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An ecosystem to support sense-making, identity formation, and belonging for first-year engineering students

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Kurt Paterson crafts learning experiences, spaces, and communities to help students of all kinds imagine, design, and build solutions that matter.

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Dr. Shraddha Joshi is currently an Assistant Professor in the Department of Engineering at James Madison University. She earned her Ph.D. in Mechanical Engineering from Clemson University with her research focused on understanding the role of requirements in engineering design by novices. At Clemson, Dr. Joshi has worked on multiple industry sponsored research projects (Michelin tweel –low rolling resistance for non-pneumatic tires, IFAI ballast friction testing project). She was actively involved in mentoring and advising Capstone design projects. She has advised over 10 different design projects –BMW, Rotary, TTi and mentored over 100 students. While at Clemson, Dr. Joshi was also awarded endowed teaching fellowship as a part of which she has taught a sophomore class on Foundations of Mechanical Systems for 2 semesters. Dr. Joshi worked as a Post-Doctoral Fellow with Professor Jonathan Cagan at Carnegie Mellon University. She investigated the avenues of internet of things and connected products. While at Carnegie Mellon University, Dr. Joshi was also instructor for classes such as Mechanical Engineering Seminar, Capstone Design and Storytelling with Machines.

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An ecosystem to support sense-making, identity formation, and belonging for first-year engineering students

Introduction

While purposefully engaging first-year engineering students has become a common approach to help them succeed through challenging transitions, no single intervention is likely to prove meaningful for all. Providing a variety of both optional and required learning experiences can create an ecosystem of support by connecting students to their peers, near-peers, academic advisors, and engineering faculty. Ultimately, a nurturing ecosystem might shift student success by cultivating an understanding of engineering expectations and opportunities (i.e., sense-making), gaining an emerging awareness of professional self and program culture (i.e., identity formation), and fostering connections to their engineering institution (i.e., belonging). Another reason to invest in these efforts is to demonstrate a commitment to student well-being, in other words that the program "walks the talk" as a place concerned with undergraduate professional development through a supportive community. Such efforts may also benefit student decision-making before, during, and after college.

This paper describes the goals, structures, resources, and outcomes of the first-year engineering ecosystem that aims to provide reinforcing support at James Madison University (JMU). While this ecosystem includes one engineering course in both the Fall semester and Spring semesters, this article focuses on four key co-curricular offerings for Madison Engineering (MADE).

First-Year Engineering Co-Curricular Programs

In this paper, we describe four co-curricular programs: *MADE Launch*, *Re:MADE Camp*, *24for24*, and *MADE Professional*. These co-curricular learning experiences are connected to curricular hooks, starting with our Fall Semester first-year course, *Engineering Opportunities*, and reinforced in our Spring semester first-year course, *Engineering Decisions*. The Fall semester course was reimagined in 2013 to strengthen contact between the entire first-year engineering cohort (our other classes are capped at 25 students), upper division peers, and faculty. Its successful launch set in motion a build-out of additional curricular and co-curricular structures to strengthen first-year success. It is a team-based, project-rich course driving student engagement through human-centered design and agile project management. In 2014, curricular efforts focused on positioning *Engineering Opportunities* as a strongly encouraged 1-credit elective in Fall, followed by a redesign of our Spring semester course, *Engineering Decisions*.

As these curricular revisions were underway, a multi-year plan was set in motion to catalyze program-wide culture-building through co-curricular components. This strategy was rooted in community-building and targeted at critical developmental needs in the typical flow of the first year. These co-curricular programs provide first-year students formal and informal opportunities to intentionally connect with each other, engineering students more senior to themselves, departmental faculty and staff, and alumni. Each program attempts to activate critical ingredients known to influence professional wayfinding and academic success. Taken collectively, they provide a robust ecosystem for supporting better transitions to college, discovering personal motivations to pursue an engineering education (or not), and creating

positive connections to others on campus.

The co-curriculars also facilitate a culture of entrepreneurially-minded learning (EML) adopted throughout MADE. The EML framework consists of (1) exploring one's innate *curiosity* of the world around them; (2) finding *connections* to realize how engineering is interrelated with complex sociocultural, environmental, and economic factors; and (3) *creating value* for themselves and for others with engineering solutions that they might actualize [1]. We applied this engineering framework to student development by designing learning experiences that engage each student in personal uses of curiosity, connection-making, and value creation as paths to explore identity, build community, and understand intersectionalities.

MADE Launch

In 2015 *MADE Launch* was created to facilitate early community formation and belonging by celebrating the start of our students' engineering journeys [2]. *MADE Launch* used a three-hour window of time on Saturday morning near the end of JMU's orientation week to host all incoming engineering students for a series of group activities in the courtyard of the Engineering Building. The location was chosen intentionally to serve as a welcoming to their place of work, study, and togetherness. The event was hosted by five engineering faculty who had built out the concept at a strategic doing workshop and was supported by juniors and seniors in our Madison Engineering Leadership Development program.

Three central activities focused on awareness, understanding, and collaboration. Each was built for movement to elevate energy states, but also to shift expectations for how engineering studies might unfold in our program. After a quick check-in and faculty welcome, activities included:

1. **3-6-9:** This opener focused on *awareness* and had three rounds; the first had each student secretly identify another that they will stay 3 feet away from. The students were asked to stay in motion. With more than 100 students in play, this made for a dynamic system that each student needs to constantly be aware of. The second round elevated the complexity by each student adding a second student they will stay 6 feet from, while also staying 3 feet from the first student. The last round added a third student to stay 9 feet from.
2. **Categories:** This activity focused on *understanding* and had students find others in their group nonverbally. Each student was given a card with a symbol; amongst the crowd there were about nine others with the same card. They were charged with finding each other without showing their card or talking. Once the groups coalesced, they were ready for the last challenge as a team.
3. **Helium Pipe:** The third activity focused on *collaboration* and had each of the newly discovered teams assigned to a senior engineering student leader. Their task was to lift a 2 m PVC pipe (1-inch diameter) from the ground to above everyone's heads with each team member only allowed to use one finger to lift. Everyone's fingers had to stay in contact with the pipe, else they needed to start over. After a practice session, the whole crowd was put in motion with a competitive round, based on time to completion.

After these active sessions, an intentional "chat and chill" period with near-peer leaders was structured into the schedule before heading indoors for a concluding activity (where hearing was more critical). Once inside a large room with all the furniture pushed to the walls, a five-minute overview of engineering program differences, aspirations, and points of pride was shared. Everyone then got into a large circle for the conclusion: a community circle in which a series of

20 prompts were shared, each person stepping further into the circle if applied to them (or they felt comfortable admitting it applied to them). Faculty and senior students joined the circle. Together, the concluding session demonstrated individualism, diversity, community, and complexity all while bringing people closer together.

Assessment included attendance, and the number of engineering people (students, faculty, staff) each student reported they could identify by name before and after the event. Attendance has been nearly 100% every year. Pre/Post name recognition averaged more than 400% increase from this event.

Re:MADE Camp

A two-day offsite camp for incoming first-year students, *Re:MADE Camp* was launched in 2017 built upon a series of individual, team, and design activities that support immersive identity exploration, sense-making, and community-building. The camp was designed and led by four faculty and staff, with small group facilitation by 20 near-peers (seniors and young alumni) and held in the three days immediately before university orientation. Schedule highlights included:

1. **Sunday:** Began with a welcome from the hosts and was immediately followed by a make-your-nametag activity so each student could share something about themselves. A dinner picnic followed. Afterwards the evening was centered around connecting through whole group games, followed by a conversation with one other attendee (three rounds). The night concluded with an unstructured bonfire, and each cabin group was led to their cabin by pairs of seniors who served as resident guides.
2. **Monday:** The day was built around eight small group activities. Each student was assigned to the same group which then travelled to different locations around the camp to engage in a variety of design, teaming, and reflective activities. The evening focused on the whole cohort coming together for a welcome to engineering ceremony around a bonfire. During this ceremony, each student's name was announced, and the seniors created a welcoming line which ended at the faculty handing them an engineering t-shirt as a token of inclusion.
3. **Tuesday:** This half-day was focused on a design sprint undertaken by each of the groups from Monday. The projects were to help improve the camp that hosted us, other than that, the students had license to identify a problem and create a solution. Camp staff came to review hand-drawn posters and quick pitches of the solutions. After some closing comments and lunch, students boarded busses and returned to campus.

Assessment included attendance and observations of impacts during Fall classes. Attendance grew from 50% of the incoming class in 2017 (60 students) to nearly 85% in 2019 (105). Consistent across the three years was the immediate familiarity and connections among students in the Fall semester class, *Engineering Opportunities*. While this was a positive for the students (and faculty) involved in Camp, it also was a notable distancing of the students who were not.

24for24

Re:MADE Camp and *MADE Launch* were successful student accelerators in the spirit of our engineering program, along the way becoming clear differentiators for our program. Spring 2020 brought these traditions to a halt. In light of the COVID-19 pandemic, we pivoted to a virtual summer experience that we dubbed *24for24*. In brief, we designed a remote summer program

that met once a week for 24-minutes nominally over a time duration of 8-weeks to welcome and acclimate the incoming class of 2024 to our engineering program.

In April all prospective engineering students were invited to the summer program (n = 395). We posited the *24for24* program as an opportunity to meet the department's engineering faculty, other engineering students, and learn more about engineering, regardless of whether the student elected to attend JMU or not. In its inaugural session on the first Monday in June 2020, 32 students joined; and at its peak in the second session, 42 students joined. The average number of students to join in the remaining six sessions was 26. All participants matriculated.

In total, eight engineering faculty each facilitated one virtual session. Each session included active learning practices manifested in diverse ways such as active questioning [3] and Socratic questioning, virtual breakout rooms mimicking think-pair-share report outs [4], remote activities such as sketching or drafting on a sheet of paper in each student's at-home location, and co-creation of content through online collaboration tools. After these active learning exercises concluded, the faculty facilitator observed themes and commonalities in student responses in an effort to foster a virtual community and encourage follow-up via a dedicated Slack workspace. Zoom was used for each with Slack, Google Docs, Google Slides, and Mural serving as collaboration tools in support of the various learning activities.

We measured the success of this virtual summer program two-fold. First, at the end of each session, we asked student attendees to respond to a 3-question survey using a 5-point Likert scale. The questions asked, based on their attendance:

1. How much this session might help your pursuit of engineering as a major/career? [question rooted in engineering identity formation]
2. How much you would recommend a future offering of this session to other engineering students? [question rooted in perceived value of the program]
3. How much you enjoyed this session? [question rooted in quality assurance of the program]

Overall, the survey results showed that there was general agreement of value toward the sessions as the students generally reacted positively to the sessions—all sessions had a positive response even when including the standard error in each survey question. The sessions were aligned with elements of the EML framework; survey feedback showed students found value in *curiosity* topics (Weeks 1-2), *connection* topics (Weeks 3-4), and *creating value* topics (Week 5-8).

MADE Professional

Launched in Fall 2020 for each of our four engineering cohorts (first-year, sophomore, junior, senior), a semester-long professional development workshop series (one hour per month for each cohort) was created to support professional identity formation and professional wayfinding. Each workshop was led by one or two engineering faculty and tailored around a critical student need; in the case of our first-year students the workshops aimed to make sense of place, people, profession, and pathways, and included:

1. **Session 1:** *Who are we?* Students prepared a slide to "introduce themselves" to the entire cohort. Students then played rounds of "people Bingo!" based on hometowns, interests, experiences to better understand their cohort. The facilitator concluded the session by talking about how there are similarities but uniqueness too, and how the diversity of people and experiences will make future team and project work stronger.

2. **Session 2:** *Who is an engineer?* Each student was asked to "Draw an engineer" then share in a small group to observe similarities/differences. The facilitators revealed that this was an opportunity to reflect on who you are and how you see yourself (or not) in an engineer.
3. **Session 3:** *What engineering problems excite me?* Small random groups were tasked to find as many pictures/things that spark curiosity as possible. Each person brainstormed open-ended curiosity driven questions that "an engineer" might ask about the pictures, then in their group, share their individual questions, noticing any themes that emerge for each student. Students were asked to think about the observed themes about them, and if they align with who they think they are or not, and what that means?
4. **Session 4:** *What have been my roses/thorns in this transition to college?* Multiple decks of emoji cards were provided to small groups of participants. Participants were asked to pick their favorite and least favorite emoji cards and asked to think about a time during the semester when they "felt" like each of the emoji cards selected. Participants shared the stories behind the emoji cards with a partner who then chooses one story to share (on behalf of their partner) with the rest of the small group. The facilitator's debrief focused on *What were joys, pains, anxieties, fears?* And how these are opportunities to grow and continue forward.

Assessment focused on attendance. Nearly all the students in the *Engineering Opportunities* course, where the faculty encouraged and reminded students of these workshops, attended these four sessions (92% on average, 135 students). About 10% of the first-year student body was not in the course (usually due to conflicts with athletics or ROTC); none of these students attended *MADE Professional* sessions, which were held on Friday afternoons.

Evaluation

Our "Connections First" strategy requires an ecosystem of efforts to support our students, yet challenges emerge in evaluating influences from specific programs in such a systems-oriented approach. Currently, we are examining summative effects. Data from immediately before the first intervention, *MADE Launch*, started (2014 first-year cohort) is compared to the most recent data (2020 first-year cohort) to explore some possible impacts from our efforts (Table 1).

Table 1. Student outcomes before (2014) and after (2020) co-curricular ecosystem launch

Engineering Student Indicators	2014	2020	Change
Total admitted first-year full-time engineering students	571	892	56.2%
Total enrolled first-year full-time engineering students	130	174	33.8%
Percentage of admitted first-year students, female	22.6%	26.2%	16.1%
Percentage of admitted first-year students, out-of-state	36.4%	28.4%	-21.8%
Percentage of admitted students, scholarship eligible	33.8%	32.2%	-4.7%
Percentage of engineering graduating class, female	16.5%	32.0%	93.9%

Several noteworthy advances on student community development were made over this period. Descriptions, anecdotes, photos and testimonials from the programs mentioned above were woven throughout engineering spaces, stories, and recruiting to convey our priorities around connections, collaboration, and belonging. This may have influenced our gains in student

admissions and matriculation. While university financial administrators are less enthusiastic about smaller out-of-state cohorts, this is a substantial victory for our young program against several long-established engineering schools in our state. Student quality, as suggested by scholarship eligibility, remained steady. Lastly, several indicators suggest possible positive influences on female engineering enrollment. Also, over this same time period, the 6-year graduation rate of female students averaged 22% greater than male students (45% vs. 37%, respectively). Our dataset continues to build as student cohorts progress through our system; with more time we may be able to generate more definitive cause-and-effect conclusions.

Beyond student outcomes, it is important to evaluate these efforts at an institutional level to facilitate strategic (re)design efforts. Because these kinds of first-year experiences exist outside of the boundaries of the curriculum, new approaches are needed to analyze these investments as a portfolio. Toward this, we have developed a 25-point evaluation toolkit for co-curriculars that helps us examine the benefits and costs for our whole learning ecosystem [5]. A visualization depicting the resource demands and potential impacts (as well as student participation) of the four co-curriculars in this paper is depicted in Figure 1 below. This kind of analysis is helpful to identify gaps and opportunities that may exist for our initiative. For us, the development of low resource, high impact efforts are critical to our ecosystem sustainability, yet remain elusive.

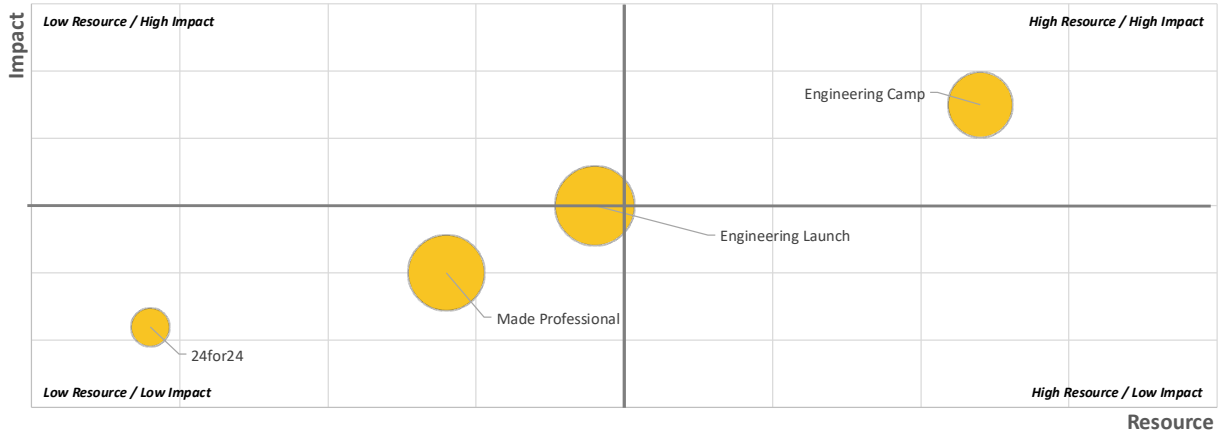

Figure 1. Cost-benefit visualization conveying average annual summary information of four first-year co-curriculars. Bubble size is proportional to the average number of students participating over the life of each program offering.

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