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Snapshot Style Poster Sessions for Formative Inter-Team Design Feedback in Capstone Courses*

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Snapshot style poster sessions where student teams prepare simple, pinned-up posters that show off in-progress status of their projects are efficient and effective sources of just-in-time design feedback. In the authors' experience, snapshot poster sessions can satisfactorily accommodate up to 30 project teams during a single class period. The intended audience is other students in the class, faculty advisors, professional staff, nearby clients, and interested students not enrolled in the class. Minimal additional preparation time is expected for mid-semester snapshot days. The idea is that project teams continue work on normal project activities for as long as possible, creating poster content in the final day before the session, reusing resources from personal logbooks and project binders. Snapshot poster sessions, scheduled several times throughout the course of a project, provide opportunities for multiple parties to provide formative assessment, share best practices, highlight common struggles, and punctuate common milestones for capstone design projects. To measure the impact of snapshot events, data was gathered from both participating students and instructors using post-event classroom activities, logbooks, and surveys. The data was analyzed to look for patterns in the subject of the feedback (design process, design products, and team processes, and the snapshot experience itself) as well as the source of the feedback (self-directed or peer-directed). The data collection showed that large quantities of feedback were generated about student design process and products while less feedback was generated about student team process. The volume of peer feedback was increased with formal writing prompts. A faculty survey identified high leverage subjects to emphasize in different snapshot events throughout the duration of a project.

Keywords: peer review; design review; capstone projects; formative assessment; just-in-time learning

1. Introduction

Timely and substantive feedback is a critical element of project success in a capstone course. A model where instructors alone give student teams feedback is limited because of the disciplinary expertise of the instructor and the constraints on available time. Many programs utilize other types of mentors such as clients, external advisors, alumni, and graduate students to supplement the feedback content and frequency. A survey of capstone programs at the 2014 Capstone Conference showed that only 5 of 20 programs were utilizing substantive and formative peer feedback on design content, whereas most (13 of 20) were utilizing peer feedback on teaming.

There is substantial documented evidence of the value of peer feedback for both the student providing the feedback and the student receiving the feedback [1]. In capstone design, the receiving student gets a multitude of new perspectives on the problem or solution, often uncovering issues that have not been considered. The student providing feedback is building a mental model of design processes and confirming or challenging that model through conversations with other students. Three acknowledged challenges are (1) a peer feedback event is more effective if a model guides action, (2) peer feedback activities must be designed to be time efficient for instructors and students, and (3) there can be a negative perception of peer feedback by students

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[2]. Snapshot style poster sessions [3] were developed to address these challenges.

Snapshot posters are potential alternatives to capstone reporting and feedback events such as technical presentations, reports, and design reviews. These other mechanisms serve valuable roles in the course for project evaluation or deep focus on detailed drawings or plans. Snapshots differ from these methods in the time efficiency that they offer to students and instructors in preparation and execution as well as the volume of feedback provided.

Snapshot style poster sessions are just-in-time design feedback sessions where student teams follow supplied guidelines to prepare simple, pinned-up posters that show off the in-progress status of their projects at critical milestones throughout the project. The term snapshot represents both the capture of project state and the quick process of turning project artifacts into the snapshot poster contents. Minimal additional preparation time is expected from students and instructors for snapshot days. The idea is that project teams continue work on normal project activities for as long as possible, creating poster content in the final day before the session, reusing resources from personal logbooks and project binders. Snapshot poster sessions are held multiple times throughout the project. Each snapshot lasts a single class period during which faculty, clients, other students and relevant external attendees provide feedback on each poster/project. Not every poster is visited by every student or instructor and the process is not graded, in part to avoid student perception of imbalance in grading and to enable snapshot events to feature dozens of projects. There are several course functions that snapshots (snapshot style poster sessions) can fulfill for students and instructors alike. For students, snapshots are an opportunity to gather project work into a coherent form and repeatedly practice communicating the technical specifics of the project to third parties. Students also get fresh ideas through feedback from fellow students, different instructors, other clients and interested parties. For instructors, snapshots serve as a forcing function for project advancement, an opportunity to gather outside feedback (and hopefully new project perspectives), and the chance to show off their students' work. Snapshots are intended to provide formative assessment rather than project evaluation, promoting horizontal communication and dissemination of best practices rather than judgment. Snapshot style poster sessions, scheduled several times throughout the course of a project, provide opportunities for multiple parties to provide real-time critique, disseminate best practices, and punctuate common milestones within capstone courses.

2. Literature review

Snapshots complement other standard capstone reporting and feedback mechanisms (traditional poster sessions, design review presentations, technical presentations, and reports) by providing an avenue for getting class-wide, just-in-time feedback. In addition to the traditional reporting and project evaluation mechanisms, several tools and techniques exist that have similar roles and structure to snapshot posters. In engineering, Toyota A3 [4–5] forms have been adapted from industry to academic use. Other domains such as architecture [6–9] and writing [10–11] employ analogous feedback methods. In architecture, the "crit" or critique is a venue for students to present work to a jury while peer-review is a frequently used technique in writing education.

2.1 Engineering templates for representation of project status

The Toyota A3 Form is a poster format intended to quickly present the key information surrounding a problem and a proposed solution. The information is presented such that members outside the presenting team can understand the problem quickly and accurately. The A3 form is named for A3 size paper. A3 forms include information on the importance of the problem, current state of the problem, objectives of addressing the problem, root cause analysis of the problem, solutions to address the problem, and a process for implementing the solutions [4].

Leipold and Landschoot [5] implemented use of the A3 format for technical presentations in a cornerstone design course. Their goals were to provide a comprehensive technical presentation in which all team members were accountable, avoid possible 'death by PowerPoint' scenarios, and provide a more authentic design review process with respect to industry. Leipold and Landschoot cite various design programs that use this method. The snapshot posters presented in this paper differ from the A3 implementation in that they focus on capstone courses and offer more content guidance, aligned with common project milestones.

2.2 Architectural critiques

The architectural critique (or crit) is a feedback and evaluative activity in which one or more students present work to a jury or panel of critics. The jury may provide a summative evaluation or formative feedback that is used to develop or refine the presented work. The jury is mainly composed of instructors and practicing architects while students may also participate in giving feedback [6]. In addition to formative and summative crit variations, crits can also be one-on-one, peer focused,

or online [7]. The one-on-one crit, often called the 'desk crit', and the crit from the practicing architect are focused on interaction between one or two jury members (practicing architect and the instructor) and the student. These types of crits did not leverage peer feedback [8].

Several articles offer perspectives on the crit process itself. Sara and Parnell studied student perceptions of the crit process. They report that many students indicate that the crit is a "stressful, fear-inducing event" [6] despite the fact that they recognize its potential benefit to their project development. Members of the School of Architecture at Oxford Brookes University [9] surveyed 99 students about crits. Their survey also revealed that a subset of students felt that crits were unnecessarily stressful and negative in tone.

Orr et al. [7] identified some strategies for maintaining student engagement and prompting peer feedback. They suggest that crit time be managed to ensure that all participants receive equal feedback. They also suggest forming small groups to jointly critique other student projects and provide general insights to the class as a whole. Additionally, they recommend pursuing opportunities for interdisciplinary crits that involve interdisciplinary projects and interdisciplinary participants in the feedback process. The authors also provide suggestions for students to capture written documentation of feedback received. Students can be assigned to record feedback for each other, enabling the recipients to absorb and reflect on the comments after the feedback is transmitted.

2.3 Peer review of writing

Peer review of writing is routinely used in academic settings [10, 11]. The benefits of peer review include improvements in spelling and grammar, organization, and clarity of thought. Student complaints of peer review include lack of trust in the reviewers' abilities to critique writing, lack of commitment on the part of the reviewer to do a good job, and simply a way of wasting class time on activities with little value. In order to address some of students' complaints, Carlson et al. [11] have used Calibrated Peer Review (CPR) as a learning tool. The tool is web-based and allows asynchronous evaluation of student writing. Students are given a focused writing assignment that is guided by questions to act as prompts. Students then read samples that serve as benchmarks for the assignment and score each sample. Based on their ability to score a sample, students are given a "reliability index" that is an indication of their proficiency in scoring written work. After receiving their proficiency scores, students then rate the work of other peers in the class. Finally, each student is asked to rate the sample of writing that she submitted and reflect on the quality of her writing. When students receive peer evaluations, they can see the proficiency scores of their reviewers. Carlson reports comparison of student work products between classes using CPR and those that did not show dramatic improvement in the classes that used CPR. Developing a CPR assignment for students is labor intensive and requires that the objectives are well-formulated.

2.4 Assessment mindset

A mindset for assessment is necessary to effectively establish an environment where effective feedback can be given and received [12]. The importance of an assessment mindset, rather than an evaluative mindset, in design work as well as in professional development has been an enduring theme in educational projects undertaken by the authors over the last ten years [13, 14]. This implies special roles for the assessor (person providing the assessment feedback) and assessee (person receiving the assessment feedback). The assessor must give feedback while avoiding judgment, focus on the characteristics of the design, not characteristics of the learner, and focus only on feedback that assessee can act upon. The assessee must see the value of receiving feedback, want feedback in specific areas, and understand that the assessment process is intended to advance, rather than criticize, their project and their personal development. This assessment model was central to the efforts of the Transferable Integrated Design Engineering Education (TIDEE) consortium which developed a series of web-based activities for individual reflection and professional development during capstone project work [15]. These were not isolated events, but were part of a larger cycle of set-up at the start of a capstone course, naturalistic timing of assessment activities within the design process, simple but meaningful instructions for high quality performance, and conscious deployment of different methods for debriefing students about assessment results [2]. Valuing of assessment feedback as well as the student-centered process for producing this feedback was found to be enduring amongst alumni who had used TIDEE materials [16].

3. Organization of snapshot events

Posters are made of 8.5 by 11 inch sheets of paper pinned to a piece of foam core or poster board. Items to feature in the poster are specified by the instructor, emphasizing design materials appropriate for the current stage of project development. Students are encouraged to work on project content for as long as possible, creating poster content in the final day before the snapshot session by using

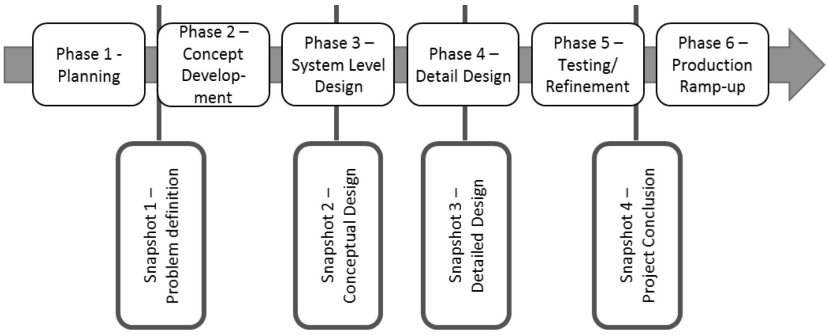

Fig. 1. The alignment of design phases with snapshot events.

existing resources in their personal logbooks, team portfolio, reports, presentations, etc. The posters should be supplemented by any hardware or software displays that teams have created as the current state of development.

Faculty should consider the timing of the session relative to the project elements about which they would like students to receive feedback. Ulrich and Eppinger [17] propose a six phase product development project: phase 1-planning, phase 2-concept development, phase 3-system-level design, phase 4-detail design, phase 5-testing/refinement, and phase 6-production/ramp-up. Good snapshot opportunities coincide with project milestones that occur naturally within that process (Fig. 1). Snapshot 1 aligns with the beginning of phase 2, problem definition, defining needs, and specs. Snapshot 2 is best positioned during phase 3, after conceptual design development (e.g. sketches created, design selected, etc.) when the system is being synthesized. Snapshot 3 is during phase 4; detailed design (e.g. detailed drawings, some prototyping, etc.). Snapshot 4 should occur toward the end of phase 5, near the conclusion of the course when prototypes are refined and tested.

In the authors' experience, four snapshots distributed throughout the project duration are appropriate. More snapshots would likely be counterproductive to student progress. The snapshot is held during the course's regular meeting time and students are asked to be at their predefined presentation location with a prepared poster by the beginning of class. Table 1 shows the standard set of instructions for the first two snapshot events in the four snapshot sequence, distributed over the length of the project. Table 2 shows the standard set of instructions for the second two snapshot events in the same four snapshot sequence.

In addition to course instructors and students, other faculty members, technical staff, college staff,

Table 1. Snapshot instructions for a problem definition and conceptual design snapshot event

Snapshot 1: Problem Definition Snapshot	**Snapshot 2: Conceptual Design Snapshot**
Outcomes • Problem Definition—Student teams have a clear and concise description of the root problem. The team can model client needs and has a credible draft of the metrics that will be used to measure the satisfaction of those needs. • Project Learning—Team documentation and files explain the technology and scientific principles that support your understanding of the problem and stakeholders. Team members can effectively describe professional practices involved with your client relationship, design process, and project management. **Instructions** • Bring any existing hardware/software, pictures from client interviews, diagrams, catalogs, etc. • Make 8.5x11 printouts to create a poster that includes: – Team name, team members, sponsor – Problem statement – Documentation of project learning such as models, synthesis of notes on the people, products, technology relevant to the project – List of needs/specs/requirements – Any concept development to date • Display a plan for project completion (milestones & dates)	**Outcomes** • System Design—The team has developed an idea for the final design. The team has identified and described the subsystems necessary to meet client needs. • Data and Prototypes—The team has designed, built, and tested relevant prototypes and has assembled evidence (drawings, flowcharts, diagrams, calculations, prototypes and/or experiments) that the concept design will work. **Instructions** • Bring any supporting hardware/software, CAD models, proof-of-concept prototypes, etc. • Make 8.5x11 printouts to create a poster that includes: – Team name, team members, sponsor – Problem statement – Outline your major areas of project learning as well as your results – Visualization (sketches, drawings, diagrams) – Convincingly illustrate that the components of your design will work. – Prototyping results – Modeling and/or Experimentation – Communicate your vision of final product architecture. – List unresolved issues and your plan for attacking these. – Plan for project completion (milestones & dates) • Supplement your poster with laptop show/tell, if appropriate

Table 2. Snapshot instructions for a detailed design and concluding snapshot event

Snapshot 3: Detailed Design Snapshot	Snapshot 4: Project Conclusion Snapshot
Outcomes • Detailed Design—The team has created a detailed design document which is composed of engineering drawings and fabrication plans suitable for interpretation by a third party. • Data and Prototypes—The team has designed, built, and tested relevant prototypes of the detailed design. **Instructions** • Bring any in-progress hardware/software, drawing packages, pictures of fabrication activities, results from experimentation, etc. • Make 8.5x11 printouts to create a poster that includes: – Team name, team members, sponsor – Problem statement – Initial effort at modeling possible failure modes in your project – Documentation of your detailed design (detailed drawings, renders, data sheets for purchased components, etc.) – Manufacturing process/results – Final test plans – List unresolved issues and your plan for attacking these. – Plan for project completion (milestones & dates) • Supplement your poster with laptop show/tell, if appropriate	**Outcomes** • Client Satisfaction—The design will meet or exceed customer expectations. This includes providing quality evidence that proves that needs are met. • Oral Communication—The team can concisely and effectively explain how the design works (including key knowledge about design, manufacturing, and testing) at the right level for each visitor. Students are enthusiastic and communicate in an organized and clear fashion. • Professionalism—Students are role models in supporting the goals of the engineering capstone program, welcoming visitors, and answering questions about the program. **Instructions** • Bring final hardware/software, results from experimentation, pictures of installation, etc. • Make 8.5x11 printouts to create a poster that includes: – Team name, team members, sponsor – Problem statement – Outline client needs/requirements – Final model of possible failure modes in your project – Illustrate final product architecture and its key subsystems/features. – Provide evidence that all design components work as intended (final test results) • Supplement your poster with laptop show/tell, if appropriate

graduate students, other undergraduate students, technical mentors, as well as current and former project clients are invited to attend. Attendees of various backgrounds and disciplines enrich the feedback received by the student groups. Student teams are directed to send a personal invitation to their client, while the other invitations are made by the course instructors. Snapshot events themselves were not conceived to be a forum for project evaluation. Instead, they are opportunities to provide a large volume of formative feedback to teams in a short period of time. It has been highly productive to have course instructors visit posters of teams for which they are they are not the advisor.

Students are expected to dress and act professionally. Furthermore, students in the course are instructed to take turns attending to their poster answering questions and documenting feedback and use the remaining time to browse other displays, asking clarifying questions. In order to close the loop on the feedback they receive and lessons they observe, students are each required to make a logbook entry on their snapshot day experience. Ideally, these notes should be inventoried and discussed in the next advisor/team meeting. An activity for generating peer feedback during the lecture period subsequent to the snapshot event is presented as a method for measuring snapshot impact in Section 5. A similar activity could be used to generate additional feedback.

It is inevitable that capstone projects will be at different levels of completion because of different scopes or starting points, especially in programs that emphasize authentic projects. Projects that are revisions and refinements of existing equipment may be further along as compared to a project that starts from scratch with no prior work. In these cases, instructors are advised to customize the snapshot instructions, moving deliverables from future snapshots back into prior ones for these teams that deviate from the norm. It is best to produce compelling milestones for each team as opposed to using a rigid framework with the assumption that one size fits all.

4. Current implementations

Snapshot events are being used in two capstone programs, the year-long, interdisciplinary capstone design program at the University of Idaho and the year-long mechanical engineering program at Rose-Hulman Institute of Technology. Each program uses the framework presented in Section 3, but has customized snapshot events to fit within their schedules and cultures.

At the University of Idaho, the instructional team uses four snapshots throughout the course of a two semester capstone experience. The snapshots coincide with the middle and end of each semester. The course is interdisciplinary and involves students from mechanical, electrical, computer, biological, and agricultural engineering as well as computer science. External clients with authentic projects are used whenever possible and are staffed with students from appropriate disciplines. In preparation for each snapshot, each student group develops a

poster with the content specified in Tables 1 and 2. Posters displays are further supplemented by the team's project portfolio. The team's portfolio is a living record of the team's progress. It contains the deliverables, synthesized and organized into a common location for team use. Examples of items in the portfolio include meeting minutes, specifications, sketches, results of engineering analysis and experimentation, decision matrices, technical data sheets, and CAD drawings. At the end of the second semester portfolio contents are synthesized into a comprehensive design report. Snapshot instructions include details on updating and presenting team portfolios.

The content required for each snapshot is timed to coincide with expected project progression which is communicated on the course website [18]. The first and third snapshot day expectations are more open-ended than the second and fourth to account for the variability of projects. The second and fourth snapshot expectations include a common set of end-of-semester deliverables that are ultimately used for grading. Hardware (and/or software) is expected to be part of the display during the third and fourth snapshots, but may not be present for the first two. The end of year snapshot is a public event which celebrates the students' accomplishments and serves to promote the program to potential sponsors, alumni, and other external entities [19].

At Rose-Hulman Institute of Technology, the capstone instructional team in mechanical engineering started using snapshot poster sessions during the 2013–2014 academic year. Currently, two snapshot events are used, coinciding with the first two snapshot events described in Section 3. At RHIT student design teams are assigned a professional mentor from the staff of engineers at Rose-Hulman Ventures. During the snapshot day, student teams are expected to identify and begin dialogue with those professional mentors that have experience in their project's domain. The student snapshot poster also features some specific program requirements such as exhibits that represent the needs, goals, targets, constraints, benchmarks, and standards tables.

5. Methods for measuring the impact of a snapshot event

Three questions were posed to evaluate the value of snapshot events.

(1) What impact did the snapshot event have on student team design process and student team products?
(2) What impact did the snapshot event have on student team process?
(3) What are faculty perspectives on snapshot event value?

Students and instructors were also queried for potential improvements to snapshots. Data was collected from snapshot events at the University of Idaho and Rose-Hulman Institute of Technology.

Table 3. Methods for collecting data about the impact of snapshot events

Source	Location	Timing	Questions Addressed	Task	Results Section
Written, structured, peer feedback	University of Idaho	At the lecture following the snapshot event.	1, 2	• Identify significant "aha's" about your project from snapshot day. Identify actions you are taking in response to this aha. • Identify significant "aha's" about other projects from snapshot day. Identify suggested actions for the team to take in response to this aha.	6.1
Student plus-delta reports about the snapshot [20]	Rose-Hulman Institute of Technology	At the lecture following the snapshot event.	1, 2	• Identify strengths and areas for improvement for the snapshot event.	6.2
Student snapshot logbook entries	Rose-Hulman Institute of Technology	During the snapshot event.	1, 2	• Make a reflective logbook entry about lessons learned and observations from snapshot day.	6.3
Written faculty survey	University of Idaho	At the instructor meeting following the snapshot event.	3	• Rate a given set of snapshot feedback areas with regard to their importance during different snapshots throughout a capstone cycle. • In the context of a snapshot event, what best practices come to mind for prompting more and better peer-to-peer feedback? • What were the strengths of the last snapshot event? Why were these valuable? • What improvements should be made in our next snapshot? What is the rationale for each change? How could these be implemented?	6.4

Table 4. Student peer feedback from the post-snapshot event at the University of Idaho

Design Process
Aha => others have problems understanding our problem/goals **Action** => work on clarifying our problem statement and understanding last year's project
Design Product
Aha => explore different heating methods & configurations **Action** => implement a cartridge heater in upcoming collet tests **Action** => investigate torroidal heaters
Team Process
Aha => important project goals/tasks should be broken down more for easier tracking **Action** => list supporting sub-tasks along with each major aspect of the project
Snapshot Format
Aha => slides had font that was too small and conveyed too much information **Action** => prioritize Snapshot information and make visible from 4-5 feet away

At the University of Idaho snapshot, 27 student groups (students per team ranged from 3–7) presented material aligned with the first snapshot event. At the Rose-Hulman snapshot, 10 student groups (students per team ranged from 3–5) presented material aligned with the first snapshot event. Both snapshot events were implemented as described in Section 3 and 4. After the snapshot events, four different data collecting methods were used (Table 3).

Table 5. Frequency of comments in each category from written, post-snapshot peer feedback

Observation category	Self-assessment Frequency	Peer assessment Frequency
Design Process	18	7
Design Product	19	5
Team Process	6	2
Snapshot Format	6	1

6. Results

6.1 Written, structured, peer feedback

The student observations were categorized into feedback on design process, design product, team process, and snapshot format. Examples of categorized peer feedback from this exercise are shown in Table 4. A summary of observations is shown in Table 5. There were 64 recorded observations total. Forty-nine of the observations were self-identified while 15 comments were peer-identified. Twenty-five comments were related to design process, 24 comments related to design products, 8 comments related to team process, and 7 comments related to snapshot format.

6.2 Student plus-delta reports

In a plus-delta activity, participants identify the

Table 6. Consolidated results from the plus-delta [20] activity at Rose-Hulman

Plus	Delta
External participants: • Provided valuable feedback • Provided unexpected feedback • Diversity was very helpful • Asked questions that I didn't think of	External participants: • More diversity is needed—invite staff, facilities, techs, other faculty • Not all projects had a passionate, external participant—teams should work with instructors to define the type of external participant that they'd like.
Peers: • Good feedback from classmates. • Critiquing other projects was enjoyable • Got to see what other projects are doing	Peers: • Classmate feedback was superficial.
Snapshot format: • The format demanded quick and effective communication. It was good practice for career fair and interviews.	Snapshot format: • Snapshot session was too long/short • Have a set rotation—staffing poster/critiquing other posters • Quarantine the NDA projects so that more external participants are allowed
Student process: • Snapshot was a good measure to gauge team's understanding of their project • Presenting at snapshot day provided the opportunity to practice presenting project material and general technical material	Student process: • Need to take more notes/remember logbook at next snapshot event

Table 7. Number of comments in each category from student logbooks

Logbook entry category	Self-assessment	Peer assessment
Design Process	13	4
Design Product	17	0
Team Process	5	0
Snapshot Format	5	0

strengths and propose changes for the specified subject matter. During the plus-delta activity at Rose-Hulman, students could write and submit their comments anonymously to the instructor. Students were also given the opportunity to share plus-delta comments in a class-wide discussion. The intention was to allow the discussion to surface additional comments or expand on existing comments. Instructors captured new ideas from the discussion and combined them with written submissions. The list of plus deltas was consolidated and is shown in Table 6.

6.3 Student snapshot logbook entries

The snapshot related entries (notes during snapshot and reflection after snapshot) from fourteen participating student logbooks were analyzed. Student observations were classified using the same scheme as the written, structured, post-snapshot peer feedback that was collected at the University of Idaho (Section 6.1.). A summary of classified observations is shown in Table 7. There were 44 recorded observations total. Forty of the observations were self-directed while four comments were peer-directed. Seventeen comments were related to design process, 17 comments related to design products, 5 comments related to team process, and 5 comments related to snapshot format.

6.4 Written faculty survey

Seven capstone instructors completed the faculty survey. The instructors were first asked to rate the importance of eight snapshot content areas with respect to four snapshot events in a yearlong cycle. Instructors rated the importance of each of these areas as high, medium, or low which were subsequently mapped to scores of 3, 2, and 1 respectively. The average of the scores is shown in Table 8.

Table 8. Average scores for snapshot content areas by faculty (N = 7) where high = 3, medium = 2, and low = 1

	SNAPSHOT 1 1st semester midpoint	SNAPSHOT 2 1st semester endpoint	SNAPSHOT 3 2nd semester midpoint	SNAPSHOT 4 2nd semester endpoint
Snapshot preparation and delivery	2.3	2.4	1.4	1.9
Project/team management	2.7	2.3	2	1.6
Design process	2.3	2.4	2.4	2
Design concepts	2.7	3	2.1	2.3
Vendor selections and manufacturing plans	1.9	2.1	2.7	1.6
Design evaluation and testing plans	2.1	2	2.6	2.4
Design documentation	1.4	1.6	2.6	3
Professional growth and development	1.1	1.3	1.6	2.3

Table 9. Instructor feedback from post-snapshot survey

In the context of a snapshot event, what best practices come to mind for prompting more and better peer-to-peer feedback?
- feature easy to understand mock-ups that can be used as talking points
- actively acknowledge and engage visitors when they come up to the display
- request that students first browse poster materials before they ask questions
- make class assignment for underclassmen to talk with seniors

What were the strengths of the mid-semester snapshot event? Why were these valuable?
- energy and participation of a crowd, enhances the project immersion
- gives students practice in public presentation skills (resembles engineering workplace setting)
- features diversity of projects that shows off breadth of the capstone program
- organization => clear communication about poster ingredients, project locations, expectations
- provided reflection questions during & after Snapshot
- allows easy access for students & faculty to observe project status
- lots of parallel communications => many ideas shared

What improvements should be made in our next snapshot? What is the rationale for each change? How could these be implemented?
- group project locations by theme if possible
- facilitate more quantified feedback by supplying scorecards/checklists
- seek out a larger, more public space and possibly run a little longer (maybe 30 min longer)
- specify effective font sizes for poster text and diagrams => 18–20pt minimum
- circulate questions for Snapshot discussion and logbook reflection earlier (week ahead)
- better communication about date/time/place, attracting visitors from outside class
- stress importance of physical and virtual proof-of-concept prototypes
- prompt teams to share knowledge about project constraints (time, machining skill, budget)

Faculty responses to open ended questions are shown in Table 9.

7. Discussion of results

The reported work has limitations because of small sample size of students (N = 124, 33 at Rose, 91 at UI) and faculty (N = 7). Additionally, student data was collected after only one type of snapshot event (corresponding to snapshot 1 focused on problem definition). Surveyed faculty however ranged in experience from only a handful of snapshot experiences to many years of experience with snapshot events.

7.1 What impact did the snapshot event have on student design process and student design products?

The quantity of feedback reported by students, captured in logbooks and formulated during post-snapshot activities shows that a snapshot style event is a time efficient method for guiding student effort. The majority of feedback focused on design process and design products (49 "aha's" out of 56 in Section 6.1 and 34 of 44 logbook comments in Section 6.3). The most significant feedback seems to come from outside visitors or other faculty and less from other students (Section 6.2 and 6.3). Students were assigned to capture observations in their logbooks (Section 6.3), but only 4 of the 44 entries analyzed were about peers. A formal reflective activity like the one described in Section 6.1 increased the quantity of peer feedback (15 of 64 "aha's"). This result is expected because engineering students lack experience giving critiques as opposed to other disciplines where the crit is a central activity. Additional time to think about peer feedback and more structure to the feedback construction helps them formulate peer assessment.

7.2 What impact did the snapshot event have on student team process?

Students are least likely to comment on team process because (1) team process is not prominently represented on their posters and (2) students have the least experience with that aspect of a project. Currently, snapshots do not have a large impact on team process. In the survey, faculty report that the most important snapshot to get feedback on team or project management process is the first snapshot. However, this is the most difficult time in the project to establish and plan a project schedule. Because of the fuzzy front end of design, students are taken in unexpected directions, and find it difficult to plan for anything other than major milestones. A purposeful concentration during the second or third phase of a design project and the project management

Table 10. Classification of snapshot subjects by faculty

Snapshot Event	**Snapshot Subject**		
	H (3.0-2.5)	**M (2.4–2.0)**	**L (<2.0)**
1-Problem Definition (1/4 point)	Project/team management Design concepts	Snapshot preparation and delivery Design process Design evaluation and testing plans	Vendor selections and manufacturing plans Design documentation Professional growth and development
2-Conceptual Design (1/2 point)	Design concepts	Snapshot preparation and delivery Project/team management, Design process Vendor selections and manufacturing plans Design evaluation and testing plans	Design documentation Professional growth and development
3-Detailed Design (3/4 point)	Vendor selections and manufacturing plans Design evaluation and testing plans Design documentation	Project/team management Design process Design concepts	Snapshot preparation and delivery Professional growth and development
4-End of Project (end point)	Design documentation	Design process Design concepts Design evaluation and testing plans Professional growth and development	Snapshot preparation and delivery Project/team management, Vendor selections and manufacturing plans

aspects of the snapshots would align with the best time for students to practice those skills.

7.3 What are faculty perspectives on snapshot event value?

The small sample of faculty surveyed highlighted which subjects were of highest value during each snapshot event (Table 10). The presentation of concepts dominates the first two snapshot events. The third snapshot event aligns with project deliverables that require detailed design and some elements of the prototype. These areas of importance in snapshots align with the natural progression of design throughout a project. Design documentation in the fourth snapshot is a catch all for the completed design representation, prototype or on paper. Faculty represented multiple disciplines, so data was reported amidst differences in discipline specific design process.

7.4 Challenges associated with capstone feedback

Three acknowledged challenges of capstone design feedback in general and snapshots specifically are (1) a peer feedback event is more effective if a model guides action, (2) peer feedback activities must be designed to be time efficient for instructors and students, and (3) there can be a negative perception of peer feedback by students [2]. Students were able to generate substantial feedback during the snapshots. While there is no data for comparison to alternative methods (presentations, traditional posters, design reviews, etc.) it is likely that the volume of feedback generated from a snapshot is greater per time spent on preparation than any other approach. Furthermore, the quality of the feedback was guided by the instructions associated with the snapshot. Snapshot events last one class period and require an hour of preparation (at most) by the instructors and students alike. Student perception of peer feedback was mixed (Table 6), but included more positive comments than negative, which only called for deeper feedback. It is important to remember that students are also practicing giving feedback in addition to receiving feedback [16].

8. Conclusions

Based on the volume and types of feedback as well as the comments of students and faculty, snapshots add value to product and process development, while professional development and team processes were impacted less often. Snapshots were effective at generating high leverage feedback for the student teams in a short period of time. More interaction is possible during a well-executed snapshot event than a traditional design review. Because snapshot events are naturalistic (low preparation overhead for students and instructors) and customizable in intended content, they can be positioned at multiple locations within a course.

The standard timing of snapshot events is at intermediate points before major course milestones. The highest value snapshot events for each subject area is shown in Table 11. It is recommended that students present deliverables aligned with that timing. In general, it is helpful to hold snapshot events before examination periods and to decouple snapshots from other course deliverables (such as formal design reviews and final reports). It is beneficial to have a healthy amount of performance anxiety associated with the event, but not at a level where it is debilitating. To help achieve this outcome and to keep the event focus on moving projects forward, it is important to maintain an assessment mindset (instead of evaluation mindset) amongst all participants, students and instructors alike. It is important that capstone course activities are seen (by students) as contributing to the advancement of their projects, not unwanted distractions. Snapshots do meet this criterion with students directly observing and experiencing the benefits. Faculty should not be overly concerned with evaluating projects, but instead generating fresh ideas and feedback for projects that may be biased towards the limited scope of feedback that teams have received thus far.

For new implementations of snapshot events, the authors would suggest getting student and faculty perceptions of the effectiveness of the event. Effective tools to use are the faculty survey described in section 6.4 and a plus-delta activity with students described in section 6.2. The authors also suggest using a method to track feedback content in order to assess feedback quality. The activity to generate written, structured peer feedback in class (described in section 6.1) is effective at both helping students formulate good feedback and measuring feedback quality. The method of analyzing student logbook entries (described in section 6.3) is helpful to track

Table 11. The highest value subjects for each snapshot event where snapshot 1 focuses on problem definition, snapshot 2 focuses on conceptual design, snapshot 3 focuses on detailed design, and snapshot 4 focuses on product realization, testing, and refinement

Snapshot Subjects	Highest Value Snapshot
Snapshot preparation and delivery	1, 2
Project/team management	1
Design process	1, 2, 3
Design concepts	2, 3
Vendor selections and manufacturing plans	3
Design evaluation and testing plans	3, 4
Design documentation	3, 4
Professional growth and development	4

peer feedback, but also other feedback received by the team and the quality of student logging process.

While snapshot poster sessions are not the only tool that can be used to fulfill these functions, they are an effective, efficient, and engaging solution. Snapshots can also provide additional benefits to the capstone program, academic departments, or colleges. Snapshots serve a role in building learning communities. Project courses are naturally divergent and snapshots allow capstone programs to build a community without resorting to artificial means to gather together students in the course, members of the college, and industry sponsors. In addition to community building, a snapshot event can be used by faculty and staff to plan resource needs based on the path of each project. The snapshot gives a holistic view into the training, space, equipment, and expertise requirements of the current set of capstone projects. Snapshots can also synergize with activities such as advisory board meetings, career fairs, ABET data collection, recruiting fairs, recruiting/interviewing faculty, and fund-raising/ development. Finally, a snapshot at the conclusion of a capstone course can serve as both a promotional event for the program as well as a celebration of student accomplishments. The concluding snapshot is enhanced by previous student experience with snapshot style events.

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