Digitizing and Remediating Engineering Assessments: An Immersive and Transportable Faculty Development Workshop

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Abstract
The design and delivery of effective digitization for formative and summative assessments that are suitable for computer-based exam delivery remains an open problem across engineering curricula. Engineering-specific exam digitization challenges include the need to adequately evaluate design skills, solution structure, intermediate work, creativity, conceptual understanding, and in many cases, rigor that exceed the capabilities of rote multiple choice formats. In our high-enrollment engineering program, we have developed, implemented, and evaluated a six-week cross-disciplinary *Assessment Digitization Innovation (ADI) Workshop* that supports engineering faculty interest in developing computer-based examinations that are responsive to best practices. Authentic assessment formats and topics of focus include incremental solutions, multiple answers, design-by-selection, declarative statement formats, and question cloning practices. Further, the remediation of computer-based exams using digitized formats also enables new opportunities to enhance learner engagement, metacognition, and soft skills, which are highly amenable to faculty edification and are integral faculty development components of the ADI Workshop.

The first ADI Workshop was conducted during the Summer 2016 semester. The experience included four face-to-face in-class sessions and two online modules. At the end of the 6-week program, each participating instructor showcased an online assessment that they had designed and developed as a result of the workshop. The topics of the pilot program included: 1) strategies to construct effective STEM assessments, 2) using relevant question types and features in Canvas, a learning management system (LMS), 3) implementing authentic assessment, 4) strategies to encourage academic integrity in online assessments, and 5) composing exemplar design vignette questions to reinforce connections between concepts to achieve integrative learning. The pilot cohort included 10 instructors and 16 Graduate Scholar Assistants (GSAs) currently teaching gateway Engineering and Computer Science courses at the University of Central Florida, and interacting with an estimated 6,200 undergraduate Engineering and Computer Science students. Upon conclusion of the program, anonymous feedback was collected from participating instructors, and was overwhelmingly positive. All respondents were "very satisfied" with the in-class sessions, the facilitators of the workshops, and the online modules. Specifically, they rated the program topics, examples, and resources provided to be highly relevant. The majority of the respondents agreed that the workshop will impact their future course design and development in beneficial ways, such as time-savings, convenience, student remediation, and the ability to serve large enrollments.

1.0 Introduction and Motivation

In this paper, we describe the motivation, contents, and outcomes of the faculty development and training component of a transportable college-wide engineering digitization initiative at the

University of Central Florida (UCF), referred to as the *Assessment Digitization Innovation (ADI) Workshop*. The ADI Workshop constitutes an important pillar of a viable digitized assessment ecosystem, which consists of digitization instructional pedagogies, engineering assessment design, and technology/personnel infrastructures/services for digitized assessment delivery. Together, these elements facilitate the successful digitization of suitable Engineering formative and summative assessments that are amenable to computer-based delivery.

Instructional technologies that enable the reallocation of valuable instructional time and expertise towards the most beneficial high-gain teaching activities, while simultaneously minimizing low-gain logistical tasks, offer substantial gains to both the quality and the productivity of engineering instruction [1]. One computer-based instructional technology application possessing such potential is assessment digitization. Assessment digitization, which involves the computer-based delivery and auto-grading of formative and summative assessments, has achieved widespread adoption within certain disciplines outside of engineering. Innovations in assessment for STEM disciplines are urgently sought, especially given that student enrollment in undergraduate gateway courses at some institutions has increased considerably. The College of Engineering & Computer Science (CECS) at the University of Central Florida (UCF) undergraduate enrollment, for example, has increased by 30.2% from 6,535 in Fall 2012 to 8,507 in Fall 2016. The trend nationally is for undergraduate engineering foundation courses to enroll over one hundred students, yet these courses often possess limited faculty and graduate assistant resources. Meanwhile, the efficacy of homework assignments, lab reports, and reused exams continue to be undermined by open-resource search engines and Internet-based solution repositories. Computer-based testing offers specific solutions to these concerns. Such solutions include computer-generated formula-based question content for randomized and/or distinct content, rapid remediation, and in-person testing centers, which engage learners via physical attendance and high integrity delivery.

Focusing on the quality of education, skills, and employability of our graduates in computing-related fields, several faculty at UCF successfully piloted a cost-effective approach to achieve these goals, which was expanded and formalized for dissemination as the ADI Workshop presented herein. DeMara et al. describe the BLUESHIFT pedagogy which integrates computer-based evaluation with a close-knit review and learning cycle based on directed and open tutoring to collectively form an Evaluation and Proficiency Center (EPC) facility [2]. Pilot results were very encouraging, as students' test scores indicated a 43% reduction in D or F grades compared to a section of the same course with the same instructor, using conventional delivery, and survey results included overwhelmingly positive responses from students regarding the effectiveness of pedagogical strategies (e.g., Exemplar Vignettes, content tutoring), assessment models (e.g., electronically delivered quizzes, flexible scheduling, use of testing center), and tutoring strategies (e.g., self-paced, exam results review). Readers are referred to [2] for content, benefits, and challenges of delivering digitized STEM assessments with the BLUESHIFT pedagogy.

The hurdles to achieving effective digitization of engineering assessments can be organized into the three broad categories of *content challenges*, *instructional challenges*, and *organizational challenges*. Content challenges are typified by the need to administer creative design problems beyond rote multiple choice and the characteristic that lengthy engineering assessment often use mechanisms to confer partial credit. Thus, in the ADI Workshop, participating faculty are exposed to a palette of approaches to design engineering assessments with partial credit that are isomorphic to conventional pencil-and-paper based exams, but are deliverable electronically. They also practice applying them to their targeted course and are able to customize Score Clarification practices for the course, which utilize handwritten image files that are retained for strengthening the learner's soft skills through one-on-one clarification with Content GTAs. Instructional challenges include the cold-start problem of building a viable test bank of digitized questions, whereas only selected topics in engineering fields have digitized test banks available from textbook publishers. Additionally, the efforts invested to digitize should have significant re-use potential to preclude reinventing the wheel for a longer-term payoff that can be pooled among alternate faculty teaching a course at their institution. Organizational challenges relate to change theory of the participants involved, both instructors and students alike. An additional organizational challenge is the need to provide a support services layer to deliver the assessments, ideally within a proctored testing facility, while maintaining the question bank via creation of technical updates and question "clones" to mitigate crosstalk among asynchronous test takers. The ADI Workshop addresses each of these challenges by engaging faculty in a six-week development course via immersive experiences in the actual digitized environment that their learners will also utilize, as identified herein.

2.0 Literature and Related Works

Although a comprehensive survey of the digitization of STEM assessments exceeds space available, we highlight selected works. Fellin and Medicus [3] describe the use of multiple choice assessments in geotechnical engineering, which elevated the performance level of undergraduate students via pre-test practice, and how students strongly prefer practice over theory in engineering content. The authors were convinced that digitized assessments used in this mode can impart long-term benefits and justify the effort required to construct such assessments. While studies have shown mixed reviews of teacher perceptions of online assessments, use of such assessments has been shown to correlate positively with overall course grades [4]. Further, while perceptions of online assessments have been mixed, many studies document the benefit of frequent online evaluation at the college-level. In one study of two sections of a statistics course, students given frequent pencil-and-paper memory tests averaged 86% on exams versus 78% in the control group ($r^2 = .44$), where r^2 denotes the coefficient of determination [5]. This *testing effect* is more easily leveraged when assessments are digitized and moved online. For example, Angus and Watson [6] administered online formative assessments to over 1500 business math students over the course of a semester, concluding that "regular testing *undertaken with online methods* enhances student learning," particularly because of advantages unique to online delivery (e.g., randomized questions, instant feedback, multiple attempts).

Challenges to authenticity of authorship and academic integrity of fully online courses is pervasive in the literature. In an attempt to deter cheating, *Proctor Hub*, *ProctorU*, *ProctorFree* and *Remote Proctor NOW (RPNow)* offer limited commercially-available products. However, continuously monitoring the student's webcam feeds for eye tracking can be intractable, and test takers cannot be prevented from capturing questions using cameras in the background despite the requirement of a lockdown browser. Thus, either a dedicated testing center or a block scheduling of an existing computer lab are the approaches recommended in the ADI Workshop. Unfortunately, with the release of test questions, students may only learn the answer to the question rather than achieving learning outcomes. Thus, engagement of Test Proctors is recommended, as they can be useful in preventing exposure and authenticating submissions. Finally, in the ADI Workshop we extend the promising aspects of an “Open Tutoring Center” where tutors are available for targeted assistance [7] by resolving the challenge indicated by the authors about the absence of an effective, integrated, and verifiable assessment methodology. The instructional approach promulgated herein is presented in Section 3.2.

Further rationale for the digitization of both formative and summative assessments in Engineering courses is supported by the *testing effect* [8], which implies that mastery learning can be enabled for complex concepts through frequent formative assessments supported with timely and thorough feedback. Affording students with increased opportunities for formative assessments allows them to utilize feedback for reflection and growth. Specific and structured feedback that can be provided via digitized formative assessments facilitate student mastery and have a positive correlation with student achievement. Further, digitized formative assessments allow instructors to mine assessment results for learning gaps and misconceptions, informing modifications to instructional approaches, pace, and ordering of content. Digitized formative assessments become a critical component of a comprehensive pedagogical framework, which maximizes the benefits of particular instructional strategies, while mitigating specific drawbacks.

A comparison between some of the existing digitization approaches for STEM programs and the approaches covered in our ADI Workshop is provided in Table 2.1. Brigham Young University (BYU) [9] and University of Utah [10] Testing Centers (TCs) both provide online testing facilities for engineering and science programs that use digitized assessments. A commonality between these and ADI is the adoption of exclusive assessment delivery within a secured environment overseen by proctors. Students are provided with the increased convenience of being able to schedule appointments to avoid conflicts with their employment duties or exams in other courses. Schurmeier et al. [10] have studied the results of 10 years of digitized assessments on over 20,000 students using the University of Utah TC to address eight difficult topics in general chemistry. This effort provides a good example of potential benefits to the instructor derived from digitization of assessments, particularly the identification of trends in learners’ comprehension. Another significant digitization initiative is the Computer-Based Testing Facility (CBTF) at University of Illinois at Urbana-Champaign (UIUC) [11], which is being used for

Table 2.1: Selected approaches for engineering digitization and their comparison to ADI Workshop.

Approach	Type	STEM Programs	Features
BYU TC [9]	Testing Center	Physics and Astronomy Mechanical Engineering	▪ exam problems are symbolic in nature which facilitates partial credit ▪ equations not given in digitized assessments, but constants may be provided
Univ. of Utah TC [10]	Testing Center	Chemistry	▪ Item Response Theory used to identify difficult within topics general chemistry
UIUC CBTF [11]	Digitized Assessments Tools & Testing Center	Computer Science Mechanical Engineering	▪ assessment digitization includes interactive graphical response tool for STEM content ▪ assessment delivery strategy allows unlimited retakes with highest score being retained
ADI Workshop *(described herein)*	*Integrated Testing and Tutoring Methodology*	*Civil, Computer, Electrical, Industrial, and Mechanical Engineering, Computer Science Information Technology*	▪ *Palette of STEM question formats including Design-by-Selection, Code Completion, Declarative Statement in Multiple Answer Format, Cloning Strategies, etc.* ▪ *Utilizes scanned scratch sheets, score clarification services, review sessions.*

computer science and mechanical engineering courses. In addition to online testing and proctoring services, CBTF provides interactive graphical response tools for faculty to digitize their assessments. As listed in the last row of Table 2.1, the ADI Workshop promulgates an integrated testing and tutoring methodology, which thus far has been adapted to support a significantly broader range of STEM programs than previous approaches. Under the ADI Workshop approach, digitization enables auto-grading of assessments, which frees up graders for tutoring, a high-gain teaching and learning activity.

Improving instructors' methods and practices constitutes a critical role in any STEM reform effort. Brief, one-time interventions typically fail at changing instructors' practices or attitudes toward innovative pedagogical approaches. We have chosen an extended professional development workshop environment because it allows more opportunities for instructors to address aspects of their teaching practice, explore various constraints in teaching and learning environments, and gain confidence to change instructional practices, which may engender persistent changes to instructors' attitudes and behaviors [12]. While many studies have espoused the usefulness of professional development workshops in increasing instructor preparedness and effectiveness, STEM professional development workshops have not illustrated the same level of success in modifying instructor behavior as other content areas [13]. Thus, the ADI Workshop includes a flipped and blended classroom environment, active and learner-centered professional development activities, and extensive time and resources to reflect on existing pedagogical practices and making modifications to instructional approaches to implement "best practices" in STEM instruction.

3.0 Theoretical Framework

While numerous efforts have been made to address the variety of problems currently facing STEM education, such as improving workforce development, increasing the number of women and underrepresented populations in STEM programs and careers, and implementing policies, supports, and processes to support enhanced STEM teaching and learning, many such efforts fail to be adopted [14]. Often times, this is due to the lack of design and development of a comprehensive change strategy prior to the implementation of the reform effort. Hence, it is critical to develop and employ a change strategy that extends the typical "best practice" approach that is typical in STEM reform efforts [15]. Rather, successful strategies of a comprehensive change approach should be continual, coordinated, and focused, and should address both changing the pedagogical conceptions of key and varied stakeholders in a STEM instructional system, as well as affording stakeholders with an iterative cycle of performance evaluation and continual feedback [16]. To address these issues, the ADI Workshop will develop and implement a comprehensive and expansive dissemination plan, derived from the Four Categories of Change Strategies model [17], and developed in an effort to provide environmental support to facilitate extensive adoption of processes and pedagogical practices associated with digitizing assessments. The change strategies to be employed will focus on: 1) developing extensive and expansive incentivized professional development opportunities for key faculty and administrators in an effort to alter instructional practices and policies, resources, and processes in place to support the integration of digitized assessments and associated pedagogical practices in STEM courses; 2) employing methods for aligning innovative instructional practices with the existing STEM conceptions of participating stakeholders, thus encouraging participants to explore innovative instructional approaches in a structured and measured manner; 3) developing an extensive and iterative plan for assessing and documenting the effectiveness of the ADI Workshop and accompanying pedagogical practices via stakeholder feedback; 4) disseminating program evaluation results to varied STEM programs and stakeholders; and 5) employing change agents to disseminate project materials and results. The aim of this comprehensive change strategy is to result in a wider adoption of the ADI Workshop content, processes, and strategies.

Learners and faculty can benefit from shifting engineering gateway courses towards computer-based test delivery for those assessments that are suitable for digitization. Figure 3.1 depicts doing so by realigning educational and human resources without a net personnel increase using the BLUESHIFT pedagogy [2]. BLUESHIFT utilizes a taxonomy of online assessment instruments that facilitates design problems beyond rote multiple choice including *multiple answer for partial credit*, *incremental solution multiple choice*, and *creative design via selection*, which offer significant comprehension differentiation beyond the benefit of grading expediency. It also facilitates GSA-based open tutoring and remediation. A detailed financial cost model was developed whereas tutoring can be provided at no additional expense, by attaining a breakeven point between the grading hours avoided and the test proctoring hours required. This is shown to occur for a combined cohort of 1,150 students per term [2]. Thus, the BLUESHIFT pedagogy refocuses instructor and GTA roles from low-value repetitive tasks towards those having more significant impacts on learning outcomes, as depicted in Figure 3.1.

Computerized testing centers support increasing enrollments while increasing practice and attainment of course outcomes, flexibility of scheduling, and rapid grading response. The approach set forth in the ADI Workshop is that the digitized assessment delivery infrastructure can be efficiently encapsulated within an *Evaluation and Proficiency Center (EPC)*. As depicted in Figure 3.1, an EPC converts grading workloads into tutoring gains by re-mapping of graduate assistant expertise from low-impact grading tasks to new roles, which have increased impact on student outcomes. Thus, owing to time savings of autograding, the course graders are reallocated

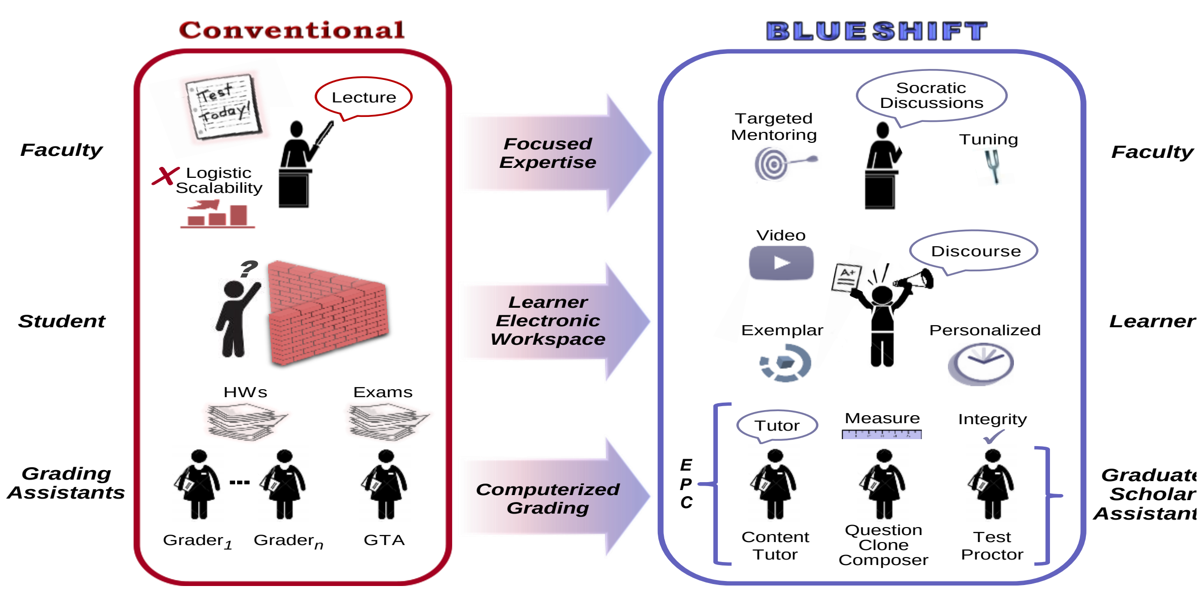

Figure 3.1: BLUESHIFT rebalances instructional expertise and classroom facilities towards the Learner's frame of reference. Learners experience an increased frequency of higher quality online and live interactions; the moniker is analogous to Doppler blueshift in astronomy.

into three new categories: (1) *EPC Tutor:* review module or remedial material, and clarify scoring of problems missed; (2) *Question Clone Composer:* develop high quality content for computerized delivery/ (3) *Test Proctor:* verify student identification, restrict prohibited materials, and prevent cheating by delivering a turnkey service for secured evaluation.

4.0 Immersive Faculty Workshop on Assessment Digitization Innovation

Three months in advance of the ADI Workshop, the authors of this paper announced the upcoming availability of the workshop at a College-wide all hands meeting. The objectives of the workshop were overviewed, identified as:

1) constructing digitized exams for STEM subject matter,
2) using relevant Canvas LMS question types and features,
3) strategies to encourage academic integrity in online assessments, and
4) composing exemplar design vignette questions to reinforce, develop, and assess connections between concepts to achieve integrative learning.

The mixed-modality delivery format was identified as consisting of two online weekly modules to develop exams for their targeted engineering course, and four face-to-face weekly modules of two hours duration. Next, a two-page enrollment form to solicit faculty participation was provided and posted on the College website. The form requested information on the course targeted for assessment digitization including annual enrollment, number of years taught, graduate-level Grader support currently allocated, number of assessments {Quizzes + Exams + Final}, percent of examinations currently using Scantrons, and any relevant publisher's test bank identified. Ten faculty participants were selected to participate representing the six engineering disciplines listed in the last row of Table 2.1. To maximize active learning during the ADI Workshop, the face-to-face meetings were scheduled in a high technology classroom, which provided each participant with student stations having large computer monitors to participate in workshop activities. Because the summer ADI Workshop required a significant time commitment, the College offered faculty participants a course release for completing it. Face-to-face meetings were held on Fridays, a non-teaching day, and were recorded using Panopto. Faculty unable to attend were permitted to review the recording and compose a brief summary.

The ADI Workshop homepage was hosted in the Canvas LMS. It defined Course Logistics, including instructor overviews and policies, while emphasizing that the workshop would be an opportunity to work together as colleagues to improve learning outcomes of our students, while also enhancing our efficiency by re-balancing our workload as STEM instructors. To encourage these outcomes, we created a formal syllabus, which was correlated with a point-earning rubric. The course completion reporting scale used S/U, whereby a grade of S (Satisfactory) was earned if 10 or more points (including mandatory Showcase submission) were accrued prior to the closing week 6 of the workshop, and U (Unsatisfactory) for absence of showcase submission and/or fewer than 10 points earned.

As listed in Table 4.1, the content of the ADI Workshop was organized into six modules, at a rate of one module per week, plus a preparation Week 0 module. The workshop begins with an overview of the BLUESHIFT Pedagogy in Week 1 and then engages the participants to plan the modularization of their target course. The immersive EPC quiz is then administered. Week 3 and Week 4 concentrate on constructing Study Sets using Exemplar Vignettes, the process of Score

Table 4.1: Course modules, topics, and anticipated effort needed by participants.

Wk	Mode	Participation Activity / Submission	Effort
0	Online	Course Logistics: Syllabus, Policies, Background, Instructor Profiles	2 hours
1	F2F	BLUESHIFT Pedagogy: Digitized Course Walkthrough, EPC Procedures, Study Set on SI units, Schedule EPC Quiz Appointment using website	4 hours
2	F2F	Modularization Planning: EPC Experience, BLUESHIFT paper, Immersive QUIZ IN EPC	6 hours
3	Online	Exemplar Vignettes and Score Clarification: Vlogger Paper [18], read Peer Review, EPC Policies & Procedures, Syllabus Starter with EPC Guidelines, Laboratory Digitization [19]	4 hours
4	F2F	Structuring Creativity/Design/Soft (CDS) questions: Question Development Flow, Canvas Quizzes Tool, GSA Panel Discussion, Respondus	6 hours
5	Online	Support Resources: Fellin Paper on Multiple Choice in STEM, Canvas Guide, Managing Academic Integrity & Honesty, IRB—Approved Research, Screencasting Procedures, Hybrid Modality Lecture Capture Procedures	4 hours
6	F2F	Showcase and Graduation: Enrollees present Quiz and Study Set, Course concludes with overview of Automated Extraction of Question Content	14 hours
		Total	*40 hours*

Clarification using scratch sheets, and the question development flow. A Panel Discussion with GSAs was also held which was very well received by participating faculty to provide a chance to ask questions about proctoring logistics. Week 6 conducted the Showcase and all completing faculty received a graduation certificate for their professional development records.

Typical module content is depicted in Figure 4.1 and Figure 4.2. Figure 4.1 shows the layout of a sample study set, which includes *given*, *sought*, and *solution* sections. Each Study Set typically focuses on a single specific technical content and/or principal, such as *the time of flight principle*, which is utilized in Figure 4.1. The fundamental information about the topic of the study set that is required to set up the problem is provided in the *given* section. Engineering problems are decomposed into more detailed subsections to realize a partial credit formulation. The guidance provided in ADI Workshop to digitize assessments in this manner includes identifying governing equations for each substep of the problem. As a result, the solutions exhibit the approach and precise calculations, which are required for solving the given problems. Study Sets should be sufficiently informative to guide students so that they can thoroughly comprehend the targeted concept without significant reference materials. They should also provide detailed explanation to adequately prepare students for the in-person digitized quiz. In the ADI Workshop homework is ‘flipped’ for open solutions without submission and credit is earned by completing the corresponding quiz for that Study Set.

Two faculty who completed the ADI workshop adopted various publishers’ content with good results. The other eight faculty who have completed the ADI workshop targeted digitizing assessments in courses without extensive publishers’ test bank materials. It was found that only about 25% of the disciplines and curricula targeted currently have sufficiently-refined publishers’ content regarding the course topics. Only a subset of those may relate to material in the textbook being used within the course in particular. Thus, techniques to offer partial credit, produce questions having a sufficient number of choices, create diverse question clones, and problem formats to exercise creative design aspects were emphases within the ADI Workshop, which were valued highly by faculty. Figure 4.2 shows a digitized quiz corresponding to technical content depicted in the Study Set within Figure 4.1. The ADI Workshop covers various types of questions for digitizing a quiz, including *multiple choice*, *multiple answers*, and *formula* questions that are shown in Figures 4.2(a), 4.2(b), and 4.2(c), respectively. The quiz questions

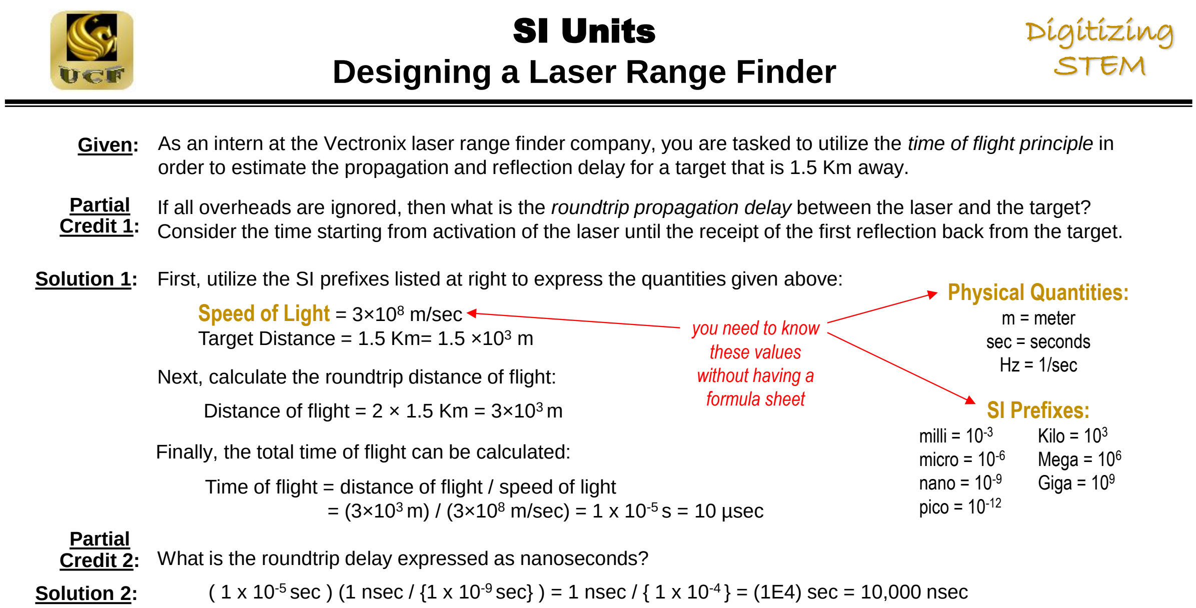

Figure 4.1: ADI Workshop assignment – Study Set open solution prior to a high-integrity quiz.

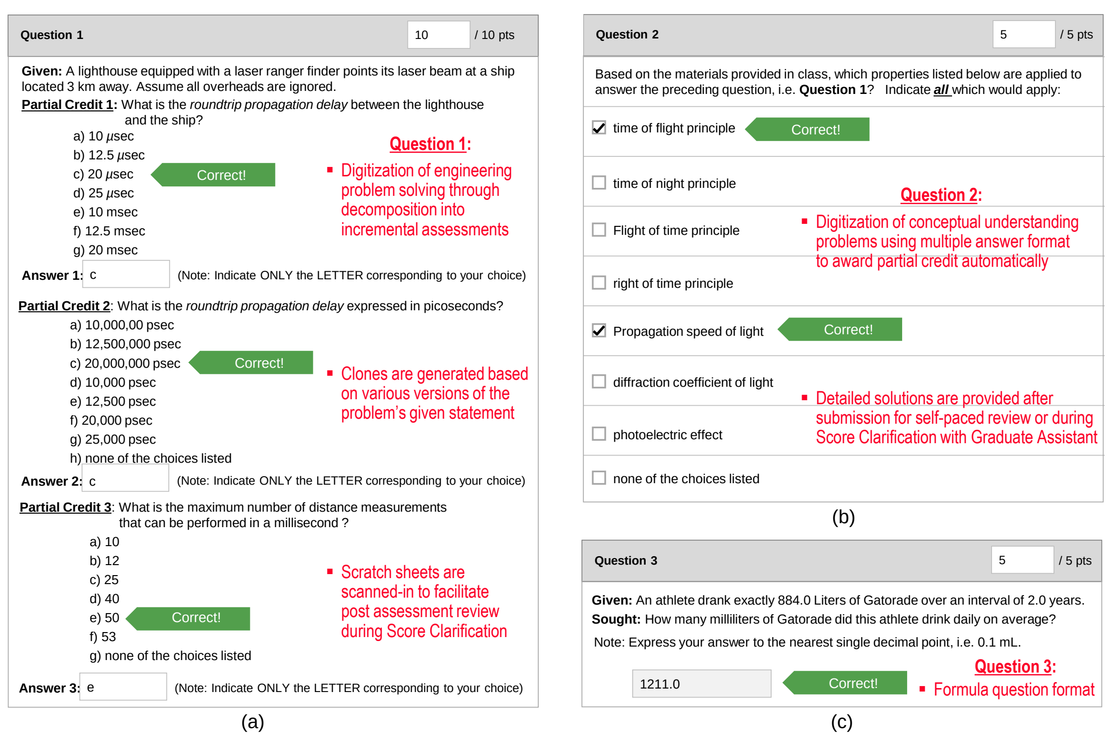

Figure 4.2: ADI Workshop immersive experience Quiz corresponding to technical content in Figure 4.1.

are also constructed using incremental assessments with partial-credit format to enable the precise evaluation of comprehension and problem-solving ability of the students. The ADI Workshop advocates assigning a multiple-day window for completing the exams; therefore, several clones of each question are generated based on the various versions of the problems to avoid different students receiving identical problems. Table 4.2 summarizes points available for faculty to earn within the workshop, which have been listed in chronological order of their coverage. Points were accrued by completing three categories of assigned weekly activities.

1) **Non-Showcase Class Meetings** (up to 3 points total). The regular in-class meetings occurring during Weeks 1, 2, and 4 accrue points in either of two ways:
   a) 1 point for each regular live class attended with active participation, or alternatively,
   b) 1 point for each live class makeup conducted via viewing the class video recording and then posting a 100-word or more discussion post in the corresponding weeks' "Makeup" discussion thread discussing the actions gleaned for the target course,
2) **Assigned Submissions** (up to 9 pts total) Elements assigned during each module accrue:
   a) 1 point for each satisfactory submission before the due date, i.e., Homework Upload, Take Home Quiz, and Assigned (non-makeup) Discussion Post, and
   b) 2 points for completion of an immersive quiz which is delivered in the EPC, whereby each faculty participant completes the quiz under identical testing center conditions including use of scrap sheets, lockers, and supplied calculators.
3) **Showcase Presentation** (3 points). The purpose of the Showcase face-to-face meeting during the final class occurring during Week 6 is to present the created quiz for the target course that has been completely digitized, and the study set materials loaded into Canvas that correspond to your digitized quiz. Showcase submission is mandatory and accrues up to 3 points based on the completeness, robustness, and innovation.

At least 10 points had to be earned in order to satisfactorily complete the course, including the mandatory Showcase submission during Week 6, consisting of a completed digitized quiz and corresponding study set loaded into Canvas for the material covered in each targeted STEM course, attaining 10 or more points. The rightmost column of Table 4.2 indicates the

Table 4.2: ADI Workshop activities and their weight towards satisfactory completion.

Wk	Mode	Participation Activity / Submission	Weight	Achieved
0	Online	**Discussion post:** Most significant advantages and challenges to digitizing assessments within your targeted engineering course? (200 words)	1	100%
1	F2F	**Class attendance:** In-person or else make-up by viewing class video and then post discussion of elements learned that week (100 words)	1	90%
2	F2F	**Class attendance:** In-person or else make-up by viewing class video and then post discussion of elements learned that week (100 words)	1	90%
2	F2F	**Immersive Quiz on SI Units:** schedule appointment on website to take a quiz in the EPC as a student	2 *	100%
2	F2F	**Modularization plan:** submit module design and assessment map for targeted course using template provided or in own format	1	70%
3	Online	**Discussion post:** lessons learned from panel of Tutor / Cloner / Proctor	1	90%
3	Online	**Study set submission:** submit a flipped homework for targeted course	1	100%
4	F2F	**Class attendance:** In-person or else make-up by viewing class video and then post discussion of elements learned that week (100 words)	1	80%
4	F2F	**Discussion post:** non-digitized quiz in targeted course with solution	1	90%
5	Online	**Discussion post:** pedagogy article regarding the validity and potential additional value of multiple choice in STEM content	1	70%
5	Online	**Take-home quiz:** identify question formats supported and their use	1	100%
6	F2F	**Showcase presentation:** each instructor presents and defends a digitized assessment module in targeted course using LMS interface	3 *	100%
		* = *Mandatory Activity* ***Total Points Available***	***15***	
		Minimum Score Required for Satisfactory Grade	***10***	***100%***

overwhelming majority of participants achieved a satisfactory or better submission for each activity. The course also utilized several discussion topics, whereby the faculty's assisgnment was to post their perspective on the instruction methods covered. The instructors kept discussions focused on the implications of the presented methods on their targeted course. Faculty discussion was very active and topics received as many as 43 posts. The Showcase Class Meeting is a symposium-style event in which each person enrolled in the course presents a fully digitized quiz which they developed. Participants developed a study set for their course including at least four solved problems. The audience utilized the Etherpad computerized whiteboard to discuss feedback in real-time to facilitate collaborative note-taking and sharing of ideas.

5.0 Outcomes

The pilot offering of ADI Workshop enrolled a cohort of 10 instructors and 16 GSAs currently teaching gateway Engineering and Computer Science courses at UCF, interacting with an estimated 6,206 undergraduate Engineering and Computer Science students in the 2016–2017 academic year. The first ADI Workshop was piloted during the Summer 2016 semester. One course was targeted by each participating faculty as listed in Table 5.1, as described previously. Nine faculty conducted the course synchronously and the tenth conducted the course asynchronously using videos of the taped classes along with instructor support, demonstrating the viability of both delivery modes. Upon conclusion of the program, anonymous feedback was collected from seven participating instructors, which was overwhelmingly positive. All respondents were "very satisfied" with the in-class sessions, the facilitators of the workshops, and the online modules. Specifically, they rated the program topics, examples, and resources provided to be highly relevant. The majority of the respondents agreed that the workshop will impact their future

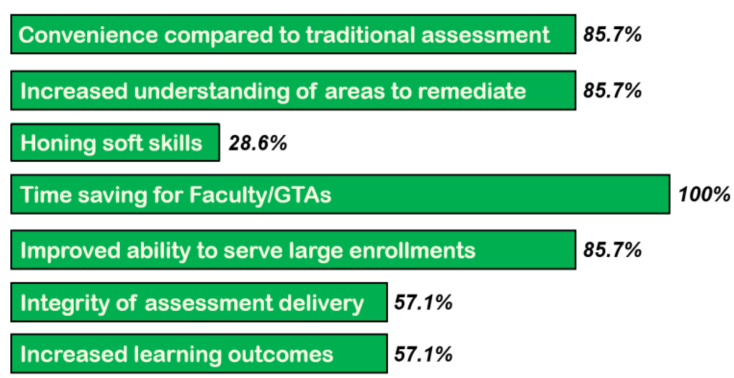

Figure 5.1: Faculty perceptions of ADI Workshop benefits.

Table 5.1: Showcase submissions of faculty enrolled in ADI Workshop.

Course Title	Topic of Module Digitized	Enrollment
EEL3004: Electrical Networks	Branch Method and Power Dissipation	420
ESI4234: Quality Engineering	X-bar & R Charts	150
EGN3310: Engineering Mechanics - Statics	Method of Joints	875
EEL4781: Computer Networks	Network Transport Layer	140
EEE3342: Logic Design	Karnuagh Maps	350
EML4142: Heat Transfer I	Fourier's Law II	454
COP4331: Object Oriented Software	Software Requirement Specification	300
CAP4104: Human & Tech interaction	Principles of Good Design	320
COP3223: Intro Programming with C	While Loops	2227
EGN3343:Thermodynamics	Carnot Engines	970
	Total	***6206***

course design and development in the beneficial ways, such as time-savings, convenience, student remediation, and an improved ability to serve large enrollments, as shown in Figure 5.1. Respondents indicated unanimously that the assessment digitization techniques presented were applicable to their targeted courses, and 100% of respondents agreed that the techniques can impart valuable time savings for themselves and their GTAs, which the freed-up GTA hours can be allocated to tutoring. Additionally, 85.7% of respondents agreed that the digitization methods would enhance the convenience of assessment delivery in their course, increase their ability to identify areas for remediation, and improve their ability to serve large enrollments. The majority also indicated valuable integrity benefits and the potential to increase learning outcomes. Only a minority of ADI workshop participants responded that they perceived benefits to students' soft skills. This is understandable, as such benefits can vary significantly by degree program, and also require a commitment to utilize Score Clarification procedures. Some participants preferred to opt out of Score Clarification whereby GTAs could discuss solution attempts documented on scratch sheets to consider limited partial credit, and preferred to pilot this option before large scale deployment in their course.

6.0 Conclusion

Embracing assessment digitization with the holistic approach conveyed via the ADI Workshop has achieved several benefits since its inception three years ago. These include inceased student engagement by fortifying the integrity and impact of homework and exams, elevating learning outcomes via tutoring and Score Clarification procedures facilitated by reduced grading loads, increased ability to serve large enrollments using a hierarchical infrastructure and dedicated testing facility, and the ability to adopt the instructional technology incrementally starting with individual quizzes progressing to summative assessments and laboratory integration. Further, results have also echoed other research that has espoused the benefits of formative assessments, but extended this through tools and processes that allow for more robust formative assessment processes through digitization. Finally, consideration of change theory throughout the deployment and rollout process have proved to be valuable and are thus recommended.

Based on the positive feedback from participating instructors and GSAs, we have received approval to offer a second ADI Workshop during the Summer 2017 semester within the College of Engineering & Computer Science. An accelerated 4-hour ADI Workshop will also be delivered at the 12th International Conference on e-Learning (ICEL 2017). We are also formulating plans to expand the scope to STEM disciplines outside of engineering, as well dissemination more broadly in venues outside of campus, including collaborations with other institutions, which the authors would welcome.

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