USING PRINCIPLES OF SCRUM PROJECT MANAGEMENT IN AN INTEGRATED DESIGN PROJECT

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ABSTRACT

Agile project management principles have been applied in a variety of settings to improve team communication, professional development and collaboration. Specifically, “Scrum” is a process used in agile project management in order to have short, iterative sequences to provide frequent feedback on the final product. In an integrated learning stream at the University of Calgary with an integrated design project, principles from Scrum were used to help support the student design project and their learning process. Specifically, using key ideas of Scrum, students were able to better visualize the steps required to complete the final design project. This paper provides an overview of the scaffolding of Scrum activities to introduce the concepts of agile project management and then apply these to their own design project.

KEYWORDS

Scrum, Agile Project Management, Design Project, Lego Learning, Standards: 7, 8.

INTRODUCTION

Scrum is an agile project management process. Simply put, Scrum provides a framework for having short, iterative timeboxes (usually two weeks) to provide frequent feedback on the product being developed. Scrum was initially introduced for software development (Rubin, 2012) however, principles from Scrum and Agile Project Management have begun to be applied in a wide variety of other disciplines such as product development (Ovesen, 2012), design thinking (Häger et al., 2015), and support organization processes (Sheth, 2009).

This paper discusses the application of Scrum principles to an integrated learning experience at the University of Calgary. As outlined in CDIO Standard 7, integrated learning provides students with technical content knowledge while also fostering interpersonal skills and system

building skills. The Scrum processes used through the design project were able to support the bridging of this connection between technical theory, application of knowledge and developing interpersonal skills.

First, an overview of scrum and agile project management processes and terminology is provided. This includes a summary of examples of others applying Scrum in post-secondary education settings. Second, a description is given for the context of the specific integrated course design. Lastly, the design and implementation of the first two Scrum activities are described in detail.

OVERVIEW: SCRUM AND AGILE PROJECT MANAGEMENT

In 1993, ideas from a concept being used in product development in Japan called “Scrum” were applied to software development processes (Rubin 2012). Scrum was brought in a solution to the challenge of keeping up with the fast pace of technology development. It was no longer acceptable to be using code that was multiple years old, and software companies needed to keep up. Scrum was helpful in achieving this due to the iterative nature of the structured “sprints” in the Scrum process.

Simply put, “Scrum is an agile approach for developing innovating products and services” (Rubin, 2012). The end product is achieved through completing multiple timeboxed iterations, commonly two-weeks, but can range from one week to one month in length. During this timebox, the team completes pre-determined product components, including the designing, building and testing. At the end of the timebox, the product components should be ready to go into production and completed features are reviewed with stakeholders to get their feedback. These agile processes allow continuous validating and comments between the product and the customer expectations (Häger et. al., 2015). By presenting a “final” product every two weeks, the iterative feedback process is much more effective at moving the product towards the goal.

A handout on the critical terminology of Scrum was prepared for the students to introduce Scrum. For readers unfamiliar with Scrum terminology, we have included this handout in the appendix. Specifically, for the context of this paper and the implementation of Scrum in our classroom, it is important to understand *backlog*, *sprint*, and *retrospective*. The *backlog* often resembles a task list. However it should also be focused on the features requested by the customer. A *sprint* is a fixed-length iteration during which the sprint backlog items are turned into “potentially shippable product”. The intent behind a sprint is that at the end of the sprint, the team has accomplished something that resembles the final product. These short iterations towards a final product allow for critical and clear feedback on the progress. A *retrospective* is a meeting following the completion of a sprint to identify improvements to be incorporated in the next sprint. The intent is not to focus on the tasks or too many details, but rather move forward with a goal of continuous improvement, particularly in terms of team processes.

It is important to note that the application of Scrum in industry environments varies widely, and generally all companies will vary the principles of Scrum to fit their needs. One study of ten companies implementing Scrum found that all companies used variations of Scrum (Diebold et. al., 2015). The least variation was seen in Sprint length, events, team size, and requirements engineering (product backlog). There was large variation seen in team roles, effort/complexity estimations and quality assurance. This is important to keep in mind, as there are many different iterations of how Scrum can be implemented in industry and in the classroom. Both from this study and from the authors' experience, organizations do not conform directly to the Scrum principles and Scrum is most effective when modified to suit the specific context.

Scrum as a Learning Tool

Scrum has been used across multiple learning contexts in postsecondary education. Sarang-Sieminski and Christianson (2016) discuss the implementation of Scrum to Capstone Design projects as a project management tool. They found that by the end of the semester student teams had consistently stuck with three of the Scrum artifacts they were using: sprint review, the role of Product Owner, and role of Scrum Master. Students reported that these three artifacts, as well as the Sprint Board, were helpful in the progress of their project.

In contexts outside of engineering, Scrum has been used as a tool to foster collaboration amongst students. For example, Scrum principles were adapted to an upper-level Publishing elective in order to help students better see themselves as collaborators and encourage professional communication (Pope-Ruark et al., 2011). One student in this course reflected, "[Scrum] is just a fantastic way to discuss the problems everyone has with projects and is a sort of safe place to admit that you are confused or have problems with an aspect of the course or project." Other courses in communications (Opt & Sims, 2015) and professional writing (Pope-Ruark, 2012) had similar findings, where students found that with Scrum there was increased team member communication and reduced team conflict.

When Scrum is introduced in classroom settings, often a game design is used to provide foundational background on Scrum principles and methods. For example, there is a quick activity called the "Ball Game" intended to help participants experience the effects of self-organizing teams. This was applied for students in a systems analysis and design course, which was found to be a useful starting point for aa discussion on Scrum principles (May, York, & Lending, 2016).

CONTEXT: INTEGRATED LEARNING STREAM COURSES

There is substantial research and initiatives globally to increase the quantity and quality of design in engineering undergraduate education. However, even when creating innovative design opportunities for students, often instructors are constrained by the silos of individual

courses. At the Schulich School of Engineering in the University of Calgary, a pilot project was implemented where all five courses for second-year electrical engineering students were designed and delivered in an *integrated learning stream* (ILS).

In this integrated learning stream, the material for all five courses is covered in a collaborative environment with content that connects the courses together (see Figure 1). There is a series of active learning experiences where students learn the material of all of the courses in more of a free-form way, putting the material in the context of real-world situations. Two key components of this course are described here to provide the context for the Scrum and Agile Project Management activities that were designed to support the primary course activities.

Figure 1. Integrated learning stream course structure.

Integrated Design Project: Audio Player

For the students participating in the integrated learning stream, there is one overarching project driving the learning throughout the semester. Specifically, the project is the design, construction, and testing of a simple portable audio player, which could have an application to e.g. allowing autistic children to express themselves easier. Component pieces of this include (a) memory design for storage; (b) Analog-to-digital and/or digital-to-analog conversion; (c) filtering; (d) amplification; (e) LED indicators; and (f) power management.

Learning Communities

A learning community can simply be defined as “groups of people engaged in intellectual interaction for the purpose of learning” (Cross, 1998). Within an academic context specifically, this means deliberately structuring the curriculum so students maintain an engaged academic relationship with their peers and/or faculty member over a period of time (Minkler, 2002). The ongoing social interactions fostered in learning communities help students develop their own voice, and gives them a worldview perspective on what they are learning. Additionally, engagement in learning communities with peers at the University-level was found to be positively linked with academic performance, engagement, attendance, and overall satisfaction (Zhao & Kuh, 2004).

For these reasons, at the beginning of the term, students in the ILS were placed into learning community groups of 5-6 of their peers. The purpose of these communities is to provide students with a peer support network. All their labs and group projects come from these learning community groups, in variations of groups of 3 or 6. Throughout this paper when discussing the Scrum and Agile Project management, the teams mentioned are the learning community groups.

DESIGN AND IMPLEMENTATION

The Integrated Learning Stream course was scheduled with three main parts:

- Week 1: Introduction, Team Building
- Weeks 2-9: Blocked courses, Integrated knowledge building, Project brainstorming
- Weeks 10-12: Project time

The scrum activities throughout each of these blocks were slightly different. In the first week, we introduced Scrum through two activities. During weeks 2-9, the sprints were timeboxed in three-week increments. During the final two weeks, the sprints were time-boxed in one-week increments. Each will be described below.

Scrum Kick-Off Activity (Week 1)

Scrum principles were applied to kick-off the audio player design project for the integrated learning stream. Specifically, students were given a brief project description and told that in 60 minutes they would be giving a presentation of their final product. In other words, the first Scrum Sprint had a timebox of 60-minutes. The goal of this activity was that the students would be required to think through the design elements of their audio player. Immediately the students were very excited about the project and dove right into brainstorming. The energy in the room throughout the 60 minutes was very high, and students considered many different design features of their audio player. This “mini Scrum” was a great way to kick-off the design project.

Lego Learning Activity (Week 1)

As discussed above, activities are often used to teach the principles of Scrum. In the Integrated Learning Stream course, we decided to use Lego as a tool to build foundational Scrum knowledge, particularly around the terminology. This activity was based on the description given on the https://www.lego4scrum.com/ website.

Students were tasked with building a city in three 7-minute sprints, and they were provided with a backlog list of items (ex. one-story buildings, two-story buildings, school, theatre, etc.). At the end of the first Scrum, the instructor provided feedback on things she liked and things she didn’t like (ex. “I want there to be a neighbourhood by the park” or “I want all the 1-story and 2-story buildings to be uniform colours.”). The teams then start to understand the value of

the Scrum. Early on they show a completed city, and they are able to receive immediate feedback and make adjustments as they go.

In total, students did three 7-minute sprints. Between each sprint were a review and a retrospective. For each retrospective, students were given an activity to do in order to build team communication:

- Each team member writes one “Opportunity” and one “Challenge” on a post-it note before everyone shares their comments with the team.
- Each team member says what they appreciate about working with their peer sitting to their left and their right.
- Each team member writes down on a post-it note how they are feeling (ex. happy, stressed, frustrated, excited, tired).

Overall, the feedback from students was positive about the Scrum activity. They were able to learn the key terminology through active learning. The one area for improvement would be to have a clearer connection to the course design project either during the activity or immediately following so they better understand the direct connections.

Project Brainstorming and Development (Weeks 2-9)

Two sprints were completed during the middle of the ILS courses. During this time, students were developing their technical content that they would need to complete the audio player through active learning and hands-on labs. For example, they learned filters and PIC through different lab assignments. While learning these concepts, the instructors were continuously helping the students make the connections to the integrated project.

Figure 2 and 3 below show the requirements of the first two sprints. Specifically, students were given clear guidance on the first sprint, with both the expected product to be delivered and the backlog items. For the second sprint, students were given the expected product but were expected to determine their own backlog items. After each sprint, students were brought through a retrospective reflection. Appendix B shows details on the retrospective, including the hand-in assignment that was required and checked as a pass/fail.

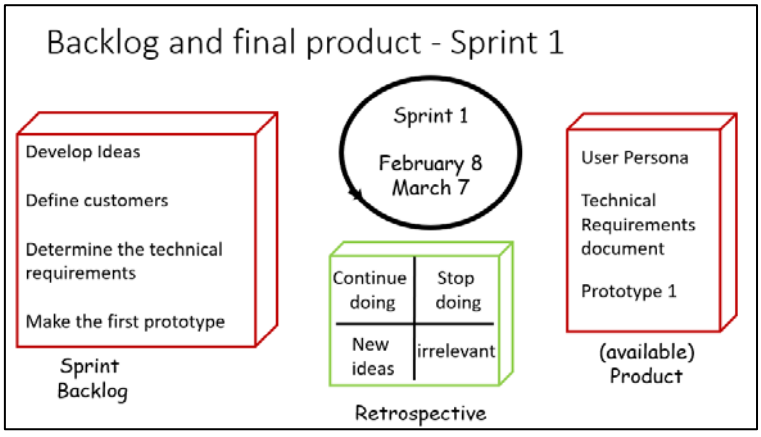


Figure 2. Sprint 1, where the instructor clearly outlined the backlog and the required product to be completed at the end of the Sprint.

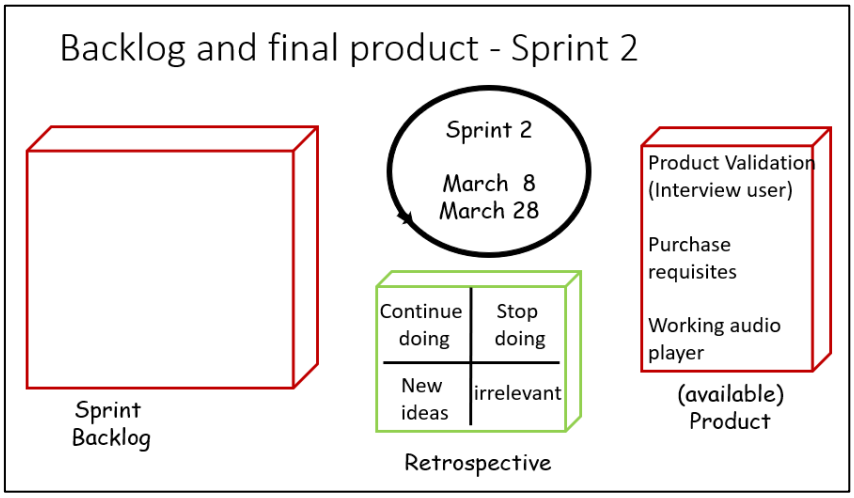


Figure 3**.** Sprint 2, where the instructor clearly outlined the required product, but expected the students to complete their own individual backlog.

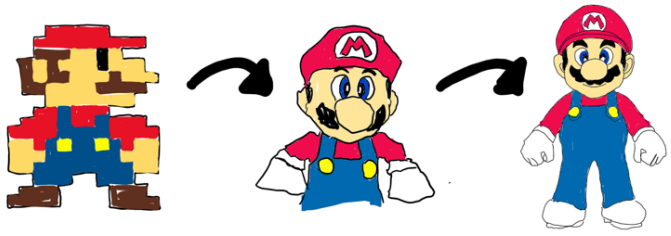
Project Building (Weeks 10-12)

In the final three weeks, the students were asked to complete weekly sprints. They were not given any guidance on their available product, but they were asked each week to pitch their product. The ABC structure was following: the end of the first sprint was considered the “Alpha” phase, the second sprint was the “Beta” phase and the final sprint was the “Completion”. Further details on the audio player project and the ILS program can be found in other publications (XX), however here we are just focusing on using the Scrum methodology to support the integrated learning experience.

STUDENT FEEDBACK

In the last week of the course, the students were required to submit e-portfolio entries reflecting on something they learned through Agile Project Management. A few student entries are highlighted below in Figures 4 to 8. Overall, from the themes below it is evident that the students found the Scrum processes effective for ensuring they stayed on track with their project through iterative continuous improvement. Additionally, agile and scrum were helpful in clearly making the integration links between the technical content and the project management skills required.

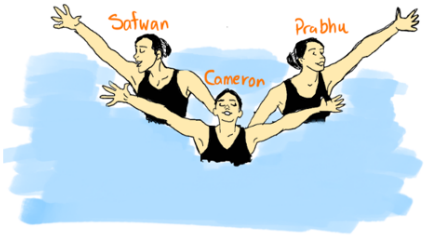
What I learned from Agile Project Development: The Iterative Process



In Agile Project Development the most important thing I learnt would have been the iterative process. As a perfectionist, the way I would have approached project development before would have been drastically different. I would have tried to make the product perfect on its first attempt and gotten really frustrated along the way. The Iterative process taught me to give a specific timestamp to do a certain amount of work which is a lot more manageable and greatly reduces stress. The iterative process was vital in the ideation of our product, as we changed our product over and over and finally got to a design that we loved.

Figure 4. Student entry reflecting on the agile project management process.

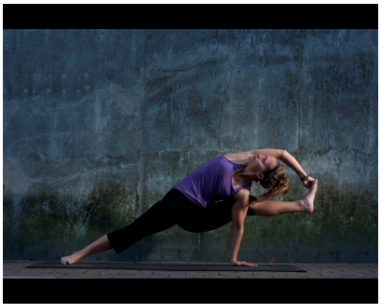
Synchronous



Prior to being in the ILS program, I was unaware about the Agile Project Management technique. After using it for an entire semester, I can confidently say that it has enhanced the efficiency of our group project. I have a better understanding of product backlogs and sprints; where a list of project specifications (backlog) and goals must be made within a time frame (one sprint iteration). Using agile throughout the semester also helped me understand why daily stand-ups are essential to a team and how it can ensure all members are on the same page throughout the entirety of the project. This ensures a synchronized team while working towards a final goal.

Figure 5. Student entry reflecting on the agile project management process.

The Process: Agile Project Management



"Flexibility", image by MemoiresPhotographiques, on Flickr.com

Agile project management has taught me the importance of using our time efficiently, above all else. Doing daily stand-ups, along with product backlogs has been a crucial aid in keeping our team on track. As well, agile project management has directed importance to keeping focus on how much work has to be achieved in the long run. Through the many iterations involved, progress is made quickly and flexibly in order to meet project deadlines in a more frequent fashion.

Rather than just building a product from start to finish, the technique of carrying out work in the form of sprints has shone a light on the significance of having flexibility in our designs. By constantly improving upon our product, more technical issues can be addressed at once. As well, our ideas can be constantly re-assessed, in order to better our product and deliver what the client wants.

Figure 6. Student entry reflecting on the agile project management process.

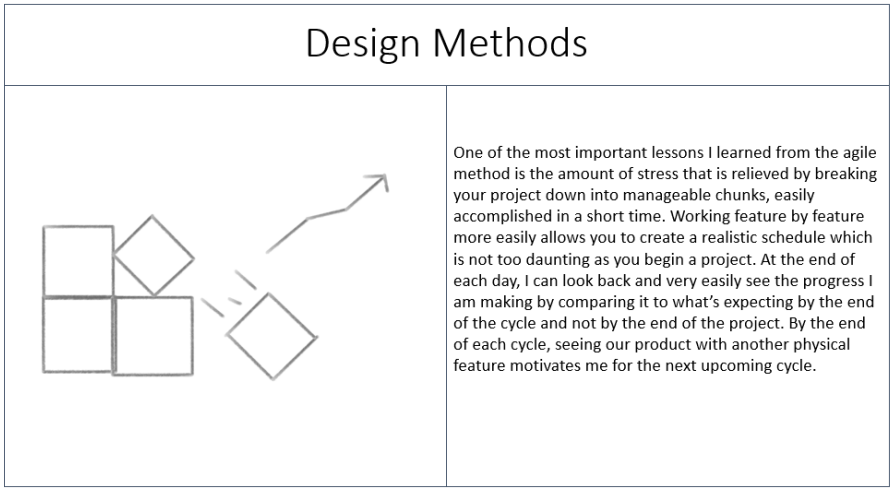


Figure 7. Student entry reflecting on the agile project management process.

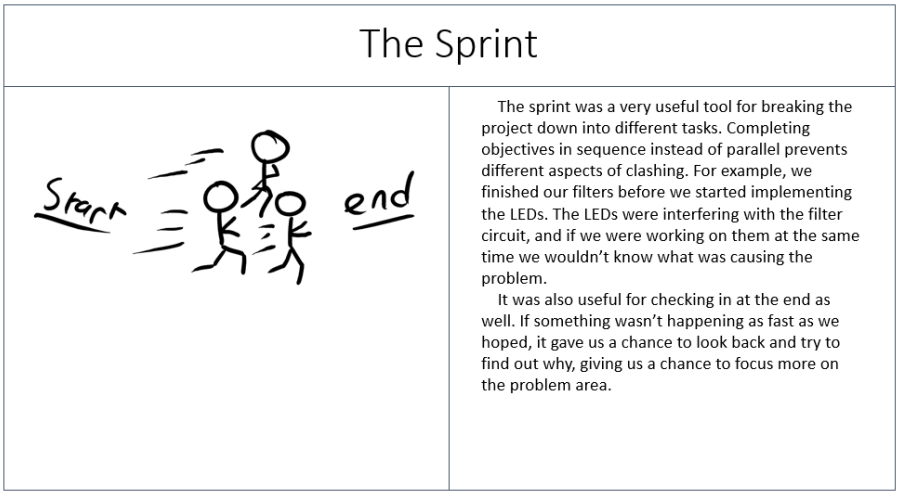


Figure 8. Student entry reflecting on the agile project management process.

CONCLUSIONS

Overall, it is evident that agile project management and scrum processes were useful in facilitating a successful integrated learning project. The CDIO Standard 7 describes activities that integrate learning experiences to acquire disciplinary knowledge as well as personal, interpersonal skills, and process building skills (Crawley et al., 2014). Scrum was able to facilitate this connection of the disciplinary knowledge with the skill-building activities. The results presented in this paper have been mostly anecdotal from the instructor and graduate teaching assistant involved. In the future, further data collection and student feedback could help to improve the understanding of which specific elements of Scrum were most beneficial to the students integrated understanding of second-year electrical engineering.

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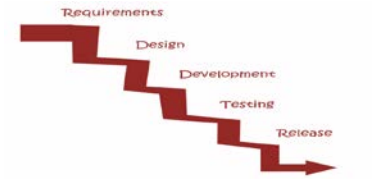
APPENDIX A – Scrum Terminology Handout

Waterfall Development:

Traditional "waterfall" development depends on a perfect understanding of the product requirements at the outset and minimal errors executing each phase.



Agile Project Management:

Agile Development refers to the project management approach of developing increments of products in frequent iterations based on evolving requirements.

Scrum Master:

The role within a Scrum Team accountable for guiding, coaching, teaching and assisting a Scrum Team and its environments in a proper understanding and use of Scrum. The Scrum Master does not have any authority over team members, however, they do have authority over the process.

Product Owner:

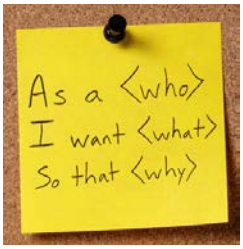
The product owner writes the acceptance criteria, and prioritizes and maintains the product backlog. Their role is to keep the Scrum Team accountable for maximizing the product value, primarily by incrementally managing and expressing business and functional expectations.

Product Backlog:

The product backlog is not a 'to-do' list; rather, it is a list of all the features the customer has requested be included in the project. The Scrum team uses the product backlog to prioritize features and decide which ones to implement in upcoming sprints.

User Stories:

A user story is a brief, non-technical description of a system requirement written from the end-user's point of view. User stories can be written according to the following structure: as a <type of user>, I want to <perform some task> so I can <achieve some goal.>

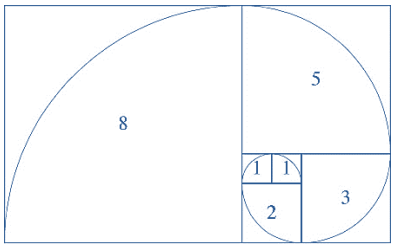


Definition of Done:

A shared understanding of expectations that a portion of the product (or an "increment") must live up to in order to be releasable into production.

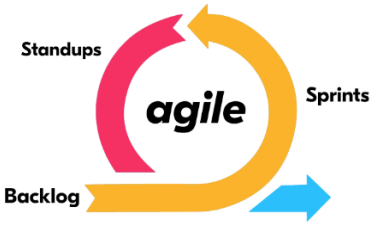
Story Points / Complexity:

Story points are a non-unit measure used to determine the complexity of a user story. Story points are relative, not absolute, and do not relate to actual hours. Often, the Fibonacci sequence is used.



Sprint:

A sprint is a fixed-length iteration during which one user story or product backlog item (PBI) is transformed into a potentially shippable deliverable.



Burn-Down Chart (or Burn-Up Chart):

A chart which shows the amount of work which is planned for a Sprint. Time is shown on the horizontal axis and work remaining on the vertical axis. As time progresses and items are drawn from the backlog and completed, a plot line showing work remaining may be expected to fall.

Retrospective:

A Scrum Retrospective is a meeting held following the completion of a sprint to discuss whether the sprint was successful and to identify improvements to be incorporated into the next sprint. The intent of the retrospective is not to conduct an extensive post-mortem but rather, to focus on specific steps the team can take moving forward toward a goal of continuous improvement.

Impediment vs. Blockers:

An **impediment** is anything that slows down or diminishes the pace of the Team. When the Team is confronted with impediments (or obstacles), the Team could move forward but in advancing they may not be effective. Progress is more difficult than it should be.

In contrast, a **blocker** is anything that stops the delivery of the product. Without the elimination of the blocker, the Team cannot advance at all.

APPENDIX B – Retrospective Assignment

When a Retrospective is…

Done Well	Done Poorly
• Continuous improvement	• Blame game, who's fault is it?
• Move team in right direction	• Opportunity for loudest voices to complain

Two Retrospective Options:

Two Questions	SWOT

• What went well?
  • Post-it (5 min)
  • Share (10 min)
• What needs improvement?
  • Post-it (5 min)
  • Share (10 min)
	
	• Post-it (10 min)
	• Place on grid
	• Discuss each quadrant (5 min each)

Hand-In Retrospective Summary (Individual) – 5 pts

Peer Feedback:

1. Summarize your peer feedback. What was the most interesting / useful piece of feedback received?

Team Retrospective:

2. Summarize your discussion. Was there anything surprising?
3. What is the biggest area of improvement for your team?
4. What is the biggest area of improvement for yourself?

Should be ½ page to 1 page in length. Point form is acceptable.

BIOGRAPHICAL INFORMATION

Robyn Paul is a first-year PhD student at the Schulich School of Engineering, University of Calgary where she also works as the team lead on all matters related to the engineering accreditation processes. Robyn recently completed her master's degree in engineering education where she studied engineering leadership development's impact on career success.

Dr. Laleh Behjat is a professor at the University of Calgary. Her research focuses on developing mathematical techniques and software tools for automating the design of digital circuits. She has won several awards for her work including the 1st and 2nd places in International Symposium on Physical Design Placement contests. Dr. Behjat's other research activities include developing techniques for engineering education.

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