Stacking Entrepreneurially Minded Learning Alongside Other Pedagogies

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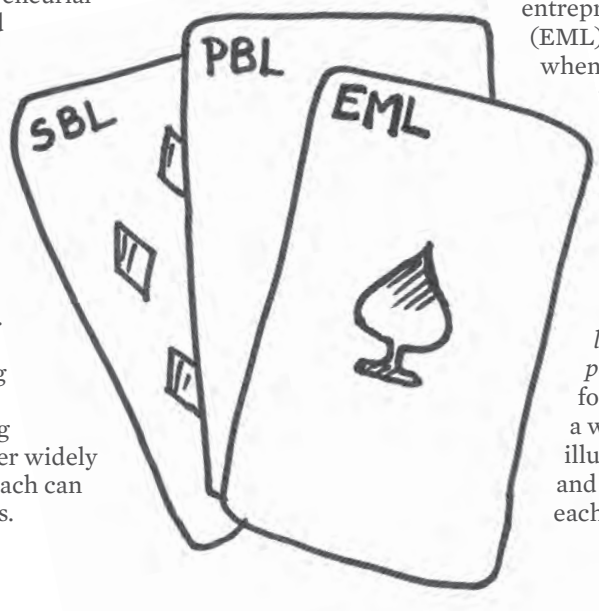
Higher education should be a transformative experience for students. I expect that you may agree. A few years of study can lead to a lifetime of success. During college, students develop professional skills. But beyond *skillset*, educational experiences in college potentially transform a student's *mindset*. This time of life is critical for reflection. Freshmen frequently reexamine their values and motivations. Thrown into unfamiliar situations with new expectations, undergraduate programs become a crucible in which students have an opportunity to *think about the way they think*, i.e. metacognition.

Professors have the distinct privilege of impacting both skillset and mindset. But how is it possible to positively transform the way students think about the world around them? I have become an advocate for using a variety of teaching methods, including one expressly intended to develop an entrepreneurial mindset. It's called entrepreneurially minded learning (EML).

EML is an emergent pedagogy that emphasizes discovery, opportunity identification, and value creation. It is a teaching method that can be applied to all areas of study and is being developed by hundreds of faculty members at colleges and universities across the country. EML's development is particularly important to faculty members and students within KEEN. At the time of this writing, KEEN partners include 22 institutions, potentially impacting more than 1,200 faculty members — who are educating 24,000 undergraduate engineering students. Importantly, EML builds upon other widely accepted pedagogical methods. So the approach can be complementarily stacked alongside others.

By organizing teaching methods, you form a *pedagogy stack* — a collection of methods for designing instructional materials and educational interventions. When you select an instructional approach, you are effectively playing a card from your stack.

Traditional subject-based learning (SBL) is the first pedagogy found in faculty member's stacks. From an instructor's perspective, SBL is an efficient method and lecturing is the classic SBL tactic. In recent decades however, educators have developed student-centered learning tactics including active and collaborative learning (ACL). To develop students' strategic thinking, stacks include pedagogies that rely on inductive learning. These include case and scenario-based learning (CBL) and problem-based learning (PBL). Finally, additional pedagogies may connect student learning to a mission or profound purpose. With this in mind, entrepreneurially minded learning (EML) is included in this stack when discovery, opportunity, and value creation for others are paramount.



Whatever the collection of methods in your stack, examine the view of authors such as Mascolo [1] who I believe gets it right; *regardless of pedagogical methods, learning is afforded by guided participation*. In that spirit, the following example assignments for a wireless communications course illustrate the approaches and expectations for each method.

Assignment: Designing a cellular telephone system

When deciding upon the location of cellular telephone towers, system planners consider the surrounding terrain and resulting radio-frequency (RF) propagation paths. Through these paths, electromagnetic waves connect tower antennas to mobile phones. A path from a tower antenna to a mobile phone is the complex combination of a direct path, reflected paths, diffraction, and scattering. Each propagation phenomenon can be characterized.

The focus of this assignment is diffraction, a familiar phenomenon from acoustic systems. Just as low-frequency sound waves travel around obstructing corners, radio waves may propagate over terrestrial features including man-made structures, hills, or mountains. Learning outcomes for this assignment include:

Skill Learning Outcomes

Students successfully completing this module should be able to:

- Predict diffraction path-loss (in dB) for terrestrial wireless connections

Mindset Learning Outcomes

Students successfully completing this module will:

- Demonstrate curiosity about the future of mobile wireless communications
- Express technical, societal, and economic insights regarding mobile communications
- Craft a value proposition for mobile wireless communications in a new context

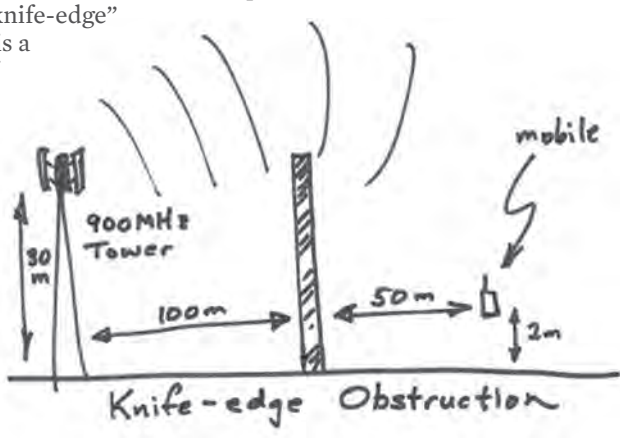
SBL

Subject-Based Learning

SBL is focused on the mastery of subject matter. Typically, an instructor targets specific domain knowledge and skills through lectures and assignments. Applied to engineering, the approach is frequently reductionist, relying on models and mathematical representations. Learning is focused on individual understanding. This pedagogy is important for developing mental models of complex physical phenomena.

Example Assignment

Due to diffraction, a transmitter and receiver can communicate over a partial obstruction. While the distance between transmitter and receiver largely accounts for signal path-loss, diffraction leads to additional losses. Using information from the provided diagram, determine the Fresnel parameter and calculate the loss (in dB) due to the "knife-edge" diffraction. The knife-edge is a simplified representation of an obstructing mountain or building. Compare your calculations to simulation results employing accepted empirical path-loss models. See Molisch.[2]



ACL

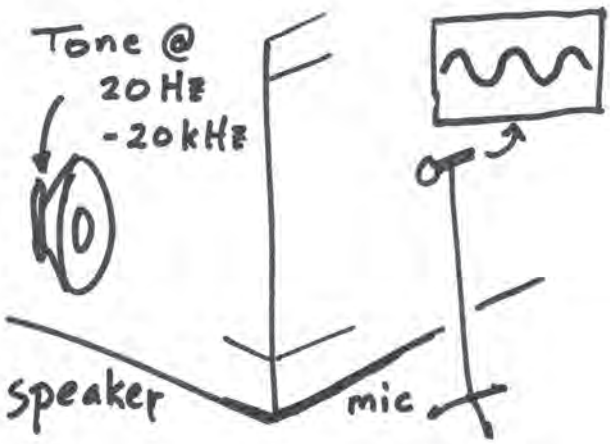
Active & Collaborative Learning

ACL engages students in the learning process through interaction with peers. Compared to a lecture format, evidence indicates that the approach promotes positive student attitudes, increased retention, and interpersonal skills. [3,4]

Example Assignment

Mechanical waves (sound, water ripples, etc.) are fundamentally different than radio waves. However, many of the wave propagation mechanisms are similar.

Work in groups of three to propose two mechanical wave demonstrations related to the study of wireless path-loss. Your group's first proposed demonstration shall use water waves to illustrate diffraction. The second proposed demonstration shall use sound waves to exhibit the effects of wavelength on diffraction. Each group will quickly present their proposals. All class participants will then discuss their merits. Selected groups will be responsible for executing and explaining the demonstrations in the next class period where we relate the observed behavior to parameters within calculations for electromagnetic propagation.



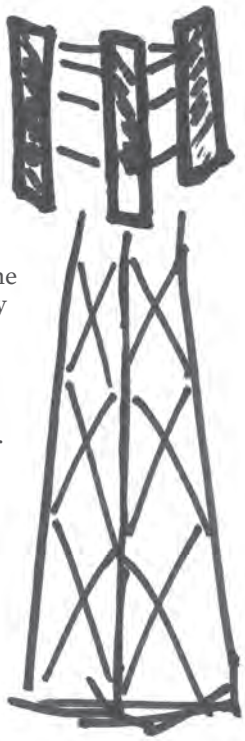
CBL

Case & Scenario-Based Learning

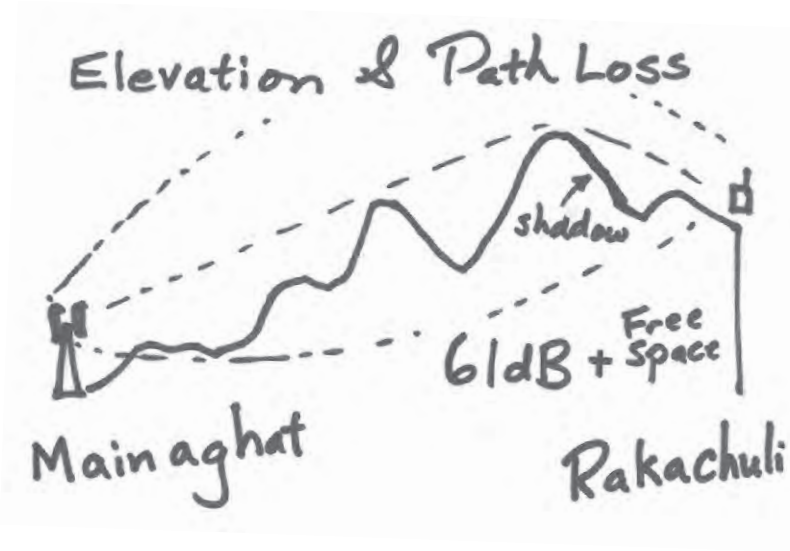
Through case and scenario-based learning, students learn by playing a role in an evolving storyline. The best case studies contain an element of mystery; students look forward to the "rest of the story." After the reveal, students compare their decision making to experienced professionals. Both case and scenario-based methods promote decision making within a specific context or situation. Instructors may employ the powerful technique of *progressive disclosure*. This allows an instructor to interact with students and observe how they adapt, gather and connect information, and generate judgments and decisions. These two pedagogies are excellent vehicles for placing engineering decisions in a larger context — they promote the importance of connections.

Example Assignment

A 2015 news article from Buffalo, N.Y. begins by asking the question, "How high should a cellular tower be?" According to the article, that's become a question for a judge. The article describes Verizon Wireless' lawsuit against the Town of Amherst, N.Y. regarding a planned tower construction in a residential neighborhood. As Verizon worked with the local zoning board, the city restricted the height to 75 feet, saying that it should be sufficient for the area. Verizon claims that a 114 foot tower is needed. After hearing arguments, a New York State Supreme Court justice will decide. In this case study, you will be asked to choose a position and support it.



First, read the article and watch the local news report which highlights the views of the affected residents. Next, read the opinions contained in the debate on the public amateur radio forum, selecting the three best points. The class will then quantitatively discuss the impact of antenna height on path-loss and consider the impact on the overall cellular system.



PBL

Problem-Based Learning

Through PBL, students solve an identified problem while determining required information, strategies, and gathering domain knowledge.[5] Students first hone a problem statement, asking, "What is the *root* problem we are solving?" The method promotes situational curiosity and connected thinking — both elements of inductive learning. Typically, no single solution is uniquely correct. As a result, the pedagogy promotes an important type of thinking for entrepreneurially minded engineers called *effectual thinking*.[6]

Example Assignment

A humanitarian organization has decided to develop a wireless communication system in the Nawalparasi District, a small, lowly populated region in Nepal. The goal is to provide mobile communications deemed vital for health monitoring and economic development. There are many design options including tower locations and frequency bands. As the humanitarian organization brokers possible deals between interested cellular companies (e.g. operating at 910MHz), VHF radio link equipment providers (e.g. 145MHz), and the local government officials, it becomes apparent that the tower locations are constrained. If the base-station tower is to be powered by the existing generator, the tower must be located in a low-lying area of Mainaghat. Using provided coordinates and topographical information through freeware such as Radio Mobile, evaluate a general radius of mobile coverage as part of a larger communication plan. What solutions do you recommend to the organization? Provide an example of a characteristic path-loss, comparing the software prediction to a Fresnel model. To complete the assignment, you will need to investigate the terrain of the region, making assumptions about tower height and path-loss limits.

EML

Entrepreneurially Minded Learning

EML focuses on identifying unexpected opportunities with verifiable merit. To do that, one must be well informed. Students are encouraged to be explorers, constantly curious, connecting information to gain insights, and always on the lookout for value.

Research on both entrepreneurs and intrapreneurs indicates that they often begin an endeavor with an incomplete strategy. [6] Accordingly, EML promotes a tolerance for ambiguity to avoid the "paralysis of analysis" that can sometimes limit action.

Within any type of market, stakeholder feedback is essential because it affords the re-evaluation of opportunities. Accordingly, EML assignments promote an understanding of stakeholders. They also afford *pivots* — information-driven adaptations. Elements of EML are a current topic of investigation within KEEN.

Example Assignment

Assume the role of an ethnographer and become more curious about wireless communications.

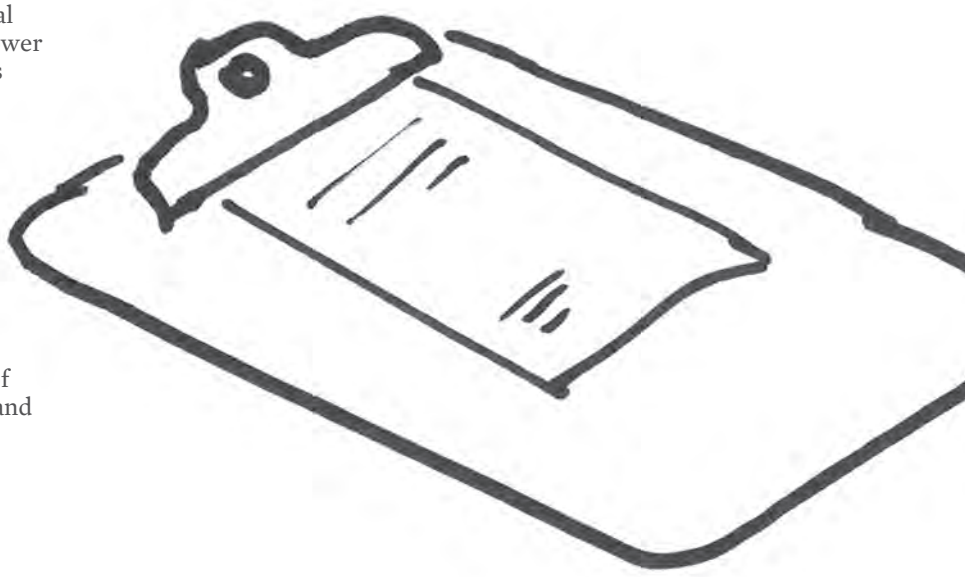
(1) Create your personal set of questions and observations about wireless communication.

(2) Create a set of questions for others about wireless usage habits, carriers, terrain, tower locations, and other factors that might influence propagation paths. Interview 10 people about their experiences with wireless communications.

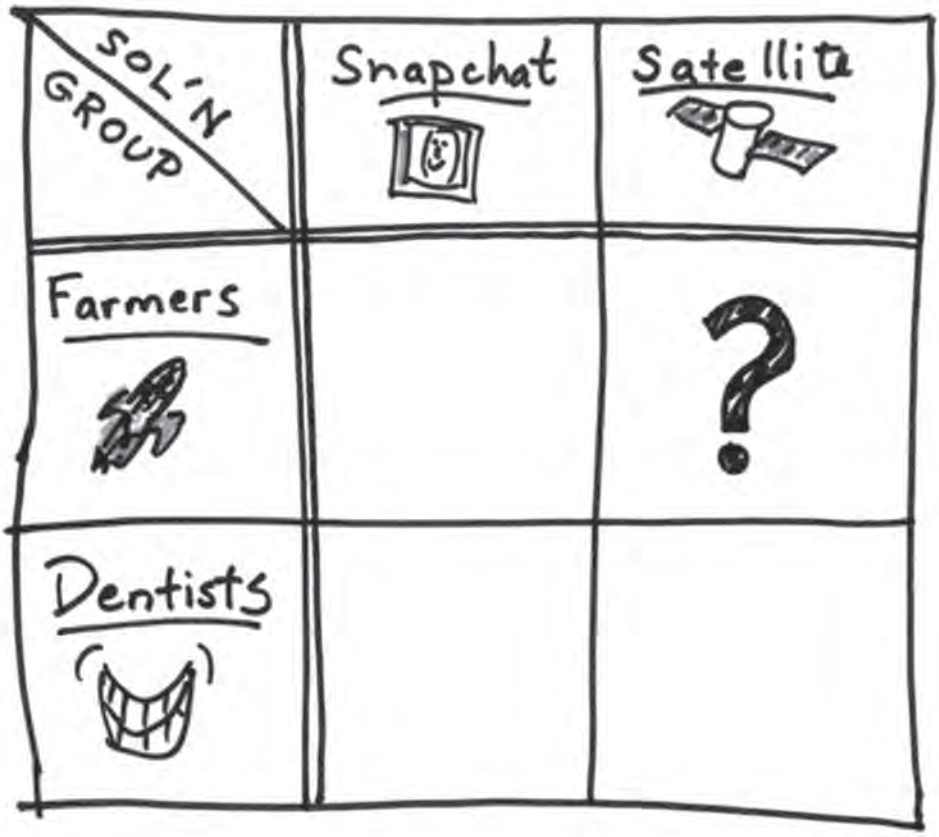
(3) Become an antenna aficionado. Take a photo of 20 mast-mounted antennas over the next week. In your antennae portfolio, accompany each photo with the GPS coordinates, estimated tower height, frequency, and modulation method. You may wish to verify your estimates with services such as www.antennasearch.com. Prepare for an oral review of the portfolio.

(4) Predict trends in the following categories:

- Technical, e.g. "What will be the next major technical advance in mobile telecommunications?"
- Economic, e.g. "What seemingly unrelated business sector will be next affected by mobile communications?"
- Societal, e.g. "What are cultural changes (caused by wireless communications) that have just begun and are likely to continue?"



Opportunity Matrix



What trends, if any, are related to path-loss (distances, obstructions, multi-band systems)? For example, consider T-Mobile's promotion of WiFi-connected telephone calls. These types of solutions reduce the reliance upon cellular towers, mitigating the large path-losses associated with sparse tower placement. With the prevalence of WiFi, what alternative futures might exist for mobile communications?

Connect information from many sources. There is no shortcut to becoming knowledgeable. In preparation for a knowledge-based quiz, read the following six items:

- Path-Loss Equations — Read the course text and provide comparisons of the author's treatment against two additional off-line resources
- Newsletter for USAID's Nepal Economic Agriculture and Trade (NEAT) project
- Deloitte report, "What is the impact of mobile telephony on economic growth?"
- WIRED Magazine article, "Where Cellular Networks Don't Exist, People Build Their Own"
- Mobile Technology Association of Michigan's eclectic list of "Unusual uses of mobile technology"
- An article of your choice, unrelated to wireless communications

As outlined in class, create a reflection on how the information in these articles is related to propagation path-loss. Record your three most valuable insights. These will be graded subjectively.

Within a group of three, create an *opportunity matrix* for wireless communications. Form the rows of the matrix by making a list of twenty people groups (e.g. farmers, dentists, soccer fans, painters). Next, form the columns by identifying various wireless solutions, mobile platforms, technologies, features, (e.g. Snapchat, SMS, Peer-to-Peer, Satellite Phones). At each intersection in the matrix, identify how the specific group might benefit from the specific wireless solution. If your group believes a verifiable opportunity has been identified, create a value proposition accompanied by a technical, societal, and economic defense.

Conclusion

Faculty members within KEEN are finding other methods to promote the discovery and identification of opportunities. For example, when converting a PBL assignment to EML, Dr. Andy Gerhart of Lawrence Technological University creates assignments with unexpected design alternatives or "Easter eggs" that, when discovered, allow students to think differently about their design choices. Through these techniques and others, nonlinear design thinking is developed.[7] Out-of-the-box thinking is essential for creating unexpected and extraordinary value. And it becomes habitual only through exercise.

Choose to help the engineering education community develop and use EML to foster entrepreneurial mindset. To be successful in a constantly changing world, your graduates need both an entrepreneurial mindset and an excellent skillset. A range of pedagogical methods organized in a stack is an indispensable teaching toolbox. EML emphasizes the 3C's of entrepreneurial mindset (curiosity, connections, and creating value) and is an essential addition to your stack.

References

[1] Michael F. Mascolo, "Beyond student-centered and teacher-centered pedagogy: Teaching and learning as guided participation," Pedagogy and the Human Sciences 1, no. 1 (2009): 3-27.

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[5] David Boud and Grahame Feletti, "The challenge of problem-based learning" (London: Kogan, 1997).

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