ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #49644

Accidental engineer's accidental university engagement and mentorship

Dr. Hoo Kim, LeTourneau University

Hoo Kim, Ph.D., P.E., is an Associate Professor in the School of Engineering and Engineering Technology at LeTourneau University. He received his B.S. and M.S. degrees from POSTECH, Pohang, South Korea, and his Ph.D. from the University of Texas at Austin

Jaden Schuster, LeTourneau University
Ray Holt

Accidental engineer's accidental university engagement and mentorship

Hoo Kim[1], Jaden Schuster[1], Ray Holt[2]
Electrical and Computer Engineering Department
LeTourneau University[1]
STEM Advancement Inc.[2]

Abstract

This paper discusses the influence of the mentor, Mr. Ray Holt, on mentoring practices at Letourneau University. The authors highlight both accidental and intentional elements that enhanced student learning and provided valuable mentoring for both students and faculty. The mentor's engineering background, including his role in designing the world's first microprocessor for the F-14 Tomcat, inspired students. The initiative began with a STEM contest engagement which follows with guest speaker series organized by Letourneau University's IEEE club, followed by a special lecture in the "Introduction to Computer Engineering" course, where students worked on projects involving the mentor's design materials. This mentoring approach, integrated into the course structure, inspired students and helped them envision their future careers in engineering. The paper concludes that combining storytelling and the mentor's unique experiences within a course can significantly benefit students and faculty.

Introduction

All educational activities in universities can be defined by various elements, and among these, the importance of mentoring has been widely discussed. Mentoring encompasses components such as academic and professional development, personal support and encouragement, and networking and resource access. Its significance is evident not only in the classroom but also in extracurricular and broader educational settings within higher education. Various approaches have been implemented to establish mentorship programs for college students, including faculty-student and peer mentoring [1, 2]. Moreover, diverse forms of mentoring have been encouraged due to their positive and crucial roles in higher education, particularly for special groups, such as transfer students or students with unique needs [3, 4]. Mentoring benefits not only student mentees but also faculty mentors, as mentoring between senior and junior faculty members has been shown to have significant and positive impacts [5, 6, 7]. When we think about projects and work, it is natural to consider factors like resources and time, as most projects tend to operate within a reasonable framework aimed at achieving maximum output with minimal input. However, alongside these realistic foundations, there is value in uncovering unique stories and approaching situations from the perspective of individualized and differentiated student needs, communication, and motivation. By focusing on relationships and weaving individual stories into a larger narrative, we can view a series of given circumstances with an intentionality that transforms them into opportunities for mentoring and connections that may initially seem accidental [8, 9]. Letourneau University, with its deep roots in Christianity, integrates mentoring

with both academic and holistic discipleship. Small schools, with smaller class sizes, offer the advantage of closer relationships between teachers and students, creating opportunities for deeper connections compared to larger institutions. However, students in smaller schools may have fewer opportunities to interact with a diverse range of people. Like many institutions, Letourneau University provides IEEE club activities, guest speaker sessions, and field trips to local companies. Efforts such as visits to Silicon Valley companies highlight the need for a more systematic approach, such as structured mentoring programs or networking events. The authors reflect on their initial meeting as team mentors and participants in a STEM contest, which evolved into a friendship and led to various projects, both big and small. While the primary focus was originally on students and the desire to challenge them, the authors recognized the mutual encouragement and challenges they experienced as educators could form an additional layer of mentorship. This paper explores how small passions and dedication to education, through unexpected events and stories, formed meaningful mentoring relationships. It also highlights the essential elements of mentorship discovered along the way and provides insights for enhancing mentoring practices in higher education.

The Story of Mr. Ray Holt

The idea for this paper's title comes from Mr. Ray Holt's book, *The Accidental Engineer: The True Story of the First Microprocessor Ever Designed* [10]. Mr. Ray Holt is a retired Silicon Valley engineer who invented the world's first microprocessor for the F-14 Tomcat [11]. Without initially knowing much about his background, Author A met him while hosting a STEM competition, also known as a machine learning competition, for K-12 students [12]. Mr. Ray Holt was a teacher leading his group and local school teachers in the competition. Through this event and interactions with local teachers, including Mr. Ray Holt, Author A witnessed Mr. Ray Holt's dedication to serving underrepresented groups in Mississippi as a president of STEM Advancement Inc. Mr. Ray Holt's team won first prize, and their visit to Letourneau University's campus initiated further collaborative efforts. Mr. Ray Holt has extensive experience working with local industries and universities in Organization A and is passionate about promoting STEM education for K-12 students. With Organization A's longstanding investment in inspiring STEM students in the area, Mr. Ray Holt has played a pivotal role in advancing STEM initiatives.

STEM Engagement and Mentorship

STEM events play a crucial role in connecting mentors, educators, and students, fostering an ecosystem where knowledge and inspiration flow freely. The machine learning contest held at Letourneau University served as an accidental yet significant point of connection between Mr. Ray Holt and Author A. The 2021 and 2022 machine learning contests, utilizing commercial software, introduced a novel STEM topic to the local areas surrounding Letourneau University. This topic was also of great interest to Mr. Ray Holt and Organization A. Both Mr. Ray Holt and Hoo Kim shared a passion for making STEM engaging and accessible to underrepresented K-12

groups. Additionally, activities such as guest speaker series and special lectures provide unique opportunities for students to interact with industry professionals and academic experts, offering real-world insights that enrich their education. Mr. Ray Holt actively volunteered to meet college students, inspiring them by sharing his engineering experiences. Meeting the inventor of the world's first microprocessor and the author of *The Accidental Engineer* in person was a powerful inspiration for students. Mr. Ray Holt shared his story alongside visual materials and the actual microprocessor chip he designed, which had been classified for years under Navy confidentiality. Hoo Kim integrated a guest lecture by Mr. Ray Holt into the *Introduction to Computer Engineering* course, which is designed to spark students' curiosity by covering a wide range of topics in computer engineering. In Fall 2024, the course included a small hands-on project using FPGA to emulate Mr. Ray Holt's microprocessor, providing a practical application of the mentor's work. These intentional events created a meaningful mentor-mentee relationship, fostering engineering discussions that helped students understand the broader applications of their studies. The hands-on project also sparked interest in cutting-edge innovations. Engaging students in these activities not only deepened their technical knowledge but also enhanced their critical thinking and problem-solving skills, better preparing them for future challenges in the engineering field.

Pedagogical Framework in Mentorship

Mentoring initiatives in engineering education can be effectively designed and structured by integrating mentors' design work and expertise directly into the curriculum. For example, in an "Introduction to Computer Engineering" course, mentors can contribute by presenting their design projects as case studies, offering students practical insights into real-world applications. Guest speaker sessions and involvement in IEEE club activities provide additional avenues for mentors to share their experiences and inspire students. Combining in-class discussions with out-of-class activities, such as hands-on workshops or collaborative projects, creates a holistic learning environment that fosters student engagement. This approach bridges theoretical concepts with practical knowledge, enabling students to gain a deeper understanding of their field while benefiting from the mentor's professional expertise. Figure 1 illustrates the key components which contributed accidental mentorship.

Student Activities and Learning Outcomes

Small research projects and term assignments in computer design offer students valuable opportunities to explore the practical application of both sub-system and whole-system architectures. These hands-on experiences deepen their understanding of engineering principles while developing critical problem-solving skills. When students meet and interact with a real-world engineer, they gain unique insights into professional practices and industry expectations,

which can inspire their aspirations for engineering careers. Such encounters also build students' confidence by providing actionable knowledge that bridges classroom theory with practical expertise, empowering them to envision and pursue impactful roles in the field of engineering.

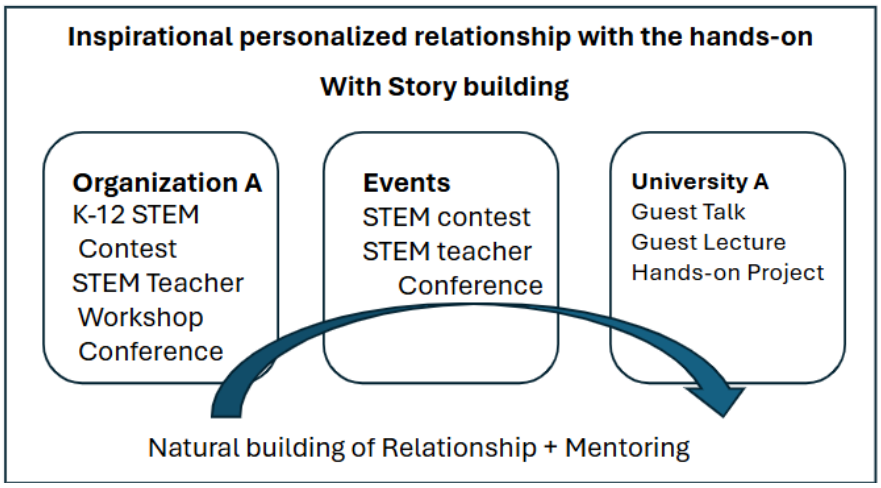

Figure 1. Key components of accidental mentorship

Project Description

The world's first microprocessor was designed by Mr. Steve Geller and Mr. Ray Holt to control the US Navy's F-14 "Tomcat" (First Microprocessor). It was designed as a 20-bit computer and consisted of six main components, each in the form of a chip: the PMU (Parallel Multiplier Unit), PDU (Parallel Divider Unit), SLF (Special Logic Function/CPU), SL (Steering Logic), RAS (Random Access Storage), and ROM (Read-Only Memory). The focus of the project was on reimplementing the SL chip on an FPGA board. During this process, a copy of Mr. Ray Holt's original engineering notes was provided, which contained logic block diagrams for each component of the microprocessor. However, Mr. Ray Holt noted that the diagrams were not complete, presenting a challenge. While these diagrams served as an excellent starting point for the reimplementation, adjustments were necessary. The notes also included a set of logic test cases that could be used to verify the reimplementation, including the required adjustments. Following this approach, the work of reimplementing the SL chip based on the provided logic diagrams was carried out. One of the primary components in Mr. Ray Holt's diagrams is a module called FA, which stands for Full Adder. Using Mr. Ray Holt's diagrams, this block was reimplemented on the FPGA board. FA accepts three inputs and produces two outputs.

Ingredients of Accidental mentoring in the Story-Building Platform

The mentor's story can serve as a powerful pedagogical tool, enriching the learning experience by connecting theoretical knowledge with real-world applications. By sharing personal insights

and experiences, mentors can create a narrative that inspires and engages students, fostering deeper understanding and curiosity. This approach has a positive impact on student learning by making concepts more relatable, while also enhancing faculty engagement by encouraging collaboration and shared purpose. Additionally, it promotes course cohesion by providing a unifying theme that ties together different elements of the curriculum. Key takeaways for creating impactful, story-driven mentorship models in academia include the importance of authenticity, the alignment of stories with educational goals, and the strategic integration of narrative into teaching and mentoring practices. The following is the excerption of students and faculty feedback which supports how the mentoring effectively impacted.

Students feedback Special Lecture

- *Truly fascinating story of the development of the fist microprocessor.*
- *It was a great experience to meet the inventor of the microprocessor in person and to hear about his life, and I am glad to know such an important person in the history of technology is a Christian. I was surprised to learn that he had to keep his achievement classified for thirty years.*
- *One thing from Mr. Ray Holt special lecture that made me excited was that he wasn't planning on becoming an engineer before he took an engineering class and got hired on the project. The reason this caught my attention is that it means that anybody can become an engineer provided they work hard enough.*
- *I was excited to learn that the first microprocessor was made for the F-14 Tomcat. Before the F-14, aircraft utilized mechanical computers, which are heavy. The microcomputer onboard the F-14 Tomcat weighed far less than a mechanical computer. The design feats that were accomplished to produce this lightweight computer are amazing. I also think*
- *Mr. Ray Holt's story is amazing. Mr. Ray Holt was told not to be an engineer, but despite this, he became a logic engineer and revolutionized computer technology. This story shows that God has a plan for us no matter what others say we can and cannot do.*
- *I really enjoyed hearing about Mr. Ray Holt's experience using AI technology. I think his views on AI are meaningful because he has such a good understanding of computers and their origin. Mr. Ray Holt recognizes that computer design has become more and more automated over the years. He told me that AI could eventually become powerful enough to be able to design complex logic boards on its own. His insight on AI is very fascinating*
- *Mr. Ray Holt mentioned that he implemented carry-lookahead logic in his arithmetic chips to increase the speed of adding and subtracting. Carry-lookahead circuitry allows the last*
  carry bit of a series of full adders to be generated from the first carry bit. This is much faster than carry ripple logic where the final carry bit is determined by earlier carries passing through each full adder
- *Something that I learned from Mr. Ray Holt lecture was the concept of ROM or read only memory. Read only memory is a type of non-volatile memory that cannot be changed or destroyed and is used to store firmware and boot instructions.*
- *I'm excited about seeing all the logic boards and how every component on them was serving a purpose, contributing to a common end-goal. All the parts aren't very useful on*

their own, until you combine them together do you see the true beauty and usefulness of them all individually.

Students feedback course project

"This project has taught me many things. Through working with Mr. Ray Holt and Author A, Author C learned the importance of learning about the implementation of older technologies. By reimplementing the world's first microcomputer, I was able to better understand how modern computers worked because I was able to better understand how the original worked. After all, the original was the bases for subsequent improvements. This project taught me a new strategy for learning. When I do not understand how a technology works or when I am developing something new and am stuck, instead of trying to push through, I will go back to previous iterations of the technology to learn how they work. After this, I will go back to what I was doing previously and try to apply what I learned."

Author A as a faculty feedback

"Initially, the programs were created purely for the educational benefit of students, and through these initiatives, I met Mr. Ray Holt. However, through this process, I, as faculty member Author A, gained tremendous strength from Mr. Ray Holt's experiences and the stories of overcoming difficult challenges. Despite facing numerous obstacles, Mr. Ray Holt remained steadfast in their beliefs and direction, faithfully contributing to STEM education. This provided great inspiration. Having Mr. Ray Holt there to listen to and empathize with the difficulties and challenges faced as an individual faculty member at Letourneau University was invaluable. Their support became an immense source of strength, and even in somewhat difficult circumstances, it became the driving force that gave me vitality and inspiration. Particularly, with the uncertainties and fluctuations in the progression of projects, it was easy to feel discouraged or uncertain at times. Yet, looking back, I am deeply thankful for Mr. Ray Holt, who, through their guidance, became someone I could truly call a mentor."

Constraints and Limits

As an individual faculty member, it is often challenging to manage all aspects of building mentorship. The process requires time, resources, and continuous effort to incorporate the mentor's unique ideas and stories while maintaining the relationship. If the school or department could collaborate with additional manpower, it would create better conditions for mentorship to flourish by reducing roadblocks and mitigating burnout. Instead of focusing on increasing the number of mentees, it is more beneficial to foster small, personal relationships that allow for deeper connections. Unearthing meaningful engineering stories with experienced engineers is valuable, not solely for achieving expected outcomes or efficiency but for creating a richer, more impactful mentoring experience. Greater systematic support, along with departmental or

institutional staffing, would significantly enhance the quality and impact of mentorship programs.

Invitation to opportunities with Mr. Ray Holt and authors

The authors strongly believe that fostering more collaboration in STEM education, particularly by involving and connecting with local schools in Texas, is crucial for serving underrepresented students. By creating partnerships between universities and local K-12 schools, we can provide students with early exposure to STEM fields, inspiring their interest and broadening their opportunities. The authors are especially open to sharing their experiences in higher education collaboration and are eager to bring dynamic mentoring opportunities to the table. Specifically, by connecting local Texas schools with industry mentors like those listed in this paper, we can provide students with valuable insights from real-world professionals, enriching their learning experience. These mentors can offer guidance, inspire aspirations for future careers, and help bridge the gap between theoretical learning and practical application. By facilitating these meaningful connections, we aim to provide a more comprehensive and supportive STEM education pipeline, empowering underrepresented students and ensuring their success in the field. The following is the list of a few ideas to apply Mr. Ray Holt's microprocessor design into the class with more collaboration.

1. efabless program – chip replication of the world 1st microprocessor.
2. FPGA emulation and VLSI design with high level courses in ECE.
3. STEM K-12 support and collaboration with Organization A: hosting, connecting local organization or teachers and schools.

Conclusion

While mentoring can be designed and platforms can be created, what matters most is the connection between people—often occurring naturally or unexpectedly, as observed by the authors. However, for such mentoring relationships to flourish, there needs to be a shift in perspective toward valuing connections over tasks and outcomes. At the same time, it is essential for institutions to systematically design platforms that focus on the core aspects of mentoring and provide mentors and mentees with the necessary resources to support their growth. Although the mentoring in this case appeared to happen accidentally, it highlights the importance of fostering relationships and focusing on the individuals engaged in engineering. This approach exemplifies the kind of education that centers on meaningful connections and the human side of engineering.

Acknowledgements

This paper is supported by the Dean's Office of Letourneau University. The authors also appreciate the support of Letourneau University in continuing the development and collaboration of our STEM program with STEM Advancement Inc.

References

1. Banerjee, J. K. (2020, June), Mentoring Undergraduate Students in Engineering Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line. 10.18260/1-2—34968

2. Early, C. E., & Velazco, J. D., & Rosales, M., & Cantu, E. (2016, June), Bridges to STEM Careers: A Student Mentor Persective Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26389

3. Nikkhah, D., & Copp, D., & Denaro, K., & Buswell, N., & Diggs-Yang, G., & Lee, H. R., & Valdevit, L., & Dicke, A. (2022, August), Experiences Of Faculty Mentoring Engineering Transfer Students Paper presented at 2022 ASEE Annual Conference & Exposition, Minneapolis, MN. 10.18260/1-2—40597

4. Surovek, A., & Karlin, J., & Groen, C. (2010, June), Effective Faculty Mentoring For Diversity: An Assessment Of Mentoring Paradigms Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. 10.18260/1-2—16133

5. Edalgo, S., & High, K. A., & Lichtenstein, G., & Lee, C. M., & Main, J. B. (2021, July), Exploring How Faculty Mentoring Influences Faculty Productivity Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2—37144

6. Bilen-Green, C., & Green, R. A., & McGeorge, C., & Birmingham, E. J., & Burnett, A. (2013, June), Mentoring Programs Supporting Junior Faculty Paper presented at 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia. 10.18260/1-2--22283

7. Mendez, S. L., & Conley, V. M., & Haynes, C. L., & Gerhardt, R. A., & Tygret, J. (2018, June), The IMPACT Mentoring Program: Exploring the Benefits of Mentoring for Emeriti Faculty Paper presented at 2018 ASEE Annual Conference & Exposition , Salt Lake City, Utah. 8.18260/1-2—31104

8. Kim, H., & Leiffer, P. R., & Neal, L. K., & Mays, K., & Kim, J. W. (2021, July), Engineering Capstone Senior Design Project as a Story-Building Platfom Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. 10.18260/1-2--37053

9. Kim, H. & Leiffer, P. and Kim, J., “Essential Elements in the Application of a Story-Building Approach Learned from Three Engineering Senior Design Projects,” 2022 Christian Engineering Conference.

10. R. Holt, The Accidental Engineer - 2nd Edition: The True Story of the First Microprocessor Ever Designed, Subtitle: A Life Leading to the Design of the World’s First Microprocessor, Pinola, MS, USA: Holt Legacy Books, 2021.

11. Ray Holt - World's First Microprocessor | 50th Anniversary 2020," First Microprocessor, [Online]. Available: https://firstmicroprocessor.com/ray-holt/. [Accessed: Dec. 21, 2024]

12. Kim, H. (2022, August), Lessons Learned from Collaborative Initialization of Machine Learning Class and STEM Contest with Letourneau Universitynd Industry Partnership Paper presented at 2022 ASEE Annual Conference & Exposition, Minneapolis, MN. 10.18260/1-2—41872