Making Science Personal: Designing Inclusive General Education Courses

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What's happening in academia is one aspect of a broader national reckoning of how we address diversity, equity, & inclusion

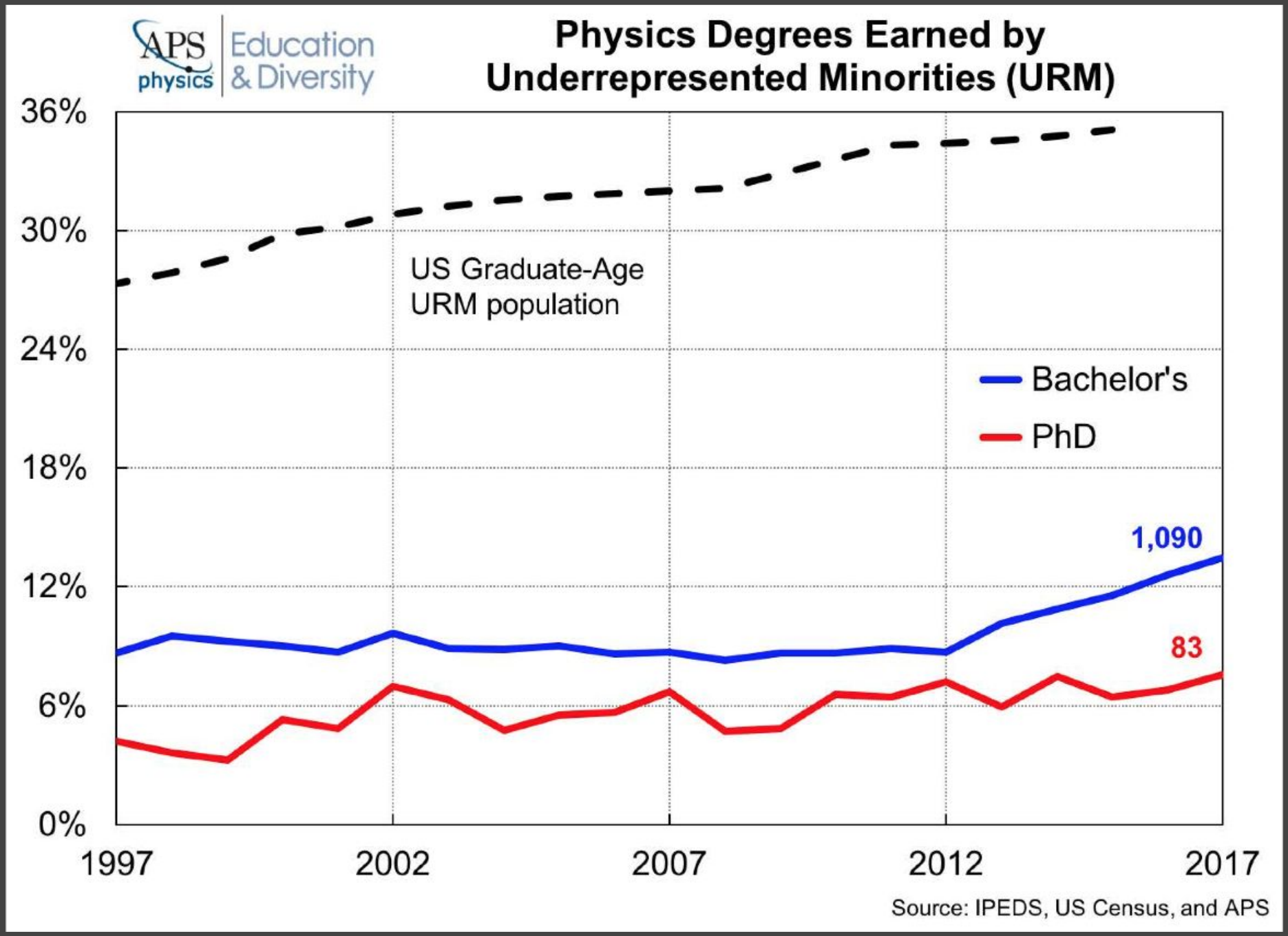
Recent and prominent examples:

- Disproportionate impact of COVID-19 in minority communities
- Breonna Taylor, George Floyd, and countless others

https://blacklivesmatter.com/

https://www.particlesforjustice.org/resources

https://www.joincampaignzero.org/


APS physics Education & Diversity
Physics Degrees Earned by Underrepresented Minorities (URM)
36%
30%
24%
18%
12%
6%
0%
US Graduate-Age URM population
Bachelor's
PhD
1,090
83
1997
2002
2007
2012
2017
Source: IPEDS, US Census, and APS

Inclusive Teaching

Inclusive teaching encompasses teaching practices, curricula, and assessments that are

- meaningful
- relevant
- accessible

to **all** students

(Adapted from Hockings 2010)

How do you interact with students?

http://bit.ly/MSP-survey

Two (Overlapping) Lines of Reasoning to Incorporate an Inclusive Mindset

Significant (Effective) Learning Experiences: Course & Life Files

Acknowledging & Addressing the Culture of Science

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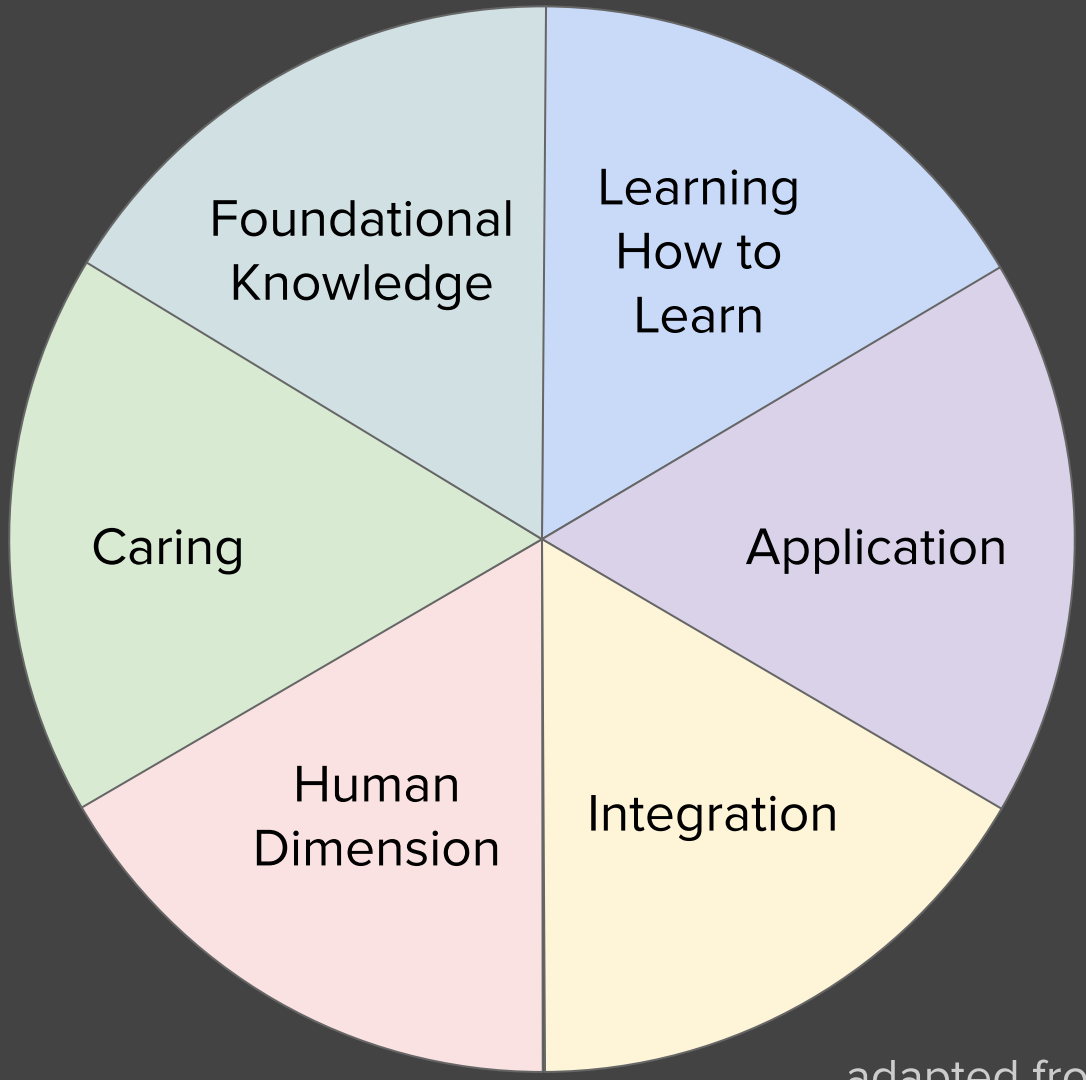
Acknowledging & Addressing the Culture of Science

Significant Learning Experiences

Fink (2013) model: students compartmentalize into "**course files**" and "**life files**"

➔ "**Significant learning experience**": transcend categories by creating lasting change that improves students' lives

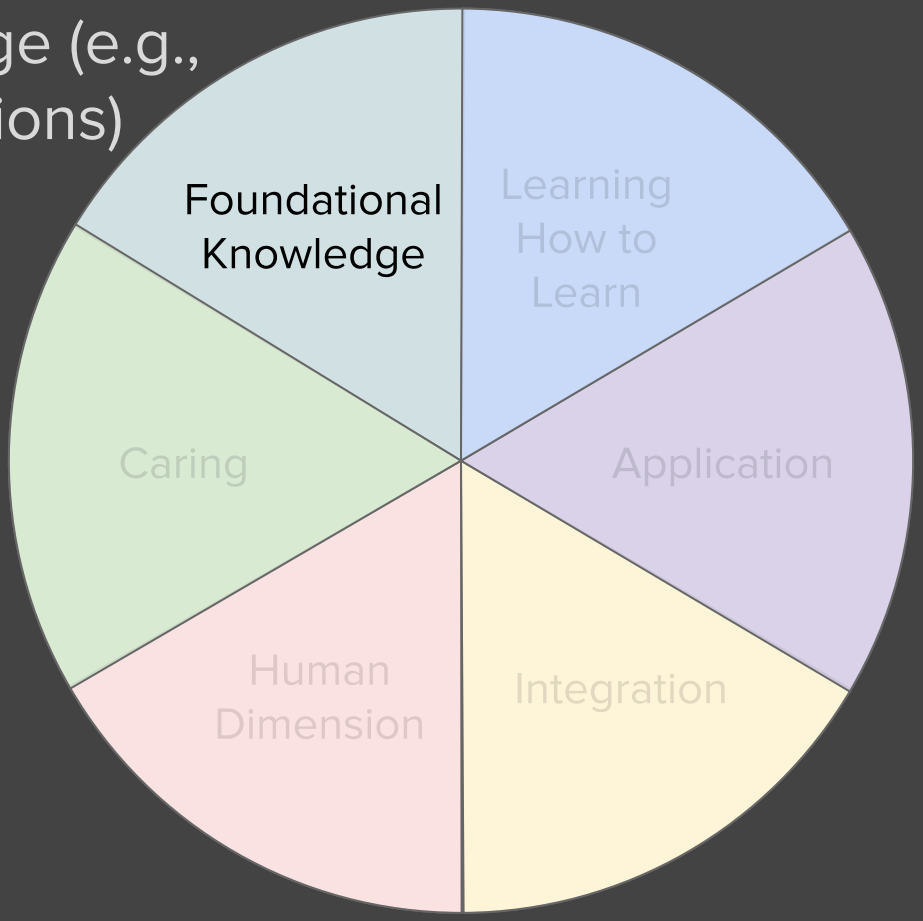
Significant Learning Experiences



adapted from Fink (2013)

Significant Learning Experiences

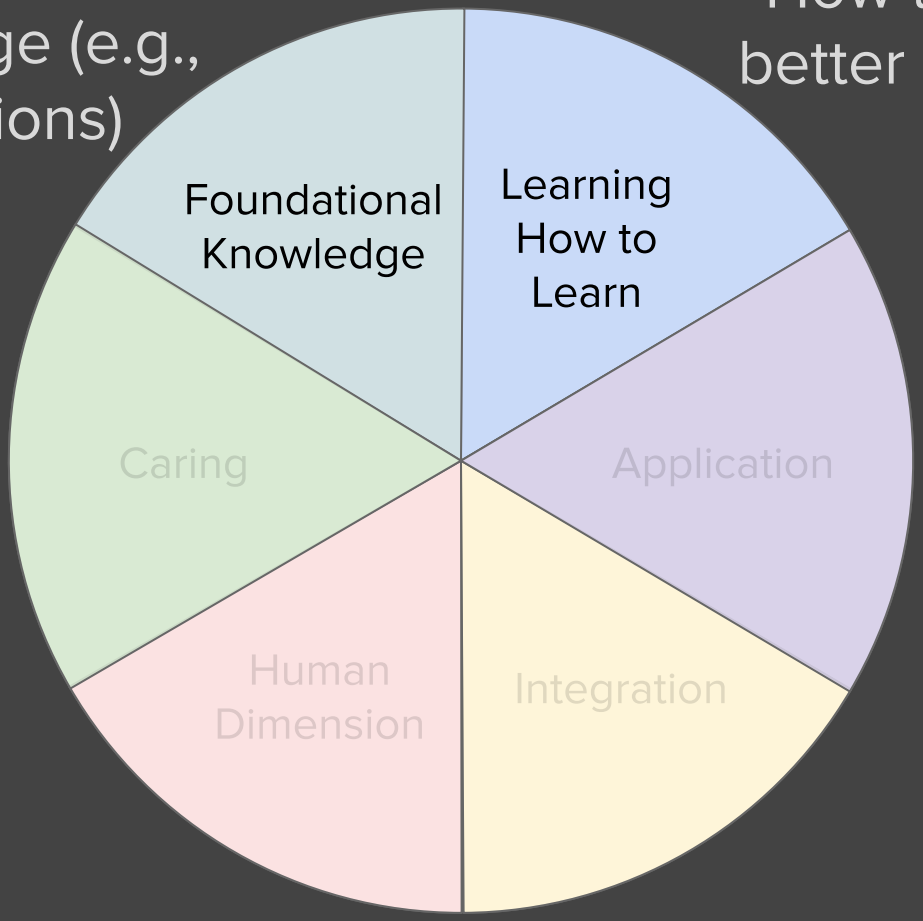
Necessary basic knowledge (e.g., definitions)



Significant Learning Experiences

Necessary basic knowledge (e.g., definitions)

How to be a better student



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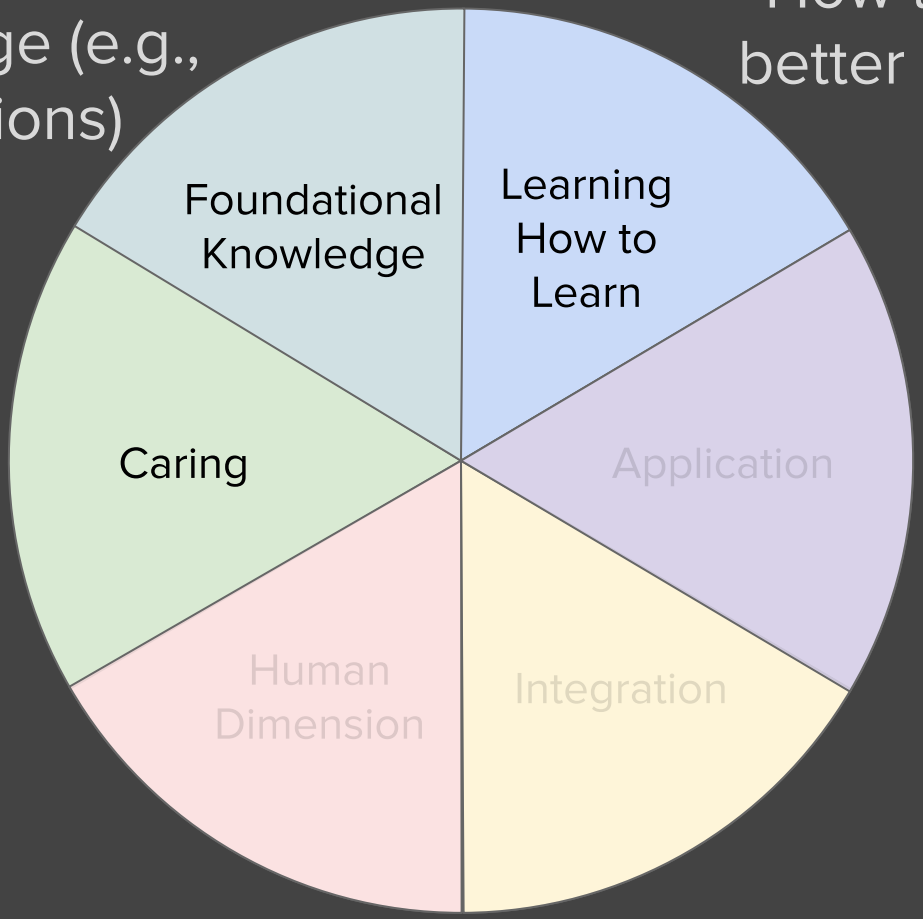
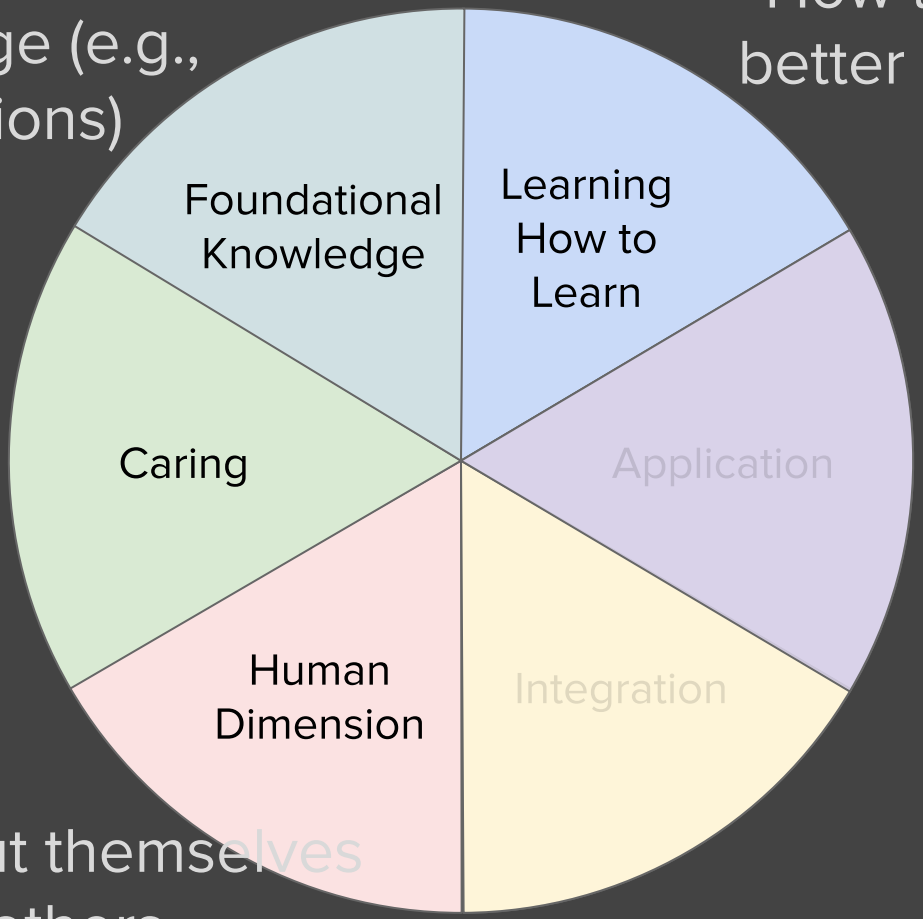


Personal interest/feelings; affective learning (Krathwohl+ 1964)

Significant Learning Experiences

Necessary basic knowledge (e.g., definitions)

How to be a better student



Personal interest/feelings; affective learning (Krathwohl+ 1964)

Learning about themselves and/or others

Two (Overlapping) Lines of Reasoning to Incorporate an Inclusive Mindset

Significant (Effective) Learning Experiences: Course & Life Files

Acknowledging & Addressing the Culture of Science

Science & Culture

Scientists often teach & communicate science in a way that implicitly (or even explicitly) assumes it is "**neutral**" or "**acultural**" (e.g., National Research Council 2009)

Science & Culture

- Naming conventions: Greek/Roman mythology names
- Recognized scientists: often European/male (Newton, Kepler, Einstein, etc.)
- Terminology: galactic harassment, stripping, strangulation, cannibalism, etc.

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- Science vs. religion: Galileo, evolution
- Individualism vs. collectivism
- Empirical vs. experiential reality (Sue 2016)

Science & Culture

Student interactions matter just as much as - if not more than - instructor efforts

Value & prioritization of "**objectivity**" makes it difficult to openly address culture (O'Brien 2004)

Science & Culture

Deciding that science is “neutral” and denying the role that opinions, cultures, and lived experiences have on science is ***itself an opinion/choice that imposes a culture on a class***

➔ Impacts students’ sense of belonging (and therefore motivation, confidence, etc.)

Our Inclusivity-Driven Course Design Model

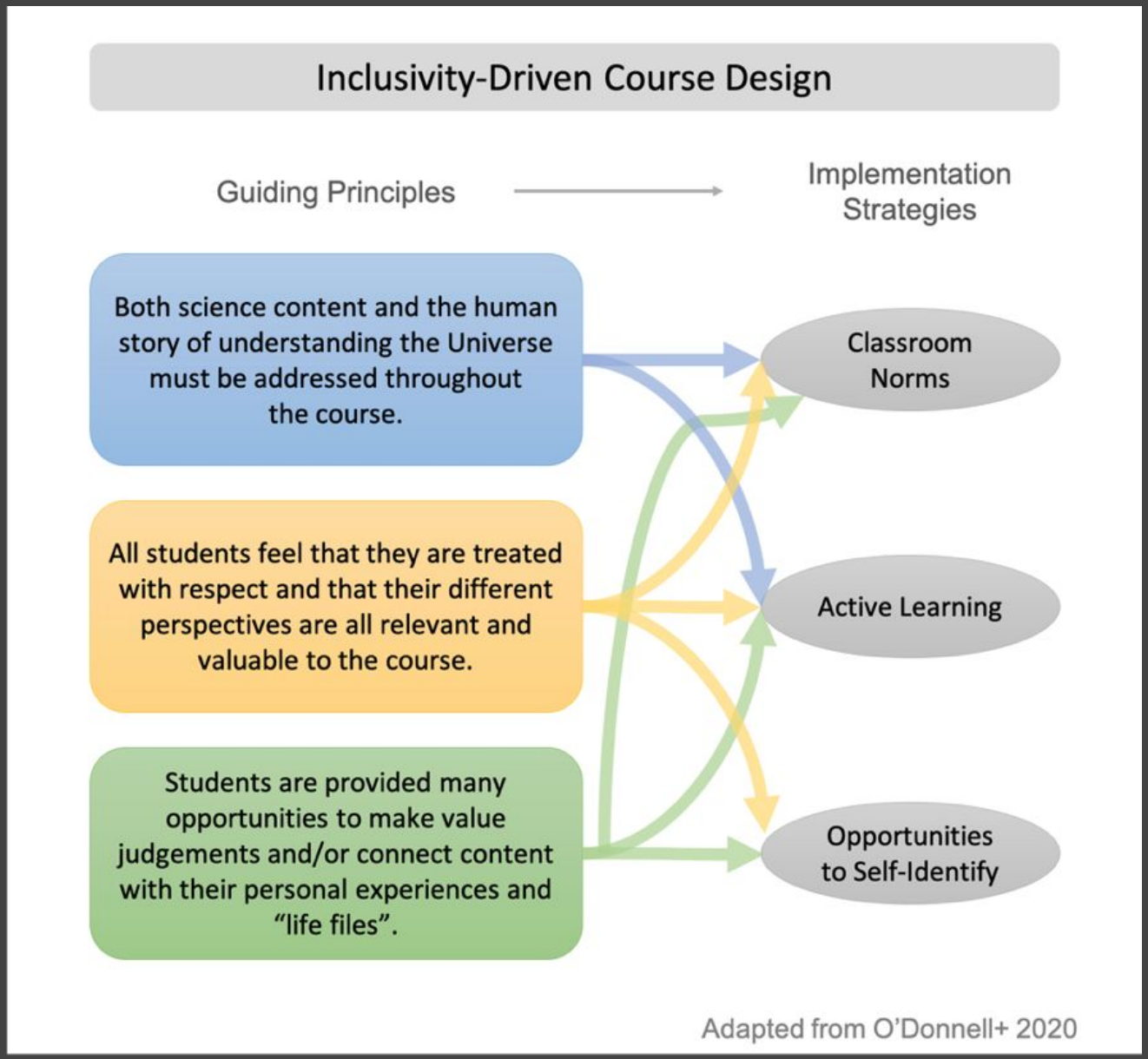
ASTR 201: Cosmology (Spring 2019)

- General-education intro course (no prereqs) at the University of Arizona
  - First time instructor taught the course, though it has been offered for over a decade
- 40 students enrolled
  - Gender: 50% self-identified as female, 50% as male
  - Race/ethnicity: 75% self-identified as White/Caucasian, 10% as Latino, 10% as Native American

Course Grades: research often finds grade differences across demographic groups

Student Identity (Self-Reported)	Average Cumulative Course Score	Welch's T-Test *p*-value
Male (N=10) Female (N=10)	84.3% 85.7%	0.877
Non-URM (N=16) URM (N=4)	84.8% 85.8%	0.915

O'Donnell et al. 2020


Inclusivity-Driven Course Design
Guiding Principles
Implementation Strategies
Both science content and the human story of understanding the Universe must be addressed throughout the course.
All students feel that they are treated with respect and that their different perspectives are all relevant and valuable to the course.
Students are provided many opportunities to make value judgements and/or connect content with their personal experiences and "life files".
Classroom Norms
Active Learning
Opportunities to Self-Identify
Adapted from O'Donnell+ 2020

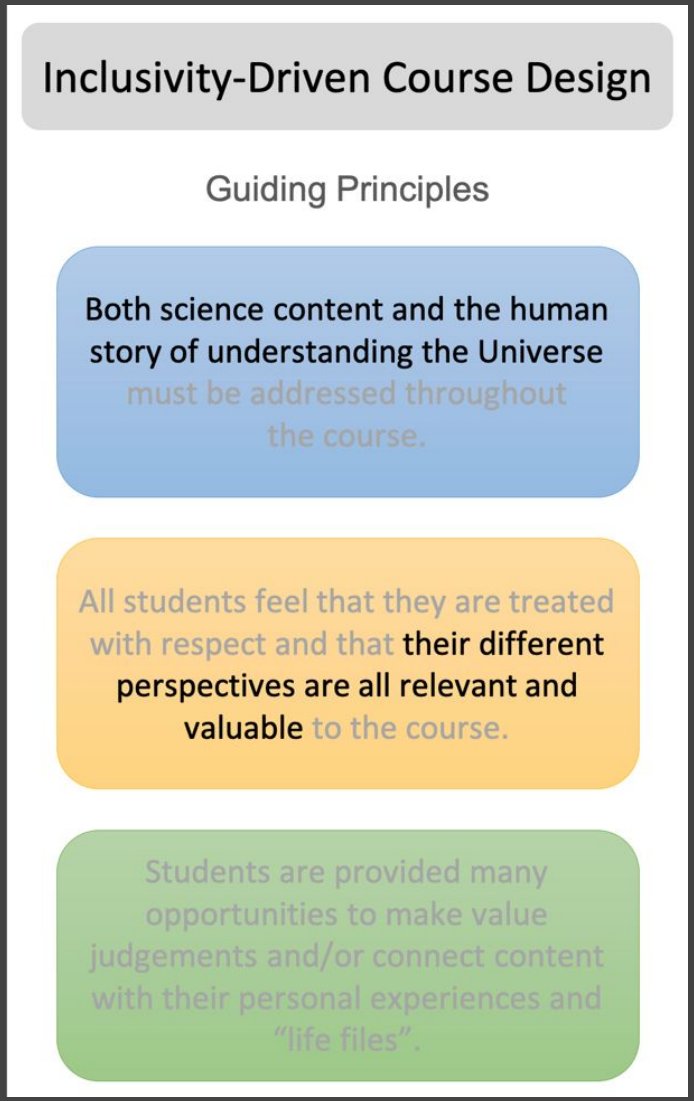
Implementation Strategies

Setting Expectations (Norms)

- Typical examples: homework policy, attendance policy
- Also includes behaviors and attitudes: “Everyone here has something to learn” (Tanner 2013)

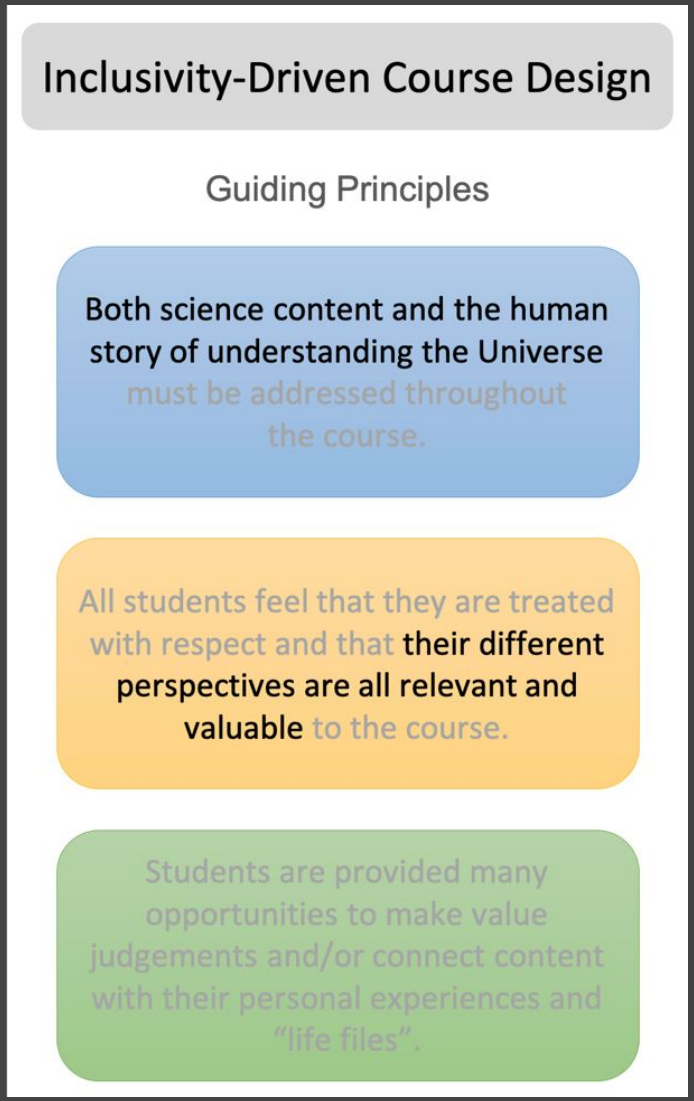
Setting Expectations (Norms)

We established a norm to acknowledge and value diverse perspectives in a way that affirmed the importance of students' lived experiences



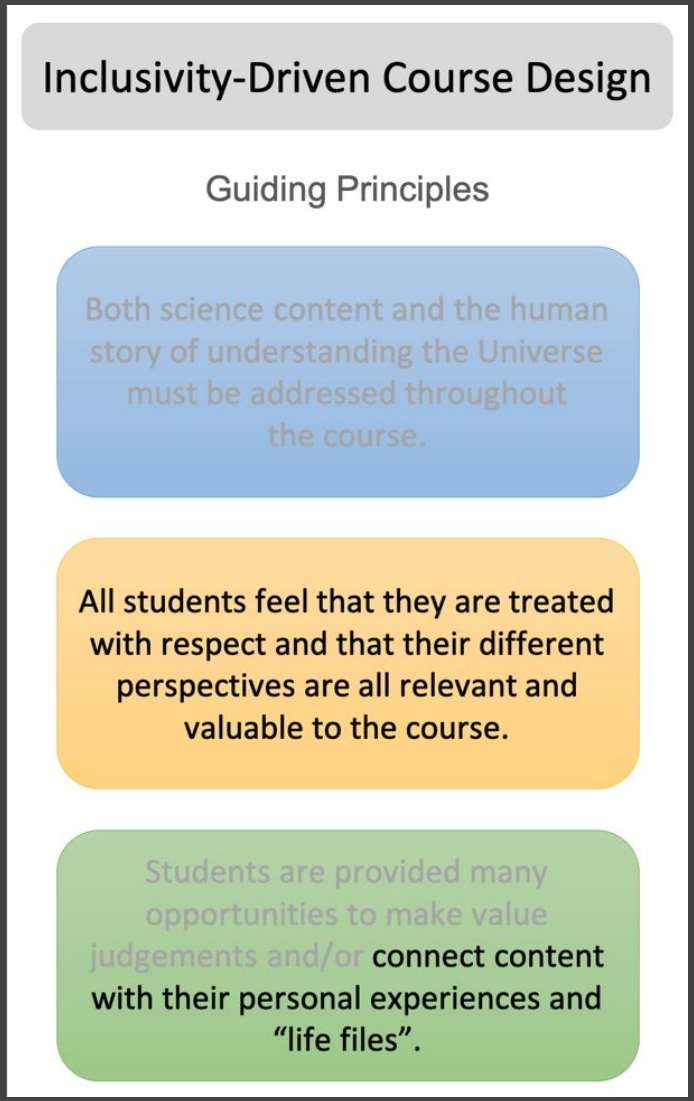
Setting Expectations (Norms)

- First day of class: 10 minute course overview + 1-hour lecture from member of the local Tohono O'odham Native American Nation
- Tied into first course unit on human and cultural connections to the sky for many different cultures



Student Participation

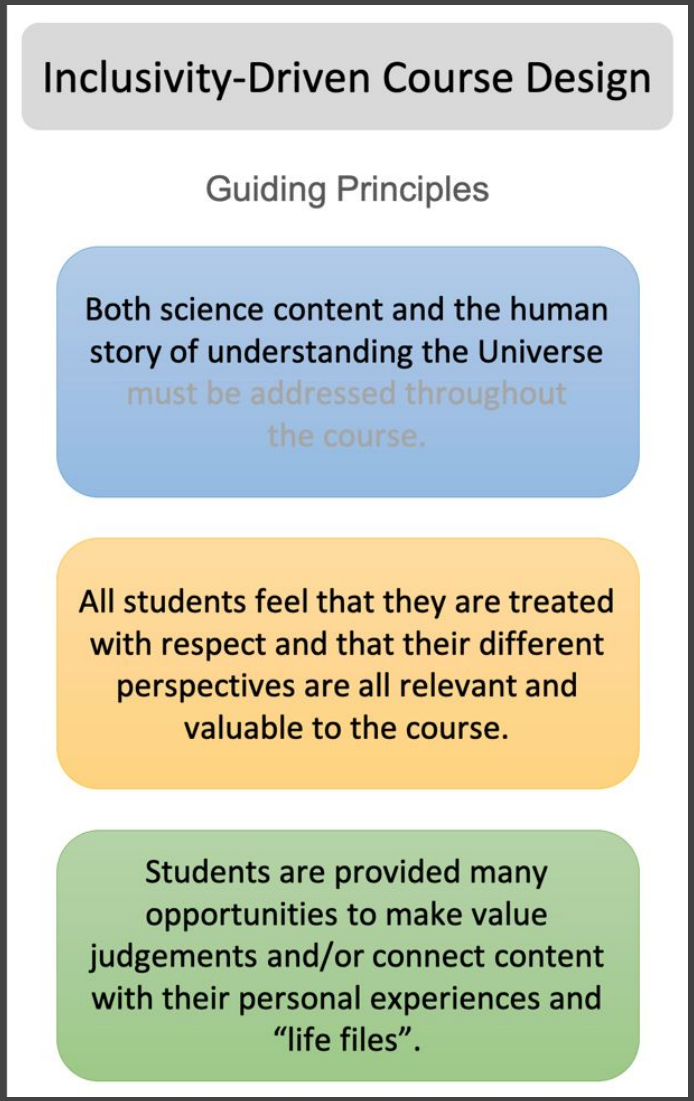
- Student participation in demonstrations during class sessions
  - Involves students in the teaching of course content



Active Learning

Adapting active learning techniques to specifically address "life file" content

- Asked the students to think about skills that are helpful to do science
- Had the students pair up and discuss
- Each group's reporter shared their answers



Active Learning

Skills reported by students: open-mindedness, communication, critical thinking, creativity, leadership

- We explicitly noted that you can change/improve skills over time
- Science is collaborative
- “There’s places in science for all different kinds of people with all of these different kinds of skills”

➔ Human dimension to science (& beyond)

Active Learning: Future Improvements

Carry the discussion from the think-pair-share throughout the course

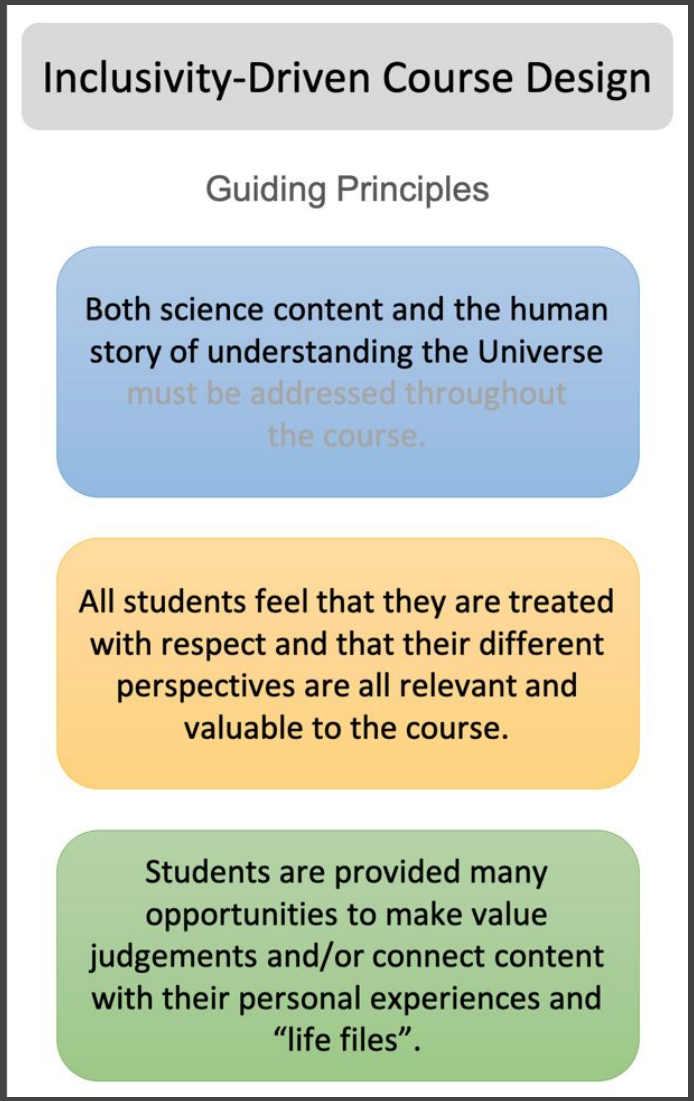
- Discuss student-reported skills in more detail, e.g. what does it mean to “communicate” (science)?
  [Credit: Dr. Tara Nkrumah, ASU CGEST]

- Tie in with lecture tutorials & other class activities

Note - this strategy can also be applied outside of a classroom environment

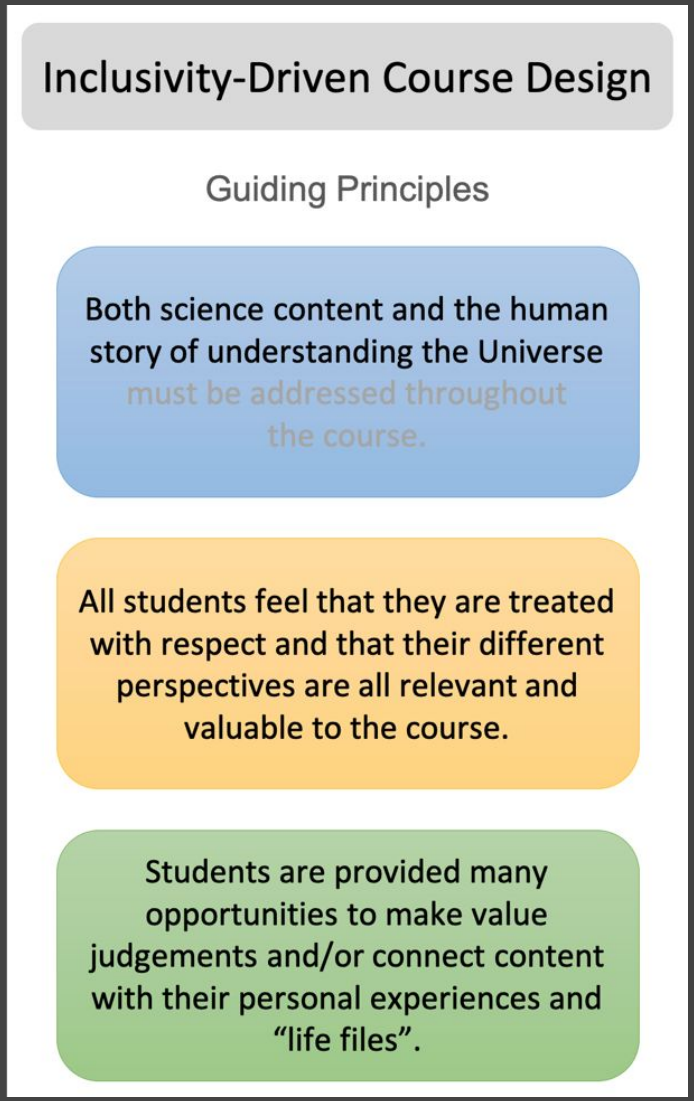
Opportunities to Self-Identify

Most classes included a 5-minute writing prompt to connect content to personal experiences



Opportunities to Self-Identify

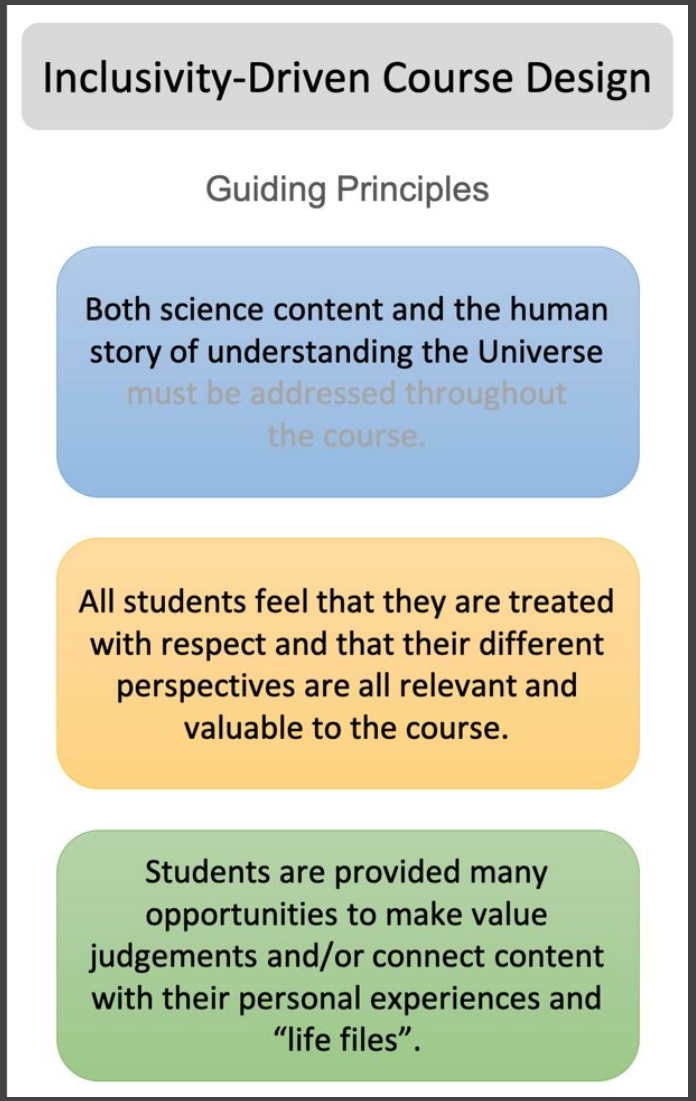
- Dark matter: we can't see it, but we infer it (from gravitational interactions)
- Prompt: what do you believe in but can't see
  - Some science answers: wind, oxygen
  - >40% were "life" answers: God, soul, love, time



Opportunities to Self-Identify

Some more example prompts:

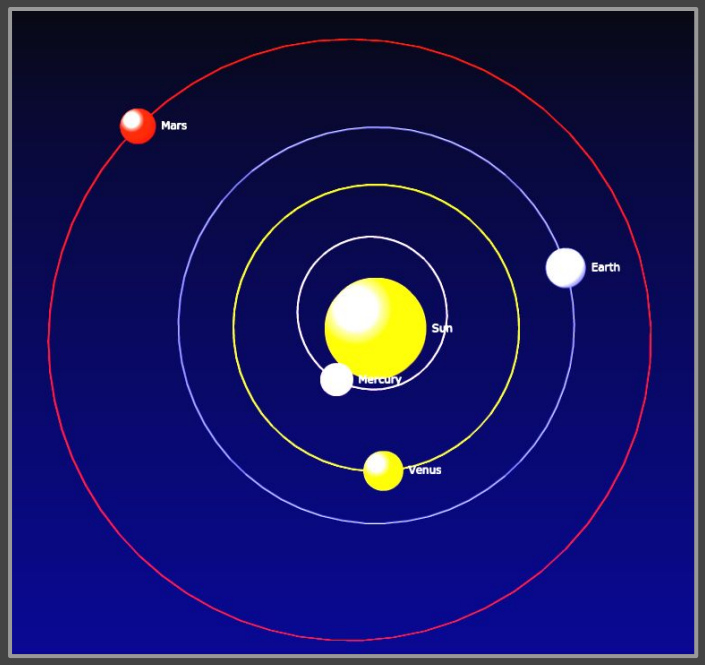
- What is the difference (if any) between using an equation and doing science?
- Write about a time when you felt your voice was not heard? What would have to change about the situation (or society) for you to have been taken seriously?

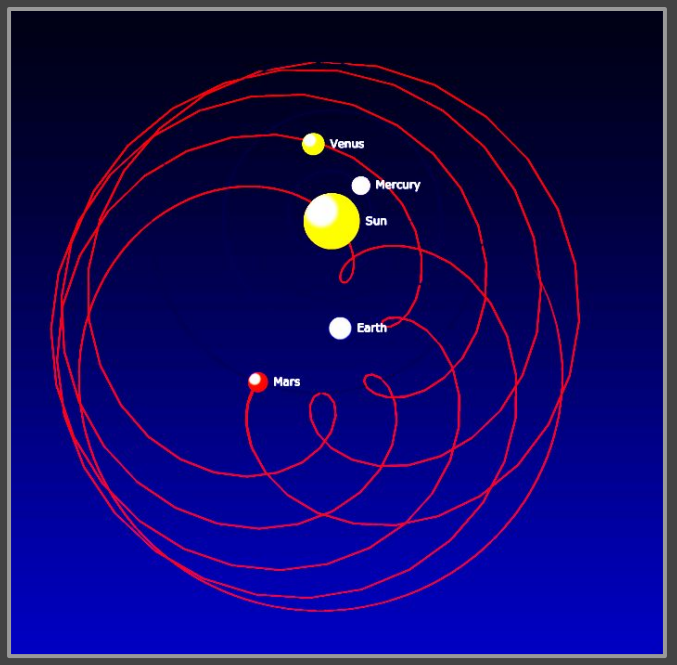


Opportunities to Self-Identify

Course theme: importance of reference frames

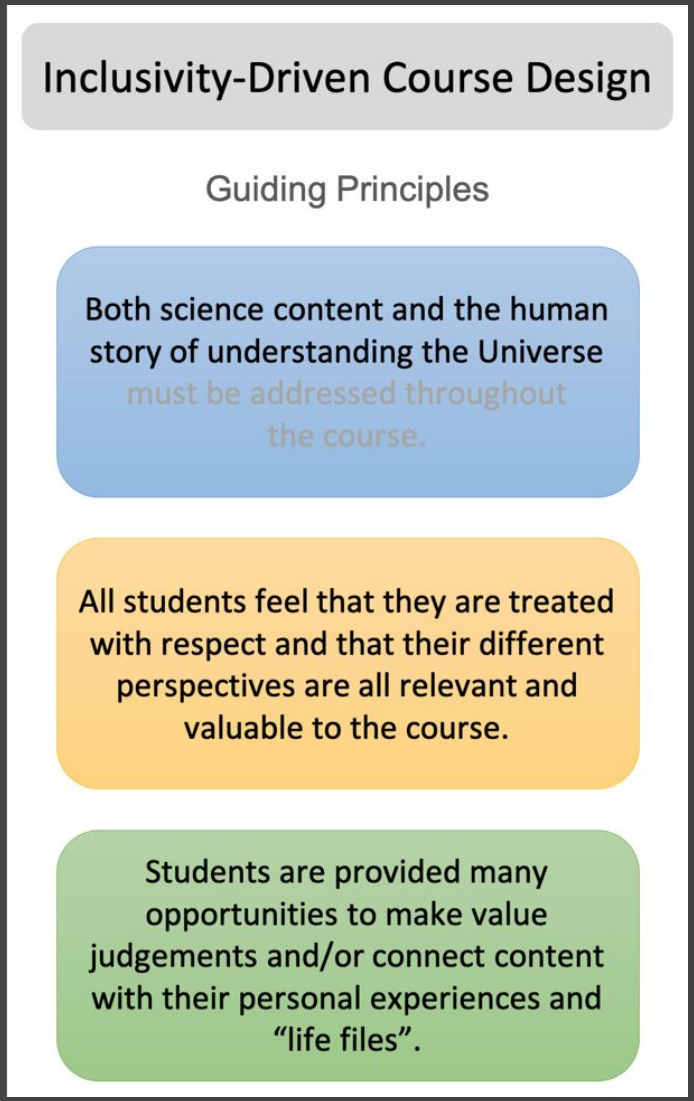
- Example: Solar System perspectives (http://gunn.co.nz/astrotour)





Opportunities to Self-Identify

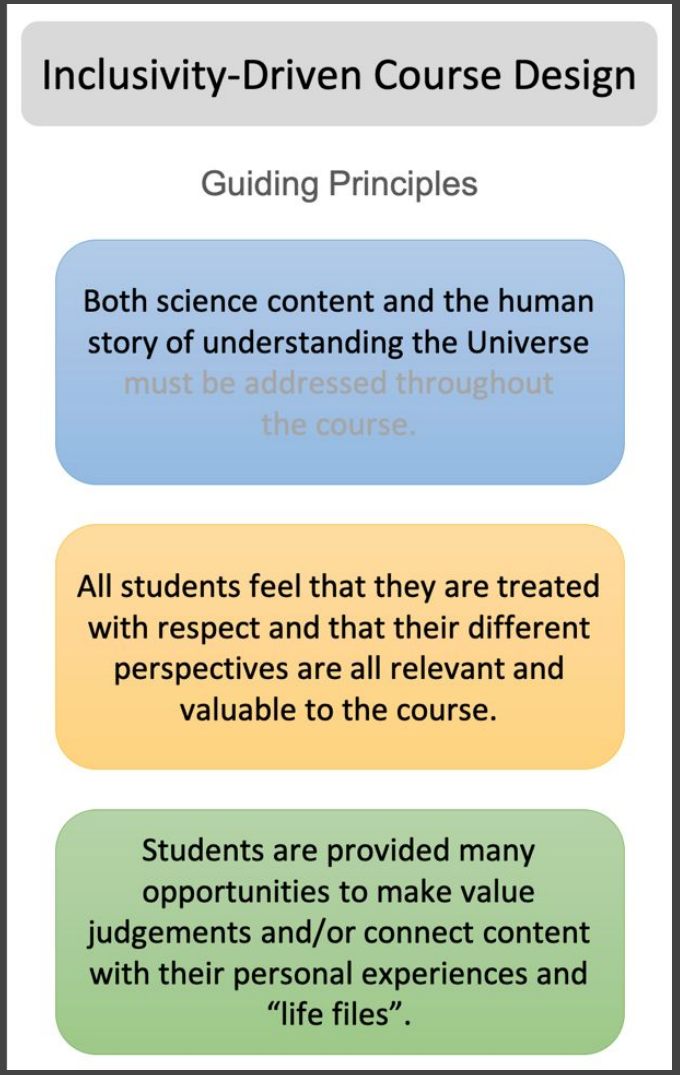
- In class: Describe a situation in your life where at least two perspectives were valid. What information would help?
- On homework: What arguments support each point of view? How does someone rationally come to the other point of view?



Opportunities to Self-Identify

Student responses included

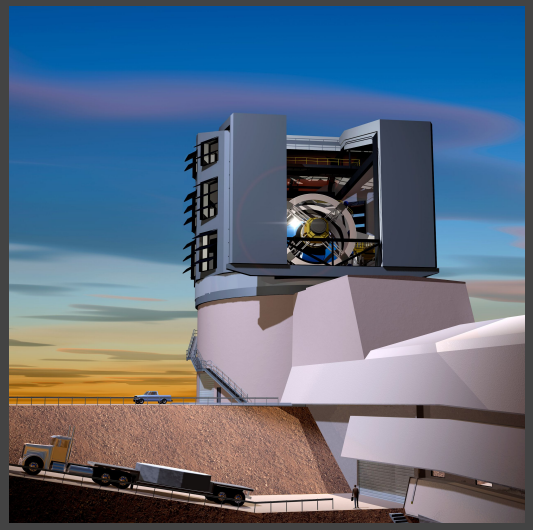
- Political disagreements (abortion, immigration, felons & voting rights)
- Religious disagreements (existence of God)
- Disagreements with family & friends



➔ Integrating science practice with their personal lives to connect the "course file" with the "life file"

Opportunities to Self-Identify

Translation to online learning environments: LSST EPO investigations



Evaluation & Assessment of Our Inclusivity-Driven Course Design

Pre/Post-Course Survey

Thinking About Science Survey Instrument tests whether students agree with a "public" portrayal of science (TSSI; Cobern 2000)

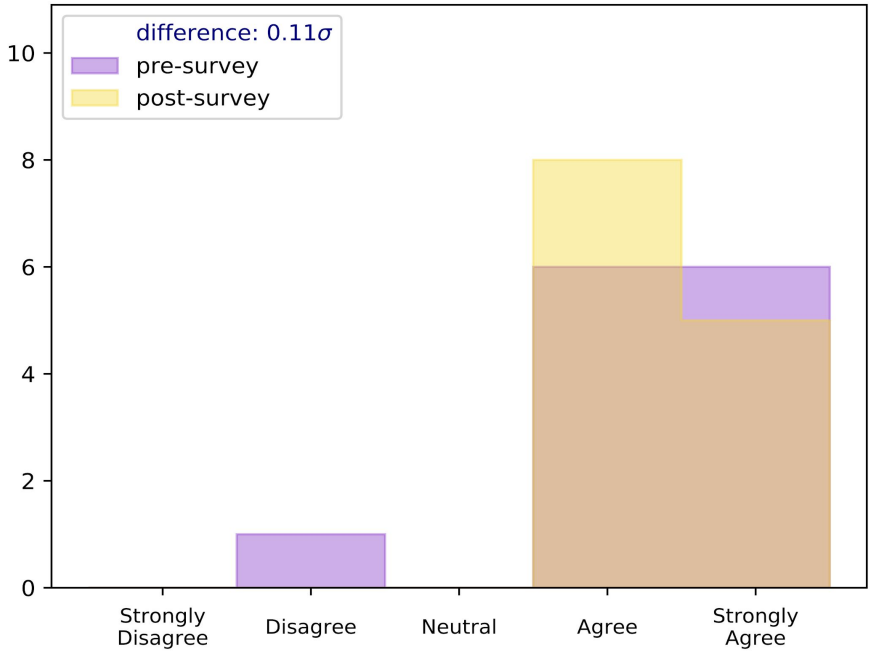
- Ex: Scientific knowledge is useful in keeping our national economy competitive in today's world.

➔ I adapted the survey to focus more closely on aspects related to **connecting "course" and "life files"**

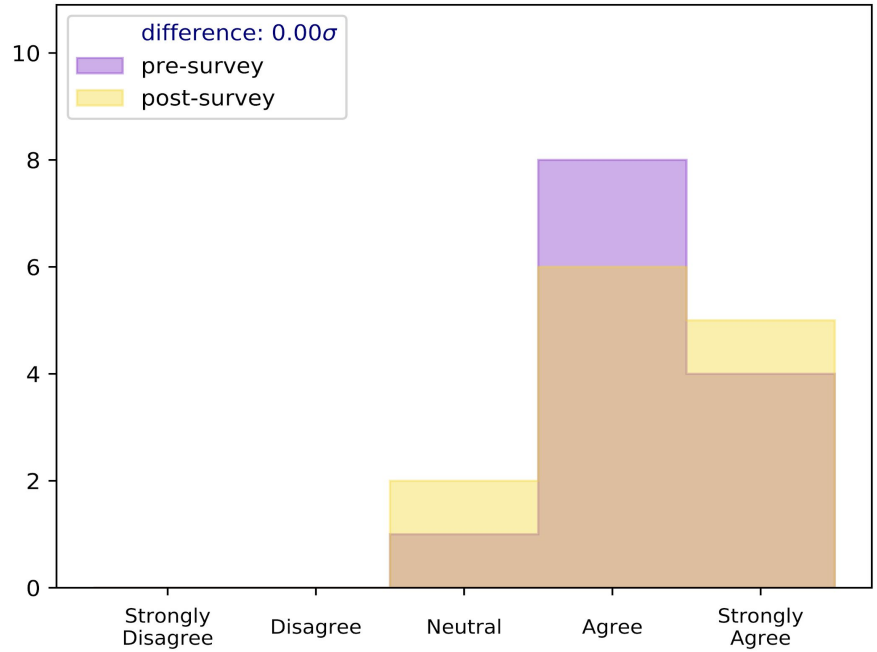
- Students started out fairly positive towards our goals (e.g., Adams 2013; Perkins et al. 2005; Wallace, Prather, and Mendelsohn 2013)

Pre/Post-Course Survey

Scientific knowledge is useful in keeping our national economy competitive in today's world.



A person can be both religious and scientific.



Small positive change: $\Delta = 0.07$ with $p=0.170$ (O'Donnell et al. 2020)

Student Evaluations

- “I was dealing with some family problems that have a lot to do with viewpoints. [...] We had been arguing unproductively for almost a month, and then we **learned about how perspective** changes how we receive information. Taking that and applying it to the conversation, my cousin and I **managed to make them understand** why she chose what she did and while unhappy, they accepted it. I apply this to most discussions now, and I’ve **become a better advocate** because of it.”

O'Donnell et al. 2020

Student Evaluations

- “This course change my thinking. I learned how to use **critical and scientific thinking** to solve the problem”
- “The questions you guys asked allowed for **honest responses**, and the way they were worded made me feel **comfortable expressing my actual opinion**”
- “[...] methods of questioning and getting us to think about our answers and why we chose them helped me **understand not just the facts but how we got them**.”
- “It was **engaging and interesting** and the professor **cares about everyone's thoughts and opinions** on subjects”

O'Donnell et al. 2020

Future Improvements

Additional evaluation techniques to enhance this research:

- Student interviews/focus groups: did they feel like they were treated with respect?

- In-class observation protocol: observe which voices are represented in various class aspects

Going forward...

- Continue implementing an inclusive course design to improve the teaching & learning of astronomy
  - Encourage & respect diverse views, empower students to make connections between their course & life files
- Create space for more explicit connections between culture & science
  - Systemic/institutional bias, social justice
  - Critical reflection by students

Thank you :) Questions?

https://arxiv.org/abs/2004.10218

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TSSI: http://www.pearweb.org/atis/tools/24 (links to both the article describing its motivation and the tool itself)