Quality Assurance Management of Capstone Course Projects

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Abstract

Pace University’s Capstone provides real world experience to students by completing projects for university faculty, the community, and businesses. Quality assurance is the management of processes as well as verification of each team’s output to ensure that they meet or exceed the customer’s requirements. This paper provides details on methods of quality assurance such as standardization of reports, oversight of teams, manual test cases, and surveys for both students and customers. In addition, the paper researches current QA methods of other colleges and universities. Survey results suggest additional requirements and processes should be put in place to ramp students up before they start on project work in order to increase quality of the end product.

1. Introduction

Pace University’s IT691 Capstone Project course teaches students how to complete real world computing projects by working to solve problems and requirements for University staff and external customers in a systematic, process-oriented way. Employers express that recent graduates are deficient in a number of key areas including communication, configuration management systems, teamwork, and project management [11]. Capstone courses aim to alleviate the skills gap [11] [16]. Students learn how to gather and analyze requirements, project management, professional communication, teamwork, and leadership [15, p. 691].

The goal of all teams is to complete their project requirements and deliverables in the time provided, of which there are 2 sets. The first sets of deliverables are those for the class and the second set are those by the team’s Customer. Completed projects then must not only meet or exceed the expectations set forth by their Customer but, also of the expected level of quality in a Master’s class [15].

Our team, Team 9, is tasked specifically as the Quality Assurance team to help ensure standardization and quality of project work. Quality Assurance (QA) is the adherence to proven processes, methodologies, and procedures, which help in completing a project or producing a product, which meets or exceeds a customer’s expectations. QA also includes quality control, which is the verification of produced output against requirements. To do so, our deliverables include oversight of the other teams’ weekly reports and milestones, watching for changes in requirements, evaluating quality of project deliverables, creating surveys to capture project process details, and creating test cases and testing developed systems, and a technical paper. In addition, the quality of the end product will be captured in a customer survey.

Agile and Extreme Programming methodologies are prescribed for the course and students are expected to study and learn their team’s chosen methodology independently. Students are currently not required to follow a specific methodology. This leads to a challenge in applying QA to Capstone courses: a team may choose from a broad number of methodologies or they may even choose not to use one. A methodology or quality process should be applied to increase the quality of project work [4]. More importantly, quality assurance should be incorporated from the very beginning of the course [6] and students should be trained in the methodology that they will be using prior to starting project work [12].

Therefore, we propose adding a class-wide deliverable that a team must choose a methodology, and learn how to implement it prior to beginning project work. An Agile methodology would be preferred (ex: XP) for projects, which will create systems, or Scrum for all other projects.

This paper begins with an introduction to QA then follows with how Capstone courses have applied QA (State of the Industry). The paper then extends the work of the previous class (Spring 2015) by researching and evaluating the current state of QA among capstone projects in other universities. After
that section we detail the methods of QA, followed by the team overviews. The rest of the paper in order includes the challenges faced, results, and finally future work.

2. Quality Assurance Overview

In the 80s and 90s, software development generally followed the waterfall methodology (Fig. 1). Waterfall is a sequential development model which goes from requirements, to design, to development, to testing, and then finally to launch. As the pace of changing customer requirements increased, other methodologies came about to address this such as Lean, Scrum, Feature-Driven, Pragmatic, Extreme Programming (XP), Agile and others. XP is a methodology which includes principles such as small releases, pair programming, simple designs, testing, customer feedback, code standards, and refactoring [3]. Agile is a set of 12 principles born in 2001 as a lightweight alternative to methodologies and processes (Fig. 2). Agile’s principles include continuous releases, a focus on the customer, accepting changing requirements, and self-organizing teams [17]. Scrum started in early 90s with the latest update in 2013. Scrum is a framework founded on empiricism, that knowledge is derived from experience, and employs small iterative releases while advocating transparency, inspection, and adaptation [14].

3. State of the Industry

Extreme Programming (XP) methodology and Agile principles are prescribed for the course. Studies have been carried out exploring the use of Agile, XP, and Scrum in Capstone courses. Agile aided in teaching leadership, design, coding, testing, and sharing of code but “requires more training/coaching and stepwise introduction [9]”. Agile helped to increase product quality in a two semester Capstone course by teaching students to adapt to changing requirements. It also helped in professional skills development.

XP in particular has been beneficial to increasing quality in Capstone projects [7]. XP works with small-scale projects, increases completion of more product features, and helps less skilled students in pair programming [1].

Paasivaara et al. found that the Scrum framework works for student projects and are suitable for distributed students [11]. Scrum advocates self-organization and for developers to choose the tasks they wish to work on. Findings showed that over time students learned more efficiently with self-selected tasks, decreased team dependences, and helped increase communication [10]. Other benefits of Scrum include increased learning of teamwork, better product quality, more customer focus, improved learning of iterative development [13].

In terms of organization, quality assurance among universities and college capstone courses have employed a dedicated Quality Manager, created a separate QA team, or brought in an external auditor [2].

4. Team Overview

This year’s projects fall in the categories of
mobile, Internet of Things, biometrics, and information systems. Three of the teams are developing systems, while the others are creating surveys, and user studies. All teams are required to produce a technical paper or report to share their results and conclusions.

Nine teams used different methodologies to complete the project. Six teams used Agile, one used XP, one team used none, and a one-person team did not use a methodology. Of the nine teams, eight provided project plans in the form of a Gantt chart.

Communication for most teams was primarily weekly and some bi-weekly using Skype and Google Hangouts for face-to-face video conferences. Day to day communications between team members was via text messaging, emails, and IM programs such as Google Hangouts.

4.1 Team 1 – Mobile Device Security

Team 1 will be continuing an ongoing project on mobile device security. Traditionally, users enter their alphanumeric or numeric passcode. There are many new ways for user authentication and this year’s team will create a user study focusing on Near Field Communication (NFC) and fingerprint as a method for user authentication.

4.2 Team 2 – Biometric Security

Team 2’s project is a continuation of a previous Biometric security project. The team will create and conduct usability testing to determine acceptability and ease of use of biometric systems and will include liveliness testing. Liveliness testing will try to detect whether a sample is from a living user or from an inanimate object such as a picture. The biometric testing specifically focuses on facial recognition. The team expanded upon the previous test data by including 3 bilingual women. In addition, the team will try to fool the system by using simple disguises such as using a wig and different types of glasses.

4.3 Team 3 – Biometric ROC Curves

A receiver operating characteristic (ROC) is a graphical plot to determine the performance of a classifier system. Team 3 is tasked with researching and obtaining classifier output scores from public commercial biometric demos and then to create ROC curves. They will create a report with their results. Team 3 chose to evaluate the Chrome browser plugin, Keyboard Privacy, for dwell and gap times in Appendix A. They also chose to evaluate Microsoft’s Facial Recognition which is part of Project Oxford in Appendix B along with facial recognition by Betaface in Appendix C.

4.4 Team 4 – Android Biometrics

Team 4’s project is a continuation of previous projects. The project will try to finding ways to capture gestures and motion orientation (scrolling and other non-text input) on Android devices through the Pace biometric classifier in Appendix D. They can take advantage of apps already in existence. The team will focus on capture of data, classification, and produce reports.

4.5 Team 5 – PHP-MySQL Systems

Team 5 is tasked with maintenance and upgrades of various systems. The first system they will work on is a Handwriting Forgery Quiz System. The second is completion of the Doctor of Professional Studies (DPS) Dissertation database which is a continuation of the 2012 project. The third system Team 5 will be working on extending the Genealogy system, which captures family history.

Additional details were provided for the Handwriting Forgery Quiz System. It is a web based quiz which gathers data from novices and experts. It has these characteristics:

1. Explanation of the quiz
2. One question: Are you a handwriting Expert or Novice?
3. 10 questions with 4 choices (1 genuine, 3 forgeries)
4. Comments field
5. Submit button

4.6 Team 6 – PHP-MySQL System

Team 6 is creating an advanced interactive web interface written in Javascript. Data input via the interface will provide data validation. The selection of MYSQL for the database will have four main tables of research. PHP scripts will be implemented to allow for ease in query of collected MetaData.

4.7 Team 7 – Internet of Things

Team 7 is to perform research on the Internet of Things (IoT) to determine if IoT can make society safer via a targeted industry. Methane detection will be the primary focus which will be analyzed through research of sensors, sensor data research, and data analytics. A deliverable of a technical paper and presentation of the data will be completed.
4.8 Team 8 – Smartphone/Smartwatch Study

Team 8 will research smartphone and smartwatch habits to determine if the data proves these devices promote good habits. The technology field is exploding with promises from companies such as FitBit, Samsung, Apple, and many more stating these devices will promote better fitness, nutrition, real time data, and much more that will be discussed. The data although relatively small should help determine if this claim is more factual than not.

4.9 Team 10 – Project Group Assignment System

Team 10 contains one member and the goal of the project is to help automate the group project assignment system. The system groups students to a desired project of choice. Students fill out a form with 5 preferences of the capstone projects while listing their own skillsets. The system then collects the data, assigns students to projects based on an algorithm provided by the customer. The characteristics of this tool are:

1. Explanation of Survey
2. Import BlackBoard Roster
3. Import Student Survey Results
4. Input skill importance rankings for each project
5. Assign each project one (and only one) Team Lead
6. Assign remaining students to one and only one project
7. Provide project roster list that is easily accessed and used

5. Methodology

5.1 Method 1 – Research Quality Assurance Among Universities and Colleges

Research was performed identifying capstone project courses at numerous universities and colleges. The purpose was to determine if other universities and colleges had dedicated quality assurance roles or teams or none at all to support our research. Each course was reviewed in detail.

In addition, email was sent to six professors at different universities asking about quality assurance. Three questions were asked:

1. Do your teams have a QA person within the team or from an outside source? (Yes/No; if so which one?)

2. Based on your previous experience do you feel a single QA person or team is needed to provide a successful deliverable? (Yes/No)
3. Do you have any additional feedback related to QA you would like to provide regarding capstone projects?

5.2 Method 2 – Standardization of the Weekly Progress Report

Each week all teams were responsible for filling out a progress report to share with their customer, the professor, and each other. We created a template to standardize the weekly reports in order to make it easier to read for all involved.

We applied the concept of a Daily Scrum, from Scrum methodology with four simple questions listed below [14]. The 4 questions are:

1. What did you accomplish last week?
2. What roadblocks did you have?
3. What are you going to next week?
4. Is there anything else you would like to share?

These questions are simple and allowed us, the customer, and Professor Tappert to identify any roadblocks easily. In addition, we added one last question for information that the teams would like to share outside of the first 3 main questions.

5.3 Method 3 – Evaluation and Oversight of Project Requirements and Deliverables

We split the teams among the 3 members of our team so that each was responsible for 3 teams of varying project types. This reduced the points of contact and helped to manage the large amount of emails going back and forth. It also allowed each member to get to know the project a bit more than if all 3 of us were managing all 9 teams simultaneously.

We then asked all teams to provide a project plan which includes a breakdown of deliverables into tasks and estimates on how long each task will take. We suggested to teams to provide the project plan in the form of a Gantt chart (Fig. 3). Each week, we compared the weekly progress reports against the project plans and discussed the teams in our own weekly meeting. We noted any exceptions and things that may affect a team’s project timeline in our own progress report for Professor Tappert.
5.4 Method 4 – Manual Test Cases

Manual test cases were created for projects that produced an application or system: Team 5, 6, and 10. The test cases were provided in a Microsoft Excel spreadsheet with each row containing a test case scenario. Each test case scenario contained the following fields:

- Test Case Name
- Description
- Prerequisite
- Steps
- Input
- Expected Result
- Actual Result
- Status
- Comments
- References

We were going to manually test the systems but, due to time constraints, we were not able to test the final products.

5.5 Method 5 – Surveys

A Survey is a procedure, which gathers information from a small sample of people to help make an educated assumption based on the results.

We created two surveys on Surveygizmo.com. One survey was for students and the second survey was for customers. The student survey is a 21 question survey meant to capture the areas of demographics, methodology and process, quality and testing, communication, and Capstone course. Questions from last year’s project surveys will be reviewed, revised, and re-used as needed.

The customer survey captured the quality of the end product as defined by the customer and the customer’s overall experience with their team. Note that the survey attempts to capture the expected outcome of the delivered products and not the final product due to time constraints of this paper.

6. University Results

Quality assurance focuses on providing confidence that quality requirements are met for deliverables. Throughout our research we have found only one University that has a quality assurance process such as Pace University’s IT691 Capstone Project.

6.1 Saint Louis University

The capstone course for Saint Louis University is part of the two semester long Computer Science curriculum.

Teams following an agile method will be required to deliver incremental deliverables with a plan for the following week. Research based teams will deliver papers that describe the work and results [20].

6.2 UC Santa Barbara

Students at UC Santa Barbara (UCSB) will have a partner, mentor, project overview, visions statement, and project requirements document, end of quarter presentation, final poster, and final presentation. The 2015/2016 student teams consist of 10 separate teams with partners such as Citrix, Raytheon, and other well-known corporations [21]. After reviewing all 10 team visions statements, the only identified team member roles were the leader and a scribe. No evidence of any quality assurance was identified.

6.3 Michigan State University

Michigan State University’s capstone project has students complete software projects for corporate clients [22]. Every team will be responsible for organizing themselves as deemed fit. The only requirement is each team must have a designated member to communicate with the client. Teams are required to divide the project up into smaller deliverables and used as milestones. Quality assurance is not a specific part on the capstone class at MSU.

6.4 University of South Carolina

The University of South Carolina’ (USC) capstone project spans 2 semesters. The class is broken up into milestones for each team to meet throughout the class. Milestone 12 is for behavioral and automated testing. This step requires a third-party unit-testing framework and some form of behavioral testing. This step is as close of a step as there is to ensure a quality product.

Quality assurance is milestone 15 which will be
completed two weeks after you get a copy of the other team's project. Each team will get a copy of another team's project and do extensive testing of the project. Teams will identify every bug using screenshots and send to the team to fix the issues before milestone 15, which is release 1.0 [23].

6.5 University Correspondence

Out of the 6 emails sent, we received 2 responses. Chandra Krintz, Professor, UCSB RACELab Director at UC Santa Barbara answered [8]:

1. “Yes” both to question 1, “No, QA feedback must come from a wide range of constituents (project owners, mentors, peers, potential users”
2. “Our projects are 6 months in duration (3 months for spec, design, prototyping; 3 months for implementation and user testing).
3. "I recommend that QA be an integral part throughout the entire process, not an add-on”

Dr. Michael Goldwasser, Director of Computer Science at Saint Louis University answered [5]:

1. "There is not typically a dedicated QA role within the team."
2. "While QA should be addressed in some form, we have not felt it necessary to have a single QA person on the team, nor would this work for our current structure."
3. "No additional feedback.

7. Survey Results

7.1 Student Survey Results

21 out of 38 students completed the survey, with at least 1 student from each team. Most students are local to the New York City / Pleasantville, NY area. Here are the notable results:

- Most students did not do any programming. Out of the 7 students that did program, only 1 completed unit or functional tests.
- Ease of communication with customers ranged from not responsive and not easy to reach to very responsive and easy to reach, while most students stated that their teammates were easy to reach and responsive.
- 55% of students stated that customer expectations were clear and understandable and 62% stated that the level of quality expected was clear and understandable.

- 71.4% of students did not receive training and 71.4% did not have experience in Agile (Fig. 4-5).
- 52.4% of students felt that if a methodology was required, it could possibly help product quality with 19% agreeing, and 28.6% disagreeing (Fig. 6).
- The top 3 blockers, things that slowed or prevented a student from completing work, were: lack of customer feedback, waiting for other teams, and gathering data.

Figure 4. Did you receive any Agile training (class, work training, etc) prior to this course?

<table>
<thead>
<tr>
<th>Value</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>28.6%</td>
</tr>
<tr>
<td>No</td>
<td>71.4%</td>
</tr>
</tbody>
</table>

Figure 5. Did you have experience with Agile or any Agile methodologies (Scrum, XP, etc) prior to this course?

Figure 6. Do you feel that if a methodology such as Agile, or XP was required (set as a deliverable), would it have helped your team’s organization and final output?

7.2 Customer Survey Results

There were a total of 12 questions answered by 10 customers for the survey. Two of the customers belonged to the same team.

- Most customers communicated with their team 1-2 times per week. These communications were via
phone, IM, email, video conferencing, and in person.

- 40% of customers changed their deliverables during the course.
- 40% of products were tested by the customer.
- 8 teams met their requirements. An average rating of 8.5 out of 10 was the result for the quality of the delivered product.
- On average 7 out of 10 customers stated that their team provided timely communication, adapted to changes in requirements, was organized, and kept them in the loop of their progress (Fig. 7).

![Figure 7. What went well?](image)

8. Challenges

We faced a number of challenges while applying QA and these are listed below along with possible solutions that were implemented.

- Communication with teams were untimely on a number of occasions and included late weekly reports, feedback on questions, and getting surveys filled out. Reminders, even those which included the professor, did not elicit a faster response.
- Weekly reports submitted were of various formats, which were solved by asking all teams to follow a template that we provided.
- Inability to test final products of team 5, 6, and 10 due to time constraints. This could be alleviated if there was time allotted during the project planning phase.

9. Conclusions

Quality assurance and testing is commonplace amongst real world projects to ensure products meet customer needs.

Research of other Universities capstone courses revealed that a number of them are 2 semesters long. This provides time for design, planning, testing and especially time for learning how to complete projects by learning processes and methodologies. In addition, USC had a milestone requirement specific to testing.

Continued research of multiple University Capstone Projects do not mention quality assurance within the curriculums, although via email we confirmed quality assurance is an important aspect of the projects. The two responses we received had different opinions on the importance of QA within the capstone project. We conclude that there should be QA, but whether it should be a single dedicated resource or external team is dependent on the project.

From the student survey, we gathered that there are only a small number of students who programmed. Out of those, only one student stated that they completed unit testing of their code. We are unsure if this student’s team had accounted for testing in their project plan. We do suggest that all teams adjust their scope to allow time for testing.

The student survey also showed that most students were not trained or experienced in the methodology they used in their project. Learning the process while also completing project work alongside may have affected quality. In the student survey, when asked if additional requirements such as a methodology would help increase product quality, 52% of students answered “possibly”. Although this is technically the majority, we believe that the lack of experience in proven processes led to these results.

The customer survey results showed that customers were happy with the product created by the student teams. 40% of customers changed deliverables, 60% stated that the team adapted and made necessary changes. This result proves we have inaccurate data within the survey results. A paid version of Survey Gizmo with added features that allow additional questions to be answered contingent on previous responses would be beneficial in trying to alleviate bad data.

In general, the teams created products successfully for their customer as shown by the customer survey. Results show 90% of products met the requirements. As noted, our results are based on expected outcomes and the high satisfaction rating may be optimistic. The customer survey also showed that frequent communication with multiple methods is important to the delivery of a quality product.

Based on all of our findings, we believe that the requirement of using a methodology would increase the quality of the end product.

9. Future Work

Future projects could extend the surveys to increase and widen captured data to further our proposal of additional quality assurance related requirements prior to starting project work.

Another suggestion for future work would be to research the QA role in regards to being a dedicated resource on a team or keeping the current structure as an external resource. Our small data sample may even
suggest a hybrid role, one where a QA person partially participates in the team project while maintaining some autonomy by also being a part of a QA team.

Our last suggestion would be to further research Scrum or some form of Scrum as a possible methodology that teams can use.

**Appendix**


B: Project Oxford Facial Recognition. https://www.projectoxford.ai/demo/face#detection


**References**


