OPEN

Nurs Admin Q
Vol. 46, No. 3, pp. 255–265

INNOVATE

Preparing Nurses to Be Health Care Innovation Leaders

Karen K. Giuliano, PhD, RN, MBA, FAAN;
Frank C. Sup IV, PhD;
Ellen Benjamin, MS, RN, CEN;
Sundar Krishnamurty, PhD

A new certificate program has been designed that augments the traditional undergraduate nursing education with a curriculum of innovation and entrepreneurship. The goal of the *Integrated Innovation & Entrepreneurship Certificate in Nursing Program* (INNOVATE) is to empower nurses to collaboratively solve health care challenges and become thought leaders in health care products, technologies, and processes, as well as service and delivery methods, with a particular focus on the needs of vulnerable populations. Toward this goal, INNOVATE is built on an integrative, immersive curriculum, experiential learning, intentional cohort building, peer and faculty support, real-world connections, and the prioritization of diversity, inclusivity, and equity to build of a cohort of nursing students ready for careers in clinical and health care innovation. In this article, we provide the outline for the proposed curriculum, program strategies, anticipated outcomes, and evaluation criteria that we believe can serve as a national model for innovation and entrepreneurship in undergraduate nursing education. **Key words:** *engineering, entrepreneurship, innovation, interdisciplinary communication, nursing education*

Author Affiliations: *Elaine Marieb Center for Nursing and Engineering Innovation, University of Massachusetts Amherst, Amherst (Drs Giuliano and Sup IV); Institute for Applied Life Sciences and Elaine Marieb College of Nursing, University of Massachusetts Amherst, Amherst (Dr Giuliano); Department of Mechanical and Industrial Engineering, University of Massachusetts Amherst, Amherst (Drs Sup IV and Krishnamurty); and Elaine Marieb College of Nursing, University of Massachusetts Amherst, Amherst (Ms Benjamin).*

The authors declare no conflict of interest.

Correspondence: *Karen K. Giuliano, PhD, RN, MBA, FAAN, University of Massachusetts Amherst, 240 Thatcher Rd, Amherst, MA 01003 (kkgiuliano@umass.edu).*

DOI: 10.1097/NAQ.0000000000000529

IN APRIL 2021, the American Association of Colleges of Nursing (AACN) published their newest recommendations for core competencies in nursing education.[1] The AACN wrote that, to prepare nurses who are work-ready in the 21st century, curriculums must address diversity, equity, and inclusion, and incorporate informatics and technology.[1] The National Academy of Medicine's *Future of Nursing 2020-2030* envisions a similar future for nursing, encouraging nursing to have an "orientation for innovation."[2(p2)] Design thinking, innovative mindsets, interdisciplinary teamwork, and communication are all identified as core competencies for nursing education.[2-4]

How can we reimagine nursing education to respond to these new recommendations? The University of Massachusetts (UMass) has responded by proposing the *Integrated Innovation & Entrepreneurship Certificate in*

Nursing Program (INNOVATE), a program designed and supported by collaborators from the Elaine Marieb College of Nursing, the College of Engineering, the Manning College of Information and Computer Science, the Isenberg School of Management, and the Berthiaume Center for Entrepreneurship. This certification program is designed to reshape undergraduate nursing education by focusing on interdisciplinary collaboration, immersive learning experiences, and design justice. INNOVATE embraces a new vision of nursing innovation and entrepreneurship (I&E) education that empowers nurses to address health care problems directly by providing them with the necessary skills to be successful.

BACKGROUND: A VISION OF NURSING INNOVATION

Today, health care technologies are mostly made without the insights and understanding of clinicians. Nurses are end users, facing health care challenges on the front lines. If something does not work well in a clinical setting, nurses adapt, create "work arounds," and improvise in filling the gaps they face in their everyday clinical practice. We envision a future where nurses are not only the end users but are engaged at the inception of shaping new technologies, system processes, and health care delivery models. As the nation's largest group of health care professionals, nurses use more health care products and services than any other health care professional. The 2020 Nationwide Nursing Workforce Survey found there are nearly 4.2 million active registered nurses in the United States,[5] about 4 times the number of active physicians.[6] The result is that nurses are in a unique position to articulate everyday health care issues, challenge assumptions and the status quo, and address unrecognized and unarticulated needs.[7] Engineers have the technical expertise and skills to create products or system models, and nurses bring their real-world health care experience. Together, the nurse-engineer team is well-positioned to be successful as health care innovators. Integral to the success of this approach is the associated collaborative clinical outcomes research to test and validate innovations.

INNOVATE

INNOVATE is built on 7 core pillars (Figure 1): (1) interdisciplinary collaboration, (2) an integrative, immersive curriculum, (3) experiential learning, (4) intentional cohort building, (5) peer and faculty support, (6) developing real-world connections, and (7) prioritizing diversity, inclusivity, and equity. INNOVATE is designed to provide connection, engage students in learning, and expose them to experiential opportunities that extend well beyond the traditional undergraduate nursing education curriculum.

This approach is consistent with the 2021 AACN Essentials for Nursing Education, which has entire sections on innovation and technology development, as well as interprofessional collaboration and systems thinking.[1] INNOVATE is designed to help students develop an innovative and entrepreneurial identity, to create a cohort of nurses ready for careers in health care innovation and product development, and to promote health equity.

Figure 1. The 7 core pillars of the INNOVATE program.

We expect this experience to decrease workforce attrition by helping nurses realize a broader variety of career options in which their nursing knowledge can be used.

Interdisciplinary collaboration

The foundation of the INNOVATE program is based on the creation of an interdisciplinary educational environment to empower undergraduate nurses to be thought leaders and realize positive changes in health care and the nursing profession. The overall program goal is to teach nursing students to think more broadly about the scope of nursing practice during their undergraduate education, and to enable them to realize their full potential for leadership in health care I&E. Beginning in their first semester freshman year, students will be engaged in an integrative, immersive curriculum (Table) with numerous opportunities to collaborate on I&E activities. Central to INNOVATE is the focus on integrated teaming between undergraduate nursing and engineering students to identify, envision, and realize solutions to health care problems.

While the nurse-engineer team forms the foundation of the program, INNOVATE also provides opportunities for broad interdisciplinary collaborations, including business, computer science and public health. Consistent with recommendations from the most recent *American Nurses Association Scope and Standards,*[8] *AACN Essentials,*[1] *and Future of Nursing* 2030,[2] this program's educational approach will teach nurses to be interdisciplinary system thinkers. The expected outcome of the program is to create a new generation of nurse graduates who have the skills and entrepreneurial mindset to forge new frontiers in health care, to improve health care at the front lines of care.

An integrative, immersive curriculum

INNOVATE is a 15-credit certification that augments the nursing student curriculum without adding extra time to the completion of their undergraduate degree. Students apply to the INNOVATE program as part of their undergraduate application process and enter the program in their first semester. The certificate has been designed to augment an undergraduate BSN degree, with most INNOVATE courses filling existing degree requirements. The 15-credit requirement may be completed throughout the students' 4 years, including the option to participate in summer experiential learning opportunities.

The core of the INNOVATE curriculum is built on 3 interdisciplinary INNOVATE courses that are supplemented by electives. In the spring of their first year, students take "INNOVATE-1: Inclusive Innovation and Entrepreneurial Mindset," an introductory course taught by a team of faculty from the Elaine Marieb College of Nursing and the College of Engineering. This class supports interprofessional collaboration and establishes an early foundation of inclusivity and design justice.

In their third year, students participate in a 2-semester seminar titled INNOVATE-3 and INNOVATE-4 "Nurse-Led Medical Product Design, Development and Commercialization: An Interdisciplinary Seminar for Nursing, Engineering & Business Student Entrepreneurs." The class is divided into teams of nursing, business, and engineering students. Over the course of this seminar, the student teams collaborate to design, produce, test, and market a product, culminating in a final business plan and presentation. The nursing students are responsible for leading the team, including identifying a clinical problem, conducting clinical focus groups, developing the product requirements, leading the usability testing, and developing the clinical outcomes research proposal. This course provides hands-on experience to teach the skills of product design and development. It also encourages interdisciplinary teamwork, innovation, leadership, and communication with key stakeholders.

Options for elective courses include a variety of topics that further develop innovation, entrepreneurship, and leadership capabilities. Notable courses include "Improving

Table. Options for the INNOVATE Curriculum

Fall Semester	Spring Semester	Summer
	Year 0: Recruitment of first INNOVATE cohort	
Year 1: Fall Community Building and Experiential Learning Activities	**Year 1: Spring Activities**	**Year 1: Summer Options**
• Orientation sessions	*INNOVATE-1 (3 CR) interdisciplinary course*	IALS Core Summer Internship *(3 CR)*
• 2-d I&E workshop for INNOVATE scholars	• Inclusive Innovation and entrepreneurial mindset	*I&E 1*: 5-d intensive at Mt Ida *(3 CR)*
• Training, lectures and workshops: sample list (UMass): Innovators Warmup Training (ICorps @ UMass); Collegiate Summer Venture Program (Berthiaume Center for Entrepreneurship); Building Bridges (Diversity, Equity, and Inclusion); Acing Your Interview & Learn Linkedin (Career Development & Professional Connections); Invention disclosure and Technological Transfer Office.	Team taught by faculty from Elaine Marieb College of Nursing, the College of Engineering, and the Berthiaume Center for Entrepreneurship at the Isenberg School of Management	Collegiate Summer Venture Program *(3 CR)* (Berthiaume Center for Entrepreneurship)
• Training, lectures and workshops: sample list (outside of UMass): Various podcasts highlighting leadership in nursing innovation such as ANA's "See You Now" and Trusted Health's "The Handoff," ANA Innovation Awards, JNJ's QuickFire Healthcare Challenges; highlighting businesses founded by nurses.	*Recruitment of next INNOVATE cohort*	

(*continues*)

Table. Options for the INNOVATE Curriculum (*Continued*)

Fall Semester	Spring Semester	Summer
Year 2: Fall Community Building and Experiential Learning Activities	**Year 2: Spring Activities**	**Year 2: Summer Options**
• Orientation sessions	*INNOVATE-2 (3 CR) elective*	IALS Core Summer Internship *(3 CR)*
• 2-d I&E workshop for INNOVATE scholars	Sample course options:	*I&E 2*: 5-d intensive at Mt Ida *(3 CR)*
• Travel to Mass Challenge networking event and tour of the Cambridge Innovation Center	• Improving Inclusivity in Innovation and Entrepreneurship Through Understanding Disability	Collegiate Summer Venture Program *(3 CR)* (Berthiaume Center for Entrepreneurship)
• Continue special "Engagement" activities. New activities will include industry site visits; networking with entrepreneurs and industry advisory board, and participation in competitions	• Economics of science, technology, and innovation	Industry-based summer internship
• Applying for internships and workshops	• Technology for innovation and entrepreneurship • Sustainable production innovation • Finance for nonfinancial managers • Health care management • Medical product development, and lifecycle management *Recruitment of next INNOVATE cohort*	

(*continues*)

Table. Options for the INNOVATE Curriculum (*Continued*)

Fall Semester	Spring Semester	Summer
Year 3: Fall Community Building and Experiential Learning Activities *INNOVATE-3 (3 CR)* • Nurse-Led Medical Product Design, Development and Commercialization: An Interdisciplinary Seminar for Nursing, Engineering & Business Student Entrepreneurs • Continue special "Engagement" activities. New activities will include faculty and peer mentoring for grants (VentureWell E-Grants) and competitions (UMass Technology Innovation); One-Collaborative workshop at Mt. Ida campus: (1) site visits; (2) access to collaborative workspace; and (3) networking with local leaders/entrepreneurs and UMASS alumni	**YEAR 3: Spring Activities** *INNOVATE-4 (3 CR)* • Nurse-Led Medical Product Design, Development and Commercialization: An Interdisciplinary Seminar for Nursing, Engineering & Business Student Entrepreneurs *Recruitment of next INNOVATE cohort*	**YEAR 3: Summer Options** IALS Core Summer Internship *(3 CR)* Collegiate Summer Venture Program *(3 CR)* (Berthiaume Center for Entrepreneurship) Industry-based summer internship

(*continues*)

Table. Options for the INNOVATE Curriculum (*Continued*)

Fall Semester	Spring Semester	Summer
YEAR 4: Fall Community Building and Experiential Learning Activities	**Year 4: Spring Activities**	**Year 4: Summer Options**
Sample course options: • Leadership for the innovation edge • Leadership in science, innovation, and entrepreneurship • Interdisciplinary approach to innovation • Integration and innovation Participation in competitions Assistance with career choices and job applications	*INNOVATE-5 (3 CR)* • Final INNOVATE course (if needed) • Graduation of first *INNOVATE* cohort *Recruitment of next INNOVATE cohort*	NA

Abbreviations: I&E, innovation and entrepreneurship; NA, not available.

Inclusivity in Innovation and Entrepreneurship through Understanding Disability." By designing an integrative, immersive curriculum, the INNOVATE program breaks down the silos that traditionally isolate nursing students. This design also encourages program engagement and retention.

Experiential learning

Students find experiential learning helpful in nursing and multidisciplinary education.[9,10] Experiential learning offers richer, deeper learning than traditional lectures alone.[9] This hands-on pedagogical approach is integral throughout the INNOVATE curriculum. Experiential activities include orientation sessions and 2-day I&E workshops in the first and second years. Students visit special events, industry sites, innovation centers, and internship search workshops in their second year. Summer opportunities include weeklong immersive learning programs, summer employment in health care innovation, sponsored participation in the National Science Foundation iCORPs program, and joint programming with the business school focused on interdisciplinary entrepreneurship.

Intentional cohort building

Intentional cohort building is one strategy employed throughout INNOVATE to foster a sense of community and teamwork and is a primary focus each fall semester. In their first 2 years, students participate in fall orientation sessions and workshops that bring together all INNOVATE scholars. Students' sense of community is deepened through engagement in competitions, site visits, networking events, and other outings.

Peer and faculty support

The Future of Nursing 2020-2030 recognizes the urgency of nurse well-being.[2] The challenges of this profession begin during education, when nursing students experience stress, exhaustion, and difficulty staying engaged.[2,11,12] Prioritizing nursing health and

well-being is necessary for nurses to serve and support their own patients.[2] One recommended strategy is to develop a culture that prioritizes student well-being with visible and accessible support.[2]

INNOVATE incorporates both peer and faculty mentorship. A dedicated graduate student mentor will be assigned to work directly with INNOVATE scholars. Their support will include advising, workshop development and implementation, and helping students with recruitment and network events. Faculty mentors will also meet regularly with INNOVATE scholars throughout the 4-year program. This faculty member's primary goals are to provide strong and personalized support. To further strengthen engagement and success, nursing students will be mentored by INNOVATE advisors who will be responsible for meeting with students individually and in small groups on a regular basis throughout their 4-year program to support them in their professional development.

Developing real-world connections

Another core pillar of the INNOVATE program is connecting students to external resources. Establishing relationships with community members and real-world organizations strengthens nursing education and builds an understanding of health disparities.[2] INNOVATE promotes external connections with industry partners, like-minded programs, and future employers.

Developing connections with industry partners is most significant in the students' third year, when students identify and try to solve a real-world health challenge. Throughout their 2-semester seminar, students will interact with potential customers, clinicians, and companies required for a successful product launch. Nursing students will be empowered to communicate and use feedback from relevant stakeholders in the product development process.

INNOVATE also encourages relationships with like-minded programs, including VentureWell and Engineering Unleashed. VentureWell is a national organization headquartered in Western Massachusetts whose mission is to foster collaboration between the classroom and the outside world, pioneering a pipeline of student innovators and entrepreneurs.[13] Engineering Unleashed is a community of engineers who empower students to develop entrepreneurial mindsets and pursue meaningful, impactful careers. Powered by the Keen Foundation, Engineering Unleashed has successfully partnered with more than 43 academic institutions to establish I&E curricula.[14]

INNOVATE will purposefully connect students with future employers. We will explore and leverage all campus resources, such as the university career center, to recruit and support students pursuing new career pathways, especially those aligned with humanitarian and innovation mindsets. INNOVATE includes workshops to help our students develop skills in interdisciplinary communication, project management, resume building, and job interviewing.

Prioritizing diversity, inclusivity, and equity

In alliance with recommendations from the National Academy of Medicine[2] and the AACN,[1] diversity, inclusivity, and equity are primary goals of INNOVATE. These priorities are integrated into the program recruitment, retention, and course curriculum. INNOVATE will address racial, gender, and wealth inequities in nursing by increasing the participation of underrepresented minority (URM) students. INNOVATE will support the development of a strong I&E identity in nursing students, something that does not currently exist, and will promote equity in our recruitment and ongoing student support.

Studies have shown that identity and competency in these areas develop differently for URM students as compared with non-URM[15-17] and that institutional factors are highly predictive of the success trajectories of URM students.[18,19] The literature highlights the importance of a sense of belonging,

self-efficacy, and ability as integral in helping students navigate their unique challenges in their academic and professional lives.[16-19] Furthermore, the URM students engaged in I&E lag nationally compared with other groups.[20-22] Facilitating the development of a strong I&E identity as part of the nursing identity and engaging students' equity ethic are core goals for INNOVATE. INNOVATE will provide opportunities for students to bring their whole selves to INNOVATE (ie, that empower students to integrate their racial, gender/sexual orientation, other social identities).

Recruitment of diverse students is needed to build a nursing workforce that more closely resembles the patient population.[2] Recruitment for INNOVATE promotes inclusivity through intentional outreach to prospective students who are underrepresented minorities. Throughout the program, INNOVATE intentionally aims to close the year-to-year retention and graduation gaps of URM students. Concrete retention strategies include both curricular and noncurricular support, as well as financial support through expanded scholarships.

PROGRAM OUTCOMES AND EVALUATION

INNOVATE aims to accomplish the 5 program outcomes described in Figure 2. These outcomes will be evaluated using the following criteria:

1. To what extent do participants engage in formal opportunities (eg, courses and workshops) and informal opportunities (eg, student clubs, makerspaces, and collaborating with faculty on I&E projects) associated with INNOVATE?
2. To what extent do participants experience changes in entrepreneurial self-efficacy, entrepreneurial mindset, and science, I&E identity over the course of their participation in the INNOVATE program?
3. To what extent do INNOVATE participants engage in interdisciplinary collaboration?
4. To what degree do INNOVATE participants persist in the program and graduate from UMass Amherst within 4 years of enrolling?

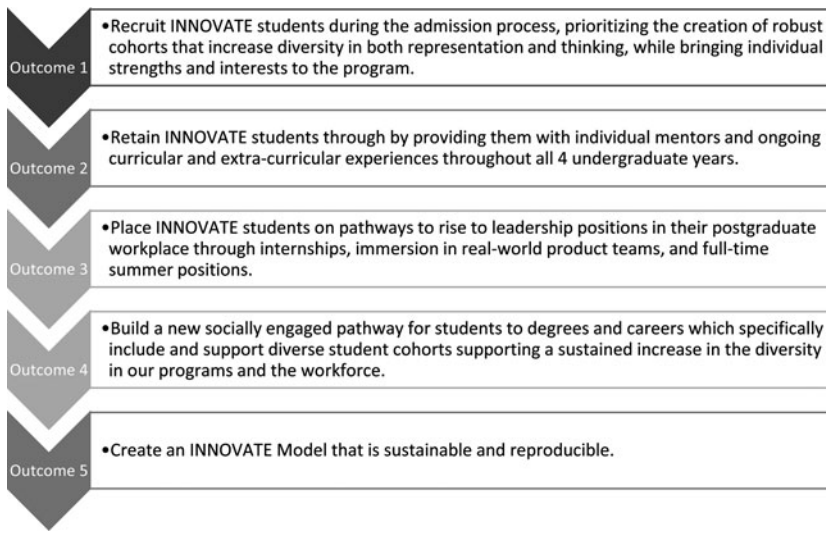

Figure 2. INNOVATE program outcomes.

5. What are participants' postgraduate employment and career outcomes?
6. How do participants experience INNOVATE as influencing their curricular and cocurricular college experiences, and their postgraduate outcomes?
7. What aspects of INNOVATE, if any, act as drivers of program outcomes (eg, persistence, entrepreneurial self-efficacy, and postgraduate employment placement)?
8. How can the program be strengthened to help achieve desired outcomes?
9. To what extent does the implementation of INNOVATE correlate with changes in the level of I&E activity at UMass Amherst that can help serve as a sustainable model that can be replicated?
10. To what extent does INNOVATE lead to changes in the ANA Nursing Reimaged Initiative intended practice, academic, and patient outcomes?

CONCLUSION

INNOVATE is being proposed on the idea that nurses are well-suited to understand, envision, and lead the design and development of innovation in health care products, processes, and services. This program will empower and prepare nurses to become leaders in health care I&E. The strengths of INNOVATE arise from interdisciplinary collaboration, an integrated, immersive curriculum, experiential learning, intentional cohort building, peer and faculty support, real-world connections, and the prioritization of diversity, inclusion, and equity. It is our belief that this program will engage students, provide them with hands-on experience, develop their innovative and entrepreneurial identity, and prepare them for careers in product development and health care innovation. Concrete program outcomes and intentional evaluation will help to continue to develop this bold, new approach to nursing curricula.

Integral to the development and implementation of INNOVATE is the new Elaine Marieb Center for Nursing and Engineering Innovation. The mission of this Center is to pioneer innovation through the intersections of nursing, engineering, and research. The Center will foster the capacity for rapid application of nursing and engineering skill sets by providing the infrastructure to help students design and test new products, services, and delivery systems to improve health care. In addition to nurse-engineer partnerships, the Center also supports teamwork with students from any discipline that can contribute their expertise, including—but certainly not limited to—business, public health, and the sciences. These wide-ranging collaborations and resources will support INNOVATE scholars and deepen interdisciplinary collaboration. It is our goal as we plan and implement the INNOVATE program for it to become a national model of collaborative, interdisciplinary undergraduate nursing education for the next generation of students.

REFERENCES

1. American Association of Colleges of Nursing. The essentials: core competencies for professional nursing education. https://www.aacnnursing.org/Portals/42/AcademicNursing/pdf/Essentials-2021.pdf. Published April 6, 2021.
2. National Academy of Medicine. *The Future of Nursing 2020-2030: Charting a Path to Achieve Health Equity*. Washington, DC: The National Academies Press; 2021:1-470. doi:10.17226/25982.
3. Ackerman MH, Giuliano KK, Malloch K. The novation dynamic: clarifying the work of change, disruption, and innovation. *Nurs Lead*. 2020;18(3):232-236. doi:10.1016/j.mnl.2020.01.003.
4. Roddy L, Polfuss M. Employing design thinking methods in nursing to improve patient outcomes. *Nurs Forum*. 2020;55(4):553-538. doi:10.1111/nuf.12461.
5. Smiley RA, Ruttinger C, Oliveira CM, et al. The 2020 national nursing workforce survey. *J Nurs Regul*. 2021;12(1, suppl):S1-S96. doi:10.1016/S2155-8256(21)00027-2.
6. Michas F. US physicians—statistics & facts. Statista. https://www.statista.com/topics/1244/physicians/#dossierKeyfigures. Published October 19, 2021. Accessed November 24, 2021.
7. Giuliano KK. Challenging precedent: critical care nursing and medical product innovation. *Am J*

Crit Care. 2020;29(4):253-261. doi:10.4037/ajcc2020275.
8. American Nurses Association. *Nursing: Scope and Standards of Practice*. 4th ed. Washington, DC: Nursesbooks; 2021.
9. Hill B. Research into experiential learning in nurse education. *Br J Nurs*. 2017;26(16):932-938. doi:10.12968/bjon.2017.26.16.932.
10. Ludwig PM, Nagel JK, Lewis EJ. Student learning outcomes from a pilot medical innovations course with nursing, engineering, and biology undergraduate students. *Int J STEM Educ*. 2017;4(1):33. doi:10.1186/s40594-017-0095-y.
11. Wang M, Guan H, Li Y, Xing C, Rui B. Academic burnout and professional self-concept of nursing students: a cross-sectional study. *Nurs Ed Today*. 2019;77:27-31. doi:10.1016/j.nedt.2019.03.004.
12. Ching SSY, Cheung K, Hegney D, Rees CS. Stressors and coping of nursing students in clinical placement: a qualitative study contextualizing their resilience and burnout. *Nurs Educ Pract*. 2020;42:102690. doi:10.1016/j.nepr.2019.102690.
13. VentureWell. About VentureWell. https://venturewell.org/about-us. Accessed November 19, 2021.
14. Engineering Unleashed. Engineering Unleashed: About us. https://engineeringunleashed.com/about. Accessed November 19, 2021.
15. Burt BA. Toward a theory of engineering professorial intentions: the role of research group experiences. *Am Educ Res J*. 2019;56(2):289-332. doi:10.3102/0002831218791467.
16. Rodriguez S, Blaney J. "We're the unicorns in STEM": understanding how academic and social experiences influence sense of belonging for Latina undergraduate students. *J Divers High Educ*. 2021;14(3):441-455. doi:10.1037/dhe0000176.
17. Rodriguez S, Lu C, Bartlett M. Engineering identity development: a review of the higher education literature. *Int J Educ Math Sci Technol*. 2018;6(3):254-265. doi:10.18404/ijemst.428182.
18. Ro H, Loya K. The effect of gender and race intersectionality on student learning outcomes in engineering. *Rev High Ed*. 2015;38:359-396. doi:10.1353/rhe.2015.0014.
19. Ro HK, Knight D, Loya K. Exploring the moderating effects of race and ethnicity on the relationships between curricular and classroom experiences and learning outcomes in engineering. *J Women Minor Sci Eng*. 2016;22(2):91-117. doi:10.1615/JWomenMinorScienEng.2016013601.
20. American Society for Engineering Education. *Engineering and Engineering Technology by the Numbers 2019*. Washington, DC: American Society for Engineering Education; 2020:1-83. https://ira.asee.org/wp-content/uploads/2020/09/E-ET-by-the-Numbers-2019.pdf.
21. Estrada M, Burnett M, Campbell AG, et al. Improving underrepresented minority student persistence in STEM. *CBE Life Sci Educ*. 2016;15(3):es5. doi:10.1187/cbe.16-01-0038.
22. McGee EO, Griffith DM, Houston SL. "I know I have to work twice as hard and hope that makes me good enough": exploring the stress and strain of black doctoral students in engineering and computing. *Teachers Coll Record*. 2019;121(4):1-38. doi:10.1177/016146811912100407.