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Incorporating Entrepreneurially Minded Learning (EML) into a Computer Networks Course

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Incorporating Entrepreneurially Minded Learning (EML) in a Computer Networks Course

This paper discusses incorporating Entrepreneurially Minded Learning (EML) into a Networks and Data Communications course. EML is a pedagogy that aims to inculcate the entrepreneurial mindset (EM) in students, specifically the 3C framework of the EM: curiosity, connections, and creating value. EML techniques aim to increase student curiosity, improve the student's ability to make connections between disparate sources of information, and ultimately equip them to create value for themselves and society. Thus, EML is closely related to inquiry-based learning, problem-based learning, and project-based learning. The distinction between EML and these other pedagogical approaches is the focus on a value-creation mindset.

EML is integrated into this course primarily through three frameworks: (1) Developing Connections, which employs risk factor consideration when designing an enterprise network; (2) the Question Formulation Technique (QFT), which focuses on enhancing student curiosity and the ability to formulate questions, and (3) the Need-Approach-Benefits/Costs-Competition (NABC) framework, which provides a formulaic approach to crafting compelling value propositions. In the Networks and Data Communications course, these frameworks are used in lab activities, a case study assignment, an exploratory research paper, and a design project.

Network professionals may fail to consider potential threats until a severe intrusion occurs. To address this gap, the course integrates the outcome of "Considering risk as a factor when designing and configuring an enterprise network" to encourage students to understand the importance of thinking like an adversary when working for a client, ultimately enhancing the security and confidentiality of the client's business.

The QFT consists of four steps: question-storming, question refinement, question prioritization, and next steps. The instructor provides a prompt to stimulate many questions from students on the topic. In the second step, students analyze and refine their questions. In the third step, students select a few questions based on some criterion. In the last step, within this course, students choose one question to write a short research paper. This process triggers their curiosity and trains them to ask and explore their own questions.

As part of the lab report, students assess the value propositions of the routing protocol or strategy used in the lab. Students summarize their findings in a 1-2 pages long NABC report, in which students identify the important need the routing protocol addresses, the approach to address that need, and compare the benefits per cost ratio to competing strategies. This practice of using NABC motivates them to focus on value creation, which is the core of EML.

1. Introduction

Entrepreneurially Minded Learning (EML) is an innovative pedagogical approach designed to instill entrepreneurial mindsets in students. In addition, EML prepares students to deal with real-world technical and innovation challenges with creativity and strategic thinking [1]. Moreover, this EML approach enhances students' technical capabilities as well as develops their mindset so

they can identify opportunities, assess risks, and generate value for society and the economy. The integration of entrepreneurial thinking into engineering and technology programs has gained significant momentum in recent years, driven by the recognition of its transformative potential. Through an entrepreneurial mindset, engineering graduates become the key contributors to economic innovation and growth [2]. These individuals, the entrepreneurial engineers, are not just contributors, but key drivers of technological advancement and economic progress. In fact, some researchers argue that entrepreneurial engineers form the backbone of national economic development [3].

Both public and private sectors have supported various initiatives to adapt this combination of engineering and entrepreneurship to increase its efficacy. The National Science Foundation (NSF) has initiated an Innovation Corps (I-Corps) program to train scientists and engineers with entrepreneurial skills to market their discoveries and innovations [4]. On the private side, the Kern Entrepreneurial Engineering Network (KEEN), funded by the Kern Family Foundation, has been instrumental in promoting the integration of entrepreneurial principles within engineering education [5]. These programs emphasize the growing recognition of entrepreneurship as an essential component of engineering curricula, which reflects a shift toward producing graduates who are not only technically adept but also entrepreneurial in their approach to solving global challenges [6].

This paper explores the integration of Entrepreneurially Minded Learning (EML) into a Networks and Data Communications course. Central to the EML mindset is the 3C framework, which encompasses curiosity, connections, and creating value [7]. Through this framework, EML fosters student curiosity, enhances their ability to synthesize knowledge from diverse sources, and empowers them to deliver value for both personal growth and societal benefit [8]. While EML shares similarities with inquiry-based learning, problem-based learning, and project-based learning, its distinguishing feature is the deliberate focus on value creation as a fundamental goal [9]. The significance of this approach is underscored in this paper, which illustrates how EML can be seamlessly embedded into the Networks and Data Communications course, a critical component of computer science, electrical engineering, and computer engineering curricula [10].

The main contribution of this paper includes a framework for integrating EML in a Networks and Data Communications course. This paper contributes to integrating EML into this course primarily through three strategies: (1) Developing Connections, which employs risk factor consideration when designing an enterprise network; (2) the Question Formulation Technique (QFT), which focuses on enhancing student curiosity and the ability to formulate questions, and (3) the Need-Approach-Benefits/Costs-Competition (NABC) framework, which provides a formulaic approach to crafting compelling value propositions. Specifically, we describe classroom activities and assignments in this paper to support the implementation of the EML framework in this course.

This paper is structured as follows: Section 2 discusses the relevance of the course to the industry. Section 3 provides an explanation of the EML framework integrated in this course. Section 4 demonstrates the importance of developing connections through risk factor analysis, including details on course assignments and outcomes. Section 5 explores the concept of curiosity using the QFT approach, along with information on related assignments. Section 6 discusses value-creation through the NABC framework, explaining the associated assignments. Finally, Sections 7 and 8 present the benefits of the course and draw conclusions from this work.

2. Course Relevance and Industry Connection

This course on Networks and Data Communications is offered at the junior level with a three-hour hands-on lab. This course aims to develop the skills of future electrical engineers, computer engineers, and computer scientists. It is a 4-credit-hour course featuring a weekly 3-hour lab session. The curriculum encompasses a broad spectrum of topics spanning the data link layer, the network layer, the transport layer, and the application layer. Key areas covered include Internetwork planning and design, network components, IP addressing, network utilities, routing algorithms, routing protocols, multiple access protocols, delay and packet loss, connection-oriented and connectionless transport protocols, congestion control, network applications, socket programming, IPv6 networks, and WiFi networks. Due to its heavy practical application, the course offers students extensive hands-on experience in the networks lab, where they work with switches, routers, and other network devices. However, beyond its technical scope, the course serves as a conduit to the IT industry, one of the fastest-growing and most transformative sectors over the past two decades. The computer industry is advancing due to new technologies such as cloud computing, 5G networks, and the Internet of Things (IoT), all of which require professionals who can adapt to change, solve complex problems, and create innovative solutions.

Incorporating EML into this course addresses these industry demands by fostering an entrepreneurial perspective in students. The EML mindset will prepare students to approach challenges with creativity, evaluate risks and rewards, and design solutions that generate tangible value. Through targeted activities and frameworks, students are encouraged to develop skills that transcend technical competence, including strategic thinking, effective communication, and value-based decision-making.

3. Frameworks for EML Integration

Networks and Data Communications course is a vital course for computer engineering, electrical engineering, and computer science students. It connects students to the Information Technology (IT) industry, which has been one of the fastest-growing industries for the last two decades and requires a large number of well-trained professionals. Thus, integrating EML-based components in this course prepares students to seek opportunities to create value in this growing field.

The integration of Entrepreneurially Minded Learning (EML) into this course is achieved through three key frameworks: (1) Developing Connections, which emphasizes risk factor

analysis in the design of enterprise networks; (2) the Question Formulation Technique (QFT), aimed at fostering student curiosity and enhancing their ability to ask meaningful questions; and (3) the Need-Approach-Benefits/Costs-Competition (NABC) framework, which offers a structured method for developing persuasive value propositions. In the Networks and Data Communications course, these frameworks are applied across various learning activities, including lab exercises, a case study assignment, an exploratory research paper, and a comprehensive design project.

4. Developing Connections and Curiosity through Risk Factor Consideration

This course centers on the design and configuration of enterprise networks, a challenging undertaking that demands careful attention to many factors, with risk management standing out as one of the most crucial. Enterprise networks are the backbone of today's organizations, connecting users, systems, and devices to support critical business operations. While this interconnectedness drives efficiency, it also creates significant vulnerabilities. To build networks that are secure, reliable, and resilient, organizations need to proactively assess and address risks during both the design and configuration stages.

Security threats are among the most pressing risks. Cyberattacks, including ransomware, phishing, and distributed denial-of-service (DDoS), can disrupt business operations and compromise sensitive data [11]. Insider threats, whether intentional or accidental, further complicate the security picture. We need a robust approach to addressing these risks. For the purpose, we need to incorporate tools, such as firewalls, intrusion detection systems, and data encryption to safeguard network integrity [12].

In case of an unforeseen calamity or a serious breach or network failure, one of the key aspects to consider in a networking infrastructure is strategizing a business plan alongside ensuring network recovery. In order to ensure that the business resists all forms of shocks, networks will need to be designed in a way where alternative routing, load balancing, redundant pathways, and protected network devices are integrated. Integrating these mechanisms will ensure that multiple measures will be available during a calamity to provide unbreakable business continuity. Moreover, on a regular basis, as part of preventing the failure of business operations, the network should routinely be tested as well to ensure maximum reliability and accessibility.

Two additional aspects that should be considered are scalability and overall performance. Any existing networks must be able to handle the current demands while still being prepared for anticipated future needs. Otherwise, outages due to insufficient capacity might occur which will frustrate a customer and bottleneck productivity. Making sure to quickly set up quality of service to assure application priorities and also from the early stages make substantial effort to enable room for growth of the network will also help in effectively dealing with further unforeseen customer needs.

Other risk factors in the network infrastructure are the supply chain and vendor risks. Hardware and software are critical providers to a firm, any unreliability with them can tarnish the entire firm's infrastructure. Thus, unverified components and devices can pose a risk to the organization's network security. This risk can be addressed by vendor assessment and careful considerations when acquiring components and devices from third parties. Another risk factor is human error, which can introduce vulnerabilities to the system configurations, intentionally or unintentionally. These challenges due to human error can be overcome by training staff, in particular. In addition, these risks can be minimized using baseline configurations, secure and tested methodologies, well-defined policies and procedures, a playbook, and a runbook. Financial considerations cannot be ignored. Implementing risk management approaches requires a significant investment upfront. However, such investment is worthwhile in protecting and securing the network and keeping the business continuously.

We discussed all these challenges in this course from the perspective of network infrastructure and configuration. Therefore, we introduced a new course outcome: "*Considering risk as a factor when designing and configuring an enterprise network*." We prepared students to think like adversaries through class demonstrations and small group discussions. We aimed to strengthen students' abilities so they can identify risks proactively, ultimately making client systems more secure and reliable.

We introduced a research assignment to implement the above-mentioned course outcome in the course. In this assignment, students explored network routing protocols, including Static Routing, Routing Information Protocol (RIP), and Open Shortest Path First (OSPF). These routing protocols are commonly employed in the data networks. We also cover these routing protocols comprehensively in this course, and students apply them to the routers in the lab. Students researched the pros and cons of each of these routing protocols. They listed all the advantages and disadvantages of these routing protocols from network resiliency and reliability perspectives. security. Students compared these protocols based on which one is easy to configure and easy to maintain and scale. They also analyzed the associated risks with these protocols.

From the anonymous course evaluation, students have appreciated the assignment and agreed that such assignments significantly improved their connection and curiosity to the real-world security challenges. It also improves their empathy and trust in the client. By equipping clients with clear and comprehensive insights into these risks, students foster trust and enable more informed decision-making.

The integration of this new outcome and this new approach significantly enhances students' risk awareness in network design and infrastructure. This approach can successfully develop well-informed network specialists who can contribute to safeguarding our nation's network infrastructures. In addition, this new development in this course can prepare graduates to meet the rising demands of the industry with confidence and competence.

This newly introduced course outcome, focusing on risk factors in networking, was assessed through a structured research report. In this assignment, students conducted an in-depth analysis of static routing and dynamic routing protocols, specifically examining the Routing Information Protocol (RIP) and Open Shortest Path First (OSPF) Protocol. The research emphasized comparing static and dynamic routing protocols from a risk assessment perspective, requiring students to critically evaluate potential vulnerabilities and challenges associated with each approach. Their findings were documented and analyzed in individual research reports. The assignment description, grading rubric, and sample student work are publicly available on a Card (webpage) at KEEN Engineering Unleashed [13], which also provides guidance for other educators on how to adapt and integrate this research activity into their own courses. This assignment was first implemented in Fall 2023 and assessed using the EAMU (Excellent, Adequate, Minimal, Unsatisfactory) performance metric [14], where Excellent is scoring 90% or better of the total points possible, Adequate is from 90-70%, Minimal is 70-60%, and Unsatisfactory is anything below 60%. For the Fall 2023 semester, the student performance was recorded as EAMU vector (43, 2, 2, 0), demonstrating that 91% of students achieved an Excellent rating on this research assignment. Notably, this was conducted as an individual assignment. The assignment was repeated in Fall 2024, and the EAMU vector (56, 5, 2, 0) indicated that 89% of students achieved an Excellent rating, further validating the effectiveness of this research-based learning approach. These results suggest that the assignment successfully engages students in critical thinking about network security risks, reinforcing their ability to analyze and articulate complex cybersecurity concepts.

As “computer networks” is a core course in most computer engineering and computer science curricula, we highly recommend incorporating such an outcome in the course to develop risk and security awareness in the existing syllabus and the course material without additional lectures or topics. Based on our experiences, a risk-aware approach ensures that enterprise networks remain a secure and scalable foundation for organizational success. The concept of thinking like an adversary can be incorporated into a computer network course. The following prompts can guide to introducing the concept of Think Like an Adversary into a computer network in order to develop assignments, discussions, and labs:

1. Identify potential threats to an enterprise network.
2. Evaluate the risks associated with specific configurations or design choices.
3. Propose strategies to mitigate identified risks.

Another assignment related to risk factor analysis in a computer network course is that students were assigned to analyze the risks associated with managing a large subnetwork. This assignment provided an opportunity to look deeper into the network size and its pros and cons. Students researched to explore increased attack surfaces, unregulated access between devices, and potential bottlenecks in large network performance. To address these challenges, students researched and applied concepts of network segmentation, such as implementing Virtual Local Area Networks (VLANs).

When students researched VLANs, students learned that VLANs divide a large network into smaller and more manageable sizes. Thus, VLANs reduce the likelihood of unauthorized access and contain the spread of potential threats. VLANs also improve overall efficiency by segmenting the network, reducing broadcast traffic, and enhancing resource allocation. Students explored the VLAN configuration and implementation in the lab using switches. In addition, students studied the benefits of VLANs in reducing risks such as lateral movement during a cyberattack and understand how they contribute to maintaining a more secure and organized network infrastructure.

This lab and research activity on VLAN improved students' technical proficiency. In addition, it fostered students' critical thinking about large and small size networks. Moreover, this activity encouraged students to implement best practices for minimizing risks in enterprise network management. To assess the effectiveness of this activity, student performance was evaluated through hands-on lab exercises and relevant questions on the final exam. The EAMU (Excellent, Adequate, Minimal, Unsatisfactory) vector of student performance was recorded as (25, 21, 1, 0) in the Fall 2023 semester and (26, 34, 3, 0) in the Fall 2024 semester. This data demonstrates the effectiveness of the lab and research activity, as 97% of students achieved Excellent or Adequate performance (a score above 70%) in Fall 2023, while 95% of students reached the same performance level in Fall 2024. These results indicate a consistently high level of student achievement and reinforce the value of this hands-on, research-driven approach to cybersecurity education.

Overall, students responded positively to these assignments, relishing the opportunity to delve deeper into the intricacies of routing protocols and VLANs, a facet of the course curriculum that had not been explored extensively in the past. When students successfully completed their research and lab work with routing protocols and VLANs in an enterprise network, they gained a newfound perspective, fostering empathy for the client's concerns. Based on the assessment data, we strongly believe that these assignments have potentially planted the seeds of empathy when these students will work with clients in the future. In addition, students will be encouraged to provide comprehensive details regarding the risks associated with new technological implementations, thereby empowering clients to make informed decisions.

5. Stimulating Curiosity through QFT in Computer Networks

The Question Formulation Technique (QFT) is introduced to this course in order to stimulate students' curiosity and connect students with the material [15]. While QFT has been successfully implemented across various disciplines in educational settings [16], its introduction in a computer networking course represents a significant departure from traditional methods. The QFT adds a new dimension to teaching and learning by emphasizing active inquiry. Based on the foundational premise of QFT, students retain knowledge more effectively when they generate and explore their own questions, making the learning process more meaningful and self-directed and empowering them to take control of their education [17].

In line with this approach, the course outcome "*Be able to formulate salient questions and research to answer their own questions*" has been incorporated into this course. Students completed a total of two QFT-based question exercises and a research paper, working in groups of two to three. Each project lasted 2 to 3 weeks, with most research conducted outside of class. However, an in-class discussion is scheduled before each project begins.

The QFT is a structured process consisting of four steps: question storming, question refinement, question prioritization, and research. Each step is designed to help students develop their ability to think critically and creatively about complex topics.

Step 1: Question Storming

The first step in the QFT process is to develop as many raw questions as possible about a given prompt. In this step, students brainstorm and discuss the given topic and list many (usually unlimited) questions. In this course, the instructor provided a carefully crafted prompt to trigger students' curiosity and initiated a discussion about a specific topic. A few example prompts are: How do data packets collide? How various network architectures do support different applications? How do IP Addressing schemes support our Internet needs? How about if one layer in the TCP/IP model intervenes in the other layer's functionality? These open-ended questions encourage students to brainstorm freely and discuss with each other in a small group. In addition, student generate as many questions as possible without judgment or the need to immediately validate their ideas. This phase supports students' natural curiosity, allowing them to explore the topic broadly and think beyond surface-level understanding.

Step 2: Question Refinement

The second step of the QFT process is refining the questions developed in step 1. In this step, students analyze and refine the questions to make them meaningful. They examine their questions for clarity, focus, and relevance. For example, a broad question like "How do networks work?" might be refined into more specific inquiries, such as "What protocols are essential for secure data transmission in large-scale networks?" or "How does the size of a network impact its vulnerability to cyberattacks?" This step challenges students to think critically about their questions, encouraging them to develop a more precise focus that aligns with their learning goals.

Step 3: Question Prioritization

In the third step, question prioritization, students evaluate their refined questions from the second step. Then, they select a few based on specific criteria, such as relevance to the course objectives, the potential for exploration, and personal interest. A few examples from this course include: a student may prioritize a question like "What are the trade-offs between static and dynamic routing protocols?" as this topic is directly relevant to the course, and it also provides an

opportunity for in-depth investigation. This step helps students develop decision-making skills while aligning their curiosity with meaningful learning outcomes.

Step 4: Research and Exploration

The final step, research and exploration, requires students to select one question from their prioritized list to explore in-depth. In this course, students wrote a comprehensive research paper on the selected question to answer it in depth. In addition, students cited the references to support their claims. For example, a student might investigate "How can network segmentation reduce the risk of lateral movement in cyberattacks?" Through this process, they explore technical resources, apply their learning to practical scenarios, and develop a deeper understanding of the subject matter. This step of the QFT process is highly impactful in developing a sense of ownership over the learning journey. By pursuing questions they have personally formulated, students become active participants in the learning process, which often leads to greater engagement and a stronger grasp of complex concepts.

Performance Assessment of QFT-based Assignments

One of the Question Formulation Technique (QFT)-based assignments in this course required students to develop and submit a set of targeted questions to a designated client in order to determine the most appropriate Medium Access Control (MAC) protocol for research. In this scenario, the course instructor acted as the client, providing varied responses to each student to ensure that no two students arrived at the same MAC protocol for their research. This approach encouraged individualized critical thinking, requiring students to analyze the given responses and identify the most suitable MAC protocol based on the information provided. By diversifying the responses, the instructor ensured that students engaged in unique research paths, allowing for a broader exploration of different MAC protocols.

To assess student performance in this QFT-based assignment, the learning outcome "Be able to formulate salient questions focusing on the given research assignment" (KEEN eKSO 1b) was evaluated based on the quality and relevance of the questions submitted by students to the client (instructor). The assignment description, grading rubric, and sample student work are publicly available on a Card (webpage) at KEEN Engineering Unleashed [18], which also offers guidance for other educators on how to integrate this QFT activity into their own courses.

Student performance was quantified using the EAMU (Excellent, Adequate, Minimal, Unsatisfactory) metric, where 92% of students achieved an Excellent or Adequate rating, demonstrating a high level of engagement and competency in formulating research-driven, inquiry-based questions. These results highlight the effectiveness of the QFT approach in fostering critical thinking, problem-solving, and research skills among students in the context of networking and cybersecurity education.

QFT Benefits in Computer Networks Course

There are several key benefits of introducing QFT in this course. The QFT moves the instructor's role from a knowledge source to an inquiry facilitator. The QFT also empowers students to take charge of their learning. Second, the QFT bridges the gap between the theoretical knowledge and the real-world application. It is observed in this course, when students refined and researched their questions, they explored the practical applications and gained skills to tackle real-world networking challenges, for example, minimizing risks or improving network performance.

Furthermore, the QFT technique fosters in students an inventive and curious attitude to problem-solving qualities that are critical in the quickly developing field of computer networking. In addition, this way of thinking improves their technical proficiency and equips students to handle the intricacies of work settings, where the proper questions frequently result in groundbreaking answers.

Although QFT has been applied extensively in other academic domains, its usage in a computer networking course is revolutionary. The approach gives students a foundation for investigating intricate systems, technologies, and approaches, and it ideally complements the discipline's technical and analytical nature. Through the integration of QFT, this course fosters research, critical thinking, and problem-solving abilities in addition to improving students' technical proficiency.

In summary, this course's introduction of the Question Formulation Technique is a revolutionary method of instruction. QFT helps students develop a stronger connection to the subject matter and equips them to succeed in an industry that values creativity and curiosity by assisting them in formulating, honing, and investigating their own questions. Using QFT, students become more than just learners; they become active participants in their education and are better prepared to handle the challenges of computer networking and other subjects.

6. Crafting Value-Creation through NABC in Computer Networks

A crucial first step in helping students develop an entrepreneurial mindset is integrating the NABC framework, Need, Approach, Benefits/Costs, and Competition, developed at Stanford Research Institute [19], into a computer networks course. By properly articulating and assessing value propositions, this method helps students develop a deeper comprehension of how technical solutions tackle real-world problems [20]. The course links technical proficiency with value-driven problem-solving, a fundamental component of Entrepreneurially Minded Learning (EML), by incorporating NABC into lab activities, project reports, and assignments.

A new course outcome, "Identify the needs and motivations of various stakeholders," has been included to emphasize the significance of value creation. As a result, students are encouraged to

take a stakeholder-oriented approach, ensuring that their technological choices consider the larger objectives and limitations of users, clients, and organizations.

NABC in Lab Activities

Lab sessions are one of the major ways that the NABC framework is implemented. In a succinct, one to two-page NABC report, students evaluate the value propositions of the routing protocols or methods used in the lab. Students must complete these reports to:

1. Identify the Need of a routing protocol
2. Describe the Approach used to meet this need
3. Compare the costs and Benefits of the protocol, highlighting its benefits.
4. Examine the Competition by contrasting the protocol's security, scalability, and performance with those of other options.

This practice has motivated students to focus on value creation, a core principle of EML, by encouraging them to think critically about the practical implications and advantages of technical strategies.

NABC in Hands-On Projects

Each project report introduces a new section based on the NABC framework to further enrich students' entrepreneurial mindset. At this initial stage, students summarize:

- Need: A description of the algorithm/technique/protocol you learned in this project.
- Approach: describe your proposition, explain the relevance of this project, and what is innovative or unique in this project.
- Benefit: what are the benefits gained using the algorithm/technique/protocol described in this project?
- Competition: how does this project's algorithm/technique/protocol stand out compared to similar algorithms/techniques/protocols?

Assignments Designed Around NABC

The integration of NABC principles extends to course assignments, which are structured to challenge students to apply the framework in the context of network design and implementation.

Assignment 1: Designing and Comparing Solutions

In Assignment 1, students were tasked with designing a network based on a client's specific requirements and providing multiple viable solutions. The instructor acted as a client and a representative of a fictitious industry (True Auto Industry, TAI). This assignment encouraged students to engage in critical thinking and problem-solving, requiring them to analyze different

networking approaches and determine the most effective solution for the client. To guide their evaluation, students utilized the NABC (Need, Approach, Benefit, Competition) framework, which helped them systematically assess the strengths and weaknesses of their proposed network designs.

As part of their work, students implemented network configurations using both static and dynamic routing protocols and compared their performance, efficiency, and applicability in real-world scenarios. This comparison allowed them to explore trade-offs, such as scalability, security, redundancy, and administrative complexity, which are critical factors in professional network design.

The learning outcome "Be able to design multiple solutions for the client and compare them using the NABC approach" (KEEN eKSO 1i) was integrated into the course and served as the assessment criterion for evaluating students' ability to develop innovative, well-reasoned network designs. To support transparency and knowledge sharing, the assignment description, grading rubric, and sample student work are publicly accessible on a Card (webpage) at KEEN Engineering Unleashed [21]. This resource also provides guidance for other educators on how to incorporate the NABC framework into their coursework, promoting entrepreneurial mindset (EM)-based learning across institutions.

Student performance was measured using the EAMU (Excellent, Adequate, Minimal, Unsatisfactory) evaluation model. It was found that 75% of students achieved an Excellent rating, demonstrating a high level of competency in applying the NABC framework to analyze and justify multiple network design solutions, while 12% of students attained an Adequate rating, indicating a solid understanding of NABC principles, though with some gaps in execution and comparative analysis. The results confirm that incorporating the NABC approach into network design education enhances students' ability to think critically and strategically. By systematically analyzing client needs, technical approaches, benefits, and competitive factors, students developed a holistic, client-focused perspective when designing network solutions. Furthermore, applying NABC to a real-world-inspired problem reinforced students' entrepreneurial mindset, encouraging them to approach networking challenges beyond just technical implementation and consider broader implications such as cost, scalability, and security risks. This assignment has proven to be an effective pedagogical tool for integrating engineering, entrepreneurship, and problem-solving in computer networks education.

Assignment 2: Addressing Specific Client Requirements

In Assignment 2, students engaged in a more client-specific network design challenge, where they were required to adhere to additional constraints set by the client. Unlike the previous assignment, where students had more flexibility in selecting network components, this task introduced real-world constraints; students were required to avoid certain routers and adhere to a designated network path. This limitation challenged them to think critically and optimize their design decisions while still meeting the functional and performance needs of the network.

To accomplish this, students designed and developed a network utilizing various dynamic routing protocols, specifically Routing Information Protocol (RIP) or Open Shortest Path First (OSPF). They then analyzed and compared these protocols using the NABC framework, assessing the trade-offs in terms of scalability, convergence speed, resource efficiency, and adaptability to network changes.

The learning outcome "Be able to develop the network model according to the requirements of the client" (KEEN eKSO 3c) was integrated into the course, ensuring that students applied both technical expertise and an entrepreneurial mindset (EM) when designing and evaluating network solutions. Student performance was evaluated using the EAMU metric, which yields 72% of students achieved an Excellent rating, demonstrating a strong ability to design and implement networks that meet client specifications while employing NABC-driven analysis. 16% of students reached the Adequate level, indicating a foundational grasp of network development but requiring further refinement in protocol comparison and decision-making strategies.
These findings reinforce the effectiveness of integrating NABC into network engineering education. By applying entrepreneurial thinking to network design, students gained a deeper understanding of how technical choices impact real-world implementation, preparing them for industry-relevant problem-solving. The detailed assignment description, grading rubric, and sample student work are publicly available on a KEEN Card [21], offering a structured framework for other educators to adopt this methodology in their courses. The results validate that NABC integration enhances students' ability to navigate complex networking challenges while reinforcing critical thinking and strategic decision-making.

Impact on Student Learning

The integration of the NABC framework into this course greatly helped to close the gap between technical understanding and practical application. The students practically practiced the ability to articulate value propositions, which is crucial for handling challenging situations in the workplace. Along with encouraging creativity, critical thinking, and curiosity, the framework gave students the tools they needed to address issues by concentrating on producing real value for stakeholders.

In summary, this computer networks course's incorporation of the NABC approach is a revolutionary method of instruction. Students who successfully negotiate the complex demands of contemporary IT settings will be able to build solutions that work well and provide significant value, thanks to the course's alignment of technical expertise with entrepreneurial thinking.

7. Outcomes and Benefits

Integrating EML into the Networks and Data Communications course has several benefits:

Enhanced Student Engagement: Students were more motivated to engage deeply with the material by connecting course content to real-world challenges and opportunities.

Improved Critical Thinking: The process of risk assessment, question formulation, and value creation helped students develop critical thinking and problem-solving skills.

Preparation for Industry: Students gained practical skills with an entrepreneurial mindset, which prepared them for successful careers in the IT industry.

Value-Creation Focus: Students learned to prioritize impactful and innovative solutions by emphasizing the importance of creating value.

8. Conclusion

In this paper, we have described the introduction of Entrepreneurially Minded Learning (EML) into the Networks and Data Communications course, which modified the course into a platform for cultivating curiosity, connections, and value creation. By integrating frameworks such as Risk Factor, QFT, and NABC, the course prepared students to excel in a rapidly evolving industry. We have also explained various course assignments where EML was successfully embedded to train students. The assessment data of various related course outcomes has confirmed the efficacy of students' preparation with the EM mindset in this course.

These techniques improve students' technical proficiency while giving them the attitude and abilities they need to succeed in their careers as value creators and innovators. With EML in the course, students should be able to think critically, create, and adjust to the demands of a changing technological environment. The course developed a forward-thinking mindset in students that motivates them to foresee market trends, tackle practical issues, and contribute significantly to their businesses and society. A scalable and effective methodology for teaching computer science and engineering is demonstrated by the use of EML, which closes the gap between technical expertise and entrepreneurial excellence.

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