Integrated Active Learning Tools for Enhanced Pedagogy in a Software Engineering Course

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Integrated Active Learning Tools for Enhanced Pedagogy in a Software Engineering Course

Abstract

Effective teaching requires effective teaching tools. This pedagogical requirement is especially important for software engineering education, where graduates are expected to develop software that meets rigorous quality standards in functional and application domains. To enhance students' understanding of the needs of the professional software industry, lecture notes are supplanted by additional pedagogical tools being developed at the author's institution for a software verification and validation (V&V) course. These active learning teaching tools, consisting of class exercises, case studies, and case study videos, are being developed in partnership with industry. The basic objective of the project is to improve software education so that it is aligned with both academic research and industry best practices. This project is being funded through a NSF-TUES grant.

Through this project in addition to enhancing twenty (20) delivery hours of lecture slides, eighteen (18) delivery hours of case studies, sixteen (16) delivery hours of exercises, and six (6) delivery hours of case study videos totaling sixty (60) delivery hours of Software V&V course modules are being created. In the spring of 2014, diverse case studies were delivered to Software Engineering juniors at the author's institution and their learning outcomes were tracked using a survey instrument. The results showed that the students were able to better comprehend V&V topics such as *requirements engineering, reviews and inspections, configuration management,* and *testing.* The knowledge disseminated through lectures seemed to be reinforced by the case studies. In the spring of 2015, additional course materials that include exercises and role-play videos are expected to be created and delivered. The results of this research work will be shared during the poster presentation at ASEE. As part of the project dissemination plan, the teaching materials will be made available to interested institutions and professional organizations. An invitation-only workshop is also planned for August 2015 to share developed course materials and delivery mechanisms.

1. Introduction & Rationale

Effective teaching requires effective teaching tools. In engineering education, student-centered lectures have been the predominant model of teaching. However, this may not be the most effective method for imparting knowledge in all disciplines, as students may not be able to retain and apply knowledge they have gained to the extent that is required in their professional careers. Active learning/teaching tools complement lectures and make class delivery more interesting to the learners. More importantly such tools effectively assist the student in retaining knowledge. Active learning teaching tools such as case studies, class exercises, and case study videos have been utilized in a variety of teaching disciplines, including Biology, Medicine, Law, and Business. It is proposed in this work that these interactive pedagogical tools are especially important for software engineering education as well, specifically for software verification and validation courses, where graduates are expected to develop software that meets rigorous quality standards both in functional and application domains. The software V&V professionals must interact with other software professionals such as developers, and with customers for requirements elicitation. They must then contribute to develop a project proposal that can subsequently be turned into a legal binding contract. The accuracy and reliability of the software product are usually the technical performance measures in which customers are keenly interested. Therefore, case-study based education and videos of SW development scenarios are expected to enrich and enhance undergraduate education in software V&V.

Active learning is "embodied in a learning environment where the teachers and students are actively engaged with the content through discussions, problem-solving, critical thinking, debate or a host of other activities that promote interaction among learners, instructors and the material" [1]. Prince [2] defines active learning as a classroom activity that requires students to do something other than listen and take notes. Active learning is achievable by complementing lecture materials with case studies, class exercises and case study videos.

1.1 Active Learning Tools: Case Studies

Case studies can serve as useful tools to teach applications of science and engineering principles. Raju and Sankar [3] define case study education as providing students with a record of a technical and/or business issue that actually has been faced by managers, together with surrounding facts, opinions, and prejudices upon which management decisions have to depend. Using case studies as a semester-long tool to teach neuroanatomy, in which students were actively engaged in the presentation and discussion of case studies throughout the semester, resulted in more understandable and enjoyable learning experience for the students. Two classes of Biological Psychology, with approximately 25 students enrolled in each section of the class participated in the case study projects [4]. In a study at Middlesex Community College [5], case studies were used in teaching General Biology I where 88.2% of the students surveyed found the cases to be useful or better for learning the course content. 90.9% of the students surveyed thought the cases were useful or better in making the course more interesting. Case studies were applied in six courses to help students (1) understand complex and complicated issues and describe interrelated processes; (2) discuss policy- and decision-making ideologies that either are politically or socially charged; and (3) engage in informative and focused classroom discussion. The results indicated that use of the case study method as an active learning tool provides students with a variety of important skills necessary for success both in and out of the classroom. Specifically, active learning helps students develop problem-solving, critical-reasoning, and analytical skills, all of which are valuable tools that prepare students to make better decisions and become better students and, ultimately, better employees [6].

Raju and Sankar [3] undertook a research to develop a teaching methodology to bring real-world issues into engineering classrooms. The results of their research led to recommendations to funding agencies and educators on the need to develop interdisciplinary technical case studies so that the innovations happening in the field of engineering can be communicated to students in the classroom.

1.2 Active Learning Tools: Class exercises

Class exercises provide class time to explicitly raise questions that invite student participation. When well designed for the context and presented in the right setting, class exercises raise questions for the students to exercise their thinking. Depending on the focus of the questions, the students may be more motivated to investigate the subject matter, may gain a deeper understanding of course concepts, or may improve their skills through hands-on experience using the knowledge in problem solving and design derived from the exercises.

There are many ways of using class exercises in the classroom setting. For a small class size, the teacher may simply use an exercise to engage students in discussion and hands-on practice. For larger classes, the students can be assigned to small groups using the class exercise as an instrument leading to group projects. Woods and Howard [7] effectively used class exercises for Information Technology students to study ethical issues. Day and Foley [8] used class time exclusively for exercises, having their students prepare for class with materials provided online. Bishop and Verleger [9] presented a comprehensive survey of the research that reviewed different ways of using class exercises in the classroom, often referred to as the "flipped classroom." Frydenberg [10] primarily used hands-on exercises to foster student understanding in data analytics. Well designed, class exercises become very effective learning tools and can be versatile in various classroom settings.

1.3 Active Learning Tools: Case Study Videos

One commonly used technique to enhance the classroom learning experience is the use of video. Videos are viewed as an effective method of presenting standard material while addressing students of different learning styles. A video engages visual learners with its images and motions, while auditory learners can listen carefully to the narration to gain an understanding of the topic.

Videos are an essential part of the flipped classroom model, in which the preponderance of lecture material is presented before class [11]. The class time is then spent on discussion and teamwork, reinforcing the material from the previous evening. Overall, the flipped classroom model has proven highly effective at increasing student engagement and enhancing the preparation of students for class sessions [9] . The flipped classroom also has been shown to allow the instructor to cover more material and results in higher student performance [12]. However, videos can also be used in a traditional classroom, and their use can be highly effective. There is extensive experience in using audio visual materials in the classroom, ranging from the usage of filmstrips during World War II to train solders [13] to modern digital video. Watching videos can reinforce reading and lecture material, help to develop common knowledge, enhance the quality of discussion and overall student comprehension, accommodate students of different learning styles, increase student motivation, and increase teacher effectiveness[14]. Videos can aid in showcasing highly complex concepts and ideas in a short period of time, provoking meaningful discussion and analysis.

Through a project funded by the National Science Foundation –Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (NSF-TUES) -- a required Software Engineering course at the author's University, namely Software Verification & Validation, is supplanting existing lecture modules with additional pedagogical tools. As software has become ubiquitous, software products have become critical. This poses a problem in the software industry, as there is generally a lack of knowledge of Software Verification and Validation (V&V) benefits and a shortage of adequately trained V&V practitioners. Through the development of active learning teaching tools, this project addresses V&V related root causes of software failure depicted in Figure 1. First, the improved courseware with the new tools will be appropriate for delivery in undergraduate education programs, thereby improving the skill and knowledge level of graduates who will enter the software development profession. Second, the courseware will be packaged in discrete modules so that the project results can be used for in-house training programs that will improve the skills and knowledge levels of current software practitioners. Finally, the courseware will be developed and tested through the efforts of a team of university and industry partners creating a V&V community that can champion and promote expanded institutionalization of V&V best practices.

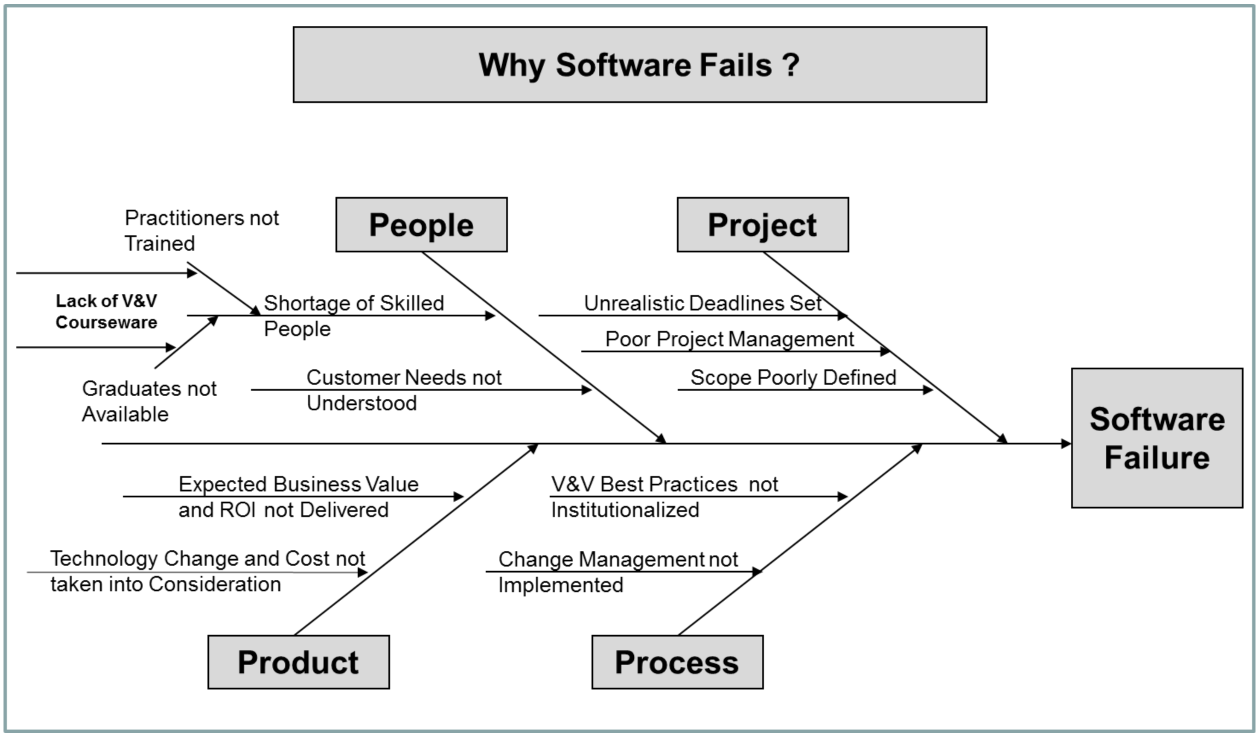

Figure 1: Why Software Fails?

As the basic objective of the project is to improve software education so that it is well aligned with academic research as well as industry best practices, authors from XXX university have partnered with four industry partners and collaborated with authors from YYY university and ZZZ university to develop active learning teaching tools consisting of case studies, class exercises, and case study videos. In the following sections we share the iterative methodology used in an academia-industry partnership to create active learning teaching tools. We then provide a project status by describing the course modules that have been developed or are being developed, followed by a brief discussion of early delivery results. More results will be shared during the ASEE conference. Finally we discuss our dissemination plan.

2. Active Learning Tools Developed in this Work

This project is developing the following: eighteen (18) delivery hours of case studies, sixteen (16) delivery hours of exercises, and six (6) delivery hours of case study videos. The twenty (20) delivery hours of lecture slides used in the author's institute have also been enhanced. In total, sixty (60) delivery hours of Software V&V active learning teaching tools and lecture slides in the form of course modules are being created/enhanced.

To develop the necessary course modules, four focus groups comprised of industry and academic partners have been created for each of the following four V&V focus areas: *Configuration Management, Requirements Management, Testing, and Reviews*. The focus groups have been given the tasks of identifying content topics and delivery formats, creating the identified contents in the desired format, and reviewing created contents for delivery readiness. The PI then deposits the finalized contents in a shareable media for delivery and dissemination.

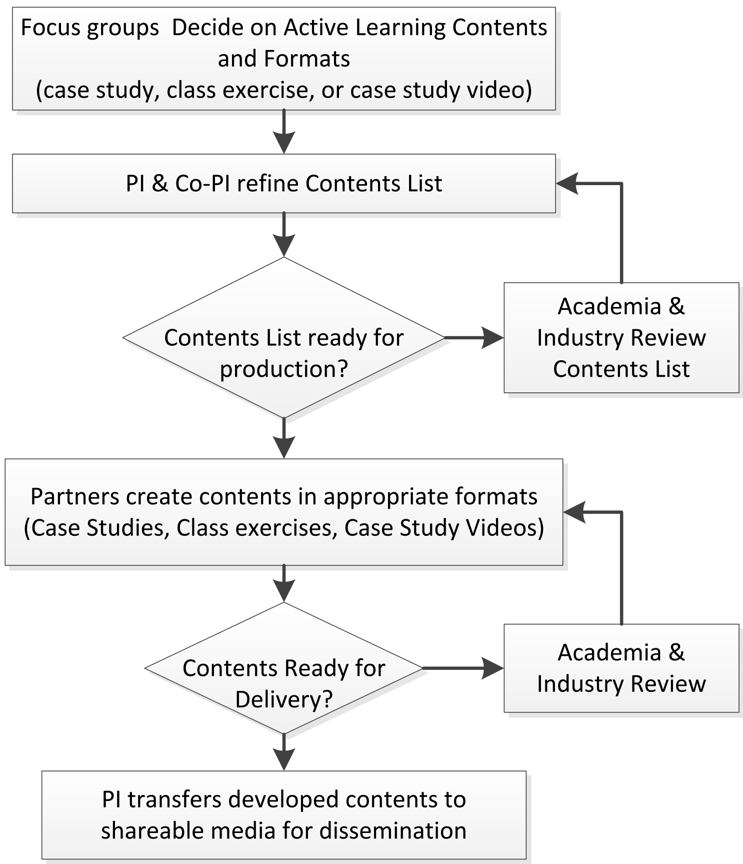

Figure 2: Content Development Methodology

An iterative review method depicted in Figure 2 is being used to ensure the modules reflect both academic research and industry best practices. The content development process began with a meeting of the focus groups at the author's institution. The groups came up with a draft list of active learning content topics and delivery formats. The list was reviewed by the PI and Co-PIs and shared with the partners for further review. The finalized list is currently being used to guide the development process. In this methodology, an industry partner or academic partner leads the development effort through a collaborative effort. Once the contents are ready for review, they are shared with focus group members and subsequently with all partners. The finalized contents are then transferred to a shareable media where they wait for round 1 delivery, further reviews, and subsequent dissemination.

2.1 Case Studies

At the time of writing this paper, nine case studies as listed in Table 1 have been created. They have been reviewed multiple times and are now ready for delivery. The case studies have three sections: *case study details*, *exercise*, and *instruction notes*. The case study details provide information on the focus area, case module name, prerequisite knowledge, ABET learning outcomes, keywords, expected delivery duration, and an explanation of the scenario. The exercise section describes what the students need to do. The instruction notes section provides details on how the instructor should deliver the case study. Some case studies can be completed entirely in 50-minute sessions, whereas other case studies are broken down by homework and classwork and require multiple sessions. All case studies require teamwork and communication in addition to subject matter knowledge. At the end of the case study delivery, students will be assessed on teamwork, communication, and content knowledge.

Table 1: Case Studies

V&V Focus Area	Case Study Modules	Mins.
Requirements Management	User Requirements	50
	Requirements Ambiguity	200
Software Configuration Management	Continuous Integration	100
	Version Control Management System	100
Peer Reviews	Reviews	100
	Peer Reviews	100
Testing	Test Case Development	50
	Performance Testing	100
	Software Test Plan	50
	TOTAL	850
	Contact hours (50 minute periods)	17

2.2 Class Exercises

At the time of writing this paper, eight class exercises have been created. These are depicted in italic font in Table 2. They have been reviewed multiple times and are now ready for delivery. Each exercise is accompanied by an exercise description in MS Word format and an instructor slide in MS Power Point format. The class exercises also have three sections: *exercise details, exercise description,* and *instruction notes*. The exercise details provide information on the focus area, exercise module name, prerequisite knowledge, ABET learning outcomes, keywords, and expected delivery duration. The exercise description section describes what the students need to do. And the instruction notes section provides details on how the instructor should deliver the exercise in class. The exercise is also available on a separate page for easy printing. Some exercises can be completed entirely in 25- or 50-minute sessions, whereas other exercises are broken down by homework and classwork and require multiple sessions. All exercises are discussed in class. At the end of the exercises, students will be assessed on communication and content knowledge.

2.3 Case Study Videos

At the time of writing this paper, three case study video scripts have been written, reviewed and are ready for video production. The completed scripts are in italic font in Table 3 below. The fourth script is being finalized. The video shooting is tentatively scheduled to take place in March 2015. All videos will have appropriate narrations and pause points for class discussions. Pause points and discussion questions will be provided in the videos for class discussions. At the end of the discussions, students will be assessed on communication and content knowledge.

Table 2: Class Exercises

V&V Focus Area	Class Exercise Modules	Mins.
Requirements Management	*Business Requirements and Functional Requirements*	25
	Ambiguity in Requirements	50
	Customer Needs Statements to User Requirements	25
	Customer Needs Statements to Use Case text or Use Case Diagram	25
	Clarifying User Requirements	25
Software Configuration Management	Research on Existing Tools	50
	Famous Bugs	50
	Using a Configuration Management Tools	50
Peer Reviews	*Code Inspection*	100
	Walkthrough	50
	Review a given SRS with Checklist	50
Testing	Testing Tools	50
	Test Cases for a Given Requirement	50
	Writing a Test Report	50
	TOTAL	650
	Contact hours (50 minute periods)	13

Table 3: Case Study Videos Details

V&V Focus Area	Case Video Modules	Mins.	# of Scenes
Requirements Management	*Requirements Elicitation*	50	5
	V&V in Scrum	50	4
Peer Reviews	*Code Inspection*	50	7
Testing	Testing and Security	50	5
	TOTAL	200	21
	Contact hours (50 minute periods)	4	

3. Project Outcomes, Evaluation & Assessment

The expected outcomes from this project are grouped into three broad areas:

i. ***Improved knowledge and skills pertaining to V&V:*** The final outcome area is focused on improving the knowledge and skills of both undergraduate students and industry practitioners. The monitoring and measurement focus in this outcome area will be to measure learning outcomes and user feedback. Student learning assessment and user feedback from students, academic instructors, and industry trainers on the active teaching learning modules will be systematically collected periodically and analyzed.

ii. ***Improved V&V teaching and learning opportunities:*** This project seeks to expand the availability of teaching and learning materials and increase their deployment in academic and industry training settings. Therefore the monitoring and measurement focus in this outcome area will be to quantify adoption of course materials in academia and industry. At this point, seven academic institutions and four industry partners have agreed to completely or partially deliver the learning modules developed through this project. It is expected that more institutions will join once the project matures.

iii. ***Development of Verification and Validation community spanning industry and academia:*** By proactively reaching out to several universities and industrial partners, the project has begun to establish a community interested in furthering the understanding and use of V&V practices. The project aims to strengthen and mature these new relationships into a sustainable community of educators and practitioners focused on V&V.

The project is using a team of two external evaluators from the author's institution to perform the following evaluation activities:

- **Develop Questionnaires and Instruments:** Evaluators are working closely with the PI and co-PIs to develop evaluation questionnaires and instruments. Various instruments in the following four skill areas will evaluate students' active learning:

    i. **Communication Skills (Ability to Communicate Effectively):** Active learning teaching tools will enhance students' communication skills. Sessions will begin with a class discussion on what was accomplished in prior sessions. Students will interactively participate in this collaborative review exercise. To have a better understanding of real work environments, students will participate in role plays, and case study videos will be used to facilitate understanding of what is expected of these roles. Students will complete a project on testing that will include progress updates via emails and a mid-project progress presentation using Power Point. In each progress update, students will discuss the following: *what has been accomplished this week*, *what will be accomplished next week*, and *what were the issues and challenges and how they were resolved or not resolved if they were*. During the final-examination week, students will give a detailed final project presentation using Power Point. Students will be made aware of the importance of professional presentations and will be assessed on their content knowledge and their communication of that expertise.

    ii. **Applied Knowledge of Methods (Applied Knowledge of V&V Principles):** Mini learning workshops (class sessions) will be used to translate theory to practice. Case-studies, class exercises, case study videos, and expert lecture sessions will enforce further understanding of V&V methods. Formal inspection meetings will be conducted, and students will be assigned to play different roles (*moderator, author, recorder, reader, and inspector*). The expert lecture sessions will focus on V&V processes and methods.

iii. **Applied Knowledge of Tools (Ability to Use Software V&V Tools):** Mini learning workshops (class sessions) will expose students to commonly used V&V tools. For example, students will make use of Sub-Version (an open source revision control system) for configuration management exercises, and Bugzilla (a server software) for defect management exercises.

iv. **Research Exposure (Ability to Engage in Life-Long Learning):** Research activities will be carried out in three ways. The first will involve discussions of case studies and case study videos. Students will read the case-studies, discuss them within their teams, and then discuss them with the class. Likewise, the students will view the case study videos and then discuss them in class. The second research activity involves the study of research papers. The students will analyze five research papers and answer questions related to the papers. The third activity will involve understanding of industry standards. SE standards for V&V will be analyzed and discussed.

- **Formative Evaluation:** From the evaluations performed, evaluators will assess the needs for the enhanced course modules and changes to the delivery strategy for the next planned delivery. As two delivery cycles are planned, formative evaluations will be critical for the success of the project.

- **Summative Evaluation:** From the evaluations, performed evaluators will assess the short- and long-term results of the project. The summative evaluation results will be used to understand, document, and share the project's short-term and long-term achievements.

4. Early Delivery Results

In the spring of 2014, three case studies listed in Table 4 were successfully delivered within the Software Verification and Validation course at the author's institution. For each of these V&V areas, a pre/post survey instrument was used to assess student learning. In these instruments, two questions were related to case studies. The results are depicted in table 4.

As depicted in the table, the post-survey responses indicate that students' understanding of the subject matter has improved. The Software V&V course is being delivered at the author's institution. The PI will deliver this class using the active learning teaching tools developed in this project. Assessment results from this delivery will be shared at the 2015 ASEE conference.

5. Dissemination Plan

In consonance with NSF's broad-dissemination requirement, the project will use the following means of dissemination to generate V&V awareness and to create experienced practitioners:

- **Centralized Course Repository:** At a suitable time, two categories of project materials will be uploaded to NSDL: an instructor's kit and project results. The instructor's kit will consists of a sample syllabus, instructional slides, pre-tests/post-tests and answer keys, midterm/ final exams and answer keys, active learning teaching tools, and grading rubrics.

- **Workshop:** To ensure that implementers are familiar with the active learning teaching tools and delivery strategies, a two-day workshop is being organized in Pittsburgh, PA from August 13-14, 2015. Both academic and industry project partners will attend this workshop. Up to five additional academic partners will be invited to attend this workshop. During this workshop, focus groups will introduce the course materials they have developed and explain in detail the delivery strategies. Implementers will also work on selected student exercises to understand how they are to be attempted and graded. Through this workshop, it is expected that a strong interaction between facilitators and peer learners will be established.

Table 4: Case Study Survey Results

V&V Topic	Case Study Module		Pre Survey	Post Survey
Requirements Management	User Requirements	Do you think a case study exercise helps you understand the role of a Requirements engineer?	Yes (50%) No (50%) Not Sure (0%)	Yes (100%) No (0%) Not Sure (0%)
		Do you think a case study exercise helps you understand the skills required for Requirements elicitation?	Yes (50%) No (37.5%) Not Sure (12.5%)	Yes (100%) No (0%) Not Sure (0%)
Software Configuration Management	Continuous Integration	Do you think a case study exercise helps you understand the importance of configuration management?	Yes (50%) No (25%) Not Sure (25%)	Yes (90%) No (0%) Not Sure (10%)
		Do you think a case study exercise helps you understand the requirements of a configuration management tool?	Yes (12.5%) No (0%) Not Sure (87.5%)	Yes (100%) No (0%) Not Sure (0%)
Peer Reviews	Peer Reviews	Do you think a case study exercise helps you understand the roles of the participants in a formal inspection process?	Yes (87.5%) No (0%) Not Sure (12.5%)	Yes (100%) No (0%) Not Sure (0%)
		Do you think a case study exercise helps you understand the skills required to carry out a successful review meeting?	Yes (50%) No (12.5%) Not Sure (37.5%)	Yes (90%) No (0%) Not Sure (10%)

- **Conferences and Publications:** A research paper on project activities was successfully presented in ASEE 2014. As the project advances, research papers on project activities and assessments will be submitted for presentation at conferences such as ASEE & ITiCSE. These conferences will provide venues for obtaining additional input and accomplishing broader community building. In 2014, a journal paper was also successfully published in the ASEE – *Computers in Education* journal. The investigators plan to submit additional articles in *ACM Queue* (Magazine), *ACM Transactions* on S/W Engineering and Methodology, and *IEEE Transactions* in S/W Engineering.

- **Professional Societies:** Project methodology and implementation results will be shared with professional societies through presentations at professional society events (such as

ACM and IEEE). The RMU-ACM Student Chapter regularly conducts public technology talk sessions.

- **LinkedIn Software V&V Community Group:** A LinkedIn "Software V&V Community" group has been established to enable V&V implementers to avail themselves of peer-to-peer learning opportunities. This professional group provides a venue for education and consultation. Implementers share ideas and best practices, ask and answer questions, and collaborate. At this point this group is exclusive for project partners. However, as the project advances, the group will be open to all interested parties.

6. Conclusions and Future Direction

Active learning teaching tools such as case studies, class exercises, and case study videos are being created so as to have positively affect student learning in the areas of software verification and validation. Through a project funded by NSF-TUES grant, a required Software Engineering course at the author's university, namely Software Verification & Validation, is being taught using active learning teaching tools that include case studies, class exercises, and case study videos. These tools are being developed through an academia and industry partnership. In addition to enhancing twenty (20) delivery hours of lecture slides, the following Software V&V course modules have been created: eighteen (18) delivery hours of case studies, sixteen (16) delivery hours of exercises, and six (6) delivery hours of case study videos, totaling sixty (60) delivery hours of active-learning materials of. To ensure that the tools reflect both academic research and industry best practices, an iterative development methodology has been used.

Survey responses of the first delivery of several of the created cases studies indicate that students' understanding of the subject matter has improved. Project outcomes and the project's Evaluation & Assessment plan have been presented. Project external evaluators will perform formative and summative assessments. A detailed dissemination plan using different means has been described. In the spring of 2015, class exercises will be completed and case study videos will be produced. Lecture materials will also be enhanced. External evaluators will have all evaluation instruments ready. A one-day Focus Group Working Meeting will be held on Friday, June 5, 2015 at the author's institution to discuss the project's status and make appropriate recommendations. A two-day workshop is being organized in Pittsburgh, PA from August 13-14, 2015; at this workshop, the active learning teaching tools will be shared and delivery strategies will be discussed. Seven committed academic institutions will attend this workshop. In addition, five other academic institutions will be invited to attend.

References

[1] (https://utah.instructure.com/courses/148446/pages/active-learning)

[2] Prince, M., "Does Active Learning Work? A Review of the Research," Journal of Engineering Education, Vol. 93, 2004, pp. 223-231.

[3] Raju, P. K. and Sanker, C. S. (1999) Teaching Real-World Issues through Case Studies, Journal of Engineering Education. Vol. 88 No 4 pp501-508

[4] Kennedy, S. Using Case Studies as a Semester-Long Tool to Teach Neuroanatomy and Structure-Function Relationships to Undergraduates, The Journal of Undergraduate Neuroscience Education (JUNE), Fall 2013, 12(1): A18-A22

[5] (https://www.middlesex.mass.edu/sotl/downloads/klein.pdf)
[6] Kunselman, J.C. and Johnson, K.A., Using the Case Method to Facilitate learning, College Teaching, Vol. 52. No. 3 (Summer 2004).
[7] Woods, D., and Howard, E (2014) An Active Learning Activity for an IT Ethics Course. Information Systems Education Journal, 12(1) pp.73-77. http://isedj.org/2014-12/ ISSN: 1545-679X.
[8] Day, J.A. and Foley, J.D. (2006) Evaluating a web lecture intervention in a human–computer interaction course. IEEE Transactions on Education, 49(4):420–431, 2006.
[9] Bishop, J.L. and Verleger, M.A. (2013) The Flipped Classroom: A Survey of the Research. ASEE 120th Annual Conference and Exposition, Atlanta, GA.
[10] Frydenberg, M. (2013) Flipping Excel, Information Systems Education Journal, 11(1) pp.63-73. http://isedj.org/2013-11/ ISSN: 1545-679X.
[11] Bergmann, J. and Aaron S. (2012) *Flip Your Classroom: Reach Every Student in Every Class Every Day*, Eugene: International Society for Technology in Education, 2012. Print.
[12] Mason, G.S.; Shuman, T.R.; Cook, K.E. (2013), "Comparing the Effectiveness of an Inverted Classroom to a Traditional Classroom in an Upper-Division Engineering Course," *Education, IEEE Transactions on* , vol.56, no.4, pp.430,435, Nov. 2013
[13] Hovland, C.I., Lumsdaine, A.A. & Sheffield, F.D. (1949). Experiments on mass communication. Princeton, NJ: Princeton University Press.
[14] Corporation for Public Broadcasting. (2004). Television goes to school: The impact of video on student learning in formal education