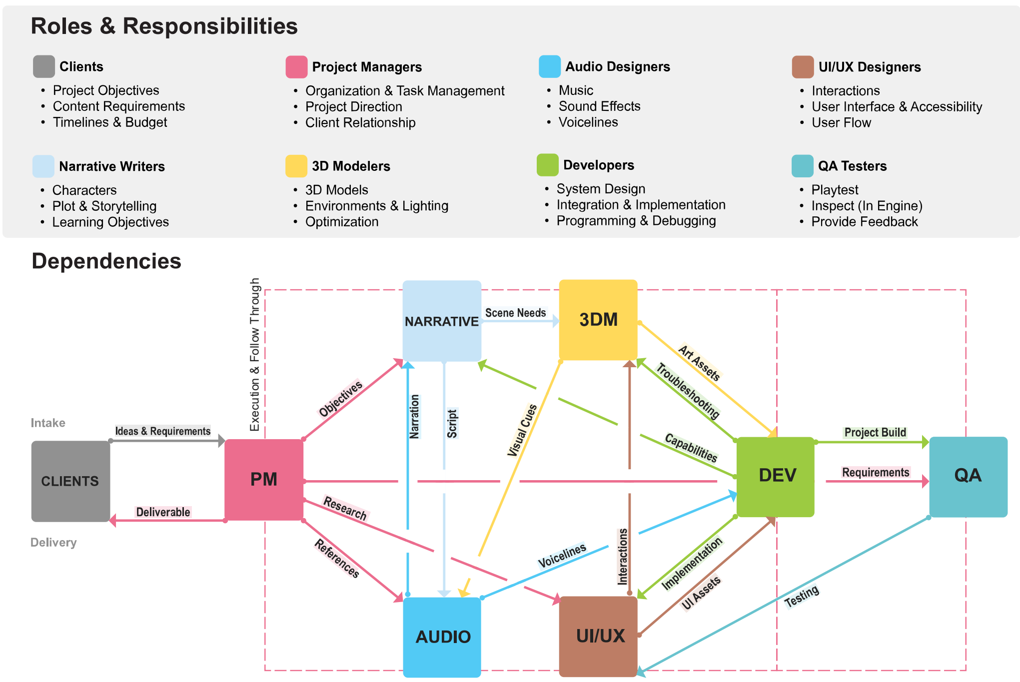

Fig. 2. MESH Weave for Collaborative XR Production. Each arrow denotes an artifact/information passed between roles.

5 MESH Model

The literature converges in its call for clear guidance to support quality teamwork. While the response will differ for every team, MESH serves as a living laboratory for student collaboration on XR production. This section reviews the MESH Labs structure, where students define their roles from the perspective of guilds and project teams. Findings from our brainstorming activity supplement that structure by informing the MESH Weave and placing student roles within the broader context of their collaborative responsibilities.

5.1 MESH Labs

Since MESH's student workers are learning on the job, the lab operates as both a production studio and a guild system. As a production studio, MESH Labs creates experiences for stakeholders and clients interested in XR research, learning, retention, and engagement. Internal and external clients come to the lab invested not just financially, but also as design partners. They are responsible for providing project objectives, content requirements, timelines, and budget. Through these assignments, students gain valuable industry experience.

As mentioned throughout this paper, MESH Labs also operates as a guild system to support upskilling and sharing within roles. Guilds have been shown to benefit project work in the classroom by providing an outlet for support, reinforcement, brainstorming, and skill building [24]. At its origination and every academic year, guilds self-identify and update a guild charter. This has contributed to a shared understanding of roles in our MESH Weave. The heart of the guild system is learner-to-learner guidance. Student coordinators guide their guilds through weekly check-ins, project-specific deep dives, and technical excursions. In this way, experienced members support newer ones without working on the same project. Since each guild represents a role in the production process, administrators spin up new teams by assigning students from the guilds to projects. Every team generally uses services from every guild at some point during production (Fig. 1). However, changes in teaming can lead to inconsistencies from semester to semester or project to project. The MESH Weave clarifies expectations so teams can connect with flexible guidance as members come and go.

5.2 MESH Weave

Based on guidance from the literature, experience with student workers at MESH Labs, and findings from our investigation, the MESH Weave (Fig. 2) is aimed at clarifying teamwork in student-powered XR production. Dependencies are represented as arrows—or the individual strands that turn connections into a weave, crossing boundaries in ways not previously documented. Complex visually and in reality, the connectors are meant to raise awareness between roles, letting teammates know what might be expected of them by others. Project managers are dependent on execution and follow-through from all roles; clients provide project scope and acceptance; and the interconnected nature offers a holistic model for team leadership.

Project Managers. Project managers work with students in every role to provide tasks and guidance with effective messaging and follow-through. They are also responsible for communicating clients' needs to the team, and team capabilities to the clients. ***The Weave:*** Dependencies of the role fall into one primary category—execution and follow-through from team members. Outlining one thread as an example, they accept ideas and requirements from the client and pass objectives on to the narrative writer. The narrative writer sends the script to the audio designer for voicelines. The developer places those files on the timeline before building a prototype, which the QA tester needs to review. Every task leads to another, and the project manager holds the threads together.

Narrative Writers. Writers define characters, describe settings, outline plots, and sculpt dialogue. Educational experiences must also incorporate learning objectives appropriately and accurately—while maintaining a sense of style. ***The Weave:*** Writers gather input from developers during the scriptwriting process to ensure their vision can come to life. They also incorporate client ideas and requirements, which are often filtered through the manager. For instance, a subject matter expert might want to show the view inside a hurricane as it makes landfall, while the developer suggests it would look better in VR if shown through a window. The project manager helps organize objectives for story about storm safety told from an indoor perspective. When the project advances to production, the writer relies on the audio team to interpret their script narration with its intended tone and character.

UI/UX Designers. This role is responsible for user flow as it relates to both project vision and technical implementation. Designers need a strong understanding of learning interactions to create an intuitive, accessible interface that integrates with the game engine. ***The Weave:*** They conduct project-specific research and may rely on project managers to connect them with the client, subject matter expert, or relevant resources. They often work in tandem with developers to integrate the UI, which then needs to be tested by the QA team with end users in mind. A menu design might start with a prototype, continue with prefab construction in the game engine, then be handed off to a developer for functionality. If QA testing reveals the window is stretched differently depending on the device, the designer and developer work together to make adjustments.

3D Modelers. 3D Modelers are responsible for designing the environment—including terrain and lighting—and optimizing the visual scene for deployment. If the project requires any animations, those tasks typically fall to the modelers as well. ***The Weave:*** Modeling is grounded by scene-specific needs from the narrative script. For instance, a story set alongside a lake requires different modeling and landscaping than a story set in the desert. On a more nuanced level, interactions may guide what users see in the 3D world. A question about what a driver should do if a camel crosses the road implies a camel and a car are present alongside the UI. Complex tasks, like programming the car and camel to animate according to user input, are often completed with developers.

Audio Designers. While narration voiceovers may be the most obvious sounds to a user, music and sound effects can have a subconscious impact. Audio designers record, produce, and integrate sound to set the tone and make the virtual world come alive. ***The Weave:*** Like modelers, audio designers strongly reference the narrative script, making inferences when sound is not directly called for. The setting and visual cues are equally important; a lake in the forest might have bird calls and sounds of water lapping the shoreline. A wildfire moving in changes things dramatically. To best meet project goals, audio designers may ask the manager or client for examples to reference.

Developers. Almost every other role has dependencies pointing back to the developers. Their technical expertise allows them to integrate assets and interactions for a fully functioning experience. In addition to implementation, they are responsible for system design and programming, and they are often called upon to help teammates troubleshoot. ***The Weave:*** Developers tend to be most dependent on the team members who create assets: modeled scenes, UI prefabs, and voice line files. For example, a scene set next to an airport requires a basic environmental layout before the developer can place the user in view of the runway. When narration indicates a plane is about to take off, they must add the appropriate animation file of its movement to the timeline. If the next voice line asks a question about sky conditions, the developer syncs the corresponding UI pop-up. They find the correct answer in the narrative script, including guidance on how the game should react if a player gets it right or wrong.

QA Testers. Prototype testing should consider the project's goals, vision, and usability through intentional gameplay and feedback at milestones along the way. Testers with development knowledge can inspect bugs themselves. ***The Weave:*** Before testing, the team's QA needs a list of requirements or things to check for. Requests are most likely to come from the project manager, UI/UX designer, or developer. The development team also needs to supply testers with an application or executable. If the manager wants to know if a smoke effect is compatible with a certain type of device, the developer needs to provide a build for that device. When the tester confirms the issue, they may attempt to troubleshoot, or they may need help from the developer. A change in the effect requires approval from artists, managers, and clients.

6 Conclusion

The interdisciplinary nature of immersive learning production is full of complexities largely undetailed in current literature. The MESH Model, made up of the MESH Labs production studio and guild system, and the MESH Weave, is our response to calls for structured information sharing [10] and awareness between roles [15] specifically as applied to collaborative XR production with student workers. Students serve as project managers, narrative writers, UI/UX designers, 3D Modelers, Audio Designers, Developers, and QA Testers. To assess dependencies between roles, we conducted a brainstorming activity with guilds and further discussed their responses from a holistic perspective as researchers. Our results are grounded in theory and defined by practice.

This is not a commentary on the effectiveness of resulting products, which is addressed through independent studies [2] and the wider literature. Our study is limited by data collection from one lab and a small sample size within that lab. Only 21 students participated in the brainstorming activity, with some roles better represented than others. Claims about teamwork are subjective and rely on perception rather than validated measures. As a qualitative representation, the MESH Weave captures data from the guilds and lived experiences—but it has not been tested as a collaborative tool. Future work will incorporate responses from our teamwork quality survey and interviews with project managers to triangulate findings, as well as look for comparisons between project teams.

The MESH Labs guild-to-project system and the MESH Weave of dependencies can be used in conjunction or in part to help student teams mesh in any higher education setting, including labs, classrooms, and clubs. Clear collaboration improves project pipelines to foster a positive experience for those learning through making. In turn, this can lead to more sustainable production and more experiences in the hands of students learning through play.

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