An Industry Partnership Model for Collaborative Course Content Generation for STEM

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Abstract

As part of an ongoing mission to advancing and applying Enterprise computing curricula in the context of Science, Technology, Engineering, and Math (STEM), IBM has completed another milestone in a novel approach to software testing course content generation by partnering with a university. This effort is the continuation of a work first disclosed in April 2010 at the IEEE Transforming Engineering Education Conference in Dublin Ireland. It has culminated in a complete course ready for instruction and is being taught by both partners currently. After briefly describing the importance of the foundational attributes of the STEM curricula to Software Testers at IBM, this paper will discuss recent IBM academic partnership activity in the area of course creation, leading up to our most recent academic-industrial collaborative effort to create a full course on enterprise system testing. The paper will discuss the logistics of the partnership, as well as the logistics of collaborative content creation used in this model. We will present an analysis of the success of this phase of the project, and outline next steps, and longer-term future work, in this area. This paper should serve as a guide for future potential collaborations between university and industry on content creation. Throughout this paper we will include our proposed best practices to facilitate future endeavors of this type.

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2. Background and Motivation

Enterprise systems are at the very core of virtually all large commercial institutions today. Enterprise systems are literally the stuff upon which global companies, and some would say the world, run. Enterprise systems are complex systems-of-systems that involve very intricate and inter-related IT infrastructures, business processes, and operational processes. Typically, enterprise systems are subject to significant regulatory process intersections as well. The combination of all of these byzantine components is what drives the design, development, testing, deployment, and operation of enterprise systems and the culture of enterprise systems design.

Consider that the culture of enterprise system design adopts a "no mistakes" attitude, and that culture is prevalent for both producers and consumers of enterprise products and services.

Enterprise ecosystems have, over time, evolved to create a composite set of institutional skills that understand, in totality, each individual component's as well as their complex interactions.

The baby-boomer generation is the demographic group that generally possesses these skills. Cross-generational skill transfer is vital to the success of enterprise companies, given the accelerated time frame of baby-boomers retirement. Enabling enterprise skill transfer from those retirees forthwith to new-hires presents a considerable risk to enterprise computing.

Current curriculum at many universities, especially at an undergraduate level, teach the fundamentals of computer science at a algorithm efficiency level along with the basic tools one would need to embark on a development job assuming ample time for on the job training in advanced enterprise development skills. There is however a problem with the current state of curricula. Current educational programs presume students are going to have the luxury of applying their tool set, and learning those enterprise-grade topics, at the same rate the previous generation had done. The urgency of skill loss from the retirement of enterprise skilled retirement-eligible workforce demands we move the level of curriculum forward to include enterprise levels of complexity at an undergraduate level. The alternative is a catastrophic reduction in world-wide services due to the inevitable mistakes that will be encountered by the next generation.

In addition, the "no mistakes" culture of enterprise computing has a deleterious effect when coupled with the increasing enterprise adoption of agile development models. This effect is creating a proportional demand increase for system level testing. Unfortunately, system testing is a discipline that is not generally taught at current universities [TEE].

It is the assertion of the authors that curriculum needs to be modified to include both the particular technologies in enterprise computing environments as well as enterprise level complexity (for instance topics like virtualization, and high-availability, along with their nuanced interactions). We further assert that the adoption of curricula intended to create graduates with a T-shaped knowledge profile, prior to their entry into industry, will be necessary in order for those students to cope with the demands they will encounter in their careers. T-shaped knowledge profiles contain technical depth in one or more areas, while simultaneously having breadth across various disciplines including, but not limited to: testing, development, design, customer relationship management, business, and performance analysis. IBM and many of our industry colleagues are seeking T-shaped candidates from universities and colleges in order to fulfill roles requiring specialized enterprise computing skills in short supply due to maturing-technical-work-force challenges. The lack of T-shaped candidates is not specific to just software testing, but is recognized across groups within IBM seeking top talent.

The current model of education results in students which have an "I-shaped" knowledge profile. It is expected that these graduates will, over time, move to another knowledge domain driven by the

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individuals desire for career change, or upon exhaustion of opportunity in the particular "I-shaped" knowledge domain.

It is precisely because of these challenges that we have taken a leadership role in advancing the state of curricula. The remainder of this paper documents our efforts on the events leading up to this contribution as well as the logistics of our most recent partnership effort along with best practices for future collaborative academic-industrial endeavors.

3. Prior Work

The effort described in this paper is the continuation of work started several years ago independently by various organizations. This section will describe some of the motivations behind this collaborative effort as it exists today, while also describing the efforts that had gone on previously to support this level of collaboration.

3.1 History

Formal explicit knowledge comes through study and is confirmed by academic degrees and business certifications. Informal tacit knowledge comes through experience and association with knowledgeable colleagues. This dichotomy has been observed for some time in both industry and academia. Several efforts to bridge these worlds have been attempted to date. This section serves as an overview of some of those efforts leading up to the work described in this paper.

Due to the rapid changes in technology and the emergence of this new 21st global market based economy, institutions of higher learning must ramp up swiftly to produce a new generation of workers and our universities must be positioned and willing to respond to this new environment. The 21st century demands uniquely skilled people driven by inter-disciplinary program and degrees that fuse technical competency with industry-specific knowledge and business-process expertise. Its success will require open collaboration among academia, government and industry.

In 2006, a report funded by the National Center on Education and the Economy indicated the major problem faced by industry is a lack of qualified workers with technical skills, including software skills, prepared to meet the challenges of a rapidly changing global economy [TOUGH]. Mike Kirst, a professor of Education Emeritus at Stanford University asserts a need for a "massive fundamental change in education structure, curriculum, teacher compensation, and assessment, as well as in the roles of virtually all our education institutions" [TOUGH2] based on results presented in a recently released document created by the New Commission on the Skills of the American Workforce (a working group of the National Center On Education and the Economy). In 2005, Diane Morello, vice president of research at the Gartner Group stated that, "If the last decade represented the era of specialists, this decade will mark the era of the versatilist. Versalitists are people whose numerous roles, assignments and experiences are enabling them to synthesize knowledge and context to fuel business value [GRTNR05]. This is a confirmation for the need for T-shaped individuals to move the IT industry forward rather than simply I-shaped programmers or engineers.

The IBM Academic Initiative is a worldwide program partnering with colleges and universities to better educate millions of students for a more competitive IT workforce. "One of the greatest concerns of leaders from industry and academia alike is the challenge of preparing talent capable of driving innovation—and thus economic growth," explains Steve Mills, senior vice president of the IBM Software Group. "Faculty is interested in access to tools that will help them infuse the most current technologies into the classroom." Since 2006 IBM's Academic Initiative Program has provided free access to a vast set of curriculum programs and course-ware support to universities that are advancing

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enterprise curriculum development projects through a Faculty Award Grant [IBMFA]. The intent of the award program is to promote course-ware and curriculum innovation to stimulate growth in disciplines and geographies that are strategic to IBM. The grants are cash awards and are allocated annually. The current maximum award to any one recipient is 40,000 USD per year. IBM Faculty Award Grants are not contracts and no intellectual property rights are stipulated. IBM strongly encourages all work to be placed in the public domain.

A more recent example of a successful collaborative university-industrial effort to improve education with IBM involved Marist College, located in Poughkeepsie, New York began in 2006. Marist College is currently offering a certificate program called “On-Demand with Enterprise Systems.” The certificate program is a post graduate program targeted for career professional development, in order to improve their understanding of enterprise operating systems and applications. The program is unique in that it is taught by recognized industry experts, some of which developed the technologies being taught. The certificate program is delivered 100% on-line yet still provides experienced-based learning through access to the very latest System z processor located on campus [CCODC].

Most recently, in April 2010, IBM presented a paper entitled “The Emerging Role of Software Testing in Curricula” to the IEEE Transforming Engineering Education conference in Dublin Ireland regarding the previous year’s efforts to produce a software testing curricula within IBM for use by academia [TEE]. The paper presented was in direct response to the identification of the growing enterprise computing skill gaps, and a lack of software testers with a “T-shaped” knowledge profile.

Other companies and universities have certainly recognized this issue as well. They too have realized the need to address new market requirements for “T-shaped” knowledge profiles. Mobile Collaborative Education Consulting Company, a university consulting company based in CA, presented a proposal the University of Maryland Eastern Shore (UMES) aimed at launching an Enterprise Systems curriculum infusion program in February 2009 [UMESIBM]. The primary focus of the program was to develop a multi-interdisciplinary program designed to produce graduates with a “T-Shaped” knowledge profile. , each of whom draws breadth from science, engineering, business, management, mathematics, operations, economics, social sciences, and business anthropology. Ultimately, the decision was made to begin by collaborating across the Computer Science, Business, and Engineering departments to design a multi-disciplinary curriculum infusion program. Prior to these efforts, as part of the IBM System z Academic Initiative, a faculty grant for $30,000 was awarded to accelerate the introduction of the first enterprise computing class at UMES (Introduction to z/OS).

Since the publication of the preceding paper regarding the IBM effort to construct a software and hardware test curricula at the IEEE Transforming Engineering Education conference in 2010, there have been numerous interested universities that have contacted our team in support of this effort with many seeking potential future collaborations in that area. Coincident to those solicitations for collaboration, MCEC approached IBM with a proposal to work side-by-side with their engineers and develop an Introduction to Enterprise Systems (Hardware & Software) Testing class to be delivered as part the UMES Enterprise Systems Program. It was this proposal that was ultimately accepted.

3.2 Content Creation

While the development of specific process discipline skills is primarily expected to be performed by the corporations that hire new employees, it is becoming extremely clear that universities must play a larger part in enterprise skills development in order for corporations to enable their newest employees to contribute effectively (and thereby improve that corporation’s ability to compete).

The approach outlined for test engineering education in “The Emerging Role of Software Testing in Curricula” [TEE] provides the fundamental model for creating process discipline skills for use at

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universities. Process discipline skills are best identified by those experts with years of technical experience in industry. For example as outlined by Astigarraga, et al., the content creation of the curriculum can be accomplished through a specialist-laden, volunteer, crowd sourcing technique. In the documented approach, content was developed for each unique phase of software testing by a team of experts in that phase. Each team also had a technical coach to ensure that overall progress was being made, as well as facilitate resolution if there were technical issues encountered by the team. The role of this technical coach with project management skills was critical in the success of assembling the content materials for the test phases. Volunteer creation of this content was performed over an 18 month period from January 2009 through June 2010.

The primary output of the crowd sourcing effort was a set of documents outlining each testing phase, and its uniqueness within the software & hardware enterprise computing arena. That information, along with the supporting identified text books, were used as input for the second phase aimed at the creation of a consolidated Introduction to Enterprise Systems Testing class.

4. Collaboration Logistics Overview

With any collaborative effort, it is best to describe the collaboration expectations up front, from each part involved. This section will describe how the UMES/IBM collaboration came to pass, as well as the logistics involved in the collaboration itself.

While logistics are seldom a glamorous topic when describing collaborative efforts, we have included this section to help shed some light on best practices for making a university/industry partnership work effectively. Such a partnership is a large undertaking and should be entered into only by the well informed.

4.1 Selecting a University Collaborator

The course-ware materials developed by IBM software test experts from the content creation stage of this effort are IBM Intellectual Property which was intended to be shared across university partnerships and partners in the business services industry. The authors had placed a call for forming partnerships with industry in the area of curricula and course-ware.

Upon completion of the content creation by IBM experts, the development phase for curriculum ready materials was planned to start in earnest in the fall of 2010. IBM was approached by several institutions after publication, and ultimately selected UMES as the partner in this endeavor. This section sheds some light about how this came to pass.

The University of Maryland Eastern Shore (UMES) is uniquely positioned to take advantage of the opportunity. UMES is authorized by the State of Maryland through the Maryland Higher Education Commission (MHEC) to offer bachelor’s degrees in 32 areas, master’s degrees in 10 areas, and doctorate degrees in seven areas. UMES is a teaching, research, and doctoral granting institution that nurtures and launches leaders in a student-centered environment. The university is accredited by the Middle States Commission on Higher Education (MSCHE).

The School of Business and Technology (SBT) is one of four academic units at UMES connected to the overall structure of the University. The School of Business and Technology is home to approximately 1,200 majors. SBT is comprised of five departments: Business, Management, and Accounting; Engineering and Aviation Sciences; Hotel and Restaurant Management; Mathematics and Computer Science; and Technology. UMES’ enrollment as of Fall 2008 was 4,290 students, of which the SBT enrollment was 1,104.

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Conversations with IBM and many of other UMES industry partners, such as Depository Trust Clearing Corporation (DTCC), whose board of directors includes representatives from virtually all of the major investment and commercial banks in the United States, suggests a general dissatisfaction by industry toward enterprise and legacy computing systems curricula at universities.

During the spring semester of 2005, representatives from IBM visited the UMES campus for the first time and conducted several informational seminars and interviewed over 20 of our Accounting and Computer Science majors. Although, the IBM representatives were very favorably impressed by basic academic acumen they indicated that specific knowledge in supply chain management techniques and related technologies would significantly enhance their marketability within IBM and the industry in general.

By joining the IBM Academic Initiative in 2008, UMES faculty and students gained free access to IBM software, course material, training and curriculum development, as well as access to an IBM System z computer (z10) through the Dallas Innovation Center. But perhaps equally important, by partnering closely with IBM, UMES will also have a first-hand view of current industry philosophies and trends to help keep the direction of its own curricula soundly grounded in real-world insights. This is an element that can be missed in more isolated academic scenarios—a gap IBM has stepped up to remedy. Mills adds, “We must help ensure that the students of today are prepared to be the technology leaders of tomorrow.”

As a result of these ongoing discussions with industry, the university is currently infusing enterprise computing technology in selected course offerings as well as introducing a legacy-system-focused Information System major in the Department of Mathematics and Computer Science. The partnership with IBM to infuse new enterprise curricula including coursework in systems testing provides an opportunity to significantly enhance offerings within the university’s Computer Science core constituency group while at the same time strengthening the opportunities available to students pursing many of the other degrees offered.

4.2 Funding Model

Many of the advantages, and perhaps more importantly the disadvantages, of collaborative models between academia and industry are outlined in Lisa Jones’ survey paper expressing commonly held views as derived from the literature in the "Advantages of the Collaborative Relationships", and "Disadvantages of the Collaborative Relationships" sections respectively [UIRC].

The funding model the collaboration used was somewhat unique and there were various sources and a significant amount of volunteer efforts. In the fall of 2008 the IBM STG test community embarked on building an introductory class on testing to be used at an undergraduate level the economy had just recently taken a turn for the worst and getting work like this into corporate budgets was not possible. The community decided to self-manage content creation of the course and since it was self-managed the decision was taken to pursue a university when content was complete. This freed the content creators from rigorous deadlines and the need for formal funding.

In 2010, after a critical mass of course content was completed in rough form, IBM funded a student internship and an instructor as an IBM supplemental employee to make the IBM-created content a viable course while simultaneously exposing the student and instructor to the hands-on testing skills required to teach the class. UMES funded a consultant from their existing budget for additional activities related to project management as well as marketing the course-in-preparation to the student population in order to secure early enrollment for the inaugural class in spring 2011.

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Volunteer efforts of IBM engineers continued throughout the process. The volunteer activities performed by IBM were expanded to include travel by IBM engineers to the UMES campus in order to engage with students and promote the testing discipline.

This mixture of funding is planned to continue with additional faculty grant nominations specifically aimed at testing.

4.3 Personnel

It took many people to facilitate the collaborative effort of this joint project. This section will outline the various roles we identified and how they fit into the overall collaborative effort. Though the various roles listed here may not require such strict separation, this was in fact the model used. We strongly recommend identifying roles and responsibilities clearly at the outset of any similarly scoped collaborative effort.

The Industry Liaison (IL) role is to ensure that the partnership is firmly rooted in culture of both the industry and academic partner. In the case of this initiative this is done by driving the industrial skill curriculum infusion process, building strong bi-directional relationships with professors, instructors and administrators, serving as and providing guest lecturers in selected areas of expertise, and ultimately using his/her political clout within the industry partner's organization to convince its human resource and hiring managers to steer internship and full-time employment opportunities to the partner institution. A discussion of the champion more specifically tied to corporate venturing is offered by Venkataraman et al. [PIROCV], resulting in four types of championing roles: championing ideas, championing opportunistic behavior, championing resources, and championing incorporation.

The IL must possess the managerial stature, political skill, and technical know-how to play each of these critical roles at different times in the life of the partnership.

To ensure that the IL can achieve the desired infusion of new and pertinent curriculum on campus, a single point of contact to act and speak on behalf of the university should be appointed (as described below as the University Industry Champion). This candidate should be an appropriately empowered university employee or agent thereof. The candidate fulfilling this role will improve overall communications between the university and the industry partner by providing a consistent and central point of contact at the expense of minimal latency by disseminating information through a centralized source. These relationships should endure long after joint deliverables are met and require relevant follow up activities long after the joint deliverables are complete. In the case of the joint project discussed in this paper, the role was fulfilled by an independent consultant on behalf of the university.

The University Industry Champion (UIC) is a critical member of the collaboration team as they are responsible for representing the university and all of its vast interests in advancing that industry on campus and providing opportunities for students with interests therein. This person must have a great understanding of university politics and infrastructure, the accreditation process, and a strong relationship with students on campus. A key part of the UIC's role is to be a strong mentor for all levels of students from incoming freshmen to graduating seniors.

Likewise, it is essential to appoint or contact someone to serve as an Industry Campus Executive (ICE) for the university. This person should be an industry employee empowered through management to mirror the role of the Industry Liaison. This will provide a clear concise voice for the industry partner while acting as a central synchronization point for university communications. The ICE and the IL are the main communication pipeline of the collaboration model. They also assess progress frequently to ensure that the most critical checkpoints are achieved. The ICE is responsible for the day to day campus activities including joint curriculum development, scheduling industry guest lecturers at the university, and managing recruiting activities across organizations.

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The Industry Executive (IE) is the main industry executive in the relationship and handles partnership possibilities such as grants, awards, research, internships, etc. They also interlock with senior level executives at bother the university and within industry. They provide the muscle behind the ability to achieve the vision of the collaborative team.

The Content Creation Lead role oversees the production of information of structured and unstructured content into a course. This role is analogous to a director in a Hollywood production. They need to be familiar with Academic instruction methods, trends, techniques, and have a strong grasp of the material being synthesized into coursework. They oversee the final product creators day to day activities, set the pace of content finalization, and generally piece together the cohesive narrative that makes up the course. While not strictly necessary, we found that in many instances it was beneficial to have the content creation lead physically co-located with the final product creators. This enabled quick turn around on design and layout questions, as well as those questions requiring a level of domain-specific knowledge needed when the raw content, as produced by the first-pass content creators, was not sufficiently detailed for this phase of production. They must ensure appropriate examples and anecdotes are added to keep the course lively and entertaining while reinforcing the general or abstract concepts presented. The final task of the content creation lead is to ensure the finished product looks like it was designed and produced by a single expert, in a single narrative voice and style.

Another key role in the collaboration process is the Final Product Creator. The members that make up this team are tasked with turning the raw knowledge into a consumable product worthy of in class instruction and present it. This team distills information and content into a single cohesive teachable unit. The skills needed for its members include strong writing, grammar, punctuation, and presentation skills. Above all else, this role requires an ability for knowledge synthesis, independent research to follow up on gaps in the expert generated material, and graphic design and presentation making ability to produce the polished content. The key here is the importance of tacit knowledge and the means of attaining it. Overall the ability to communicate through effective speaking is equally important as the ability to write effectively to the members of this team.

Though the final content creators are pivotal in producing the completed final content, they stand on the shoulders of giants. To generate the raw input required to create a university course curriculum, sponsored by industry collaboration, someone needs to mine the knowledge of the experts within the industry partner. The task at hand is to take a corpus of knowledge, be it internalized skills, experience, papers, text books, etc and produce modular, and reasonably structured content. This work is not "camera ready" and is generally considered too rough for external release, but is consumable by final product creators as their input. The focus is on content and not style. These contributors are typically experts in the field as practitioners or academics. These participants wish to confirm the validity of the information that is built into the curriculum. They may have a desire to refine the material further, while such work is prevented by regular roles and responsibilities within the industry.

The roles of the instructor or instructors are to review the content as it is finalized to ensure that it meets the standards for teaching at the university. This task includes ensuring the right level of the details is present in the material as well as ensuring any supplementary course artifacts (tests, handouts, syllabus, etc) meet the standards set forth by the academic participant institution. This role is pivotal because the content is being generated with an industry partner who likely has little knowledge of university specific requirements such as academic calendar, testing requirements, syllabus guidelines, etc. We recommend that at least one instructors act as a Final Product Creator as was done in our collaborative effort to ensure that standards are enforced while contents are being produced, rather than attempting to remedy any issues post-creation.

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The role of the project manager is to coordinate the deliverables and interactions needed to produce the content. This includes keeping the schedules straight for all the other contributors on the team as well as defining progress review meetings between the university and industry partners. This person is also responsible for ensuring deliverables meet requirements specified in any deliverable agreement documents. As there are many people to coordinate in this process, and numerous status issues involved, this role requires a dedicated figurehead.

Though the list of roles here is not exhaustive as it pertained to our collaboration, it is the recommended minimum subset for success.

4.4 Collaboration Management Structure

A critical success factor for any partnership is the management of the project and the ability of management to handle any complex situations as they occur, even when occurring with great frequency. The team structure needs to facilitate communication paths to address issues as quickly as possible. Defining leadership roles with extreme clarity makes the collaboration viable. Figure 1, shown below, outlines the various main roles as performed in the IBM/UMES collaboration. The main participants in the model are the Industry Executive, the Industry Campus Executive, the Industry Liaison and the University Industry Champion. These core roles provide the leadership infrastructure of the partnership and collaboration. But the effort involved a much broader team especially in the context of management support and curriculum construction.

The overall team structure, as outlined in Figure 1, shown below, was not only important in the construction of the course, but was also critical as a structure for responsibility and accountability. The sponsoring management team provided funding and support which allowed the industrial team members the time and resources to collaborate with the university in the creation of the course curriculum. The project directors were the leadership group that worked to manage relationships with the IBM Academic Initiative along with test discipline experts and consultants. Those project directors also gave guidance, when needed, to the content creation lead and project manager based on any changing priorities during the project.

The content creation lead, the project manager and the University Industry Champion provided the direction for building the course and managing its progress on the short six month schedule. The university student, in an internship role, along with the proposed class instructor and the lab and homework consultants (primary content creators) were the work horses of the course development effort. Their close interaction and daily communication with the content creation lead and the project manager of the effort was another critical success factor of the collaboration.

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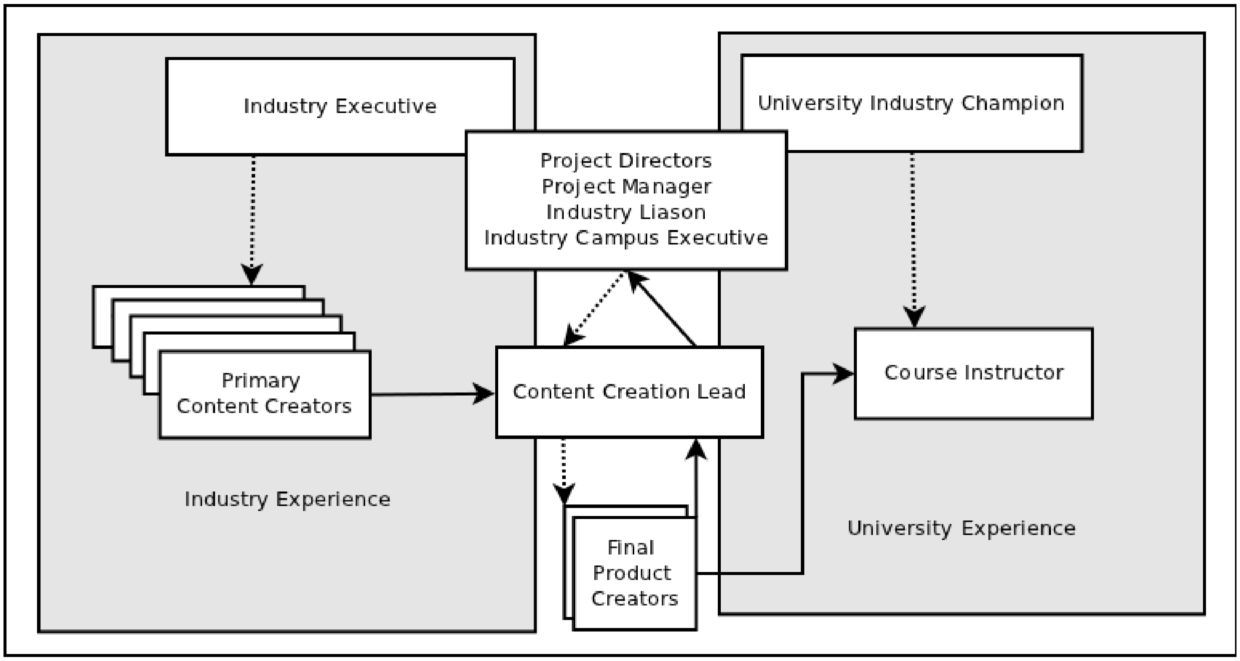

Figure 1 - Collaboration Team Structure

Note that solid lines indicate deliverables. While dashed lines indicate strategic direction.

As shown in Figure 2, transitioning from the industry phase to the collaboration phase occurs when industry has a body of work that it feels should be taught in educational settings. It is a responsibility of academic institutions to assist industry by teaching organizations how to teach their area of expertise. Finally, it is the responsibility of the university to deliver the content to students in order to produce high-value graduates from an industry perspective. The initial complexity of this process stems from the need to teach industry how to teach. Once this has been accomplished, the goal is a streamlined delivery model from subject matter expert to university student by way of university professors and the industry-delivered materials.

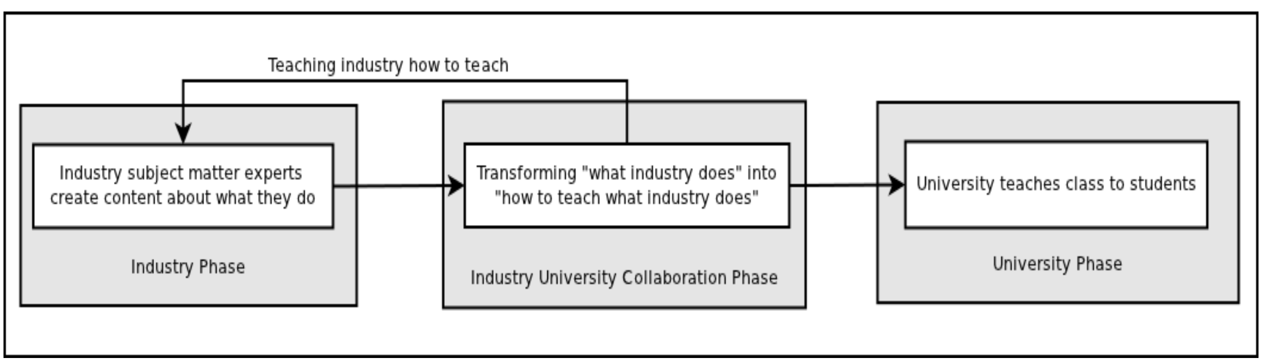

Figure 2- Delivery Model

5. Project Management

Project Management is key and paramount to the successful delivery of any project and especially one as complex as this. These projects had to be broken down into manageable process groups, knowledge

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areas, and professional roles and responsibilities had to be identified across the vast hardware and software testing groups. The use of a mainline Project Management tool is strongly recommended where tasks and activities, key checkpoints and milestones, all stakeholders (primary and secondary), perk charts, and resource leveling can be managed.

5.1 Industry Partner Time-line & Deliverables

A very high level project management plan was initially developed to define the scope of this effort the key stakeholders identified. Next, key tasks, activities, milestones, and deliverables, had to be established. A consensus between cross-functional teams (hardware & software test) had to be reached with respect to a time-line for delivery. As the project evolved and became more inclusive, the plan incrementally expanded.

By using an Agile content development methodology, the project retained the flexibility required to develop over the six month development cycle while containing scope-creep and meeting deliverables. Table 1 below outlines the major checkpoints and tracking activities for ensuring progress.

Industry Activity	Plan Target	Actual Completion	Academic Activity
	5/15/10	5/15/10	Identify Lead Instructor
	6/11/10	6/11/10	Enterprise Curriculum Development/Training
Joint Project Kickoff Session	6/11/10	6/12/10	
1st Pass Lecture Slides & Course Outline	8/11/10	8/11/10	
UMES Course Syllabus Outline	8/11/10	8/11/10	
	9/01/10	9/01/10	Syllabus Outline Input Received From IBM
2nd Pass Lecture Slides & 1st pass exams	9/10/10	9/10/10	
	10/01/10	10/01/10	Syllabus Outline Approved By UMES
	10/05/10	10/05/10	Develop Class Schedule Time
SW Test Process Map	10/10/10	10/10/10	
1st Pass Labs & Final Lecture Slides	10/15/10	10/15/10	
	10/15/10	10/15/10	Class Added to Pre-Registration Schedule
2nd Pass Labs & Final Draft Exams	11/15/10	11/15/10	
HW Test Content & Process Maps	11/15/10	12/17/10	
Final Executive Review	1/11/11	1/11/11	
	1/12/11	1/12/11	Completed Syllabus Received From IBM
	1/15/11	1/15/11	Labs / Exams / Lecture Slides From IBM
	1/24/11	1/24/11	Pilot Class Launched: 1st Day of Class

Table 1 - The table above is included as a broad measurement of the timeline involved in each phase, while illuminating project milestones as were foreseen at the start of the collaboration.

The effort began formally on June 11, 2010, and was completed on January 12, 2011. The pilot class launched at UMES on January 24, 2011, and was launched shortly thereafter internally at IBM. This timetable was accelerated and we would not recommend any shorter duration for projects of this scope as we feel it would be unlikely to produce high-quality results.

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5.2 Academic Time-line & Deliverables

Likewise, in order to have the ability to merge the externally developed courseware into the university's class scheduling system, a comparable university Project Management Plan (PM) had to be developed to manage the courseware integration into the degree required program.

Both the industry partner and academic project managers must be strategically aligned to ensure a smooth deliver and transition of the class into the university system. Table 1 also lists the major checkpoints that were used to track the plan ensure the deliver and launch of the pilot class from an academic perspective.

6. Evaluation of Created Course Content

This section of the paper describes the efforts undertaken by both UMES and IBM to assess the outcomes of this collaborative effort.

6.1 Deliverables

The collaboration between IBM and UMES produced a large amount of academic materials that can be used as a whole package or in a modified form to introduce the aspects of Enterprise Systems Testing through an academic environment. The overall time-line for producing "camera-ready" materials for instruction at the university was approximately 29 weeks. The artifacts of the course included approximately 1253 lecture slides that were distributed over the 15 week period of the class. Please see the Appendix for the sample detailed course outline. These lecture slides were supplemented with twelve short prerecorded videos from experienced professionals in the area of enterprise system testing. Certainly if the area of discipline was something other than test, experts from the subject area of interest could have been chosen accordingly. The prerecorded shorts included topics such as careers (ranging from early to mid tenured employees through those of extensive technical and executive experience), test phases (including unit testing, function testing, SW and HW system testing, performance testing and usability testing), and also insight into the importance of testing (such as ensuring data integrity).

The course material also included materials by which student comprehension could be assessed. Homework assignments related to testing topics were organized to be distributed roughly each week of the class, while laboratory assignments were assigned every two to three weeks for classroom efforts. Instructor versions of the assignments were also provided for use as the answer key and with grading guidance. Examination questions (with corresponding answers) were also provided to allow the instructor to design and build their own version of a mid-term and final exam.

6.2 Evaluation Models

Virtually any educational endeavor for course content creation should be set out with strict evaluation models in mind. This is especially the case when working a joint deliverable produced in conjunction with academia and industry. It is highly likely that industry and academia may use orthogonal means of success measurement, as success may be relative to each. In order to evaluate the success of a collaboration model, similar to the one proposed above, one must perform in-process reviews of the curriculum as it is being administered to an audience of students. A simple post-mortem activity is not sufficient because it does not provide the amount of time needed to iteratively make updates and enhancements to the curriculum. The class or curriculum would not be deemed "official" until one or two successful pilots have been undertaken and evaluated.

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This section will describe the ongoing and planned mechanisms for objectively measuring the success of this project.

The course is currently being offered within IBM in a pilot class consisting of hand-selected students with high-applicability of the subject material. Students in the IBM classroom are meeting on a schedule comparable to that of the university students with similar course frequency and duration. Each of the candidates enrolled in the IBM course are performing professional test roles as a new hire, or someone who has been with IBM for some time and has recently transitioned into a test role for the first time. Internally, IBM has used face to face and classroom feedback directly from the student body on their opinions and concerns. In addition, student feedback forms have been distributed approximately every five weeks (3 per semester) to get private feedback on textbook effectiveness, instructor effectiveness, the relationship of the text books and the lecture slides and an overall feeling for the course. At the conclusion of the course, homework, lab assignments and examinations will be reviewed in close detail to ensure their clarity and relevance. Evaluation records for homework grades, tests, and labs are being kept and analyzed using standard methods (mean, median, mode, standard-deviation) to ensure the exams, homework, and other student measures are fair and reasonable.

At UMES, the course is being taught with identical materials, to students who have elected to enroll in the course as a free elective. First, the students that have registered in this class are from different backgrounds, such as computer science, business and engineering majors. For the evaluation, the university course instructors will compare analytical data about the performance of the students. The performance of the student is based on tests, class participation, homework and labs Also the instructor will collect typical student feedback forms provided during the course (at the mid point and the end). There will also be student feedback forms for the instructor to quantify notions of subject matter material quality from instructor quality. Meanwhile there is an open discussion with the student inside and outside of the classroom. All measurements obtained are shared with the IBM team at the end of the course. In addition, an independent third party can correlate the results and provide analysis and feedback for the final evaluation.

Once all of this input is analyzed, modifications to the materials (slides, exams, homework, and labs) must be made to provide a “true camera ready” version to the IBM Academic Initiative for broad university distribution. It should be noted that more than 30 students enrolled in the inaugural class at UMES, and there have been a total of 16 UMES enterprise job placements (to date) recorded for the current 2010–2011 academic year. This is a marked increase over previous years.

7. Future Work

Future phases of this work include placing the content created onto a publicly available portion of the IBM Academic Initiative website. This will be done after the initial validation of the content is complete and preliminary adjustments are made based on the initial round of feedback.

The next phase of content development is currently in progress within IBM. For this phase, software and hardware test content creation is being generated at a much deeper level than was done for the introductory course. The objective is to provide instruction that would allow students to complete the course with knowledge that could be put to work immediately within industry without significant test discipline training. In addition, the need for subsequent courses will be reviewed over time. The STG test community is once again volunteering to build the next three classes over the next three to four years. The created material is planned for use by IBM test engineers as part of a test services asset.

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8. Conclusion

In conclusion, both IBM and the University of Maryland Eastern Shore feel the collaborative content development approached herein was a successful endeavor. The university commends the approach and active industry involvement to better train students to enter the highly competitive modern workplace. In addition, IBM formally recognizes the benefits to all of our industry partnerships across all of our enterprise computing clients by the infusion of talented students who demonstrates the T-shaped model of career development. Each joint deliverable participant believes the documentation of the experimental process used, as well as the recommendations put forth in this document, will be of great value in supporting future content creation activities within industry, within academia, and across each in partnership.

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John Thompson is the owner and President of Mobile Collaborative Education and E-Learning Consulting, an independent consulting company based in San Jose, California. His company provides consultancy services to universities interested in developing interdisciplinary curricula for the infusion of Enterprise Systems (ES) technology by creating commercial and philanthropic partnerships between universities and major corporations. He currently serves as Curriculum Infusion Consultant and Partnership Liaison to the University of Maryland Eastern Shore (UMES), located in Princess Anne, Maryland. Most recently, he created a strategic partnership alliance between UMES and IBM’s System and Technology Group (July 2010) which led to a joint collaborative effort to develop an “Introduction to Enterprise Systems Testing” class. The class was completed in January 2011 and successfully delivered during the Spring 2011 semester at UMES. He has consulted with a number of universities across the country to infuse these types of technology programs.

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Shari Thompson is a recent IBM hire. In July 2008, she accepted a job position with IBM's Storage Technology Group located in Poughkeepsie, New York, working as a Development Test Recovery Engineer. Shari has an undergraduate degree in Business Information Systems, and after she received her degree from the School of Business, she was awarded a GEM Fellowship (sponsored by IBM). She attended Rensselaer Polytechnic Institute (Troy, New York) and in May 2008 received her Masters Degree in Industrial Management Engineering. Since joining the System z Test & Recovery Team, Shari has been given primary responsibilities for the design of enterprise test recovery procedures and virtual power on methodologies for IBM's flagship product.

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Appendix A: Course Syllabus

Week 1: Introduction, Development Models, and Test - The Big Picture
- Syllabus and Course Introduction/Overview, Career Paths in Test
- Development Process Part 1 (w/ Homework)
- Development Process Part 2

Week 2: Testing Overview - Test & Development Divide, Tester Mindset, Where to Start
- Test Development Divide
- Where to Start Part 1 (w/ Homework)
- Where to Start Part 2

Week 3: Testing Overview - Mathematics, Management, Test Plans and Contingency
- Fundamental Mathematical Techniques, Project Management Concepts (w/ Homework)
- Project Management Concepts, Core Principles
- Test Plan Focus Areas & Planning for Trouble (w/ Homework)

Week 4: Injecting Testability, Test Code Reuse, Developing Test Programs, Test Tools
- The Magic of Reuse, Developing Good Test Programs (w/ Homework)
- Tools (w/ Homework)
- In Class – Lab Assignment

Week 5: Unit Test
- Unit Test Part 1 (w/ Homework)
- Unit Test Part 2
- In Class – Lab Assignment

Week 6: Function Test
- Function Test Part 1
- Function Test Part 2
- In Class – Lab Assignment

Week 7: Midterm Week
- Function Test Part 3
- Midterm Review
- Midterm Exam

Week 8: System Test
- System Test Part 1
- System Test Part 2 (w/ Homework)
- Midterm returns to class; post-test review

Week 9: Integration Test
- Integration Test Part 1
- Integration Test Part 2
- In Class – Lab Assignment

Week 10: Orthogonal Defect Classification
- Orthogonal Defect Classification Part 1
- Orthogonal Defect Classification Part 2
- In Class – Lab Assignment

Week 11: Performance Test
- Performance Test Part 1
- Performance Test Part 2
- In Class – Lab Assignment

Week 12: Hardware Test Introduction
- Hardware Test Lecture 1: Hardware Function Test Overview
- Hardware Test Lecture 2: Patch Test Overview (w/ Homework)
- In Class – Lab Assignment

Week 13: Hardware Test
- Hardware Test Lecture 3: Reliability/Availability/Serviceability Testing of Hardware
- Hardware Test Lecture 4: Compliance Testing (w/ Homework)
- In Class – Lab Assignment

Week 14: Overview of other Testing, both functional and non-functional
- Lecture: Beta Test, Algorithmic Verification Test, Combinatorial Testing
- Lecture: Usability Test, Accessibility Testing, Security Testing
- Lecture: Service Test, Regression Test, Testing at Scale

Week 15: Finals Week
- Team Presentations and Guest Lectures
- Final Exam Review
- Final Exam

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