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Reflection on Integrative Project-Based Learning in Business and Information Technology Programs

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Abstract

Recently there has been an increase in demand for interdisciplinary programs that enable graduates to demonstrate a blend of technical and 'soft skills'. As a result, many higher education organizations are developing programs that integrate areas such as management and information technology or entrepreneurship and engineering. The wide range of topics covered in these programs and the need for graduate to be able to integrate and apply of core concepts. Since 2010 we have used integrative project-based learning as a core element of our game development and entrepreneurship program. In this model, students work in project teams to create a "complete" video game following a set of specific feature requirements drawn from the students' courses. This project requires students to integrate concepts across all courses taken (including those from business, game design, programming, and game art) and develop a commercially viable game. More recently, we have developed project-based learning elements for our networking and information technology security program. In this paper, we reflect on the success and challenges of implementing integrative project-based learning throughout a university program. Elements considered include scalability, management of student groups, faculty engagement, program scheduling, and effectiveness of content integration. Results have demonstrated that students are better able to understand how fundamental concepts from the various curriculum areas interact while gaining additional opportunities to practice 'soft skills' such as project management, communications, problem solving, and leadership. The paper will provide recommendations on the necessary learning environment and supports for successful implementation of integrative project-based learning.

Keywords: project-based learning, curriculum

Information technology (IT) and computer science programs regularly undergo program evaluations and accreditation reviews by professional associations such as IEEE and ACM in the United States or the British Computer Society in the UK. Unlike other professional programs such as engineering or medicine, IT and computer science programs do not required post-graduation work experience before practicing independently. Traditionally, computing programs have been designed to separate the academic learning from professional practice in the form of internships and co-operative placements (Clear, Claxton, Thompson, & Fincher, 2012). This design creates a disconnect, not only between topics within the curriculum but between industry expectations and the skills of graduates. In today's economy it is no longer sufficient to have a strong background knowledge in a diverse set of

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technical skills. Employers today require graduates who can integrate the knowledge from a variety of disciplines for addressing complex problems with creative problem-solving and innovative thinking. Critics of existing higher education programs point to weaknesses in graduates in the area of "soft skills" including leadership, project management, critical thinking, and change management. In the most recent curriculum guidelines from the ACM, there has been an increased emphasis on the importance of the development and mastery of problem-solving skills integrated with real-world group-based project learning activities (Cameron, 2014). The problem-based learning approach has been developed to address these shortcomings of traditional pedagogy approaches.

Problem-based learning is a learner-centered approach empowering learners to integrate theory and practice while applying knowledge and skills to create viable solutions to defined problems (Savery, 2006). Critical to this approach is the selection of the problems to ensure that they are ill-structured and provide an opportunity for students to explore the integration of a variety of concepts in creative ways resulting in a wide variety of potential feasible solutions. Projects must be challenging and force students to step out of their comfort zones to learn new skills and technologies in a realistic environment (Cameron, 2014). It is also important to ensure that a cycle of critical reflection, guided by a mentor or tutor, is conducted at the conclusion of each learning experience. This reflection supports the development of communication, evaluation, and critical thinking skills (Barrows, 1988). There has been a significant amount of research into the effectiveness of problem-based learning, particularly in professional programs such as engineering (Abatzoglou & Boulos, 2011), medicine (Barrows, 1994; Bolender, Ettarh, Jerrett, & Laherty, 2013; Dahle, Brynhildsen, Fallsberg, Rundquist, & Hammar, 2002), and nursing. In particular, a meta-analysis of 20 problem-based learning evaluation studies concluded that a problem-based learning (PBL) approach was equal to traditional teaching pedagogy in terms of student performance on traditional tests of knowledge but that students who studied using PBL demonstrated better clinical problem-solving skills (Alabanese & Mitchell, 1993).

Anecdotal evidence from practitioners also supports a higher level of student engagement in achieving the expected learning outcomes (Torp & Sage, 1998). Students using a PBL approach tend to engage in a sustained, collaborative focus to complete a specific project, often chosen by the students themselves which further increases motivation (Larmer & Mergendoller, 2010).The application of the PBL approach can be implemented in a number of ways including integrative case studies in courses, integrative design courses (e.g. Capstone courses in Engineering or Commerce), and complete redesign of curriculum around the problems (e.g. Roskilde University in Denmark) (Fincher & Knox, 2013). More recently, there has been increased interested in using PBL to support integrated learning (Cameron, 2014). In his model, there is a recognition that in order to integrate real-world problems with sufficient complexity the artificial timeline of a 15-week semester is too short. For PBL to provide all of its potential benefits, students need to have sufficient time to dedicate to the work in order to feel

that the results will be valued by the industry. A similar model was followed at UOIT in the development of our integrative workshops.

Bachelors of Information Technology at UOIT

The University of Ontario Institute of Technology's Bachelor of Information Technology (Honours) degree offers two majors– Game Development and Entrepreneurship (GDE), and Networking and Information Technology Security (NITS). Each major provides students with the knowledge and skills to be successful in the IT field.

The major in *Game Development and Entrepreneurship* is designed to provide students with a breadth of game design, game programming expertise, and the fundamentals of starting up and running a game development business. With streams of courses in the program focused on technical programming, game design, art/animation, and entrepreneurship, there was a risk that silos would occur which would inhibit student learning. To integrate the curriculum, all students in years 1 to 3 participate in the Game Development Workshop (GDW) spanning 2-semesters and students in year 4 participate in either a group capstone consulting project or industry internship placement. Each course taken during year 1 to 3 is integrated with a GDW project for a yearlong game project. Successful students develop their knowledge and skills in a diverse team environment and learn to work with programmers, artists, and designers to create innovative products that push the medium to its limits.

The major in Networking and IT Security prepares graduates with theoretical and hands-on knowledge and skills in planning, designing, installing, operating, managing, and securing information technology infrastructure. This program involves a stream of courses that prepares graduates for two levels of the Cisco certification program: Cisco Certified Network Associate (CCNA®) and Cisco Certified Network Professional (CCNP). The core curriculum includes mandatory courses in business and management in addition to technical courses, providing students with the necessary business background and technological skills to make significant contributions in today's workplace.

Game Development Workshop

At its most basic level, the GDW presents a unified context for the theoretical concepts taught to our students (see Figure 1). The underlying goal of the GDW is to facilitate critical thinking and group communication as these two areas were ones in which we found students were having the most difficulty with. To accomplish this task, students enroll in their courses as usual each semester and, with the help of a GDW Coordinator, teams are formed. Together, a project scope definition is developed to define the requirements of a large game development project. In Figure 2, the GDW process is shown in which each course instructor creates a list of "features" or requirements that pertains to the specific course material. The GDW coordinator compiles these lists into a single list defining the scope of the project and communicates this to the team. The team works throughout the first semester to satisfy these requirements and build a prototype of the game. The prototype is evaluated

by the course instructors for correctness, the GDW coordination team for project management and completeness. Finally, the public evaluates the project on its overall playability.

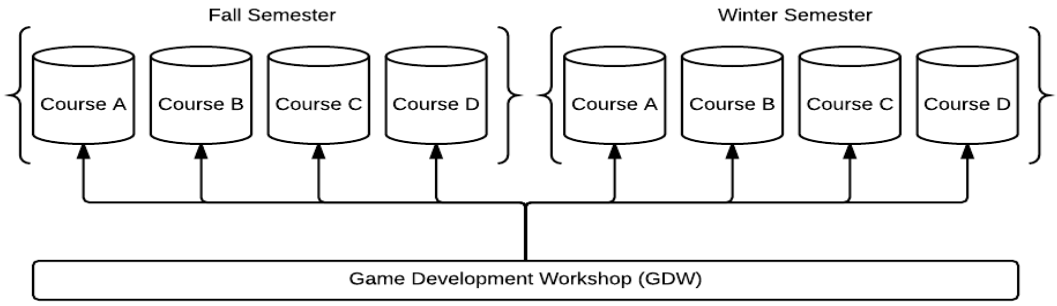

Figure 1. The Game Development Workshop Project-Based Learning

One of the goals of the GDW is to ensure that the final product is of sufficient quality that a member of the games industry would understand how the team worked together to build a polished game while learning new concepts. First, it must be understood that students are "learning by doing" which plays a role in the amount of polish they can develop on a particular project. Second, students in our program must develop most of their tools on their own which ensures that they understand the fundamentals of computing. Third, scope of the project plays a significant role on the success of the defined project which students usually learn the hard way by taking on too much. To address these issues, we have implemented the following support mechanisms.

We define the project in two phases: Prototype and Polish. The fall semester is focused entirely on developing a prototype which does not require final assets be developed. This allows the team to focus on design of the gameplay and foundational software skills. The winter semester is focused on Polish allowing the students to hone individual skill-sets to finalize the gameplay, art, and design. Next, we loosely manage their projects by specifying team-specific milestones throughout each semester. This ensures that the teams are on track by specific dates. The challenge with developing milestones is to ensure that the features required by milestones are coordinated with the course progressions (i.e. cannot expect a feature to be completed prior to the introduction of that concept). The project progression and management is relevant to how work is actually completed in the games industry. This allows students to gain insight into how projects are developed from concept to completion.

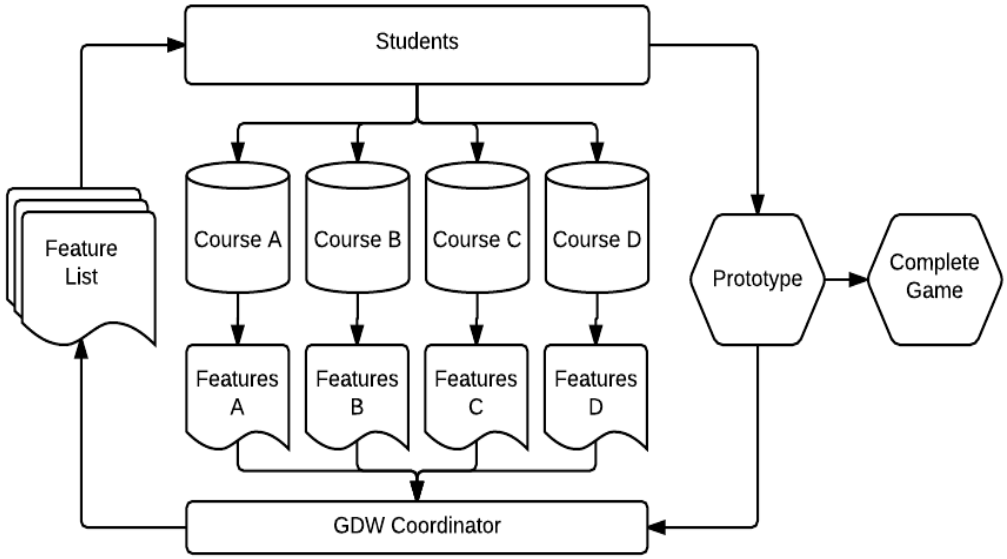

Figure 2. The GDW Process.

Students enroll in courses (A-D), The course instructors define a feature list. The GDW Coordinator compiles the feature lists and communicates this to the students. The Students then build a prototype which is evaluated and demoed to the class for feedback. The feedback is integrated into the final Complete Game.

IT Networking and Security Workshop

Initially the IT Skills Workshop (ITSW) was loosely structured around the design of the existing Game Development Workshop (GDW); however, it became quickly apparent that additional restructuring would be required to meet the needs of existing course layouts, deliverables, and education goals. The ITSW was originally supposed to address the students' perceptions on existing courses and how they relate to each other in industry. The underlying premise of the workshop was that students had a lack of understanding regarding the courses and a coherent view of our Networking and IT Security program and its transferability to professional settings.

Course integration was selected based on existing program maps (5 courses per semester, often with 1 or more non-technical courses included) with a single initial focus on Year 2 NITS students. To meet the minimum needs of the faculty and a successful ITSW, it was decided to integrate all four INFR (technical) courses into the workshop while requiring students to be enrolled in a minimum of three of the included courses. Students groups (ranging from 3-5 students) were formed at the beginning of the semester during a mandatory meeting with all students enrolled in the ITSW –these groups were static across all included courses in order to achieve maximum consistency.

Some primary concerns from the faculty perspective were student inclusion, clarity of deliverables, and a well-defined workshop structure. To overcome possible communication issues, meeting times for the ITSW were set weekly (3 hours in duration) that allowed students to meet with their groups and the ITSW coordinator. This time slot was often used to discuss personality mismatches, group dynamic issues, and questions about specific course

deliverables. In addition, specific weeks were designated as milestone weeks, requiring student groups to meet with the ITSW coordinator. On these milestone weeks the coordinator discussed work breakdowns, progress on deliverables, group dynamic issues, and related issues with each group. Overall, weekly optional meetings combined with mandatory milestone meetings provided an effective way to keep students on track and content with the workshop.

In terms of the ITSW itself and its deliverables, the faculty opted to include a 10% assessment overhead in all integrated courses that would be allotted to the ITSW. This allowed lecturers to structure their courses and deliverables with minimal interference from the ITSW coordinator while still providing a motivator for students to complete workshop deliverables. Each included course contained a final project or major assignment that conformed to an overarching ITSW scenario developed for each semester. This scenario was used to tie together course deliverables in a way that helped students connect the dots between existing course content. For example, during our first semester running the ITSW, student groups were given a scenario where they acted as a contractor responsible for deploying and assessing the security of an enterprise network while integrating concepts covered in their project management and leadership courses.

In addition to each included course's ITSW-relevant deliverable, students were required to complete a presentation upon completion of the semester outlining their contribution to each course. This presentation aimed to provide a safe and pressure-free environment where the student cohort could work on their soft skills. Presentations were completed in front of their cohort and the ITSW coordinator and were assessed primarily on their understanding of integrated content, how it related to other courses, and how their group members overcame group dynamic issues, deliverable due date pressure, etc. A summary score was then provided for each student based on group dynamics, milestone attendance, and their final presentation quality. This summary score was then provided to each instructor to fill the 10% assessment overhead in her or his course assigned to the workshop.

Reflection on practice

Over the past six years of using the workshop approach to integration of PBL into the Game Development and Entrepreneurship program, and our initial attempts this past year with the ITSW, a number of benefits and challenges have been identified. This section describes the primary benefits of using the integration workshops each semester as well as potential challenges that should be considered if planning such a pedagogical approach. It is important to note that most of the challenges relate to program scheduling, strong commitment to the PBL approach by all faculty, and the leadership of the coordinator. The workshops provide a valuable tool to increase the engagement of students in the learning process and provide them with the opportunity to build critical thinking skills that will enhance their technical competencies for the remainder of their careers.

Benefits of an Integration Workshop Approach

Integration of concepts. The beginning of the semester involved a lot of complaining about the workshop, as many students did not understand its purpose. As the semester progressed, many opportunities to discuss the workshop with the students were created, including discussions about the discontinuity between existing courses for their cohort. Feedback at the end of the semester was extremely positive - many students indicated that they appreciated the workshop and were glad it was included in their course map. Feedback indicated that students felt like the workshop reduced their course load within the context of the final projects in each course.

Soft skills development. One of the primary goals of the workshops is to encourage collaboration between peers of the same cohort to hopefully foster some kind of community between students. There seems to be some positive gains in this regard - students are much more open during weekly workshop sessions and are generally more talkative amongst themselves when planning their projects. This was particularly pronounced during the optional skills development component of the ITSW since it attracts students from a variety of backgrounds. This appears to cascade over to soft skills like interpersonal relations, presentation skills, confidence in the classroom, etc. This positive environment appears to encourage collaboration and group learning while excluding significant academic penalties, ultimately reducing pressure on students while still ensuring they have a motivator to develop their soft skills. Presentations at the end of the semester were overall very professional and exceeded expectations. In addition, students struggling to communicate or converse with each other at the beginning of the semester improved dramatically by the end of the semester, with few exceptions.

During the first semester running the ITSW, notes were kept in regards each group's chosen leadership style and how it impacted group dynamics. With only one exception, students took a hierarchy-free and distributed approach to leadership. This involved students taking personal responsibility for tasks assigned to them, standing up and taking a leadership role only when needed, and allowing other group members to have some aspect of academic freedom in terms of their contribution to group work, presentations, etc. Overall this approach worked very well for most groups and appeared to require increased coordination and communication between students. Students were effective at delegating tasks, following up with each other when deadlines were approaching, and performing quality control on contributions from each student. Feedback from groups at the end of the semester indicated that students preferred this hierarchy-free approach to project management and leadership – many students indicated that they would not change this approach, even in retrospect.

Demonstrating program based outcomes. Milestones were set for the students (4 per semester) that involved meeting with the coordinator to discuss team dynamics, deliverable progress, etc. These milestones seemed tedious for some students; however, they proved to be essential for identifying and mitigating group issues before they evolved into larger problems. This pre-emptive intervention approach supported students in balancing individual

course objectives while still meeting integrative program-based expectations from the workshop.

The main deliverable of each workshop is the end of the semester final presentation and demonstration of project deliverables. This presentation included components from each included course and encouraged students to explore the integration of topics between their courses. Secondary deliverables were the components included in each course that the students would have normally completed during the semester. Students initially balked at the idea of a final presentation; however, feedback indicates that they appreciated undertaking the presentation in a non-competitive environment to practice their presentation skills.

Aligning Courses Content. One of the major advantages is that the workshops require all instructors that are teaching the same cohort get together to align the material from their courses and ensure that the students have the knowledge and skills to complete their final project in the workshop. Instructors, who tend to be focusing only on the material in their courses, started aligning their materials, and students were able to see how content from different courses can integrate together. Another important positive aspect of the workshop was that instructors, with the help of the workshop coordinator, worked to ensure greater continuity in content from one semester to the next; a critical aspect when topics are covered in 2 or more courses.

Recruitment of new students. The workshop has helped in recruiting new students to the program. The student work is showcased online, at recruitment events such as Open House, and through various competitions. The student ambassadors for the program are able to discuss the program with potential applicants and their families to demonstrate the breadth of learning that is achieved in the program. Many parents also recognize the importance of the 'soft skill' development process and express increased confidence in the program due to their structured integration to the learning outcomes. Since the inception of the GDW, the average of high school grades for incoming students has increased by 1.2%. The demonstration of the complexity of games that are developed by student studios after one or two years of study helps students understand not only the program objectives but also the growth in skills that are achieved throughout each year of the program. This results in a greater number of high quality applicants to the program.

Challenges of Using a Workshop-based Approach

Individual vs Group Knowledge Development. As in the real-world, students in a workshop based approach will reflect upon the strengths and weakness of each individual in their workshop group. This results in students taking on specific role definitions for the management of the project and distribution of tasks. It also results in students doing tasks that reflect their specific interests and strengths. Although efficient for meeting the workshop outcomes, there is a risk that students continue to practice skills within their comfort zone and do not explore or learn the other aspects of the project. This development of specialists could undermine the desire for students to

learn and integrate all aspects of the program. In particular, students risk developing skills that may be necessary in the 4th year of their program where the group project is no longer integrated into their specific course evaluation structure. There is a need to consider the design of each integrated course to apply a blend of assessment methods to ensure students individually achieve learning outcomes of each course.

Faculty Resistance. Faculty acceptance of the ITSW was very poor during the inaugural semester. There was active resistance from some faculty members and minimal contribution to the integration of the included courses. This may have been due to the extra effort required for integration and its impact on their existing course structures. Some courses, particularly non-technical courses, were not possible to integrate due to the minimal overlap in content and the possibility of significant group formation issues. These courses were also primarily designed to serve larger student cohorts not participating in the workshops such as the case of management of the enterprise, a core first year commerce course. This is a challenge also found with the GDW and the integration of the courses in the entrepreneurship stream of the program.

As the semester progressed it seemed to the coordinator for the ITSW that the problem is equally about faculty and their willingness to evolve their teaching methods to address issues of concept integration as much as it is about supporting students with concept integration. It appeared like the discontinuity between full time faculty and sessional instructors in terms of communication, course design, community, etc. may have encouraged the drift of content seen in courses and the program as a whole. This is a challenge that occurs in both workshops due to the uniqueness of the integration workshops in IT curriculum and the lack of experience of the sessional instructors in using such problem-based learning approaches.

Challenges in Coordination. Project clarity was difficult at the beginning of the semester for first year students and those new to the workshop model due to not all professors being totally onboard and student unfamiliarity with an integrative approach. This meant that students were initially confused about deliverables and deadlines. Communication with students was key, as the semester's project clarity seemed to break down quickly without coordinator intervention. This meant regular communications with students via email regarding deadlines, expectations, changes in course deliverables, etc. were critical for ensuring students remained on track with the workshop deliverables. A weekly optional meeting period was set aside for all students in hopes that they would use this period to meet with the coordinator regarding issues, meet with their groups, work on deliverables, etc. Some groups preferred to meet in such a neutral setting when issues arose, allowing the coordinator to also act as a mediator for larger personality and group dynamics issues.

Challenges in Integrating Some Courses. One of the challenges that was faced with the workshop was that, while most courses can be integrated together, that integration might not be natural. This is mainly the result of the

process of adding courses to the program map, without a consideration to the workshop. Courses were typically added to the map to satisfy the pre-requisites requirement, and also taking into consideration other factors such as the course load, instructor availability, and opening in the program map. This challenge could be mitigated through more thoughtful program design to maximize the potential integration of courses scheduled in a particular semester.

Group Formation and Off-map Students. The determination of which workshop a student should be enrolled in is a complex problem due to the design of the program and problem feature requirements expected for each course. One method is to have any student who is registered in one of the courses integrated into the workshop participate. In this case, some students could need to be enrolled in multiple workshops making them act more like consultants working on a particular aspect of a project for multiple companies. A second method is to have students attend the workshop which best reflects their current progress in the program and simply transition some of the additional features or outcome components to that problem. In both cases, students express concerns regarding workload, integration into the team, and scheduling problems. At UOIT, the GDW has attempted both of these models. Student and instructor feedback with the consulting model was negative as the complexities of group dynamics, coordination, and management of expected deliverables proved to be very challenging. Although not without its drawbacks, method two is the model that seems to work the best for student motivation as well as efficient coordination. Here the only issue that must be considered is the scheduling of the workshop and program courses to ensure that students are able to participate in any workshop to which they may be eligible (e.g. the GDW for year 2 must be conflict free with all courses in year 1 to 3 of the program).

Group formations are difficult from a pedagogical perspective due to variable deliverable complexity from each included course. This results in course components included in the ITSW having different group size requirements, etc. Ultimately this means that some groups with many members in each included course do less work than those groups that have members not enrolled in certain courses. As a result, it is important for the coordinator to carefully design each group to ensure representation across all courses integrated into the workshop.

One major difficultly involved dealing with students that dropped courses at the last minute. Sometimes this reduced a group's sizes by 25%, creating an unfair workload on the remaining group members. This issue can be mitigated by forming slightly larger group sizes pre-emptively; however, we then run into the issue mentioned above regarding unfair distribution of work complexity between different groups.

Role of the workshop Coordinator

The role of the workshop coordinator is critical for the success of an integrative PBL model. The coordinator must demonstrate a strong technical basis to support students in the application of the course theory to the

workshop objectives. The individual must also have strong communication skills and knowledge of acting as a mediator for group concerns. Research has shown that process related concerns of group activities consume as much faculty time as issues related to specific course content (Cameron, 2014).

Since the workshop coordinator loosely manages a large number of student team projects (up to 30 projects over years 1-3) as well as managing the communication flow between the teams and faculty members, the coordinator must have a background in large-scale project management, be meticulous and organized and keep track of what is stated to the students. On more than one occasion in the past, the coordinator has communicated a feature list to student teams incorrectly causing confusion between the faculty and team project submission. More recently, the coordination role has been aided by a series of student volunteers from the upper year teams. For instance, we currently have several fourth year students helping on a volunteer basis to help the first and second year teams, which has seen a positive response in engagement from the first and second year students.

Originally, the role of the coordinator was focused on teaching through case studies however we realized that the students were benefitting more through peer mentorship from the coordinator and the upper year students. This change in dynamics increases the importance of communication and mediation skills in the coordinator role.

Effect of workshop on student success

Although the initial pilot found a significant improvement in student retention and success in courses in the GDW (Hogue, Kapralos, & Desjardins, 2011), this trend is not supported on a longitudinal basis. Participation in the workshop quickly introduces students to the dynamics of working in a game design studio and highlights the importance of time management, communication and leadership skills. The students continue to support the GDW as a valuable component of their program but the retention values have returned to similar numbers as seen historically before the workshop was implemented.

That being said, the games developed in the GDW have had a positive impact on the portfolio development of students during the program. Many students have showcased work they completed in the GDW at industry events such as the LevelUp Showcase resulting in employment with companies upon graduation. There has been significant successes with students winning awards (Best Programming @ Ubisoft Academia 2014, Best Technical Award @ LevelUP Showcase 2014, Grand Prize @ Great Canadian Appathon 2014) for their work. Graduates have also demonstrated their entrepreneurial outcomes by starting companies (SkopWorks, Squabble Studios, and FrostFire Games). On a qualitative note, we have noticed that the GDW does impact students' ability to create complete games. Prior to the introduction of the GDW, students had not developed a complete game until 4th year. This limited their knowledge and ability to learn through iteration about proper project management and scope issues. While retention has not been

positively affected, it is our belief that student knowledge and skills are stronger than without the GDW due to their exposure to multiple disciplines, ability to adhere to project management guidelines, work as a team to solve conflicts and communicate their design ideas effectively to their peers.

Conclusions and Recommendations

The IT workshops need to be equally about encouraging students to make connections between course content and working with faculty to tightly integrate content while designing projects and assignments with their peer's content in mind. This community-oriented approach to course development and design is a crucial aspect that must be addressed, causing the IT workshops to be merely a Band-Aid to the underlying issue.

In order to make integrative workshops successful in a university setting, specific supports must be put into place to ensure that:

1. The objectives of the workshop are clearly communicated to faculty involved
2. The faculty involved meet with the coordinator on a regular basis to resolve any issues and facilitate communication and integration of concepts
3. The requirements are communicated effectively (and often) to the teams
4. Team formation not be based upon friendship but rather ability, skills, and knowledge
5. The coordinator involves upper year students to create a peer mentorship ring
6. The coordinator is actively involved in discussions about managing scope
7. The coordinator is knowledgeable in conflict resolution and project management

With these supports in place, workshop-based studio projects can be integrated effectively in a traditional university curriculum.

The design of each course integrated through a workshop must be developed to incorporate individual, group, and instructor reflections and feedback on the learning outcomes. This will facilitate the prevention of "free riders" receiving the same grade as team members who contributed significantly to the workshop project. It will also ensure that each graduate meets the minimum standard for the program and course-based learning outcomes.

Additional reflective elements need to be added to the workshop where groups share their experience with others. This will enhance the learning of all students and provide opportunities for the coordinator to address common issues in an efficient and meaningful manner. Reflection on the learning process and final project outcome is a critical part of the problem-based learning method that is currently insufficiently integrated into the workshop design. This will require additional coordination and grading to be completed by the coordinator and must be included in the consideration of the number of workshops an individual should be responsible for coordinating.

Unlike traditional models for PBL and integrative courses, the workshop approach requires significantly more coordination as multiple courses must be

integrated into a cohesive project. The role of the coordinator is critical to the success of such a model as they must support both faculty and students in the integration process. Although more costly to administer, the workshops provide a significant level of benefits to students with respect to achieving the program learning outcomes and preparing for the market. Future research will monitor the effectiveness of the workshops for the demonstration of learning outcomes, retention, and student satisfaction.

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