

Teaching Societal Impact in the STEM Classroom

Jorge Jimenez

Bioengineering PhD candidate
STEM & Society Lecture Series

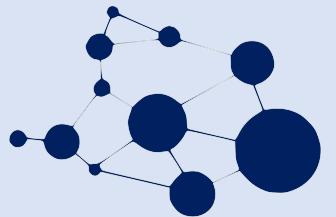
November 19th, 2020



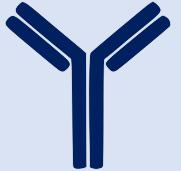
Outline

- I. Learning about evidence-based teaching & learning practices
- II. Applying concepts to the STEM classroom
- III. Assessing teaching practices

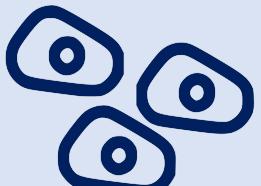
My background: drug delivery for rare corneal disease



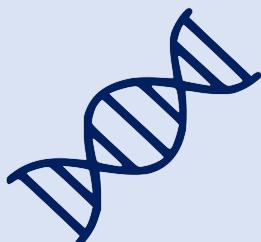
Small molecule



Biologics



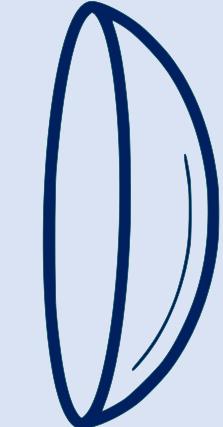
Cells



Gene

Topical

- Eye Drops
- Gels
- Ointments



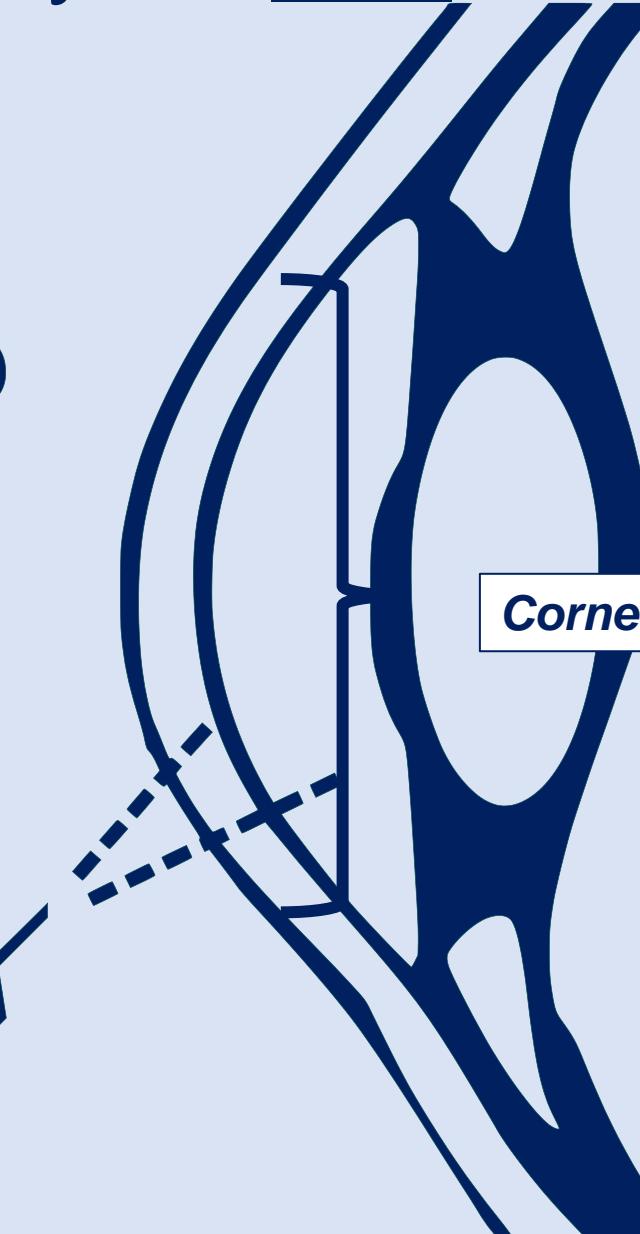
Polymer Devices

- Contact lens
- Ocular inserts
- Punctual plug

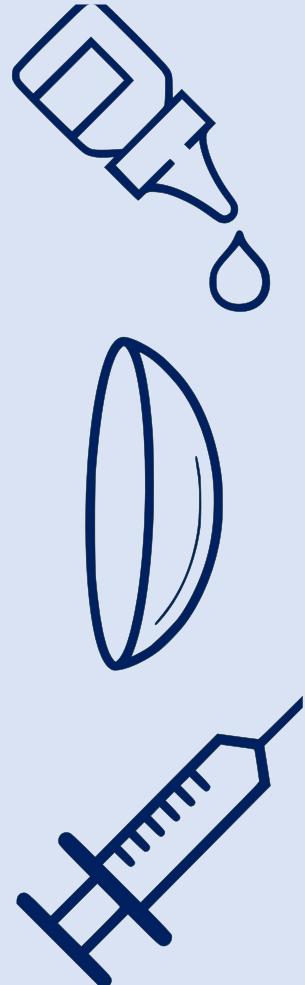


Injection

- Intrastromal
- Anterior chamber



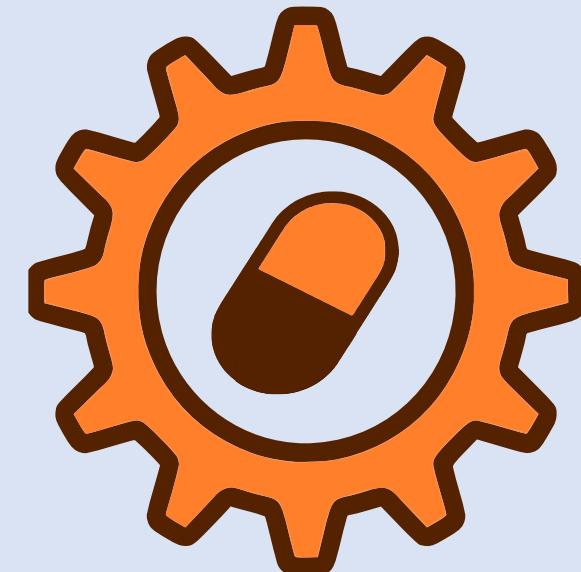
My journey: inclusion of corneal rare diseases in teaching...from a social-public health perspective



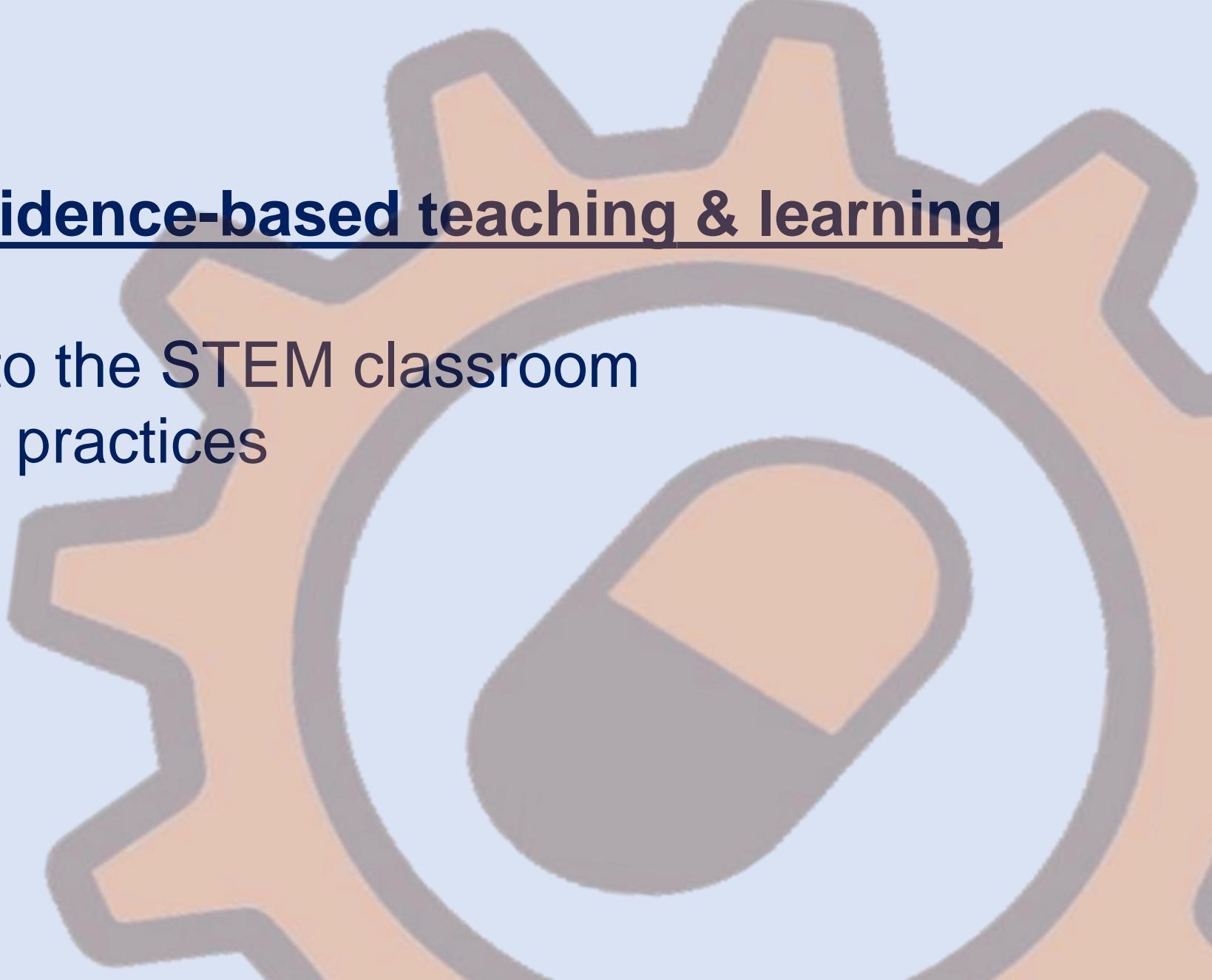
Center for Integrating
Research, Teaching and
Learning (CIRTL)



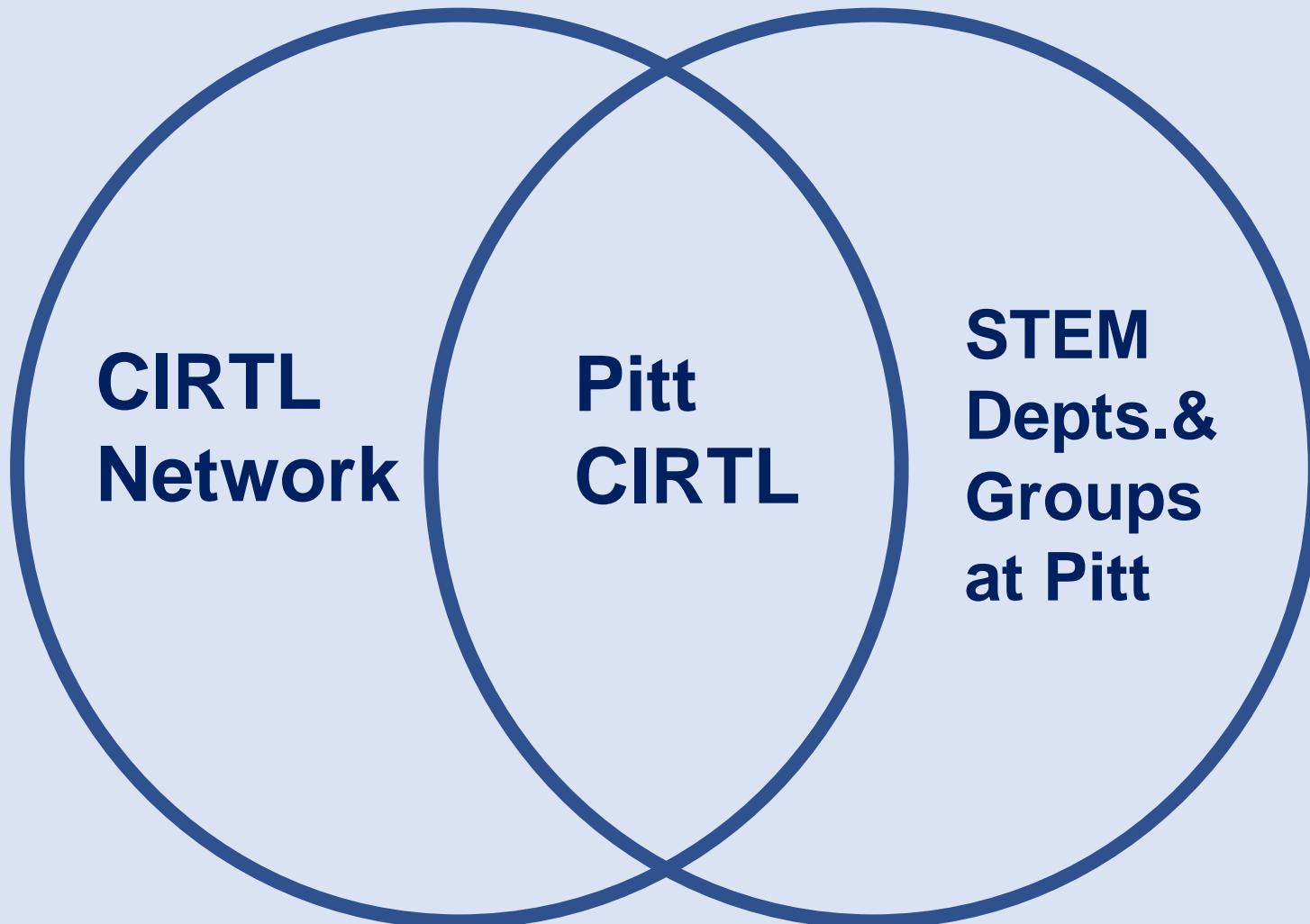
Spring 2020
BioE/ChemE: 1533
Controlled Drug
Delivery



Outline

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Teaching as professional development



Prep for the STEM Classroom

- BIOSC 3001
- CHEM 3001
- ENGR 3001

Advancing Learning Through Evidence-Based STEM Teaching

- BIOSC 3002
- CHEM 3002
- ENGR 3002

CIRTL network offers asynchronous and synchronous courses to all
(cirtl.net)

- Training the next generation of STEM faculty members with knowledge of and engagement in evidence-based teaching/learning practices

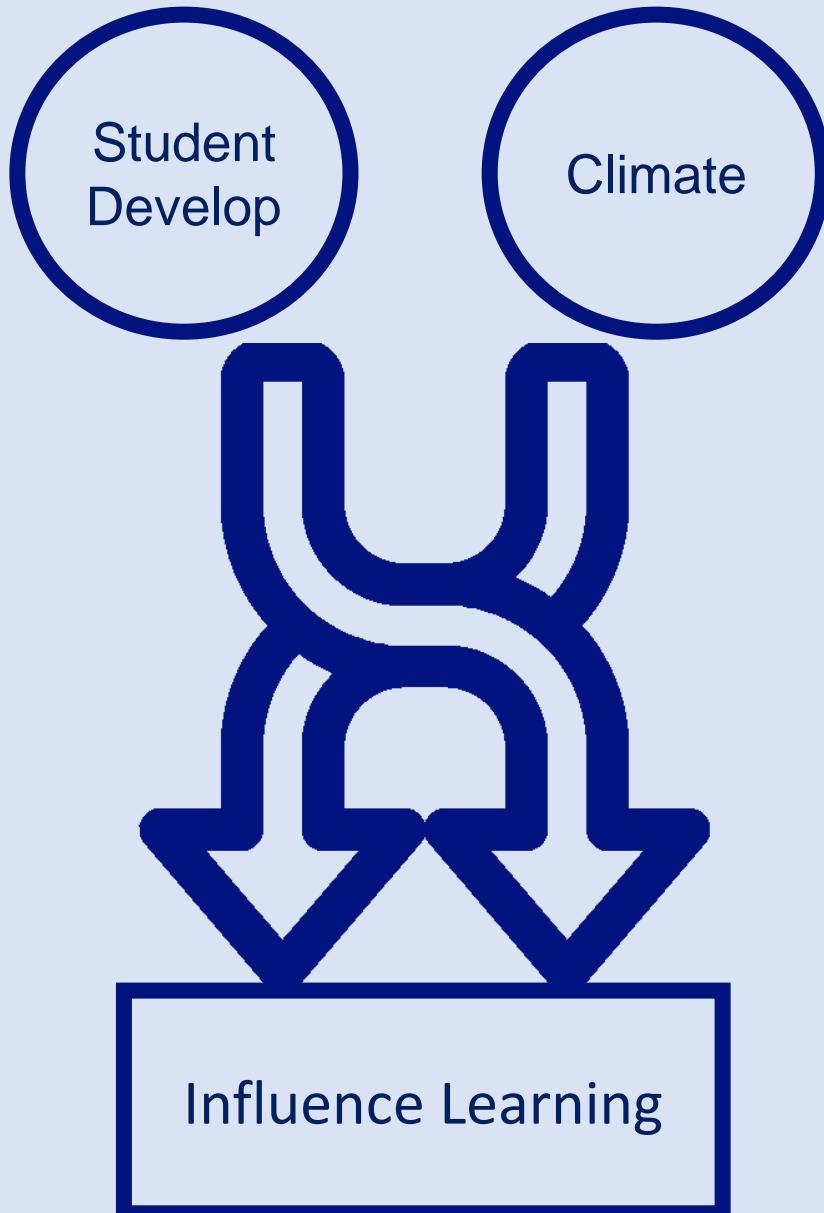
Seven Research-Based Principles for Smart Teaching

- I. Students' ***prior knowledge*** can serve to help or hinder learning.
- II. Students' ***organization of knowledge*** impacts how students learn and apply what they know.
- III. **Motivation** determines, directs, and sustains what students learn.
- IV. To develop ***mastery***, students must develop the skills, practice integrating them, and know when to apply them.
- V. Goal-directed ***practice*** coupled with targeted ***feedback*** enhances learning.
- VI. Level of learner ***development*** interacts with “course” ***climate*** to impact learning.
- VII. To become ***self-directed***, learners must be able to monitor and adjust their approaches to learning

How Learning Works: Seven Research-Based Principles for Smart Teaching.

Susan A. Ambrose, Michael W. Bridges, Michele DiPietro,
Marsha C. Lovett, Marie K. Norman, editors. with a foreword
by Richard E. Mayer San Francisco: Jossey-Bass. 2010.
ISBN-13: 978-0470484104.

Why does course climate matter?



- I. Concepts: Holistic student development and course climate (includes classroom environment!)
- II. Emotions and social processes influence students' ability to engage productively with the material and to learn.
- III. Recognizes that students are not only intellectual but also social and emotional beings, and that these dimensions interact within the classroom climate to influence learning and performance

Susan A. Ambrose “How Learning Works: Seven Research-Based Principles for Smart Teaching”

What type of climate would Prof. Beardsley's course have?



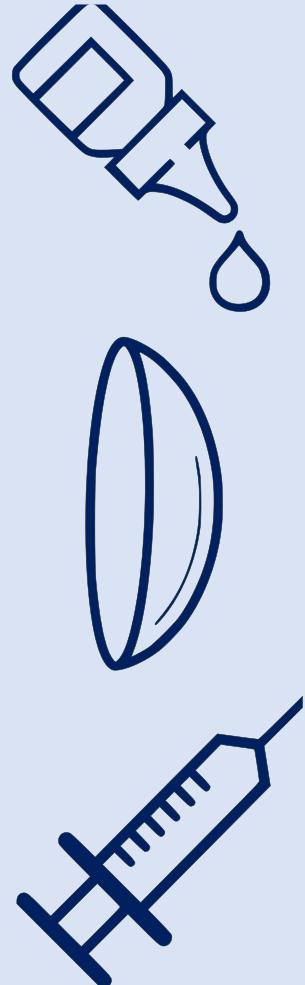
Talking out of turn? That's a paddlin'. Lookin' out the window? That's a paddlin'. Staring at my sandals? That's a paddlin'. Paddlin' the school canoe? Oh, you better believe that's a paddlin'."

- Jasper Beardsley, *The Simpsons* "The PTA Disbands"

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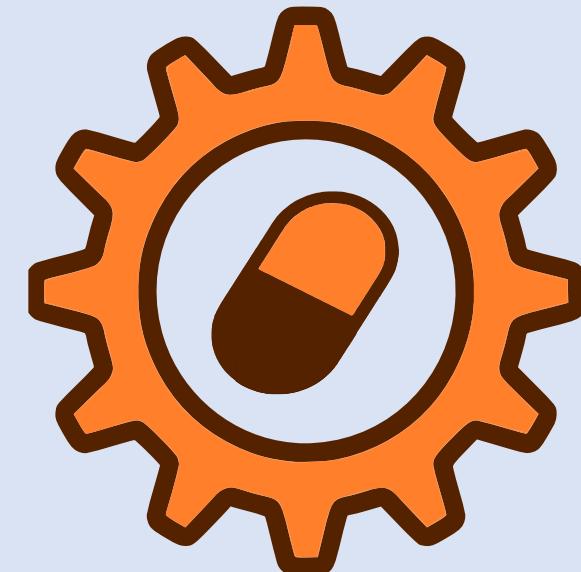
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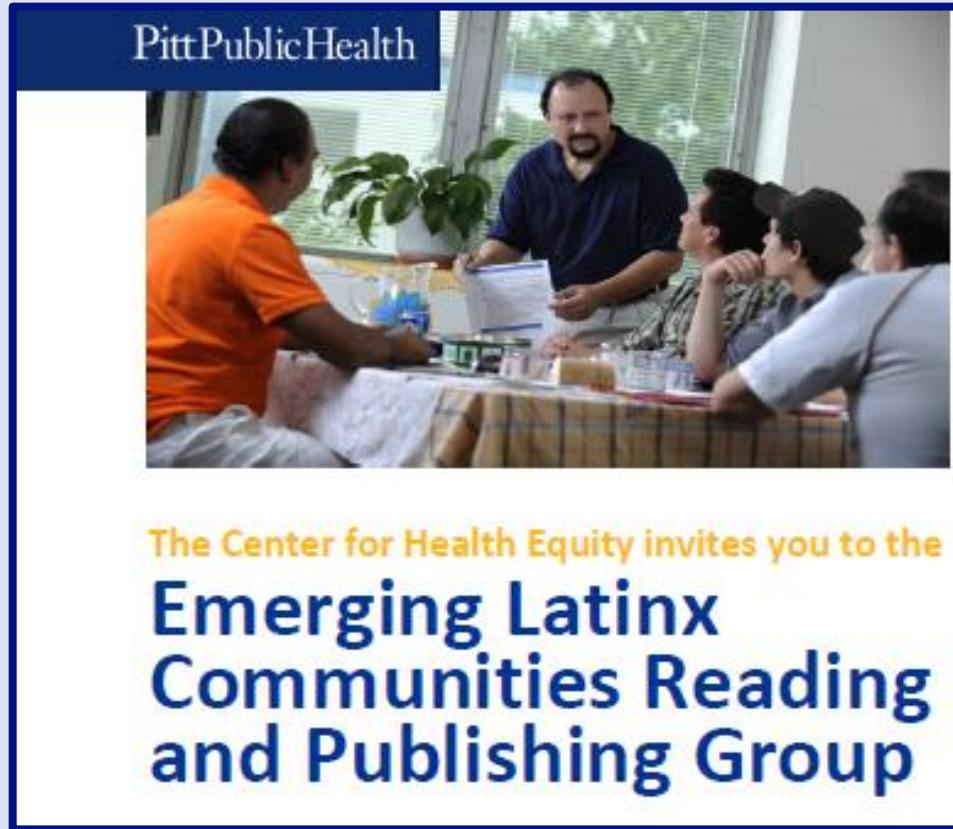




Where do I begin?
Student motivation?
Course climate?

KC Green “On Fire” Webcomic 2013
<https://www.theverge.com/2016/5/1/1592622/this-is-fine-meme-comic>

Background- Center for Health Equity, Emerging Latinx Community Group



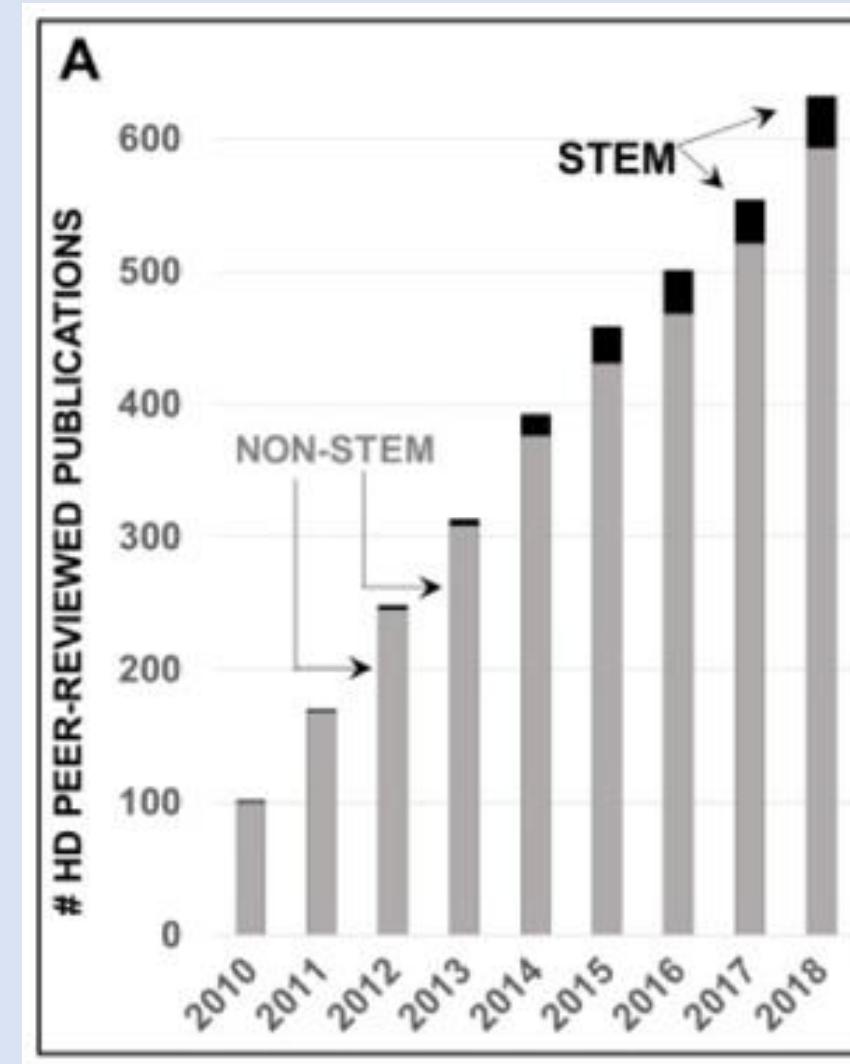
- I. Working with a community: building relationships based on trust by **LISTENING**
- II. Health Disparities (HD) - higher burden of illness, injury, disability, or mortality experienced by one group relative to another that are closely linked with social, economic, and/or environmental disadvantage.

Jacquez, Farrah, et al. "Health Care Use and Barriers to Care among Latino Immigrants in a New Migration Area." *Journal of Health Care for the Poor and Underserved*, vol. 27 no. 4, 2016, p. 1761-1778. Project MUSE, [doi:10.1353/hpu.2016.0161](https://doi.org/10.1353/hpu.2016.0161).

Research Motivation – Integration of HD research into STEM education

- I. There is a rising trend in HD research by Science, Technology, Engineering and Math (STEM) investigators – highlighting the need for interdisciplinary strategies to address HD.

- II. “Non-STEM” social science....
Apparently



Vazquez M (2018) Engaging Biomedical Engineering in Health Disparities Challenges. J Community Med Health Educ 8: 595. doi: 10.4172/2161-0711.1000595

Pedagogical approach to HD in STEM Education

- I. Literature analysis of HD agents as case studies
- II. Intersects social science, public health, policy, regulation, healthcare systems, and historical context

HD Agents	Peer Review Literature	Description of Concerns
Clinical Trials	Literature Review Assessment	Analysis to HD
Genetic Screening		
Technologies and Tools		
Access and Quality		
Historical and Societal Factors		

Social Determinants of Health (SDoH) and HD

- Social determinants of health include factors like socioeconomic status, education, neighborhood and physical environment, employment, and social support networks, as well as access to health care.
- Researchers state **SDoH are a root cause of HD.**
- **Addressing SDoH** is important for improving health and **reducing longstanding disparities** in health and health care.

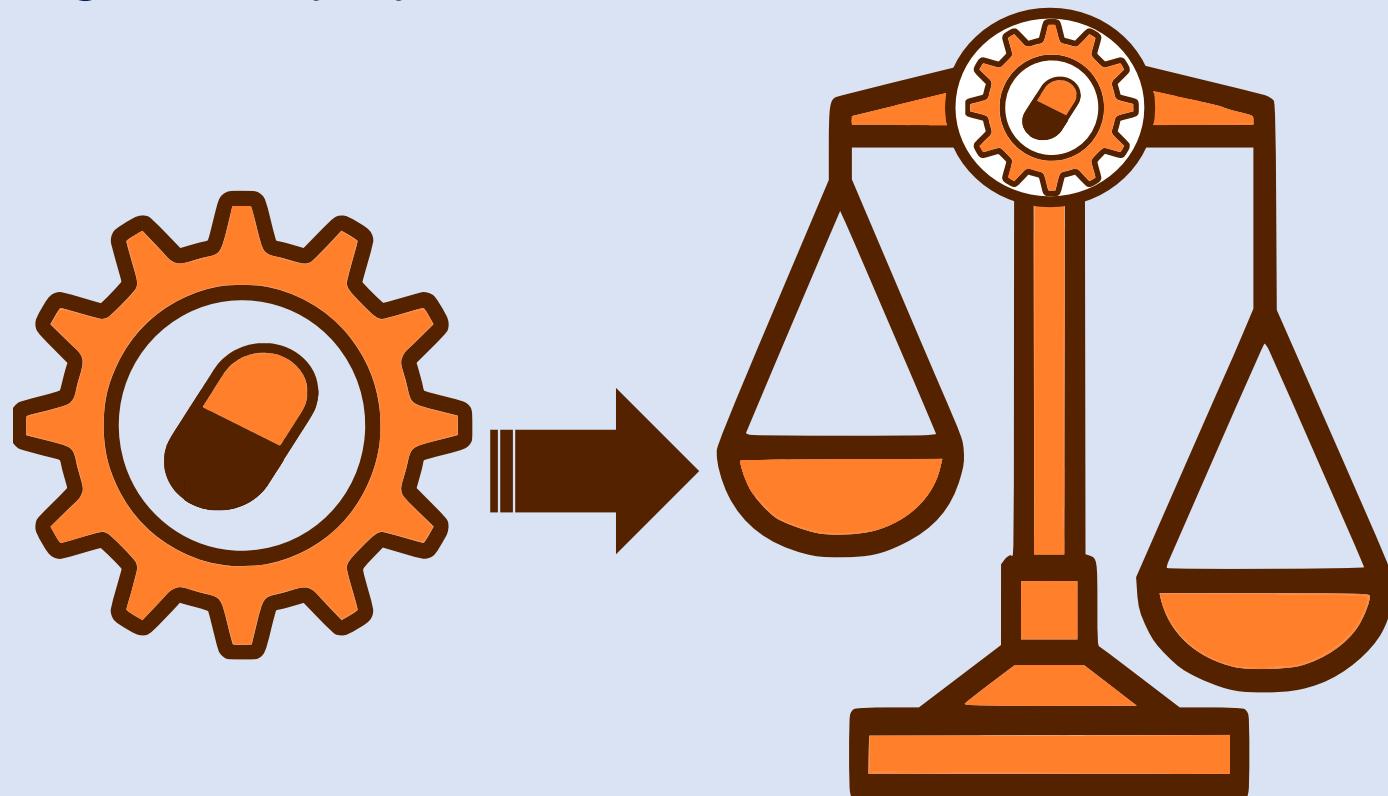
“Beyond Health Care: The Role of Social Determinants in Promoting Health and Health Equity.” KFF (blog), May 10, 2018.
<https://www.kff.org/disparities-policy/issue-brief/beyond-health-care-the-role-of-social-determinants-in-promoting-health-and-health-equity/>.

Research Question:

Can we use the public health topic of SDoH to teach engineering students the social impact of drug delivery system technologies and measure their interest?

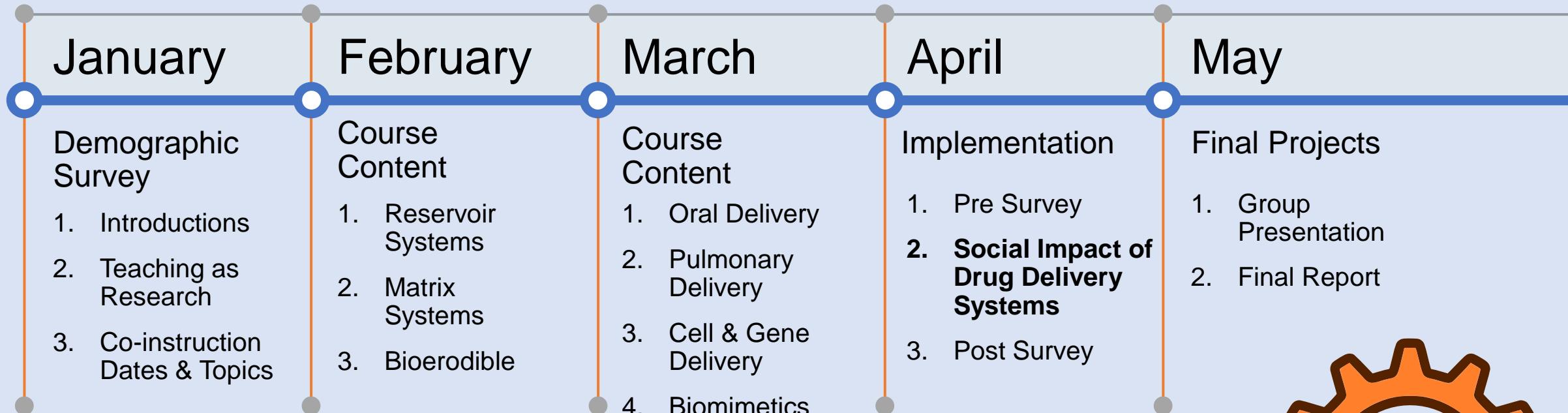
Hypothesis

- I hypothesize biomedical engineering teaching pedagogies that are adapted for health disparities will engage student interest in social impact of drug delivery systems



Spring 2020

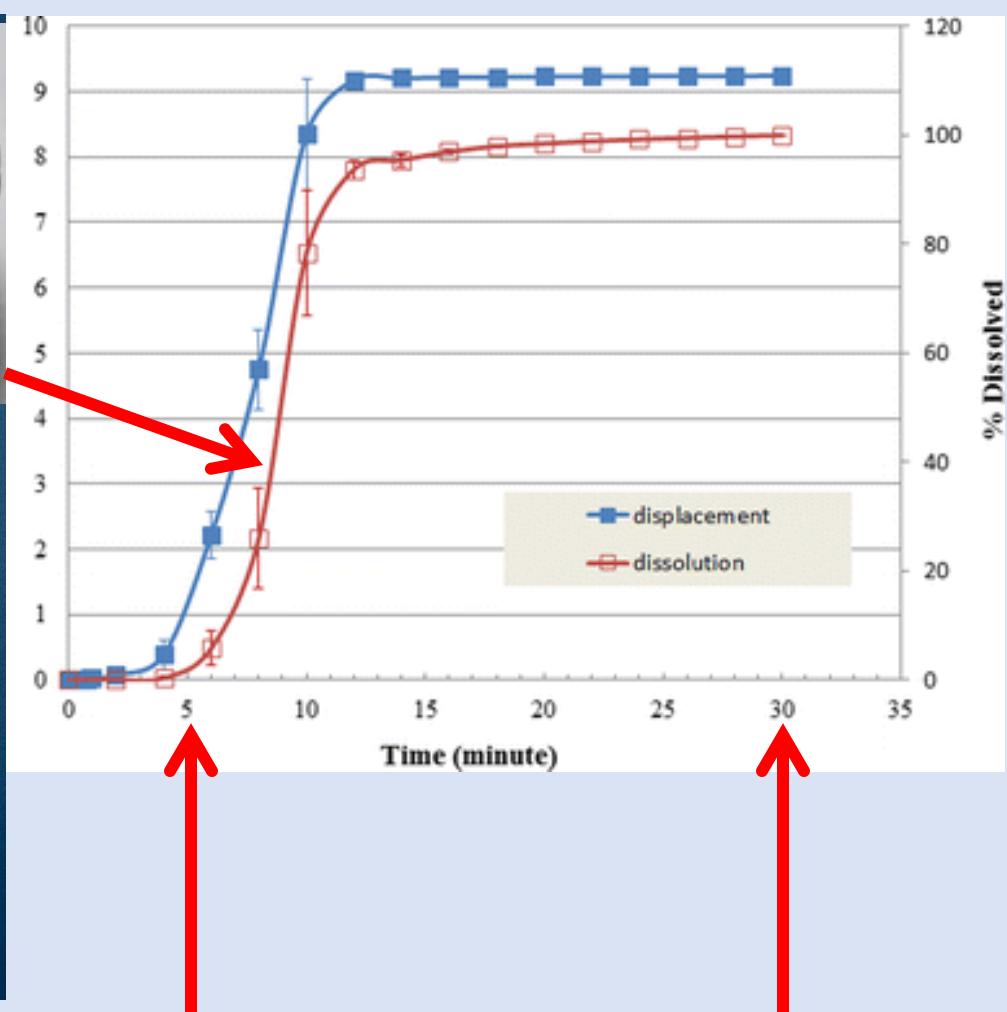
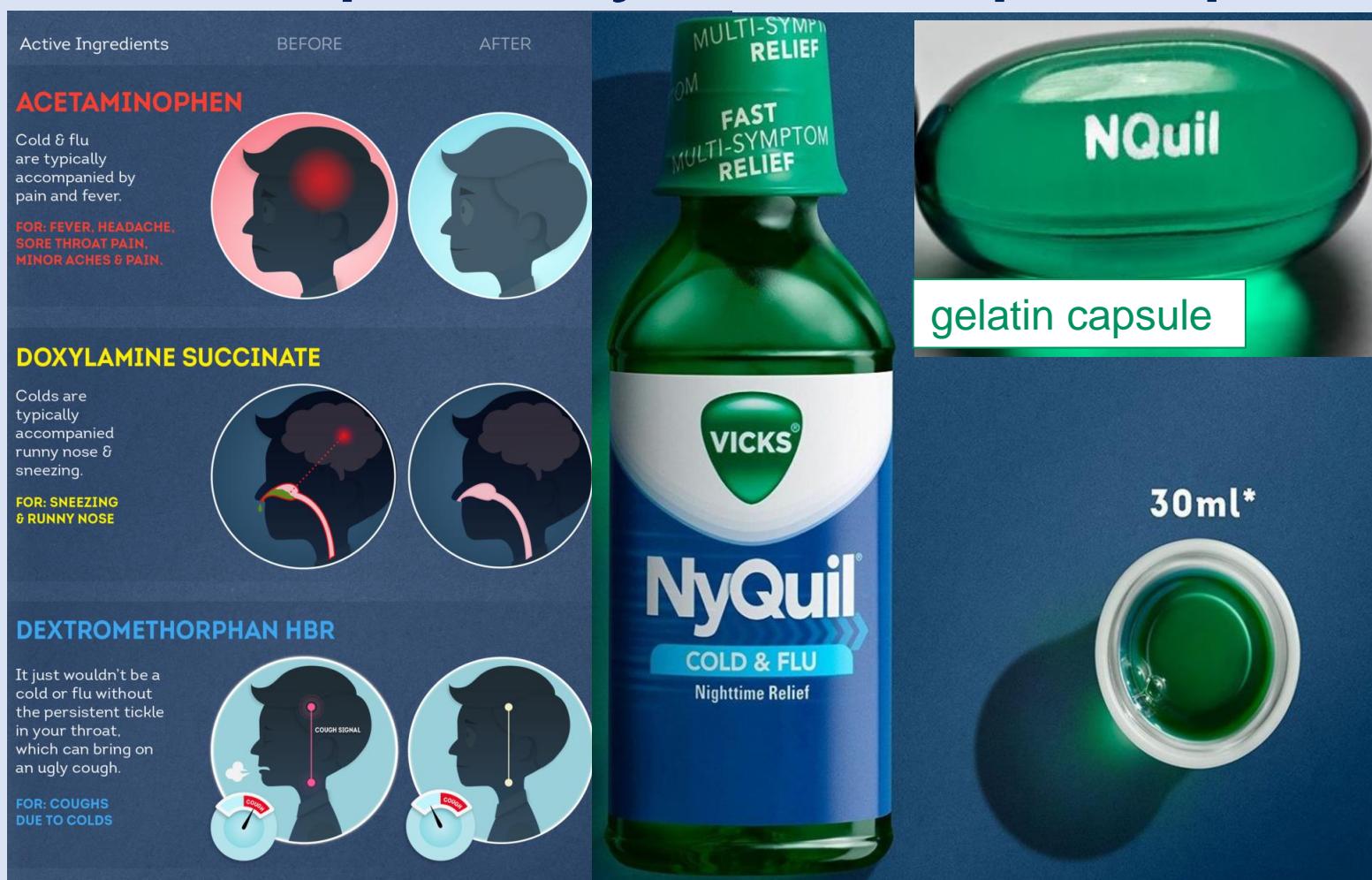
BioE/ChemE: 1533 Controlled Drug Delivery



- Co-instruction: Dr. Morgan Fedorchak
- Enrollment: 26 students
- Educational IRB



Example: NyQuil Liquicaps



Gao, Zongming. "In Vitro Dissolution Testing of Gelatin Capsules with Applied Mechanical Compression—a Technical Note." *AAPS PharmSciTech* 18, no. 1 (January 1, 2017): 231–37. <https://doi.org/10.1208/s12249-016-0506-2>.

5 mins: begins to dissolve

30 mins: 100% dissolved

Student Demographic

Spring 2020 Cohort		
Characteristic	No.	Percent of Student Responses
Major		
Bioengineering	15	60%
Chemical Engineering	10	40%
Program		
Undergraduate	25	100%
Region		
Domestic	23	92%
International	2	8%
Experience		
Research	21	84%
Community	17	68%
Industry	10	40%
Response count N = 25		

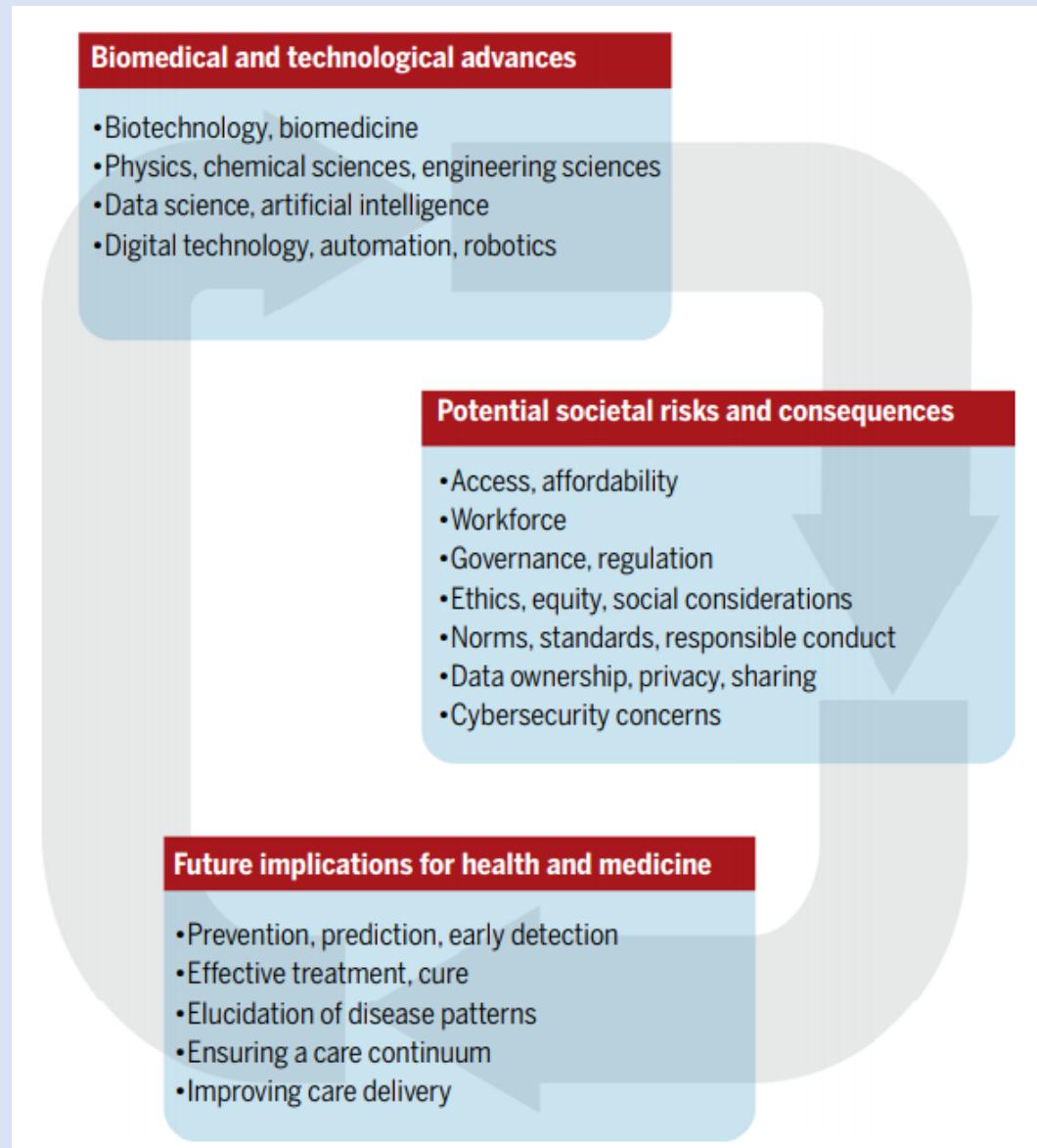
- I. Students are mainly trained at the University of Pittsburgh with an emphasis on research experience (84%)
- II. More students had community experience (68%) than industry experience (40%)

Course Interest

- I. Prompt: “Here is a list of common reasons for taking a course. Please read each one and indicate if the reason was important to your decision to take this course”
- II. Interest in the subject matter was a very important reason for enrolling in the course**

ID	Reason	Not Important	Moderately Important	Very Important	Response Count N
R1	Interest in the subject matter	0 (0%)	6 (24%)	19 (76%)	25
R2	I need it for graduate or professional school	14 (67%)	5 (24%)	2 (9%)	21
R3	It fit my schedule	7 (28%)	15 (60%)	3 (12%)	25
R4	To fill a major requirement	3 (12%)	8 (32%)	14 (56%)	25
R5	I need it for my desired employment after college	7 (33%)	10 (48%)	4 (19%)	21
R6	To learn about lab techniques	13 (57%)	10 (43%)	0 (0%)	23
R7	To learn about science and the research process	1 (4%)	13 (54%)	10 (42%)	24
R8	The course has a good reputation	4 (19%)	10 (48%)	7 (33%)	21

Research & Technology Social Impact Cycle



Dzau, Victor J., and Celynne A. Balatbat. "Health and Societal Implications of Medical and Technological Advances." *Science Translational Medicine* 10, no. 463 (October 17, 2018).

Implementation of Social Impact

Biomedical and technological advances

- Biotechnology, biomedicine
- Physics, chemical sciences, engineering sciences
- Data science, artificial intelligence
- Digital technology, automation, robotics

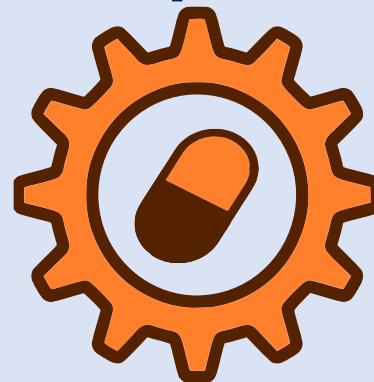
BioE/ChemE: 1533

Potential societal risks and consequences

- Access, affordability
- Workforce
- Governance, regulation
- Ethics, equity, social considerations
- Norms, standards, responsible conduct
- Data ownership, privacy, sharing
- Cybersecurity concerns

Future implications for health and medicine

- Prevention, prediction, early detection
- Effective treatment, cure
- Elucidation of disease patterns
- Ensuring a care continuum
- Improving care delivery



Implementation

- Health Systems
- Pharmaceutical Industries
- Patient-Physician Relationships
- Community Health
- Social determinants of health

**Case studies, evaluation of
drug delivery systems impact,
social-health perspectives**

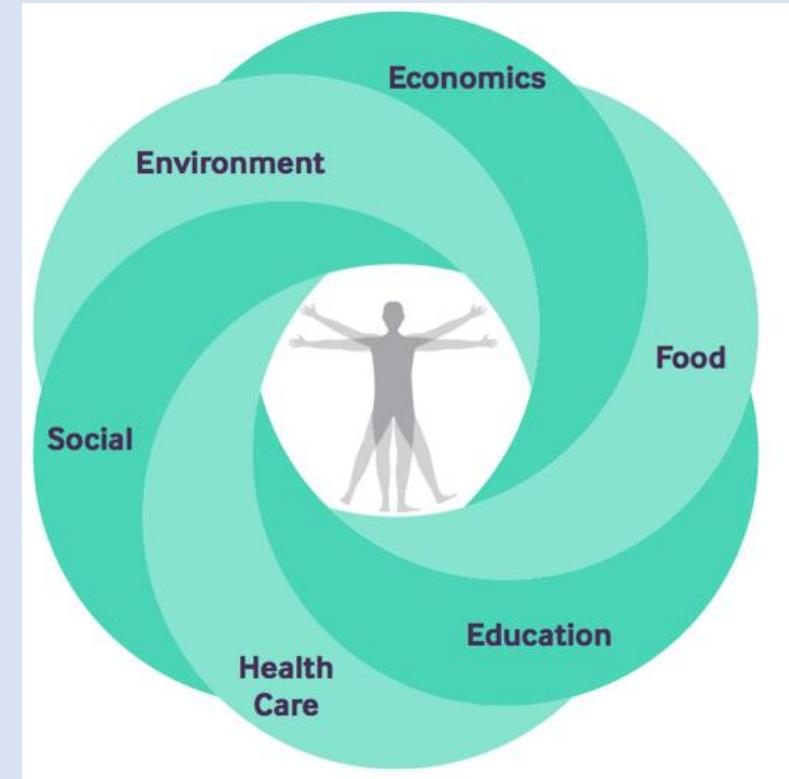


Learning Goals

- Intersecting course content by analyzing how drug delivery systems may impact social determinants of health
 1. Define social determinates of health
 2. Identify social determinates of health factors related to a drug delivery system therapy
 3. Analyze literature for social impact of drug delivery systems

New course content: Social Determinants of Health

1. Income level
2. Education opportunities
3. Occupation, employment status, and workplace safety
4. Gender inequity
5. Racial segregation
6. Food insecurity and inaccessibility of nutritious food choices
7. Access to housing and utility services
8. Early childhood experiences and development
9. Social support and community inclusivity
10. Crime rates and exposure to violent behavior
11. Availability of transportation
12. Neighborhood conditions and physical environment
13. Access to safe drinking water, clean air, and toxin-free environments
14. Governance and regulation



“Social Determinants of Health (SDOH).” NEJM Catalyst
Innovations in Care Delivery, no. 6 (2017).

Barriers to drug delivery

Biomedical and technological advances

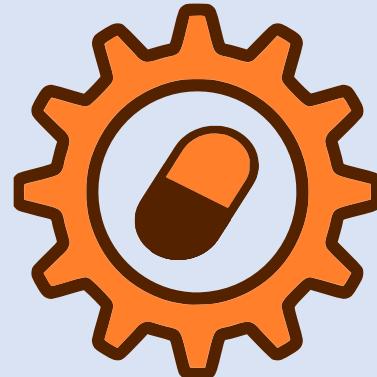
- Biotechnology, biomedicine
- Physics, chemical sciences, engineering sciences
- Data science, artificial intelligence
- Digital technology, automation, robotics

Potential societal risks and consequences

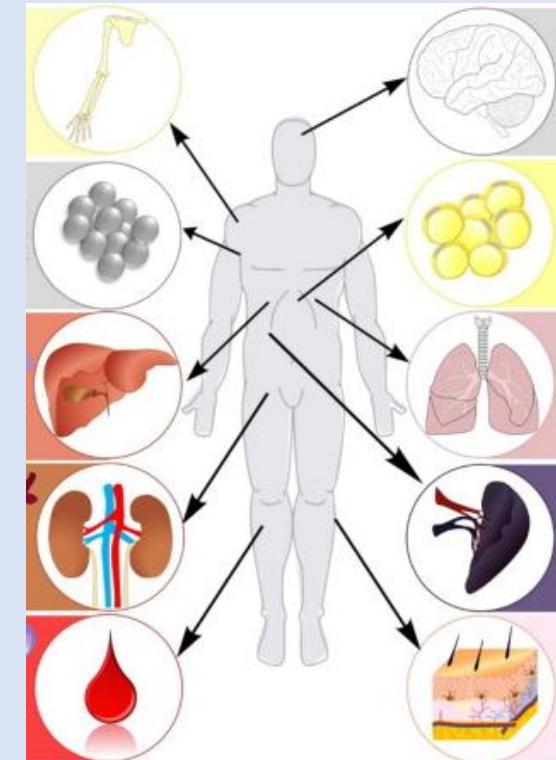
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Future implications for health and medicine

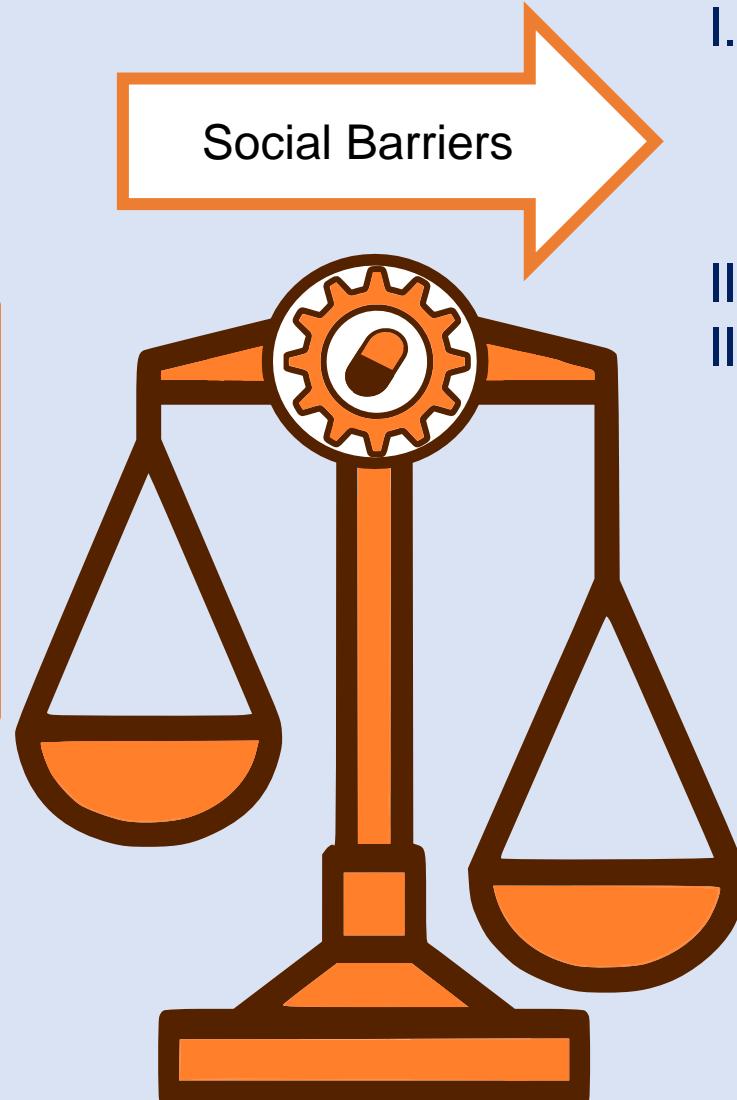
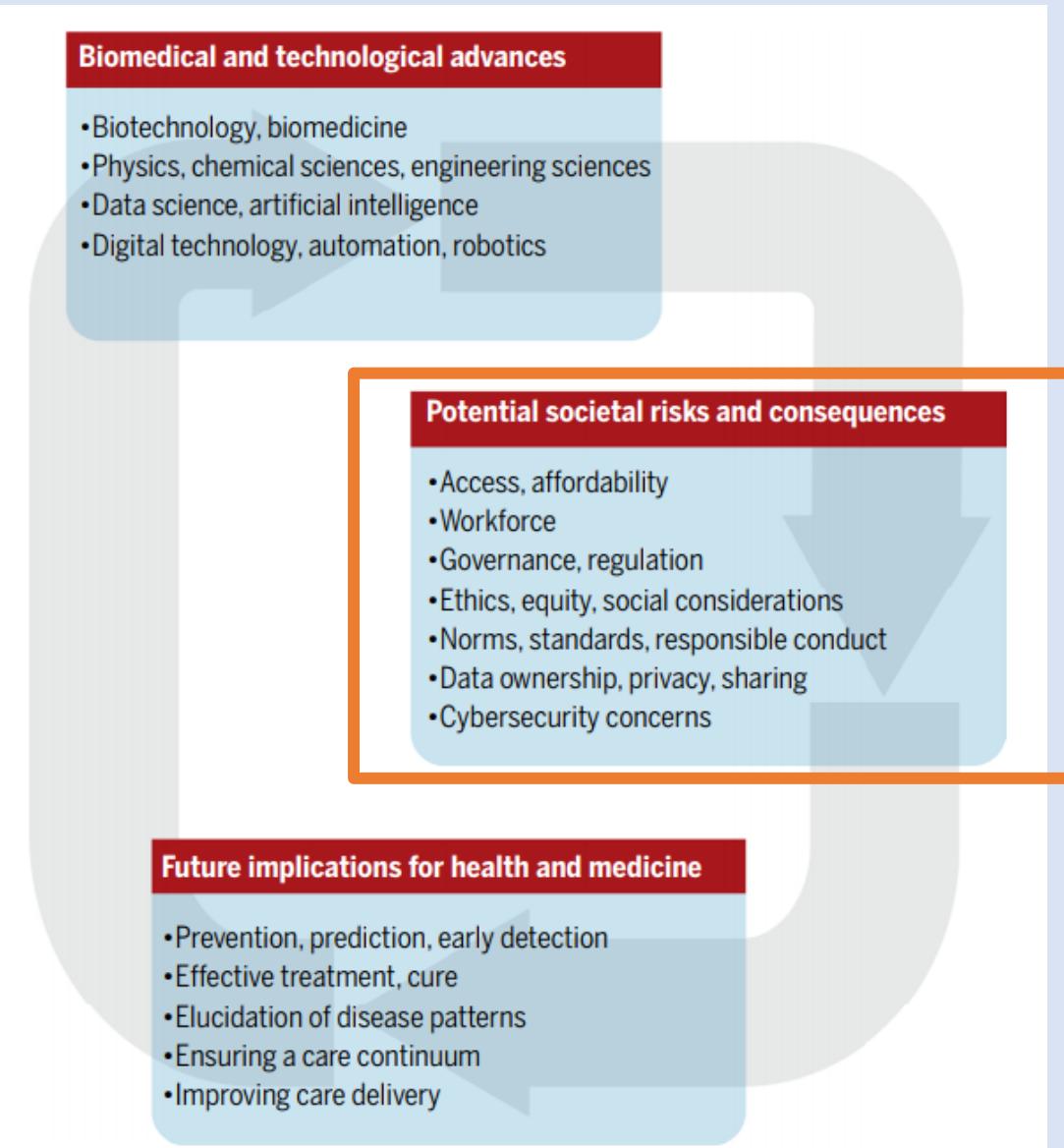
- Prevention, prediction, early detection
- Effective treatment, cure
- Elucidation of disease patterns
- Ensuring a care continuum
- Improving care delivery



Biological & Physiological

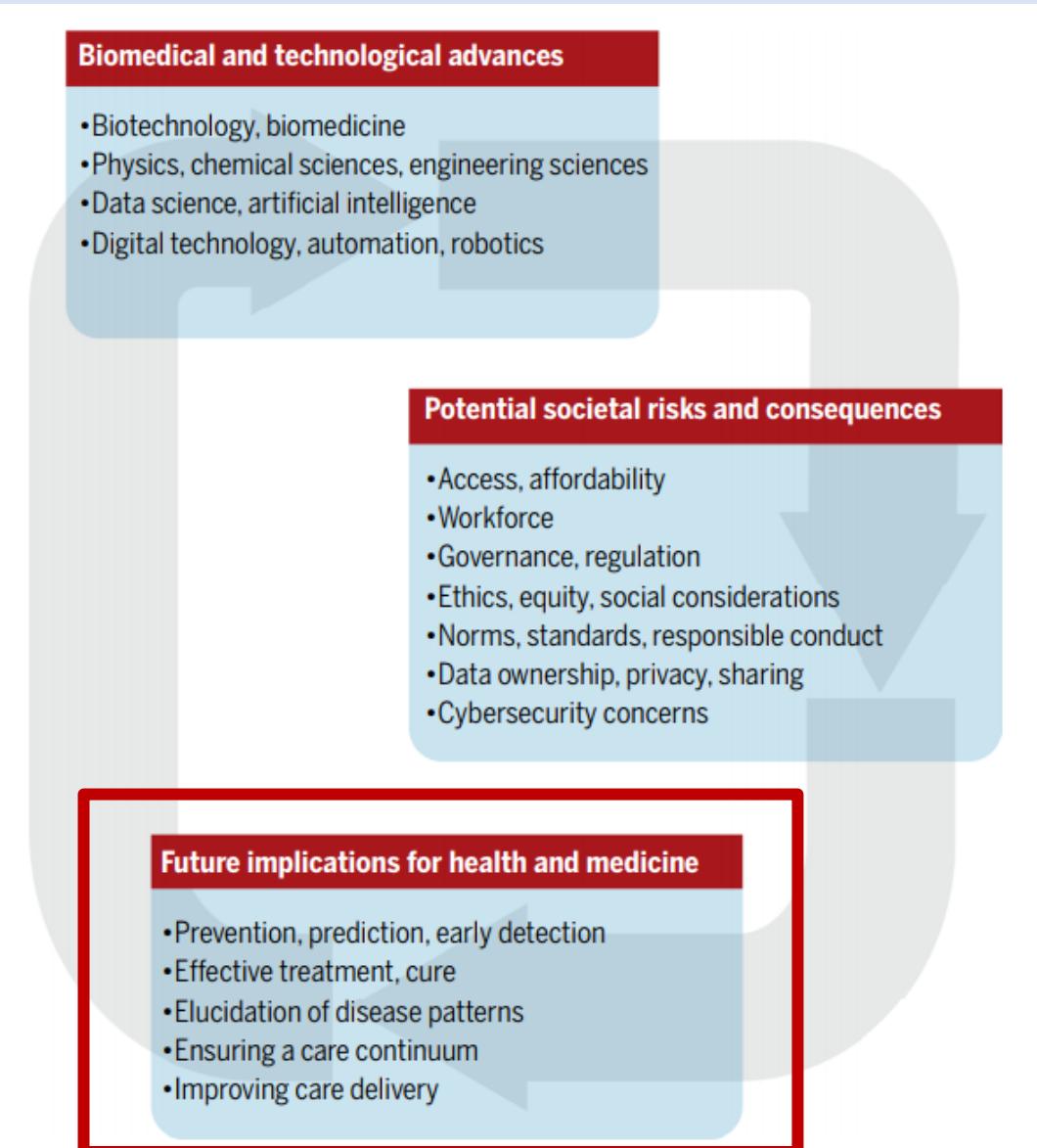


Barriers to delivery of drug delivery systems



- I. Do drug delivery systems reach the desired patient population?
II. If not – Why? SDoH?
III. If so –
 - I. Do they understand the importance of that specific therapy (education)
 - II. Can they afford it (socioeconomics)?
 - III. Do they have access? Support? (social, healthcare)

Case studies to understand social impact



1. Cysteamine extended release oral formulation
2. Implantable, long acting reversible contraceptive (LARC)
3. Opioid addiction and extended release of oxycodone

Case Study Overview

- I. Cysteamine extended release oral formulation
- II. Implantable, long acting reversible contraceptive (LARC)
- III. Opioid addiction and extended release of oxycodone

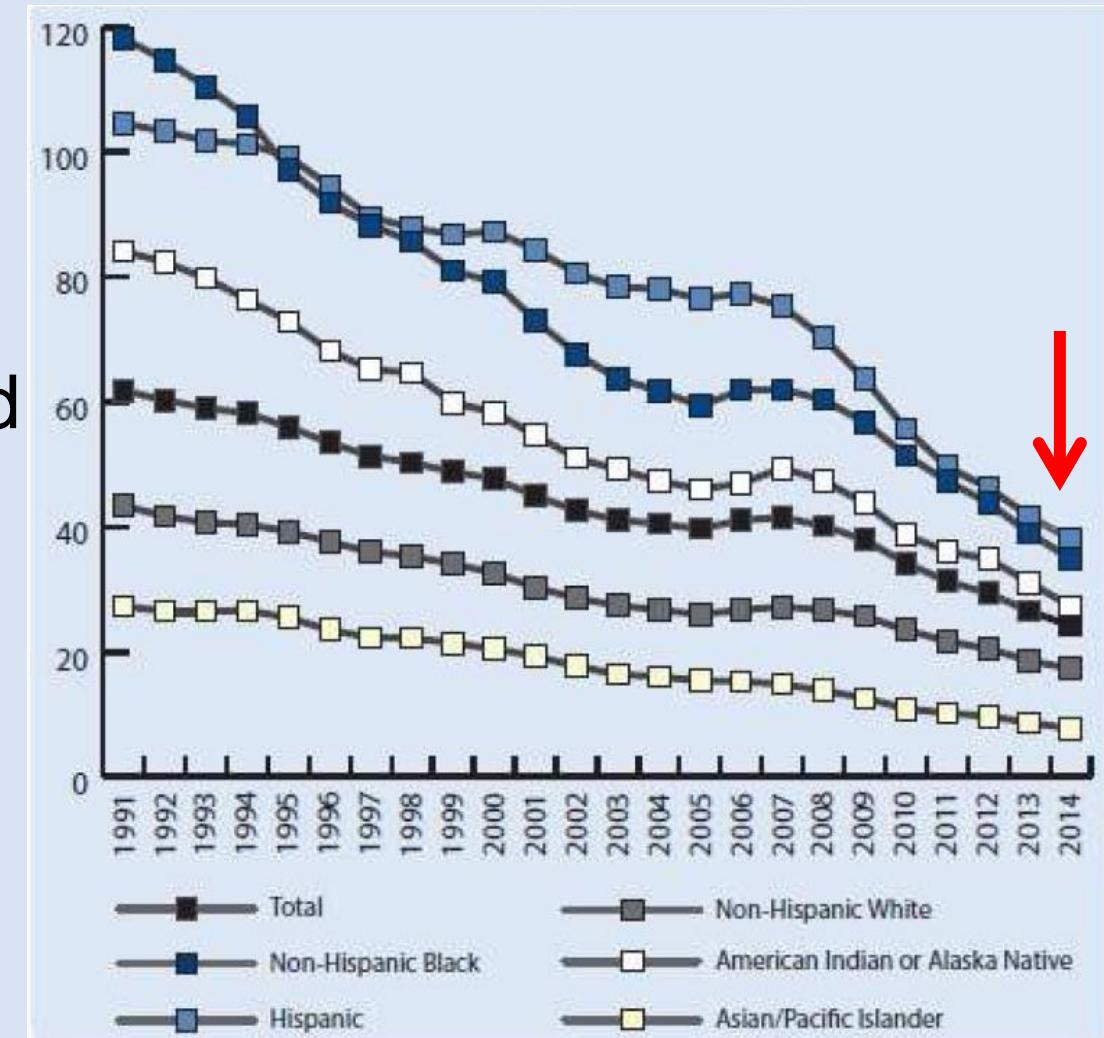
Pharmaceutical	Purpose	Delivery	Design	SDoH Factors	Rationale
	Traditional course content			New course content	

Case #2 – Implantable, long acting reversible contraceptive (LARC)

- Planned conception
- “Increasing the use of highly effective contraceptive methods may provide one solution to persistent problem of the health disparities of unplanned and teen pregnancies in the U.S”

Pharmaceutical	Purpose	Delivery	Design
Etonogestrel	hormonal contraceptive	Subdermal implant	single rod, long-acting reversible (3 years)

Parks, Caitlin, and Jeffrey F. Peipert. “Eliminating Health Disparities in Unintended Pregnancy with Long-Acting Reversible Contraception (LARC).” *American Journal of Obstetrics and Gynecology* 214, no. 6 (June 2016): 681–88.



Case #2 – Implantable, long acting reversible contraceptive (LARC)

Pharmaceutical	Purpose	Delivery	Design	SDoH Factors	Rationale
Etonogestrel	hormonal contraceptive	Subdermal implant	single rod, long-acting reversible (3 years)	1. Education opportunities 2. Income Level 3. Racial segregation	1. Half of teen mothers did not receive a high school diploma by age 22, perpetuating a cycle of lower educational attainment 2. unplanned pregnancy 5 times higher in poor women compared to their wealthier counterparts 3. Racial bias in resources may result in unintended pregnancies in Black and Latinas

[Parks, Caitlin, and Jeffrey F. Peipert. "Eliminating Health Disparities in Unintended Pregnancy with Long-Acting Reversible Contraception (LARC)." *American Journal of Obstetrics and Gynecology* 214, no. 6 (June 2016): 681–88.

Case #1 and Case #3

Pharmaceutical	Purpose	Delivery	Design	SDoH Factors	Rationale
Cysteamine ¹	cystine depletion	Oral	enteric coated extended release (2x daily)	1. Income level 2. Early childhood experiences and development 3. Governance and regulation	1. The price can be significant over a lifetime 2. Cystinosis is a genetic disease 3. Licensing to Raptor Pharmaceutical
Oxycodone ²	pain relief	Oral	viscous hydrogel, extended release (daily)	1. Crime rates exposure to violent behavior 2. Gender inequity	1. Street selling of oral formulations 2. Prescription pain reliever overdose deaths among women increased more than 400% from 1999 to 2010, compared to 237% among men

[1]. Pharmacoeconomic Review Report: Cysteamine Delayed-Release Capsules (*Procsobi*): Horizon Pharma Ireland Ltd. Indication: For the Treatment of Nephropathic Cystinosis. CADTH Common Drug Reviews. Ottawa (ON): Canadian Agency for Drugs and Technologies in Health; 2018.

[2]. Severtson, Stevan et al. "Sustained Reduction of Diversion and Abuse after Introduction of an Abuse Deterrent Formulation of Extended Release Oxycodone." *Drug and Alcohol Dependence* 168 (November 1, 2016): 219–29.

Outline

- I. Learning about evidence-based teaching & learning practices
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IRB approved surveys

- I. Self-identified codes were selected by individuals in Pre Survey and Post Survey responses

Area	Pre Survey	Post Survey
Demographic	X	X
Awareness	X	X
Interest		X
Relevance		X
Familiarity		X
Lecture Impact		X
Comments & Questions		X

Awareness

Awareness Section			Pre			Post			Comparison		
ID	Questions		Yes	Maybe	No	Yes	Maybe	No	Yes	Maybe	No
Q1	Should engineers learn how their technology impacts society?		25 (100%)	0 (0%)	0 (0%)	25 (100%)	0 (0%)	0 (0%)	No change		
Q2	Do engineers have a role in informing the public about drug delivery systems as therapies (etc. dosage, frequency of administration, side effects)?		20 (80%)	5 (20%)	0 (0%)	22 (88%)	3 (12%)	0 (0%)	+2 +8%	-2 -8%	No change
Q3	Are patient's chances of using a novel drug delivery system increased if an engineer (who designed it) informs them of the design?		12 (48%)	13 (52%)	0 (0%)	17 (68%)	7 (28%)	1 (4%)	+5 +20%	-6 -24%	+1 +4%
Q4	Do engineers serve as role models to the public?		16 (64%)	7 (28%)	2 (8%)	19 (76%)	5 (20%)	1 (4%)	+3 +8%	-2 -8%	-1 +4%
Q5	Should we design therapies for specific populations (race, gender, economic status)?		13 (52%)	9 (36%)	3 (12%)	18 (72%)	7 (28%)	0 (0%)	+5 +8%	-2 -8%	-3 -12%

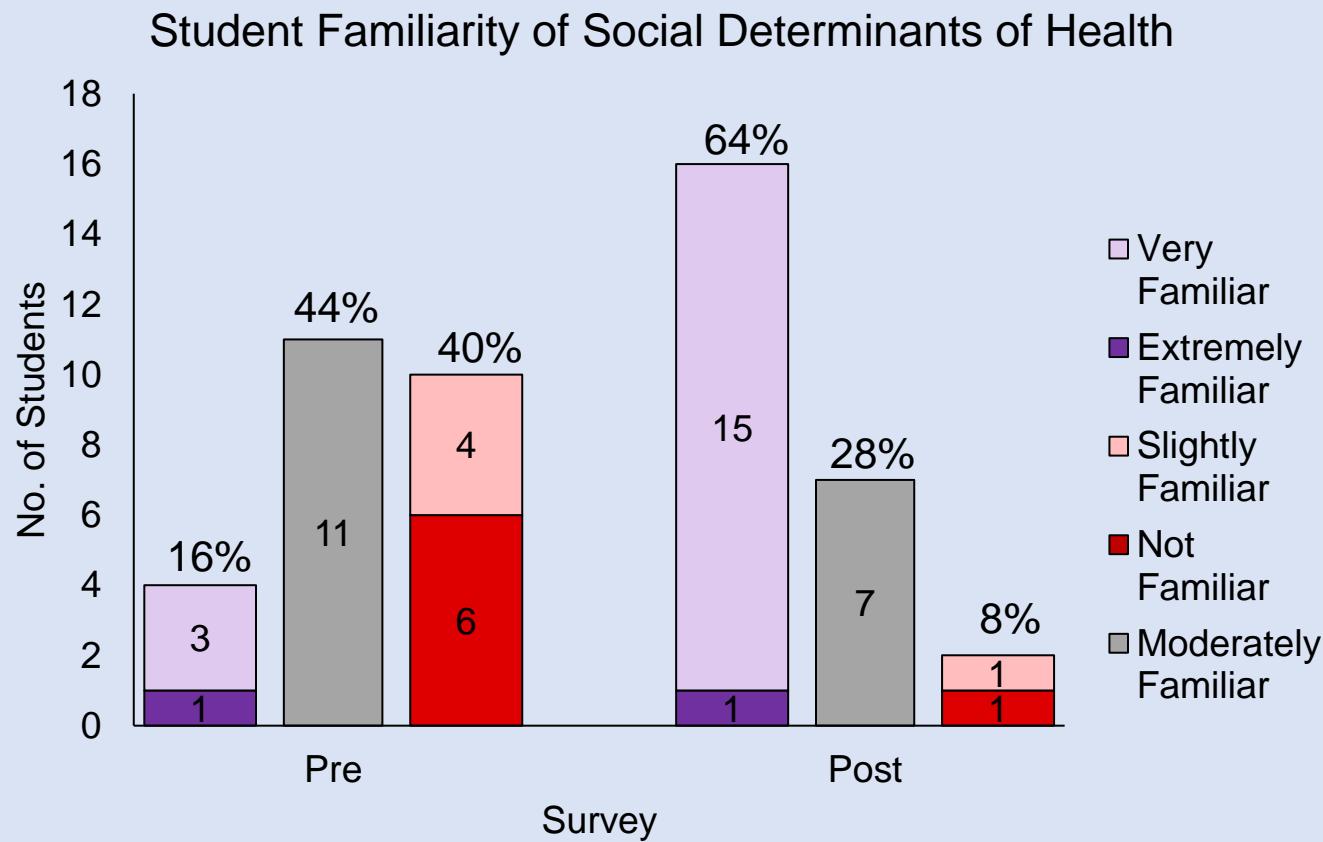
Response count N = 25

- A positive trend towards increased awareness was observed after implementation of lecture

Jimenez J., Dukes A.A, Fedorchak M.V. "Work in Progress: Integrating Public Health Topics in Drug Delivery Systems Education". American Society for Engineering Education Annual Conference 2021. *Paper in peer review*

Social Determinants of Health Familiarity

- Prompt: How familiar are you with Social Determinants of Health?



- 64% of students indicated they were “very” or “extremely” familiar with Social Determinants of Health after implementation

Jimenez J. et al “Work in Progress: Integrating Public Health Topics in Drug Deliver System Education”. ASEE 2021. *Paper in peer review*

Social Determinants of Health Importance

- Prompt: Here is a list of common social determinants of health discussed in lecture. Please read each one and indicate if they are important considerations for drug delivery systems.”

ID	Social determinants of health	Not Important	Moderately Important	Very Important	N
SDoH1	Governance/regulatory	0 (0%)	4 (16%)	21 (84%)	25
SDoH2	Availability of transportation	1 (4%)	8 (32%)	16 (64%)	25
SDoH3	Access to nutritious food	1 (5%)	5 (20%)	18 (75%)	24
SDoH4	Income level	0 (0%)	3 (14%)	19 (86%)	22
SDoH5	Educational opportunities	0 (0%)	8 (35%)	15 (65%)	23
SDoH6	Gender inequity	0 (0%)	13 (52%)	12 (48%)	25
SDoH7	Racial Segregation	0 (0%)	12 (50%)	12 (50%)	24
SDoH8	Accessibility of nutritious food choices	1 (4%)	4 (17%)	18 (78%)	23
SDoH9	Access to housing and utility services	0 (0%)	8 (33%)	16 (67%)	24
SDoH10	Early childhood experiences and development	0 (0%)	7 (29%)	17 (71%)	24
SDoH11	Social support and community inclusivity	1 (4%)	7 (29%)	16 (67%)	24
SDoH12	Crime rates and exposure to violent behavior	0 (0%)	10 (43%)	13 (57%)	23
SDoH13	Neighborhood conditions and physical environment	0 (0%)	7 (29%)	17 (71%)	24
SDoH14	Access to safe drinking water, clean air, and toxin-free environments	0 (0%)	3 (12%)	21 (88%)	24

- 84% of students felt Governance/regulatory and access to safe drinking water, clean air, and toxin-free environment were very important SDoHs to consider for drug delivery systems

Jimenez J. et al “Work in Progress: Integrating Public Health Topics in Drug Deliver System Education”. ASEE 2021. *Paper in peer review*

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SDoH13	Neighborhood conditions and physical environment	0 (0%)	7 (29%)	17 (71%)	24
SDoH14	Access to safe drinking water, clean air, and toxin-free environments	0 (0%)	3 (12%)	21 (88%)	24

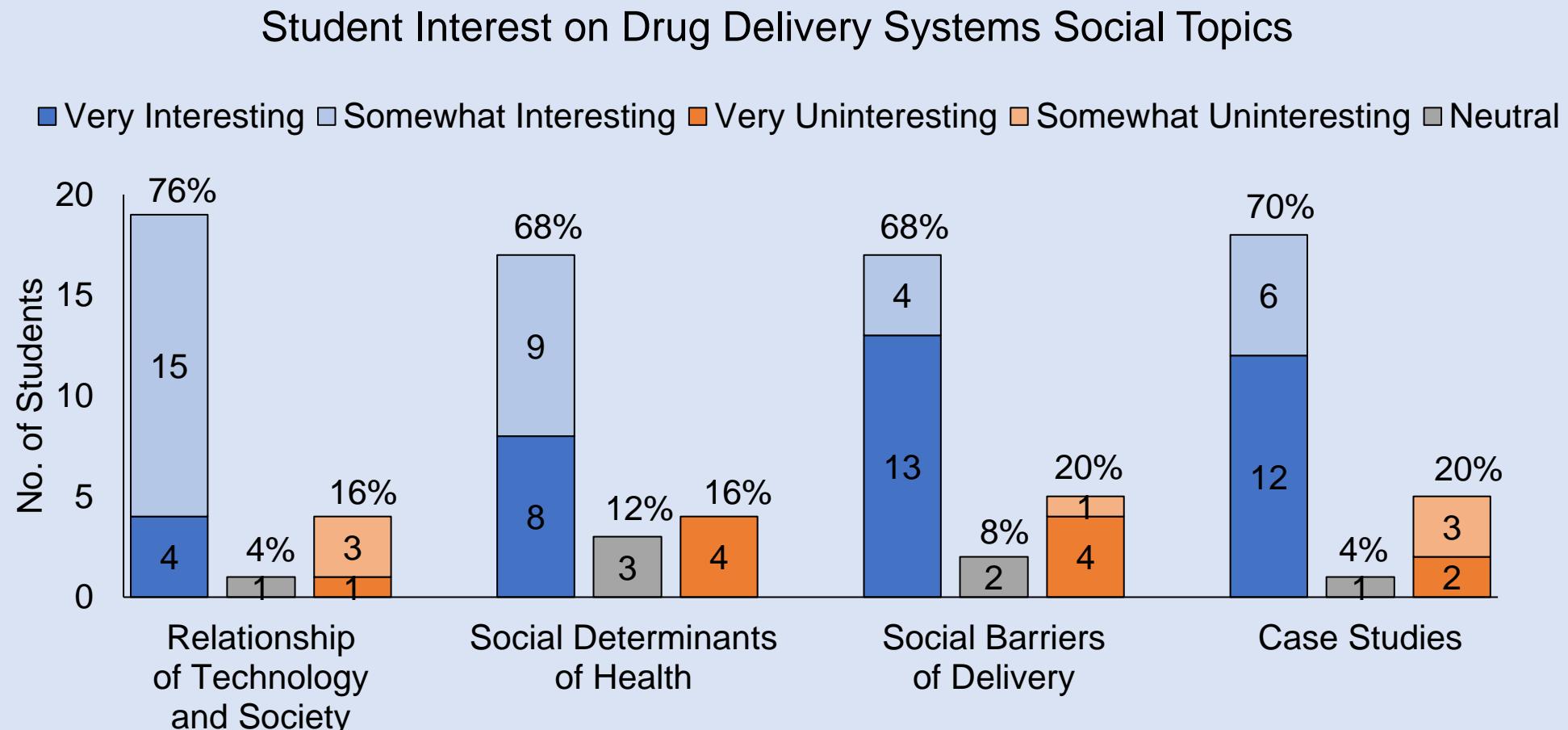
- 84% of students felt Governance/regulatory and access to safe drinking water, clean air, and toxin-free environment were very important SDoHs to consider for drug delivery systems

- A majority of students (> 50%) indicated 12 of 14 SDoHs were very important to consider for drug delivery systems

Jimenez J. et al “Work in Progress: Integrating Public Health Topics in Drug Deliver System Education”. ASEE 2021. *Paper in peer review*

Interest in topics

- Prompt: “These are a few topics covered in the lecture, please indicate how you felt about them.”

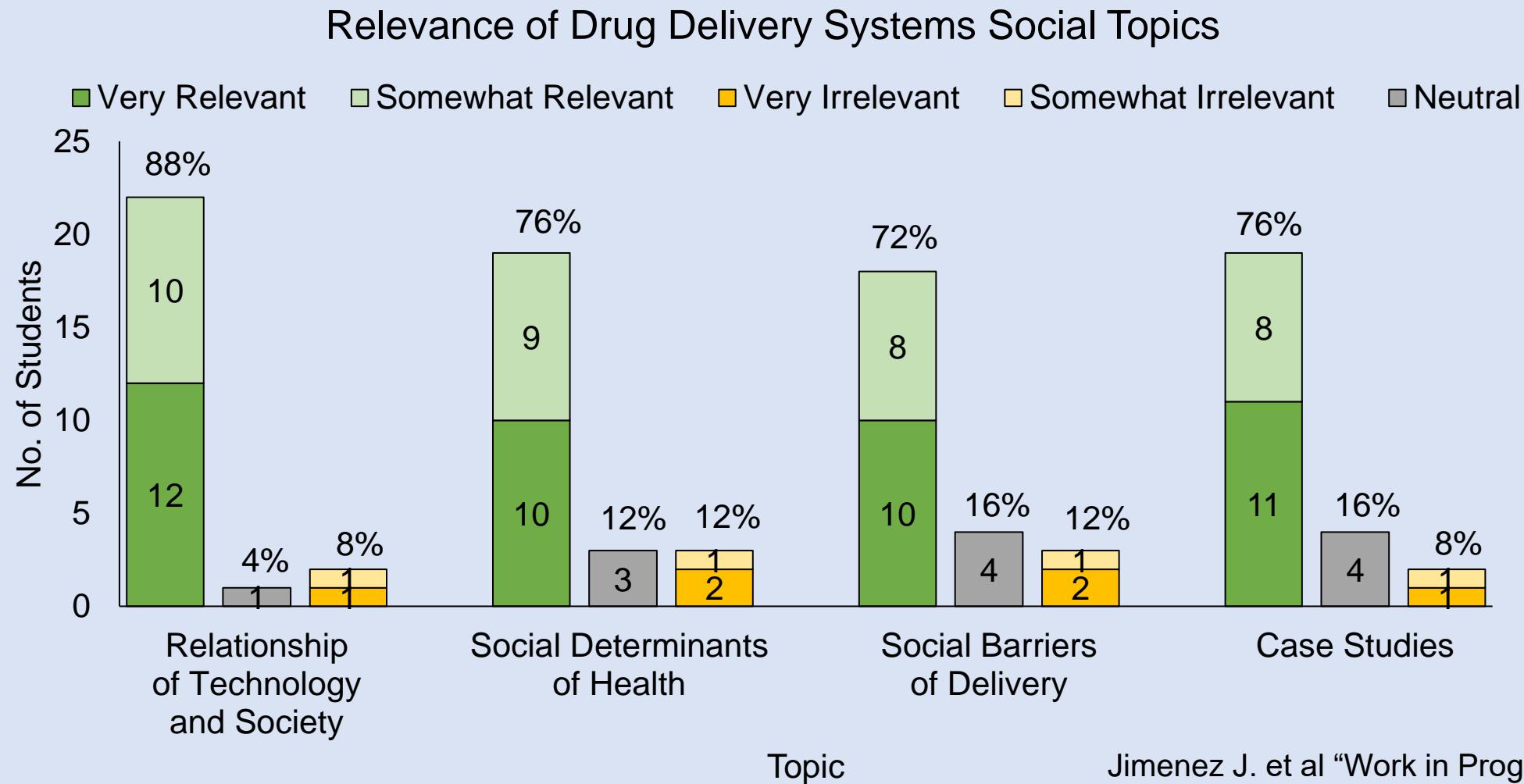


- > 68% students indicated topics interesting
- 20% students indicated social barriers and case studies uninteresting

Jimenez J. et al “Work in Progress: Integrating Public Health Topics in Drug Deliver System Education”. ASEE 2021. *Paper in peer review*

Relevance of topic

- Prompt: "These are a few topics covered in the lecture, please indicate how relevant they are to your studies."

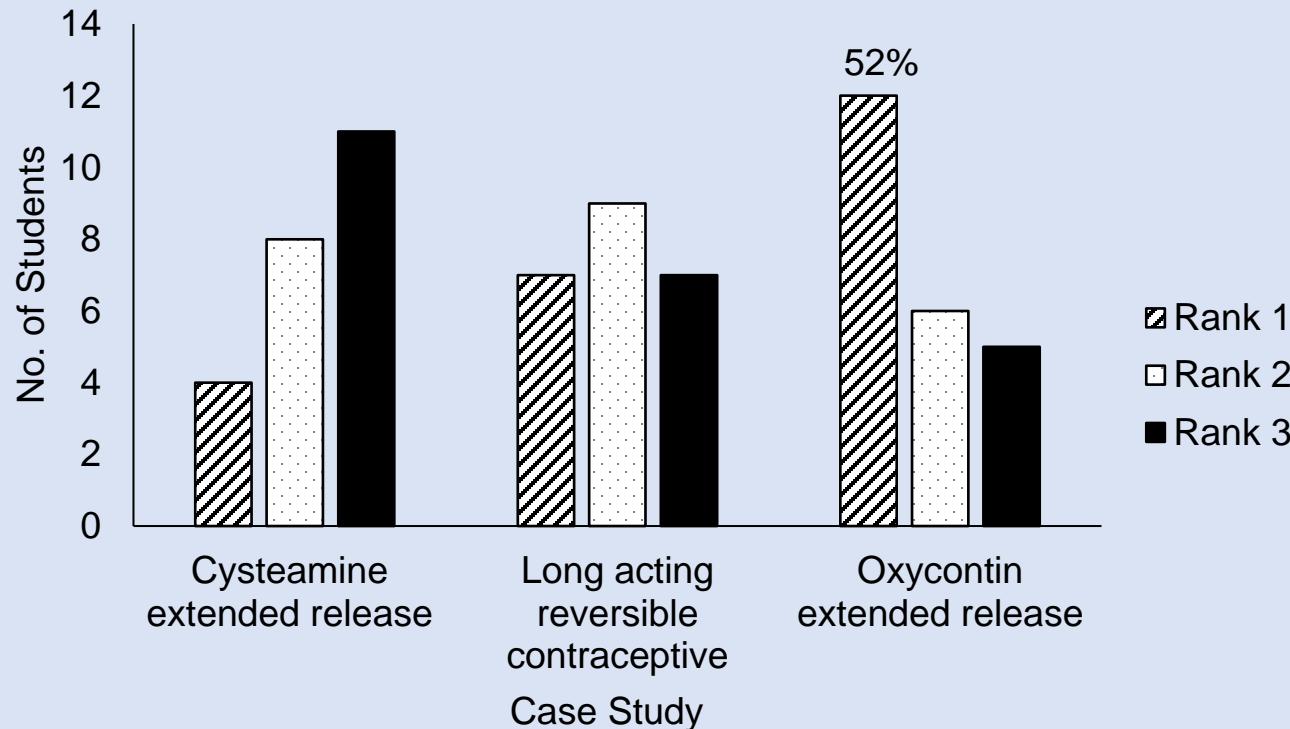


- > 72% students found these topics relevant to their studies

Jimenez J. et al "Work in Progress: Integrating Public Health Topics in Drug Delivery Systems Education". ASEE 2021. *Paper in peer review*

Case study interest

- Prompt: “Three case studies were presented, please rank which was the most interesting to you.”



- 52% of students ranked oxycontin extended release as the most interesting case study

Jimenez J. et al “Work in Progress: Integrating Public Health Topics in Drug Delivery Systems Education”. ASEE 2021. *Paper in peer review*

Lecture impact

ID	Questions	Yes	Maybe	No
Q1	Do you think these topics would be beneficial for engineers in biomedical research to learn?	23 (92%)	2 (8%)	0 (0%)
Q2	Would you recommend sharing this topic to your peers?	20 (80%)	5 (20%)	0 (0%)

Response count, N = 25

- 92% of students think the topics would be beneficial for engineers to learn
- 80% would share the topic to their peers

Free response

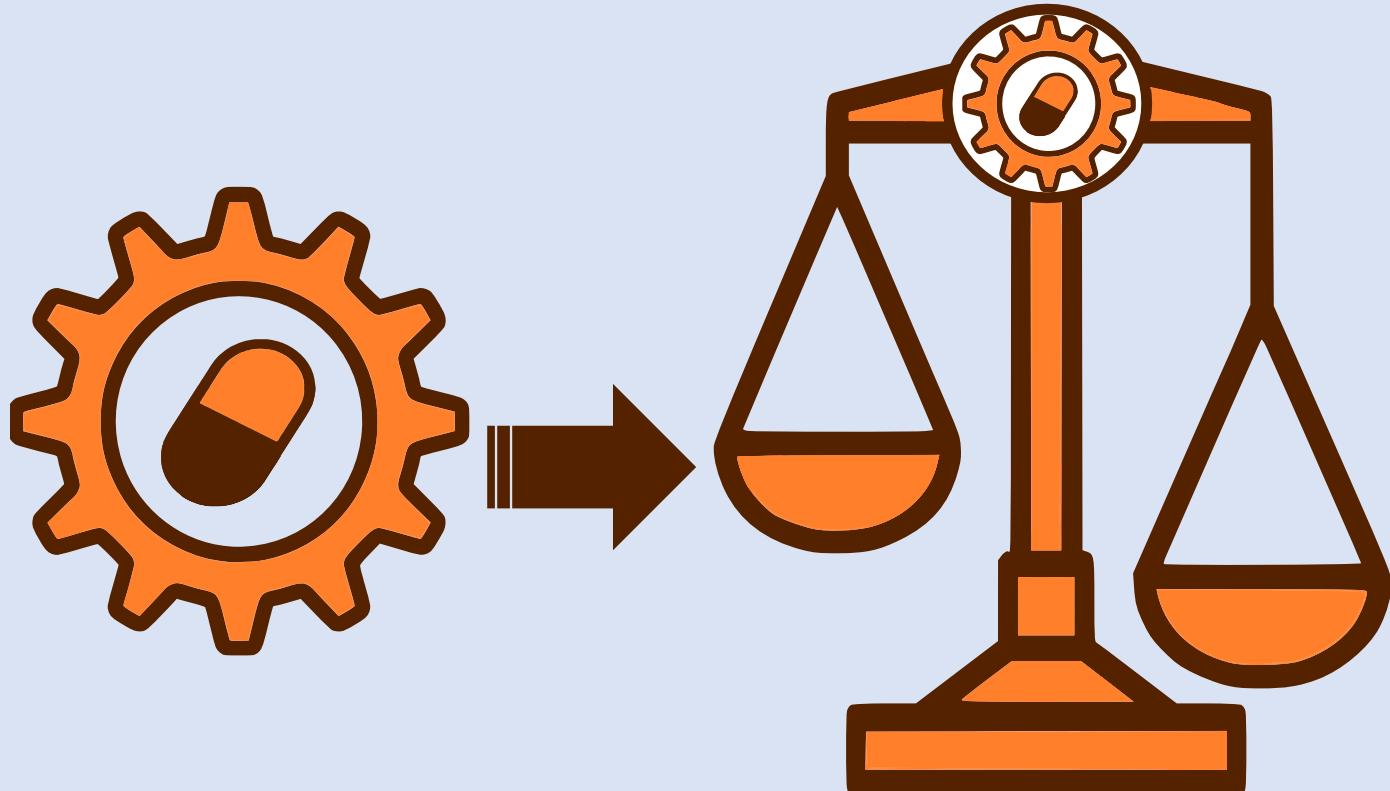
- Prompt: Please provide any questions or comments you may have

ID	Responses
R1	I believe societal impact is a huge factor in the healthcare industry and really appreciated this lecture.
R2	I'm so glad we're talking about this! I wish we could've had the discussion in class, but it was still great to learn about this online!

- R2 in response to online format due to COVID-19 restrictions on in-person classes

Results summary

- I. 68%-72% of students were interested in the topic of social impact of drug delivery systems
- II. ≤ 20% were uninterested in topics
- III. 76-88% found the topics relevant to their studies



Conclusion

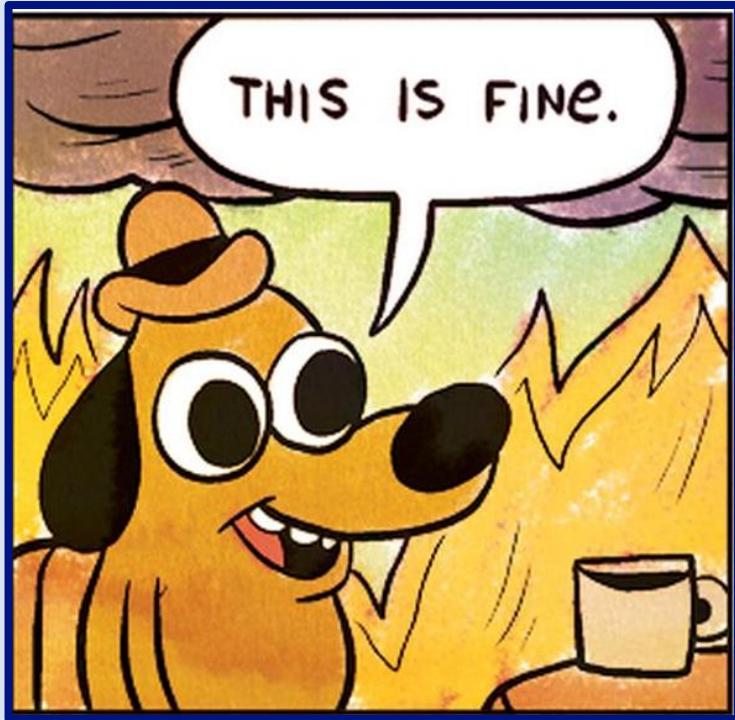
- I. Students found the intersection of public health, social impact and engineering technology interesting and relevant
- II. Incorporation of HD and SDoH in a STEM courses as case studies is an effective approach for student interest

Future Work

- Ongoing thematic analysis of engineering design report
- Introduce HD Module earlier
- Provide HD focused mini project
 - HD agent with public health focused therapies (infectious disease)

HD Agents	Peer Review Literature	Description of Concerns
Clinical Trials		
Genetic Screening		
Technologies and Tools	Literature Review Assessment	Analysis to HD
Access and Quality		
Historical and Societal Factors		

Parting message: teaching is an iterative learning process



[Reddit user: u/leolambertini](#)

- STEM students are interested in learning about social-public health topics
- Student motivation? Course climate? – maybe when I have my own classroom??