Something old and something new: The time is right to offer geriatric engineering programs

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Something old and something new: the time is right for geriatric engineering programs Amy E. Herr, MS, PhD\textsuperscript{1,2}, and Janice B Schwartz, MD\textsuperscript{3}

\textsuperscript{1}Department of Bioengineering, University of California, Berkeley, Berkeley, CA; UC Berkeley – UCSF Graduate Program in Bioengineering, Berkeley, CA; \textsuperscript{3}Department of Medicine, UC San Francisco, San Francisco, CA

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Short running title: Adding engineering to the geriatric team
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Adding geriatric engineering creates a powerful new opportunity for contemporary health care education curriculum to more effectively and efficiently address the unmet needs of older adults today, as well as (perhaps even more importantly) educate next generations of leaders in adaptable design thinking approaches. (Figure 1) The incorporation of design thinking frameworks into the fields of gerontology and geriatric medicine will equip us with leaders who are adept at continually evolving our understanding of aging, so as to identify and address not just today’s needs, but also to address the emerging needs of tomorrow.

In this Issue, Lubiner describes inception and maturation of one such geriatric engineering program. In addition to providing important context on the scope and scale of the geriatric engineering sub-discipline, the article shows the rich diversity of curriculum that brings medicine, geriatric medicine, engineering, and older persons together, moving beyond the more familiar combined MD/PhD degree programs. In addition to outlining learnings in development and launch of the geriatric engineering program at the author’s institution, we see the article as
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The power of integrating gerontology and geriatric medicine with engineering is that – in a
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Several key elements increase the likelihood for impactful outcomes from use of the engineering
design process, even for novice adopters and college students. First is the iterative (not linear)
use of the staged design process, with frequent looping between stages to integrate new learnings
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Secondly, integrating human-centered design considerations into the curriculum ensures that real
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Human-centered design is adaptable, again educating practitioners who can adapt to emerging
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Thirdly, and highly relevant to geriatric engineering, is adoption of a version of engineering design that not only is human-centered in nature, but places tremendous value on solution outcomes beneficial to all stakeholders. This ethos is exemplified by ‘universal design’ and ‘design for all’, which applies the engineering design process to arrive at solutions that are ‘barrier-free’ for all users, regardless of abilities. A set of principles adapted from M.F. Story guide how to foster solutions with universal applicability, comprising roughly: (1) equitable use, (2) flexibility in use, (3) simple and intuitive use, (4) perceptible information, (5) tolerance for error, (6) low physical effort, and (7) size and space for approach and use. Entire technical conferences and pedagogical research themes exist to address aging-focused engineering design, including the “Universal Design & Higher Education in Transformation Congress” (https://www.udheit2018.com/). Certainly, architecture and the built environment have pioneered older adult-focused design, but the bioengineering, mechanical engineering, and computer science & electrical engineering disciplines are also now engaged, albeit most often not
through full degree programs (i.e., European Alliance for Innovation’s GOODTECHS). Clearly, universal design principles are directly relevant to geriatric engineering.

There is great hope for technology to help older adults maintain independence and overcome social isolation. There are early examples of success such as simplified computer tablets modeled on phones or televisions (GrandPad, 12 the Norwegian Komp13), electronic pets (robotic seal pup Paro or the robot Pepper14,15), electronic devices and robot virtual assistants for reminders of appointments and/or medications16, robots and devices able to lead older adults through daily balance and exercise tasks and/or become a dance partner or robotic walkers17,18, activity detectors and sensors19, and top of the range hearing aids with fall detection capability20,21. But, there are also unmet daily life challenges for older adults that could be addressed using lower technology solutions as has been demonstrated for assistive devices for walking, for entering and exiting cars, for stairclimbing, for dinnerware and eating utensils for patients with tremors, among others. Input from patients and allied health care professionals are needed to identify the needs but engineering expertise is also needed to create solutions. Currently, health care professionals and engineers live and train with little knowledge of the other. This must change to more successfully address the challenges that many older adults face in their daily lives. To better address the needs of older adults, the time is right for geriatric engineering programs.

We have learned that we cannot recruit or graduate adequate numbers of geriatric-trained health care professionals to provide medical care for all older adults and that geriatric knowledge must be integrated into all adult health care professional training curriculums.22,23 We similarly predict that we would not be able to produce enough graduates of geriatric engineering programs such as described by Lubiner6 to meet either current or future needs. We propose that the focus be on interdisciplinary efforts and expansion of our joint programs and efforts. We should
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REFERENCES


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7. Sandholdt, C.; Cunningham, J.; Westendorp, R. Towards Inclusive Healthcare Delivery:


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**Author Contributions:** Indicate authors’ role in study concept and design, acquisition of subjects and/or data, analysis and interpretation of data, and preparation of manuscript.

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