ADAPTING WATERFALL DESIGN TO AN EIGHT MONTH CAPSTONE COURSE

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Abstract –York University’s multi-disciplinary capstone design class was established “to include significant elements of design and implementation” in such a manner as to “resemble engineering projects in practice.” The class was restructured in summer 2016 to coincide with the introduction of fourth-year cohorts in both the Electrical and Mechanical programs. The changes were designed to more closely emulate an industry-standard approach. Choosing an industrially-accepted design methodology would provide a good framework for the project design and implementation and would be motivational to the students as they transitioned from university to professional life. In parallel, the course directors used a narrative structure, the Hero’s journey, to help students identify their pathways through capstone and to tell their capstone stories after the experience.

We adapted the gating reviews for the Waterfall model often used in large government contracts. At the start of the project, students are provided a governing document (similar to a contract). Gate reviews are held at preliminary and critical design stages, test readiness and post-test review and final delivery. Every deliverable requires team reflection, similar to bidder self-evaluations on government contracts. The project concludes with an open house, similar to a product release, for students to present their projects and processes to stakeholders and the general public.

This paper presents the results of the first two years of the newly revised capstone, using the Hero’s Journey metaphor and the waterfall model.

Keywords: Capstone Course : Design : Waterfall : Multi-disciplinary

1. INTRODUCTION

York University’s Lassonde School of Engineering has been running its multi-disciplinary capstone design course for a number of years, where it is taken by students from our Computer, Electrical, Geomatics, Mechanical, Space and Software programs. In the last two years, there has been considerable growth in the number of students taking the course, as a result of additional engineering programs in Electrical and Mechanical engineering. To prepare for

this new growth, the course structure and content has undergone some significant evolution, to allow for this growth, and in the process to learn from best practices being applied in other institutions - as well as to try our own innovations.

As part of the best-practice review, several surveys of capstone design courses over the years have been reviewed to identify practices, emerging trends, design pedagogy, and challenges. [1 - 6]

A series of three surveys were conducted in 1994 [1], 2005 [2], and 2015 [6] to catalog practices in the capstone design courses, identify emerging trends, and provide historical comparisons. In a recent study, Goldberg [7] summarized the main previous survey results and emerging trends over the years. The results showed that more than 50% of respondents from 2015 survey [6] reported durations of two semesters, representing a significant increase compared to results from the 1994 [1] and 2005 [2] surveys. York’s course format has traditionally been a 2-semester format, and the data from the literature supports continuing this. More than 50% of 2015 course director survey respondents indicated having six or more years of industry experience. In the York model, at least one course director is required to have significant industry experience, and project supervisors may have such experience. In addition, every project has an industry advisor, who is a practicing engineer. From the survey comparison, the top topics presented in capstone design courses have not changed significantly throughout the years and included written communication, planning/scheduling, oral communication, concept generation/selection, and team building/teamwork. These are all present in the York model. Teams with four members represented the most common project team size in the broader capstone survey - the York model allows for teams of 3 or 4 students. The most common sources of project funding reported were institutions (82%), which agrees with York’s model: every student team has funding of up to CA\$1000 for their project, but they are allowed (and encouraged) to find other actual or in-kind funding. The most common sources of design projects in the 2015 study were industry or government sponsors, followed by faculty research. In York, projects are sourced from faculty

within Lassonde, and from other departments across the campus, as well as from industry partners.

The literature identifies a number of common challenges with capstone projects that we were keen to address with our new design. One such challenge identifies how a lack of formal management scheme within student teams can have a negative impact on team performance [8]. Goldberg [9] brings up the question of course content in a multidisciplinary environment: helping students find relevance in their projects or the course when their discipline seems disconnected from these can be problematic. A corollary to this is that student teams who do not believe they have the skills to complete some aspect of the project may conclude they cannot complete their projects. Goldberg also identifies the challenge of design courses that follow one project management style: this does not easily map to both hardware- and software-based projects (the latter more typically using an agile project management approach).

In terms of best practices, the benefits of including the use of multiple communication formats at specified decision points to both internal and external audiences, for both formative and summative assessments of the design process can be significant [10]. Both forms of assessment are best evaluated using a standardized set of rubrics, providing benefits to students by explicitly stating performance expectations and to faculty by establishing a common definition of skill competencies.

Ward [11] noted that most of the top-ranked universities use some variation of a Design-Build-Test model for their capstone programs. This model reflects an emphasis on applied design projects, rather than a research model. Learning takes place through the design and creation of a product. Although most of the student's time is normally spent in design, the product must be built to a state where it is operationally testable. This is important so that the student can verify the product meets its requirements and identify possible improvements [12].

Ward [11] also identified that prospective employers can have an especially strong interest in capstone projects, given the objective of capstone programs is to prepare students to become professional engineers. Most also solicit industry to serve as student advisors, provide funding, and/or assess the projects. Finally, Ward notes that group projects generally require a number of sequential assignments throughout the course, for example, design notebooks, coach's evaluation, oral multimedia presentations, technical milestone reports, etc.

2. COURSE DESIGN

2.1. Course Outline

York's multi-disciplinary capstone engineering design course is offered over the Fall and Winter semesters, nominally in the final year of study. The course requires student teams of either 3 or 4 students to conceive, design,

develop and test an engineering product or service over the two semesters. Teams are supported by the course directors (one from each of the represented program departments), and each project unit consists of the student team, a project supervisor who provides domain expertise, and an industry advisor who provides real-world knowledge, practice and expertise.

In the York model, students are allowed to select their own teams and projects, although course directors maintain the right to allocate students to any team, to ensure all students can be accommodated. This allows for some teams of students from a single discipline, however most teams have members from two or more of the engineering programs. The first deliverable for all teams consists of a team and project reflection document, where the groups identify the skills likely needed for their project and the skills within their group, and teams are encouraged to identify tools, people or resources that can fill in any holes.

Projects are curated during the summer prior to the course from faculty and industry partners, and in the spirit of Lassonde's Renaissance Engineering goals to break down barriers between engineering and other disciplines, also from non-engineering faculty across the campus, and the broader community. Students are also able to propose their own projects, provided they find a faculty supervisor for the topic. Each project is subject to approval by the course directors to ensure it has an engineering design focus (as opposed to a research focus), and key skills and background knowledge for each project are identified on a short project summary sheet. Projects are posted shortly before the start of the course for students to begin reflection and selection.

Despite the recommended best practice to allow for agile development in software projects, and the desire to accommodate both waterfall and agile methodologies, the course organization was simplified to use a single methodology for the first few iterations of the new structure. The Waterfall model appeared to be the more appropriate methodology for applying unilaterally, as it can be applied to multidisciplinary teams. Students were nonetheless not prevented from using a hybrid model with agile development between formal waterfall gates. The project reviews were based on a design gate approach.

The course structure, deliverables and assessment rubrics are provided to students in a "governing document" at the start of the course, styled on a government request for proposals, with similar section headings and language. The document details the deliverable due dates, weighting, expected content and assessment criteria, funding and expense mechanisms and all other material relevant for project execution. The self-assessment rubrics proposed in the government document were replaced with rubrics taken from Lassonde's graduate attribute indicators. The document also includes a statement allowing students to negotiate adjustments to deliverable content, dates or weighting. The deliverables include gated design review

materials for an initial project scoping and preliminary and critical designs in the Fall, and test readiness and test review, and a final project documentation pack in the Winter. The course concludes with a capstone presentation day at the end of the Winter examination period.

Feedback on deliverables is provided formally from the course directors, and from the teaching assistants for the course who act as “red-team” reviewers, reviewing the delivered content “blind”. Student teams are also actively encouraged to seek feedback from their supervisors and advisors. An advisor and supervisor feedback session is held with the course directors at the mid-course and end-of-course points, but is not intended to address project-specific issues, rather capture any systemic challenges or positive feedback.

The course itself is delivered as a series of 24 1-hour weekly seminars covering timely topics on the project lifecycle, guest speakers and in-class activities, with an expectation that teams will meet with their supervisors and on their own outside the seminar time to advance their projects. The course directors also run a “fake” example project a couple of weeks ahead of the student teams by way of illustration of what deliverables could look like.

3. CAPSTONE COURSE JOURNEY

The capstone course was designed around “the Hero’s Journey”, a narrative structure derived from Joseph Campbell’s Monomyth detailed in *The Hero With A Thousand Faces*. The structure, Figure 1, can be found in many stories throughout history, up to the modern day. It is traditionally depicted as cyclical and requires the

“journeyer” to be called to an adventure from the “known world”, given some offering of a supernatural aid, and then to cross a threshold into an “unknown world” where they will face challenges and temptations, but will have helpers and mentors that they meet on their journey. At some point, they will reach an abyss, which will require them to have some revelation to transform and extract themselves from the abyss. As a result of the transformation, the journeyers will atone for their past mistakes and receive some “gift of the goddess” allowing them to maintain the transformation when they return to the known world, ready to face a new adventure.

The semesters, seminars and deliverables were prepared and organized around the phases of the Hero’s journey, as shown in Table 1.

Figure 1: Hero's Journey [17]

Table 1: Mapping different phases of the Hero's journey to Capstone Course

Hero's journey phase	Activities	Seminars	Deliverables
Call to adventure, supernatural aid	Project and team selection Needs statement/requirements definition	Brainstorming Project management	Team and project summary Requirements document
Threshold crossing, Helpers/ Mentors/Challenges/Temptations	Design, development, iteration Design trade studies Start build	PDR and CDR gates Interfaces and subsystems Rapid prototyping What/how to test Budgeting	PDR gate documentation CDR gate documentation
Abyss and revelation	Test readiness Testing	The TRR and TR gates IP and NDAs Managing change in the build phase Library resources Design for universal use Failure and nonconformance reporting	TRR and TRR gate documentation
Atonement and return	Project completion Final report Capstone presentation	How to present How to document as-built design NCR closeout Lessons learned / failure report Self-reflection Wrap-up	Final report Capstone presentation (product release presentation or industry-style booth)

In addition, regular student reporting on progress was built into the entire journey.

The Hero's journey metaphor has been helpful for both the course directors and students. From the course director perspective, the analysis in this paper reflects some of the ways the Hero's journey has framed course evolution. Students were given the structure to help them situate themselves within the project lifecycle. The metaphor explicitly helped students narrate their own journeys, in their deliverables during the project, and importantly in their presentations on capstone day. The capstone course has been run twice with the new structure. The next sections detail the experiences of these first two iterations of the course. The iterations have been presented as Hero's journeys, from both the course directors' and students' perspectives.

3.1. Year 1 of the journey (2016-17)

The first iteration of the modified capstone was offered starting in Fall 2016.

Call to adventure: The course director call-to-adventure happened early/mid-summer 2016 in preparation for the Fall 2016 start. For the 2016 cohort, 13 student teams were created. The student call to adventure started at the end of the summer but continued into the first week of the semester to ensure all students had met the required course prerequisites. Students were asked to identify their three highest project preferences from an existing list of projects curated from industry, faculty and community over the summer, from which they were organized into teams. Students could also propose their own projects at this time, provided (as previously discussed) they had a faculty supervisor ready to supervise, and only after review by the course directors. Inevitably some students did not get one of their top three projects, although the number of students in this category was small, and all were accommodated within the first two weeks in an appropriate project.

The team and project summary document was prepared by student teams at the end of this phase, which did not earn students any grade, although feedback was provided on the delivered content. Students restated the proposed project objectives in their own words, considered the key stakeholder groups for such a project, discussed their team's connections to the project and their strengths and weaknesses to address the project. This could be considered as the threshold guardian deliverable for the students, helping them feel prepared to embark on their journeys. Students were also asked to start their regular progress feedback, through a monthly progress report.

Supernatural aids: In addition to the previously discussed course design reflections, the course made use of best practices from past course directors at York and used texts from capstone pedagogy and from systems engineering in industry - specifically from NASA's space systems engineering handbook, and their online course. There was also a teaching assistant assigned to the course, who was

himself a system engineer on a graduate research project. The TA role was allocated to acting as a blind "red-team reviewer" of each of the project deliverables, providing an independent assessment of the deliverables with no specific prior knowledge or close engagement with the project teams. The governing document was given to students as they set off on their journeys as their supernatural aid.

Helpers and mentors: When thinking about helpers and mentors as course directors, the course structure appeared to support the projects well, and the content that reflected the real world appeared to be successful. Having templates for deliverables and the "fake" project that ran mostly successfully also acted as a good support for the course. The student cohort for the course was strong and engaged.

Student advisors were introduced to their teams at this point. The York chapter of the PEO was consulted with over the summer, as they had previously had a close connection to York's capstone projects. This proved invaluable in identifying industry mentors for projects: the York chapter has a large and active membership, and a good number of advisors volunteered to support our student teams. Many student teams engaged well with industry mentors, office hours were used well and the example projects seemed well received.

Temptations and challenges: Temptations were elements of the course that we thought were working well, but that were perhaps not as successful as we had thought. Challenges were elements that were known to be having issues. As course directors, we found the document deliverables from students early in the course were generally of good quality, suggesting projects were advancing well. In reality, we later discovered, for many groups the focus was on writing design documents rather than doing the design work behind it. As course directors, we were looking for students to do their design activity and write about what they were doing. As such, the deliverables became a focus rather than a gate ("what is needed for the next assignment" vs. "how do I progress my project to the next development gate and what do I then need to capture to show I got there?"). The challenges that were known to the course directors included the timing of the course seminar (8.30 am), and the trade study activity: at the preliminary design phase, we had asked teams to develop a point design for their project and identify the areas of their design they needed to perform a trade analysis on, using simulations, experiments and prototyping. For many groups, however, this became a paper exercise involving a theoretical comparison of the options.

From the students' perspective, document templates and the course director example project documents appeared to be helpful, but some teams used these reports "blindly" rather than reflecting on how best to use them. In particular, students did not reflect on places where the course directors identified their own documents as "meeting" or

“marginally meeting” rubrics as places where they should have considered improving their own versions.

Abyss: At this point, the course directors realized students were struggling with the deliverables being asked of them, taking the requested deliverables to equate to documentation. The result of this was a lack of sufficient prototyping activities early enough in the design cycle. We also recognized that student timetables had some unique challenges for students to find times to meet to work on their projects. The timing challenges resonate with other findings in the literature [7]. The inability of capstone design team members to find common meeting times is a major source of conflict among teams. More than 50% of 2015 survey respondents reported a mix of in-class team meeting times and student-arranged team meeting times outside of class [7].

The variation in students’ prior experiences with design was also noted. The course directors themselves found giving students timely feedback on the monthly student reports was challenging, especially immediately after a gate review deliverable, resulting in some level of student disengagement from the monthly feedback.

From the student perspective, many recognized at this point that their project scope was larger than they could achieve in the remaining project timeline. This resulted in some level of disappointment that their capstone would not live up to their expectations. The process of completing their capstones had moved from a project they were connected to, to an academic chore, for some teams.

Transformation: In the Winter semester of the 2016/2017 class, the class time was able to be changed to a midday time slot, which was much more favourable for students. The seminar activities were also adapted: class seminars included a peer review element every week, giving students the opportunity to raise concerns and discuss them with their peers, and flag their level of confidence in completing on time. This helped make the seminars more relevant again. In parallel, there was more encouragement given to student teams to be flexible in the formats of their deliverables. The governing document had never been prescriptive with regards to deliverable format, but the template deliverables and the sample project deliverables had been documents. For the Winter sample project deliverables, we provided students with some video deliverable examples, which did encourage some teams to experiment more and get out of the mindset of the documents being the focus of the projects. Longer-term transformations were also hatched at this point, looking at possible change-ups of gate reviews to reduce paperwork and better incentivize prototyping earlier in the design cycle, adding some extrinsic (grade) motivation to this aspect of the project development. The monthly progress reports were also targeted for some adaptation for the next course iteration.

The student transformation was most evident in terms of the chances to address concerns/problems during seminar time, and to give peer-to-peer feedback. The change in deliverable formats tried out by some groups also resulted in reduced workload and a renewed focus on the project rather than the assessments. The test readiness review gate was also a transformative experience for some teams, who realized in developing material for this gate that they had to have a system in a state for testing, and that reflection on how they would test (which had been a part of previous gates, but not the core component) helped them finally recognize what their project was really about.

Gift of the goddess and return: The first new iteration of the capstone course came to a close the week after final exams, with a very successful first capstone day: all student teams presented their work well, and most were able to show successful projects. The event garnered some very positive feedback from students, faculty and guests, and inspired the course directors to drive the changes that had been highlighted during the transformation phase ready for the second iteration of the new course.

3.2. Changes planned for year two

The second iteration of the new course added the first cohort of Mechanical engineering students as well as a larger cohort of Electrical engineers. The specific areas for change that were looked at included reducing the content expected in the project deliverables, in an effort to have students focus less on documentation and more on project execution. A specific goal was to revise the progress feedback mechanism for students, from a monthly report to a less onerous and more frequent weekly team photo with a couple of team evaluation questions. A stronger emphasis, and grading component, for prototyping activities was added in the fall, as well as an incentive for student teams to plan to spend a quarter of their budget on the early prototyping activities.

In addition, the Mechanical engineering department ran their first engineering design graduate attribute committee meeting targeted at reviewing this GA across their curriculum. The capstone course directors were invited to participate in this meeting. This provided an opportunity for the flow of design-related curriculum content leading to capstone to be reviewed (albeit for only one of the six programs from which students take the common capstone).

3.3. Year two of the journey (2017-2018)

The review of the second capstone journey is now presented. The course was not heavily changed, therefore for simplicity we have only highlighted the differences in the activities and effects from the first iteration below.

Call to adventure: The second year's journey was defined by a larger class and an increased focus on implementation rather than reporting. The student enrolment increased from 52 to 82 students (due to the aforementioned increase in the maturing Electrical Engineering program and the

introduction of the first cohort of Mechanical Engineering students). The course director group expanded from 2 to 3, to include a Mechanical Engineering faculty member, and the teaching assistant group went from one TA to two, both systems engineering researchers. The growth resulted in 22 projects (a significant increase from the first iteration's 13 projects). The student team and project summary document was slightly reduced from year 1, removing some elements of assessing personal connections to the project and removing the requirement for students to provide their curriculum vitae. The student progress tracking through monthly progress report was replaced by a weekly team photo and a Likert-scale assessment of team status, with an optional comment box.

Supernatural aids: The governing document reflected changes to reduce the level of documentation deliverables and emphasize the prototyping. A graded prototype milestone in early December, with an accompanying budget penalty to incentivize students to engage in a reality check of their paper designs in such a way as to permit them sufficient time to reflect on.

Helpers and mentors: The new components showed some positive trends. In particular the team photos gave the course directors a chance to check that student teams had been able to meet regularly, and the short weekly team health questionnaire did allow for some early interventions to address team dynamics issues, with success, for those teams that recognized to ask for this. The feedback for assessments was provided similarly to year one, however there was early recognition by some teams that the value in the feedback was not just from the grade - the notes provided were reviewed thoroughly by some teams. In addition, the quality of the TA reviews of projects was invaluable with this larger cohort of students: the feedback in year had been excellent, but with the expanded number of teams, consistent excellent feedback from both TAs proved very helpful to the course directors.

For students, the opportunity to provide some confidential feedback on team dynamics issues early-on did seem to help.

Temptations and challenges: Compared to the first iteration, there was a recognition early-on that students were not finding the same value in many of the activities during early design and prototyping. This led to quite significant push-back from a subset of students and led to an early student disengagement from some teams. As is perhaps common in capstone design courses, there was a desire by the students to rush into the solution domain, before critically evaluating the problems they were trying to address, and the approach used to explain the rationale for considering the problem space did not resonate well.

Abyss: The course directors noted a significant drop in student attendance and engagement compared to the first iteration. Factors beyond pedagogical approach, including the larger cohort, a traditional lecture space (as opposed to a smaller design space), and a Monday 8:30 am year-long

time slot. In addition, a strike by contract faculty and teaching assistants at York in the latter half of the Winter semester complicated student access to campus and team spaces. Despite these factors, there was clearly some impact resulting from the seminar content not resonating as well with this student group. Some specific activities such as team tool exploration (e.g. De Bono's Thinking Hats [13]) and cardboard prototyping [14-15] which had worked in 2016-17, were met with a high degree of resistance, and some challenge in recognizing their value for project work. Students also struggled to interpret the assessment rubrics, and the governing document was not a successful at communicating the project requirements, with many more questions and greater uncertainty in where to find information and how to apply it. With the larger cohort, there were some anecdotal indications of student team disengagement from supervisors and industry advisors that were not picked up on promptly; the lack of a formal tracking mechanism for student interactions with supervisors and advisors was noticed. There was also a higher percentage of teams with one or more members under-engaging. Timely feedback for students was still noted to be challenging for the course directors.

From the student perspective, team scheduling and project management was noted much more significantly as a challenge, with other project deadlines, midterm schedules and other important events not necessarily being taken into account by teams when planning project activities. Seminar content was not always seen as sufficiently valuable for the 8.30 time slot, and disengagement between teams and industry advisors was noted, due to some communication challenges between these groups. There were also a larger number of student teams working with a significant software component to their projects, and these teams used agile project management methodologies, but found some of the gate review process challenging to layer on top of this. The course directors have been keen to allow for more flexibility in project management approach, and this second cohort was keen to see that flexibility.

Transformation: One of the most significant shifts from supporting this larger student cohort has been the realization of different team profiles, that could broadly be categorized into lower-performing groups and higher performing groups on one axis, and groups who are eager to solicit support and feedback from a wide range of sources vs. those groups who are looking for more precise, targeted inputs on specific issues they may face. Differentiating support for these four categories is an ongoing reflection activity being undertaken by the course director team.

A couple of specific changes were able to be made during the second cycle, with positive effect: Many of the students struggled with the guidelines in the governing document in the second cycle. To address this, we experimented with creating short video summaries to

explain the milestones from the governing document. These videos explained the background behind the milestones and re-visualized the existing marking rubrics, putting them in bullet form and colour-coding them, as shown in Figure 2. Student feedback for this was positive. Many wanted to see these videos at an earlier stage, which will be considered for the next cycle.

Rubric 1: Did you Build the Right System with Right Tools?
Use appropriate engineering tools to produce a complete system that matches its requirements

1. Incorrectly applies tools; cannot produce a system
2. Uses some engineering tools but system is incomplete or does not completely match its requirements
3. Uses appropriate engineering tools to produce a close-to-complete system that adequately matches its requirements
4. Effectively uses appropriate tools to produce a complete system that matches its requirements

Fig. 2: Updated Rubric Scheme

Part of the reflection on the governing document and rubrics included recognition that using GA rubrics unmodified for students was not the clearest way to present the course-specific interpretation of those rubrics. Some of the rubrics were challenging to interpret directly in the required deliverables, and this needed addressing. For the second cohort, explanation tables were provided for students as a workaround solution, but there is an intention to change the rubric language for students for the third cycle of the new course.

Gift of the goddess and return: Despite some of the new challenges and the ongoing industrial action, there was another generally successful capstone day, although it was noted that fewer projects were completed as successfully.

4. SUMMARY OF THE JOURNEYS

Having completed two cycles of the new course structure, there have been many things to reflect on. The use of a real-world framing for a project does not immediately translate for students who have not necessarily had wide exposure to industry practice. Scaffolding this framing is helpful for some. The focus on documenting project progress and gating the progress had an unintended consequence of having students focus on the gate deliverables rather than the project progression through the gates. Simply reducing documentation requirements, experimented with in year two, is not necessarily sufficient to help students refocus on the project progression, and in some cases may actually have had the opposite consequence to that intended.

Going into our third iteration of the course we see that some lessons have been learned and should be applied going forward, including making more of the class material available to students earlier and more consistently. While having a single reference for the course in the form of the governing document is helpful, it is difficult for some students to engage with it, having had little exposure to such types of documentation prior to capstone. Providing

them with short videos (approximately five minutes in length [16]) for just-in-time referencing when working on deadlines is helpful. Formatting grading schemes (rubrics) in colour-coded bullet points, with wording more specific to the particular milestone is also key to better student comprehension, compliance and buy-in.

Going forward, the course will again undergo some changes as it enters its third iteration of the new format. Specific changes currently under consideration include:

- having advisors and supervisors provide inputs to grades for assessment points, to help encourage better communications and check-ins between student teams and the supervisory/advisory groups
- adding more guest speakers from industry, specifically to present some of the design tools that students find difficult to recognize relevance in, such as cardboard prototyping: the message of the utility of these tools may be more easily digested from industry practitioners directly
- changing the course scheduling from a weekly 1h seminar and no preplanned team meetings to a dedicated 3-hour time slot comprising both a seminar and team meeting component. This should help ensure teams have a dedicated time to meet each week. It will also allow the course directors to run a few longer peer evaluation activities, and for students to share presentations, during some of the team times.
- providing face-to-face feedback to student teams after each gate deliverable through the expanded team time, to ensure the benefits some teams have gained from the feedback notes are gained by a larger cross-section of the teams.
- tailoring the assessment evaluation rubrics from the generic school-wide graduate attribute indicator rubrics to ones that are tied more clearly to the project deliverables
- supporting waterfall and agile program management styles from teams, with appropriate adjustment in project deliverables, in a hybrid model
- a mid-project team statement articulating the role for each team member and the expected outputs from each member
- expanded use of the course TAs to support weekly team health assessments, and identify teams with challenges (reducing the course director load for this component to focus on those with challenges only)

Finally, another factor to re-examine is how to differentiate the approach to project development and supervision for the diversity of team needs. It may be appropriate to consider how to engage high-performing groups who are keen for limited, punctual

support/intervention to participate in the classroom by giving them more responsibility, through opportunities to mentor or guide lower-performing groups, for example.

5. CONCLUSION

This paper has highlighted the redevelopment of the capstone project course at York university as a result of significant growth in the cohort size and a much greater degree of multidisciplinary. The paper highlights the use of an industry-standard implementation of Waterfall development, its successes and challenges. It details the use of the narrative construct of the hero's journey as a way to frame the capstone course, and the changes made to it.

The results of the first two iterations of the newly designed course have resulted in ongoing recommendations for small evolutions, in terms of the technical content of the deliverables to ensure a focus on project progression rather than assessment grades, seminar content and timetabling to engage and address the diverse student needs, stakeholder engagement and involvement modes, and the structure of the program as a whole. These recommendations will continue to be a work-in-progress, and continuous evolution of this course is expected to be an integral part of its structure going forward. The lessons from these first iterations are nonetheless offered to the community for their thoughts and feedback, with the hope that they may be helpful for others.

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