Rethinking Network Administration Curriculum Design

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Abstract: Networking has been a popular Information Technology (IT) field for decades. Currently different types of networks, primarily Intranets, are implemented by both industry and academia. There is a growing necessity for colleges and universities to provide effective network administration (NA) curriculum and practice to meet the myriad of emerging industrial demands, especially in a cloud environment. However, most curriculums related to network administration for IT degrees are unable to provide state-of-the-art network administration concepts, content and practices. We address curriculum deficiencies, with new depth by proposing a methodology that creates the best practices to improve teaching and learning of network administration.

Introduction

The Industrial Revolution perpetually moves forward leaving the old ways: methods and technologies to stagnate before finally becoming irrelevant. The same stagnation is being felt in the education of Information Technology (IT) area, such as Network Administration field. Its greatest dramatic change has been with the advent of the "cloud computing" that is spurred by the new generations of phones and other mobile devices. Presently the management of IT departments has been compromised by the deficiency of experts who can adapt with the complexity of the changing technologies. Without the proper delivery of training using current NA technologies, many graduates will inefficiently adapt to the rigors of work and change. These students in NA field lack the skills or resources needed for additional training and never gain the self-efficacy required for job performance. In addition, they are unable to find the time, money or resources to learn the technologies demanded by emerging industry. In reality, this is due to a lack of effective NA education methodology which can be solved by applying an elastic system with the best practices of: educational curriculum support, network technology, engineering and management, which can make the NA curriculum effectively adapt to the drastic changes of industry requirements. Consequently, college education in NA needs to adapt and promote viable curriculum innovation in order to improve the efficacy and preparedness of the next generation network administrators.

The students and faculty in NA field must be trained in carefully designed programs that consider constantly shifting demands brought by cloud computing and other emerging technologies. These advanced skill sets demanded by industry are required before the student's graduation. To gain effectiveness, students need to work at projects consistent and coherent with present technology. Any breakdown in this system will trigger dissatisfaction with studies, additional failure of the educational system, and the loss of personnel efficacy. Eventually, it will result in an unquenchable demand for IT experts in the workforce.

The urgency to create relevant NA program design is indicative of a lack of collaboration between industry and academy. A collaboration that concurrently sets goals through an optimized feedback system that openly voices industrial and educational venue concerns. To be concise, NA students need to build self and organizational efficacy through project responsibility. Student learning experience will improve when students are able to experiment with relevant technologies in an environment where failure is not frowned, but nurtured and expected as part of the learning process. For the system to succeed the NA program, it must introduce emerging technologies which can be applied directly to their respective industries.

A satisfying but incomplete NA training approach requires a minimum of technologies and methodologies including:

- Project based learning that reinforces NA knowledge
- Use of NA simulation tools
- A learning outcome model based approach
- Designing of competitive and collaborative learning systems
- Hybrid content delivery using both hands-on and online strategies
- Design oriented curriculum that improves students' efficacy – reducing fear and raising the chances for success when working on the design and completion of future projects
- Using online platforms to effectively deliver hands on NA lab experience
- Delivering a curriculum immersed in both current and emerging technology that is readily amenable to change

Our goal is to develop an effective NA curriculum design that ensures proactive delivery of the best curriculum by using the best practices as documented by the systems gathering "lessons learned". After researching many curriculum designs, we decided on adaptable but technology specific method which can be applied to any NA curriculum. For curriculum content, we propose current topics while establishing a mechanism that constantly questions the efficacy of the delivery. We propose strategies that include hybrid teaching and fully online based methodologies. To cultivate the delivery of labs and projects we propose online tools and web-based lab methods. We also aspire to incorporate best industrial experience, practices and "lessons learned". Effective methods of documentation will help nurture new concepts and increase training efficacy which will ensure better NA practices into the 21st Century.

For clarity, we divide the paper into the following sections: Literature review, Curriculum design, Best Practices, and Lessons Learned, Survey Practices, Survey Results, Conclusion and Future Research.

Literature Review

Historically MBA programs have depended on project based learning and often through case studies published by both Harvard University and Yale University. More recently Electronics Engineering programs have espoused similar project based learning. The findings show that the best educational methods force students to cooperate using their knowledge of interdisciplinary subjects to solve problems within an environment using "incomplete or imprecise information"[1]. For decades the instruction of Engineering and other disciplines have used "Capstone", where final projects are used to reinforce skills and foster design[2]. Since 1990 the National Information Assurance Education and Training Partnership Program (NEITP) has been responsible for information assurance, awareness and training. They issue the IT education guidelines for NA educators. NEITP guides education institutes through the National Centers of Academic Excellence in Information Assurance Education and sponsors the National Colloquium for Information Systems Security Education and the "National Information Assurance Training and Education Center".

In 2008 "The Joint Task Force on Computing Criteria"[5] composed of the Special Interest Group on Information Technology Education (SIGITE), The Association of Computing Machinery (ACM), and the Institute of Electronic and Electrical Engineers(IEEE) completed its study that sets recommendations for Bachelor Programs in IT education. ACM's recent guidance on IT curriculum design[6], did not include the design of NA curriculum.

Additional and extensive research in the development of educational programs concerning NA security found that the systems required for training were comparatively lacking[3]. These results demonstrate that students were unable to meet industry and governmental standards for performance.

Previous to NEITP, a study by Auburn University Engineers documented a multidisciplinary approach[4] to teaching Electronics Engineering (EE) of which many skills and methodologies are required by NA educators. The substantial documentation of project requirements seemingly specific to engineering we found to be easily adapted and compatible to NA educational programs. A system that works pluralistically with engineering programs may be the new norm.

Using a similar methodology, a multidisciplinary learning approach was further substantiated in a 2006 Technical University of Madrid study showing that students were not only happier with their study but were better able to complete tasks and retain information. Teachers were better able to offer help and gained more free time for critical duties. The project based learning strategy posed real problems that taught students to deal with imprecise information, definite management objectives and learn cooperation when dealing with interdisciplinary issues[4].

Coursework in software engineering, closely tied with NA, was evaluated at Taiwan's National Chiao Tung University. Students delved into the booting of operating systems and memory allocation for virtualization. By using a virtualized 386 processor students were able to build systems, create interrupts to utilize memory and build drivers for peripheral hardware. These same technologies are the core of IT field and closely related to NA[7].

Through cooperation between the Universities in Belgium, Slovenia, Spain, Finland and Portugal students were able to institute a globalized program using current technology to integrate different networks functionally. The knowledge delivered not only encompassed NA but multimedia, computer science, telecommunications and engineering. The required competencies of system management, mobile wireless technologies, infrastructure, on demand media, security and storage were further developed in an operational program. Affiliations with industry, faculty and students gave feedback on the efficacy of the educational program[8].

As early as 2000 a network simulation tool (COMNET III) allowed students to arrange network building blocks through the use of a GUI to teach the OSI/ISO Networking Reference Model Layers: Data Link, Network, and transport. Subjects included WAN LAN packet switching, frame relay on Ethernet, and Token ring. At the time this simulated teaching method was very successful and cost conscious[9]. More recently, similar teaching methods have been used predominately for the study of NA in vendor supplied training such as Cisco. The training delivered in modules is very expensive for either individuals or corporation.

Constructivist methodology of student centered education was studied in Hebei University and North China Electric Power University. Both amended the idea that student based learning was superior[10]. One approach to use a simple on-line computer interface that could teach the very different NA technologies[11] is proposed in the First International Workshop on Education Technology of Computer Science 2009. A study at the 2009 International Forum on Information Technology and Applications further suggests that teachers are the key to improving education but are too encumbered to attend courses that should be mandatory and required for improving their content delivery to students[12].

A 2007 National Science Foundation Study attempted to assure educators that the greatest problem facing industry is the procurement of IT professionals[13]. Other studies pointed directly to the lack of female participation in IT related training [14] [25]. Armstrong Atlantic University tried to revitalize its NA system by merging the technologies of Windows Server with that of Cisco Routing. They were successful in attracting freshman interest in the NA curriculum but did not consider the female contingent[15]. Applying actual technology was proposed in a study starting from 2005 that required an internship. The internship in turn, generated more demand for interns[16]. Not long after a study of graduate students assessed courses of Internship and the evaluation of using group projects for learning. The graduate survey response shows that "group projects, blending programming and theory, and hands-on lab activities is the as most helpful" [17].

While feedback on educational programs has been sparse to nil the government has established crowd sourcing as a means to gain citizen participation[18]. Our NA programs would benefit from such crowd sourcing endeavors as part of surveying and feedback. Crowd sourcing for NA feedback seems even more urgent when we consider the hiring preferences of IT personnel with certifications. The reasons for such behavior are not fully understood considering that such certifications do not necessarily mean the employee will do a better job[19]. Feedback is imperative concerning certification evaluation and should be considered even more urgent.
Last on our literature review is the use of VMware and other systems to allow students to develop their own virtual networks and successfully work in them. A graduate study follow-up showed the efficacy of such a program[20][22]. A model based approach[21] was successfully implemented for engineering students who were given open lab time to finish their projects rather than using a rigid lab environment. Such teaching methods along with hybrid course and the group/people centered education[23-24] are increasingly being required by industry and demanded by students.

NETWORK ADMINISTRATION CURRICULUM DESIGN

While many different methods have been adapted to improve the teaching effectiveness of NA curriculum, one of the most significant deficiencies of all these systems/teaching models including the studies by the ACM and IEEE appears to be the lack of effective feedback. The feedback channels lack the focus that should be garnered with a more local and flexible system that includes universities, faculty, and most importantly the students and industry that educational systems are meant to serve.

Further, based on the study of existing work on NA curriculum, we found that none alone effectively delivered the outcomes needed to dynamically fit industrial needs. However, schools required graduate students to equip with current IT networking skills and conversant knowledge of NA to enable successful transition and integration into the work force. To combat lost efficacy in NA training programs, our NA curriculum design embeds a feedback system of pertinent and updated surveys for program improvement. Other channels of feedback are inherently incorporated with the promotion of open communications fostered by the survey system.

Overall, the design for effective NA curriculums depends on:

1) adaptability to industrial needs;
2) maintaining the existing effective components;
3) using effective teaching strategies from related subjects;
4) mechanisms that ensure relevant feedback and improve the efficacy of the curriculum.

Based on these criteria, we provide complete solutions for the design of a network administration curriculum, which can be expanded into practice.

1.Open surveys and gathering live feedback

Network administrative programs need a flexible system to maintain discernible objectives. Using a system of constant feedback through the use of formal surveys along with documented informal meetings between students, industry, graduates and faculty.

Preliminary surveys are focused to discern industry needs. Local and remote industry involvement will create a vestment that lends to the students professional development. Perpetual student and faculty surveys, started with school application and completed quarterly are analyzed and compared with industries survey results. As the feedback system is created and maintained openness and request for comments will maintain an open forum and help maintain communications.

Gathering online statistics and understanding federal investment through the use of the Federal IT dashboard will help us recognize trends in technology demands and IT focus. For system effectiveness, general surveys will be open, random, pertinent and online. Open forums will gather comments which can be discussed or analyzed at any time.

Idea generation and feedback should be done in a way which can enhance the project design. After gathering all the feedbacks, the design of NA curriculum adapts the technology changing and reflectively embeds into teaching.

2.Active, flexible and basic online NA training

A simple training system will reinforce the technical basics of NA. The system will cover basic TCP/IP, naming conventions, backup, theory, DNS, topologies, basic user admin, rights management and databases. This system will allow self-study that frees faculty evaluation time. Ultimately it will guide educators to target the student's problem areas.

The online training system should fully utilize the existing training tools, such as Blackboard, WebCT and Wimba et.al. These types of systems also provide effective strategies to organize discussion and team activities. Other tools such as Skype and Facebook should be integrated to make it easier for students, faculty and industry to collaborate.

3. Intermediate level training using programs that emulate NA software and hardware

Traditionally, NA training provided students with network environments which meant purchasing costly hardware and software to build physical labs. Concurrently, the developing trend is to use online emulation software and hardware to reduce costs and increase teaching efficiency. The flexibility of an NA emulator allows students to practice in varying network topologies in a myriad of scenarios. Students are given the ability to arbitrarily customize the network configuration; chose the selections of users and groups; deploy hardware; set up virtual spaces and virtually imitate other environmental and connectivity issues. These flexible emulations are easily updated to meet industries' technical requirements and software purveyor changes [19].

4.Corroborative and multidisciplinary projects

A comprehensive “Capstone Project” with a cooperating industry(or universities) is required. Sophomore students whose interests were previously defined by surveys will be assigned in groups with students of similar interests. The groups will be required to complete a specific project with a participating industry or if motivated, propose a project that is applicable and accepted by the cooperating industry and faculty. The students will not be picked by compatibility or affinity as per best management practice. The NA project, depending on complexity, may require the involvement of students with various disciplines such as electronics or statistics. Students, faculty and business will attempt to complete the project in an agreed upon time. Completion of all-encompassing reports will include formal: surveys, evaluations and feedback along with individual and group evaluations of goal completion. The rating and evaluation process is imperative to the individual student projects and to the NA educational system as well. If goals are unattainable the results will be well documented along with the reasons for failure.

Most projects will require a multiplicity of disciplines such as rights management, data storage, system design, system migration and upgrade, security, mashing, performance issues, WAN, LAN, router configuration, user training and many more. A project plan will incorporate a Program Evaluation and Review Technique (PERT) that will help with time management. Other critical project planning may include:

a) Market research.
b) Needs assessment.
c) Benchmark by comparing with other projects
d) Determine program failure points or weak links and barriers preventing program participation; Proactively developing strategic incentives to minimize barriers and or eliminate their source; Constantly evaluate strategies and objectives
e)Follow project partnership agreements while using best practices; Be aware of what can and cannot be changed
f) Market the changes needed internally for cooperation, validation, feedback and comfortability; Insure participation and training if required. Allow the quality assurance sections of PERT to work; Do all required work inspections

5. Final corroborative feedback and assessments concerning the efficacy of the educational delivery

Specifically, from the NA groups projects team evaluations (non individual), the individuals involved including faculty, pertinent members of industry and school administration.

The final cooperative assessment of non competitive projects should be at a level far above the student projects which the overall system defines.

These assessments need continual refinement so that they can flexibly meet faculty, industry, and students group needs. Those assessments, feedback, surveys, other evaluations and reports should include the evaluations of group dynamics; the best practices and documentation of Network Administration duties; and how the project was conceived, project progress, technical evaluation of work, planning, and successfully learned Network Administration duties. Mistakes or project design failure needs to be well documented and treated critically so these perceived mistakes and failures can be evaluated in the long term. New project data must be correlated with the old project results.

Presentation of surveying practices

Initially, surveying should search for and include data that is both, widely available (broad and specific) to the specific industry segment and also data that is general and encompasses all industries.

Various survey data requires databases that uniquely separates and secures data from industry, discipline and or randomness. Data from questions that are software and hardware specific should not be stored with non focused data.

Even focused surveys need to be separated from project focused and industry focused data. Random survey data should be kept separately from those where the contact courteously completes a survey that includes personal data. Security of some data and openness of others is project critical. Some data must be stripped of personal information before it can be used.

Project specific results should be stored together for future reference by all including the graduating students and open for review by other groups or entities for update and critical comments. Private evaluations will be secured on a need to know basis if they are required at all. An example of this may be failure of group performance due to member illness or a deleterious evaluation from a known source. These items will be handled with serious concern for security. The use of focus groups along with those NA groups need specialized advice on surveying methods. These survey focus group will include the best of management science, social science and engineering science.

While surveying seems very task oriented to some, surveying was designed to work within many systems and disciplines to help prevent bad practices, further openness, improve overall communication and promote decision making. While some projects are required to be particularly task oriented it is essential that the task and grade type orientation does not permeate the project. Additionally our projects are carefully designed to enhance the functioning of IT departments. To do so would mean becoming overly task oriented and make the programs a disservice to all involved.
Gender based research within IT and particularly in NA has shown that the gender gap is steadily growing. This should be increasingly worrisome within our project groups because the issue must pertain to a failure of the education and industrial relationship. Some schools have instituted the use of a program called Alice to attract and help retain females in the IT fields. Feedback from our

project may help determine the efficacy of such software use and determine other packages that may help with learning and retention. Careful survey practices may help to find the root cause of the burdensome gender issue among others.

In general, each NA school group might design different survey and feedback systems based on our criteria to collect both academic and industry input. In the following paragraph, we provide an example survey which could be easily modified to be used in academics.

Network Administration (NA) Initial Class Survey

(circle #) Strongly Disagree = 1 5 = Strongly Agree

1.Did you effectively learn the core topics of:

Network Fundamentals	1	2	3	4	5
Building networks	1	2	3	4	5
Routing Protocols	1	2	3	4	5
LAN Switching	1	2	3	4	5
WLAN Management	1	2	3	4	5
Accessing WAN	1	2	3	4	5
Peripheral management	1	2	3	4	5
Server Management	1	2	3	4	5
Remote Systems Management	1	2	3	4	5
Network Troubleshooting	1	2	3	4	5
Unix (Linux) Systems	1	2	3	4	5
Cloud Management, VMware	1	2	3	4	5

2. Should (NA curriculum be delivered using Cisco's approach or MCSE?

CCNA (CCNP)	1	2	3	4	5
MCSE	1	2	3	4	5

3. Should NA be taught with an online approach?

1 2 3 4 5

4.Should training use web-based network hardware and software?

1 2 3 4 5

5. Should collaboration on project coursework be allowed?

1 2 3 4 5

6. Should a NA coursework be industry oriented?

1 2 3 4 5

7. Should Network Administration courses be designed oriented?

1 2 3 4 5

8. Should coursework be updated at least every year?

1 2 3 4 5

9. .Rate your agreement on the effectiveness of this survey

1 2 3 4 5

SURVEY RESULTS

In this example, we used a survey to collect feedback from Industry and Academy by using the survey example in the previous section. The results are in Fig. 1 and Fig. 2. From Fig. 1, we can see that server management, remote systems management and cloud management are considered to be increasingly important to be covered in NA curriculum. From Fig. 2, we can notify that Web-based hardware and software delivery method will become priority in providing effective delivery strategy.

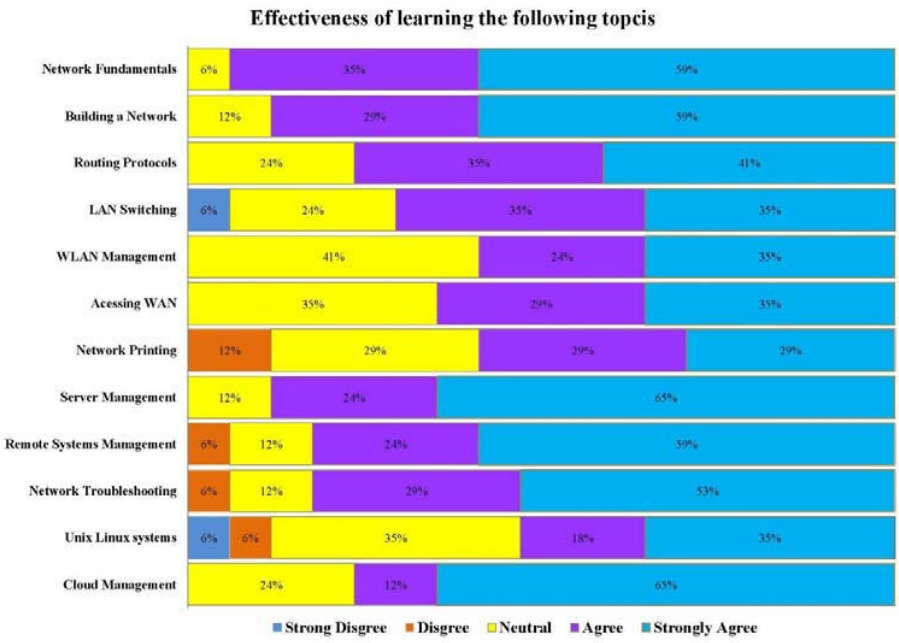

Fig. 1: Effectiveness of Learning in NA Topics

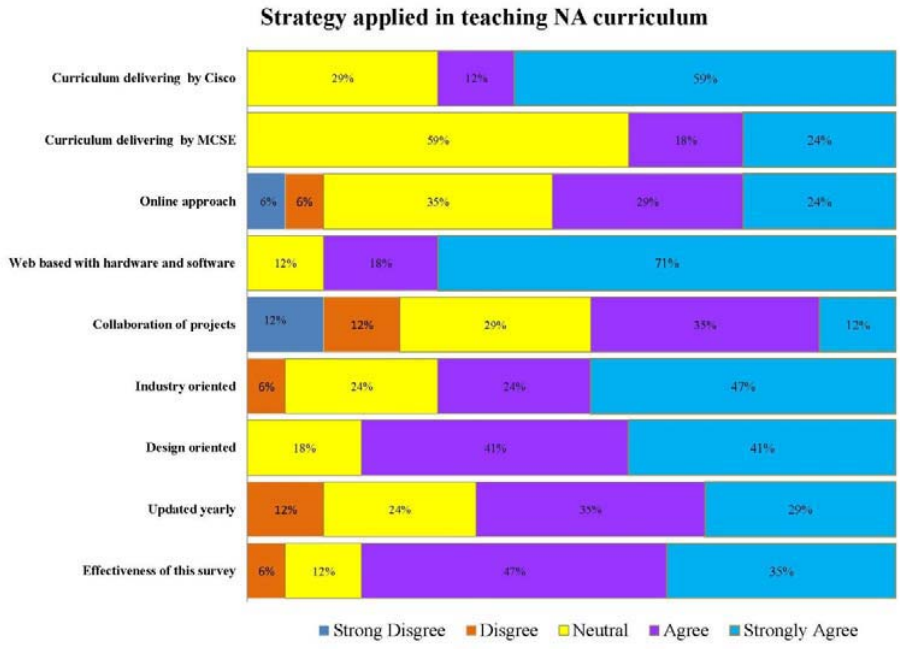

Fig. 2: Strategy Applied in Teaching NA Curriculum

CONCLUSION AND FUTURE WORK

We provided our new practices of designing effective NA curriculums through the use of planning and feedback. These living systems will help NA training in both industry and academics. We also provide NA survey systems when effectively used can support collaboration between academics and industry. With new practices and survey systems at hand, different schools can dynamically adjust their NA curriculum and can dramatically improve the teaching quality in NA field.

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BIOGRAPHY

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