Student-centered Multicultural Perspective in the Science Classroom

A case study about infusing the college physics classroom with a multicultural perspective through student-written texts.

Lilly Conference - Austin, Texas - January 10 – 12, 2019

Elmar Bergeler, Ph.D.
elmar.bergeler@txstate.edu

TEXAS STATE UNIVERSITY®

The rising STAR of Texas

Goals

- Show possibilities to infuse science classes with multicultural perspectives
- Investigate what multicultural perspectives students bring into the science classroom through written texts
- Show how students perceived “creativity assignments,” which were used to infuse a college physics class with a multicultural perspective

Overview of the Topic

- Students' cultural background plays a role in their performance in science classes (Hill, 2015)
- To allow all students to achieve affective learning goals in classrooms and to develop a positive self-image, the National Council of Accreditation of Teacher Education (2011) requires teachers to adapt to a culturally diverse classroom
- Current material used in science classes does not support the inclusion of different cultural backgrounds (Meyer & Crawford, 2011; Hodson, 1993)
- College instructors must develop more teaching strategies to include students with diverse backgrounds (Larke, 2013)

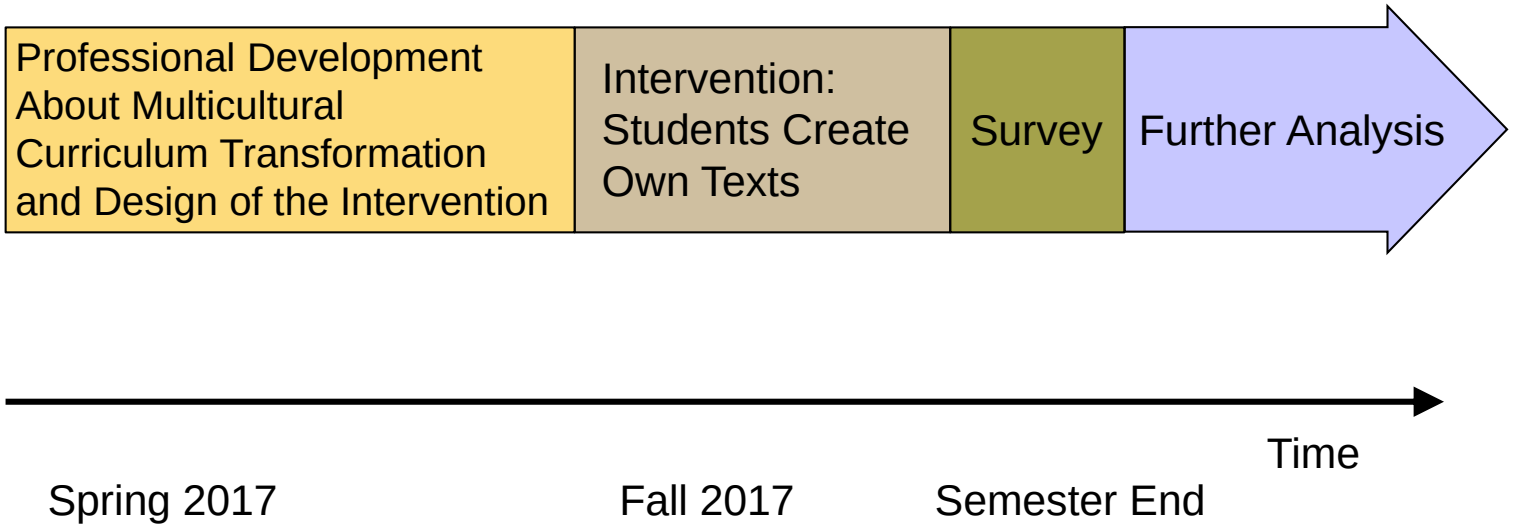
Intervention

- Group: The algebra-based General Physics 1 course for non-physics majors at Texas State University in fall 2017 (5 sections with100 students each)
- I created and assigned “Creativity Assignments” to infuse the physics course with a multicultural perspective. Otherwise, the course remained unchanged compared to previous semesters
- Students had to pick one of 7 different types of creativity assignments weekly (see next slide) as homework
- The creativity assignments were graded as 100% if submitted on time. No feedback was given

Creativity Assignments to Create Own Texts

- Explanation
- Reflection About Own Learning
- Word Problem
- Example for Application
- Illustration
- Application in Future Career
- Story

Research Study



Research Questions

- How do students bring in their own perspective, experience, and background when they write physics texts?
- What perspectives do students bring into the physics class if they have free choice? What are the students' cultures?
- What are the benefits of writing texts in college physics classes?
- How did the physics writing task affect students' self-reporting on motivation and learning?

Qualitative Results of the Study

Explanations

- Embedded in the student's personal life e.g.
  - Driving to the parents or to school
  - Sports
- Address the class room topics and activities
- Add own applicaton examples

Qualitative Results of the Study

Explanation

Example student text

Vectors can be used to describe the location of a point. They are used to measure quantities that are not scalar. They are are not used to measure qualitative traits. A vector cannot be used in order to obtain measurements of height or weight. An example might be measuring both the velocity and direction in which a train is travelling. Vectors can be very useful when the angles being measured are not 90° angles. The most common method of measuring a vector is the tip to toe method which is done by placing two or more vectors with the tip of the point touching the adjacent vector's non-pointed end. If one is adding two vectors, a third vector is then drawn from the tip of the pointed end to the non-pointed end of the adjacent vector. The third vector is then measured and recorded. If a train goes 550 mph heading west towards Monteverde then goes north at 600 mph, how far west is she from the starting point?

Qualitative Results of the Study

Reflection About Own Learning

- Personal back story about their own learning and prior knowledge
- Personal learning problems about physics
- Connection to classroom activity
- Future outlook on how the student will succeed
- Suggestions on how the topic could be taught better
- Addressing learning strategies
- Looking for reasons for not understanding
- Express extrinsic motivation

Qualitative Results of the Study

Reflection About Own Learning

Example student text

These past few lessons have brought up a couple different difficulties I will have to overcome moving forward with the semester. The easiest will probably be the math aspects of our current topics. I am returning to college for a second degree this semester after being away from school for five years, so with the exception of the type of math I use on regular basis professionally and personally, I'm a bit rusty. Lucky I foresaw some of these issues before beginning this fall and tutored with a friend to freshen up on some of my college algebra. This is why I believe I should be able to overcome this setback pretty quickly (I hope) because at least I'm not walking into it blind, I just need a refresh. The other difficulty I have had and will probably continue to have is concerning conversion of units of measure. It's not that I'm even rusty with this; it's just not a strong suite. I spend years as a cook working in a kitchen, putting together recipes. I still cook as a hobby on my own. It's arguably my favorite hobby. Ask me to convert a measurement however and I am stumped without my conversion app. probably because I don't often measure. All in all and up and down start to the year. But im not going anywhere without my passing grade.

Qualitative Results of the Study

Word Problems

- Embedded in the student's personal life e.g.
  - Driving to the parents or to school
  - Going on campus from one building to another
  - Sports
  - Texas State University specifically
  - Using their own name for the protagonists
  - Include a social component (like spending time with a friend, going together…)
  - Personal problems
- Use locations familiar to the students:
  - Cities they are familiar with
  - Locations on the campus
- Fiction/fantasy or realistic
- Visualization of the word problem
- Textbook-like
- Creative with a story around the word problem

Qualitative Results of the Study

Word Problems

Example student text

Kelsey and Brianna decide to go to the movies, they leave from Brianna's house and drive 7 km due east before realizing that Kelsey forgot her wallet. They turn around and drive back to Brianna's house 7 km due west, get Kelsey's wallet and then head back to the movies. They drove 30 km due east before finally arriving at the movies. What was Kelsey and Brianna's total displacement? Use correct SI units

A. 44 km
B. 44,000 m
C. 30,000 m
D. 37,000 m

Qualitative Results of the Study

Example for Application (in General or in Future Career)

- Give background about their major and future career
- Students give background about themselves
- Application of physics and transfer to their major
- Describe their appreciation for the physics content
- Cultural background is brought up sometimes

Qualitative Results of the Study

Example for Application (in General or in Future Career)

Example student text

Understanding concepts such as displacement, velocity, and acceleration is imperative in my realm of study. I am a biochemistry major. The bread and butter of understanding biochemical reactions in organisms is being able to analyze data obtained from actual experiments. There are two very important graphs that are generated from enzyme catalyzed reaction data. The first is a Michaelis-Menten enzyme kinetics graph. This graph displays the velocity of a reaction enzyme concentration increases or decreases. The second is a Lineweaver-Burke plot that represents the acceleration of said reaction at different stages of a reaction. Being able to use equations such as v=change in distance/ change in time or a= change in velocity/ change in time in order to analyze this data is critical. Values such as the maximum velocity of a reaction can give major insight into someone's health and the efficiency of biochemical reactions in their body. Therefore, the understanding of basic motion and physics is absolutely required in order to understand and work in the field of biochemistry.

Qualitative Results of the Study

Story

- Comedy or satire
- Realistic
- Fable
- Style of fairy tale
- Social aspects (being bullied, unsuccessful, famous, happy)

Qualitative Results of the Study

Story

Example student text

Vectors with Lightning McQueen

One sunny day, Lightning McQueen was training for the World Grand Prix against other racecars across the nation. He wanted to win so badly. He knew that he had the drive, the passion for it. Heck, he knew he even had the luck. Even so, he felt like he was missing something about it. There had to be something he could do to gain an edge against the other racecars. Thinking upon it for a long while things began to slowly piece themselves together into his mind.

Driving on the race track there were a lot of things that come into play he thought, magnitude and direction being a bit of it. Continuously he tested out his skills, but this time keeping in mind his velocity, force, magnitude, and the direction his wheels would take him. He noticed where he would lag and where he would be at his top speed. Finally gaining a rhythm for it, he was able to drive better each and every time.

Qualitative Results of the Study

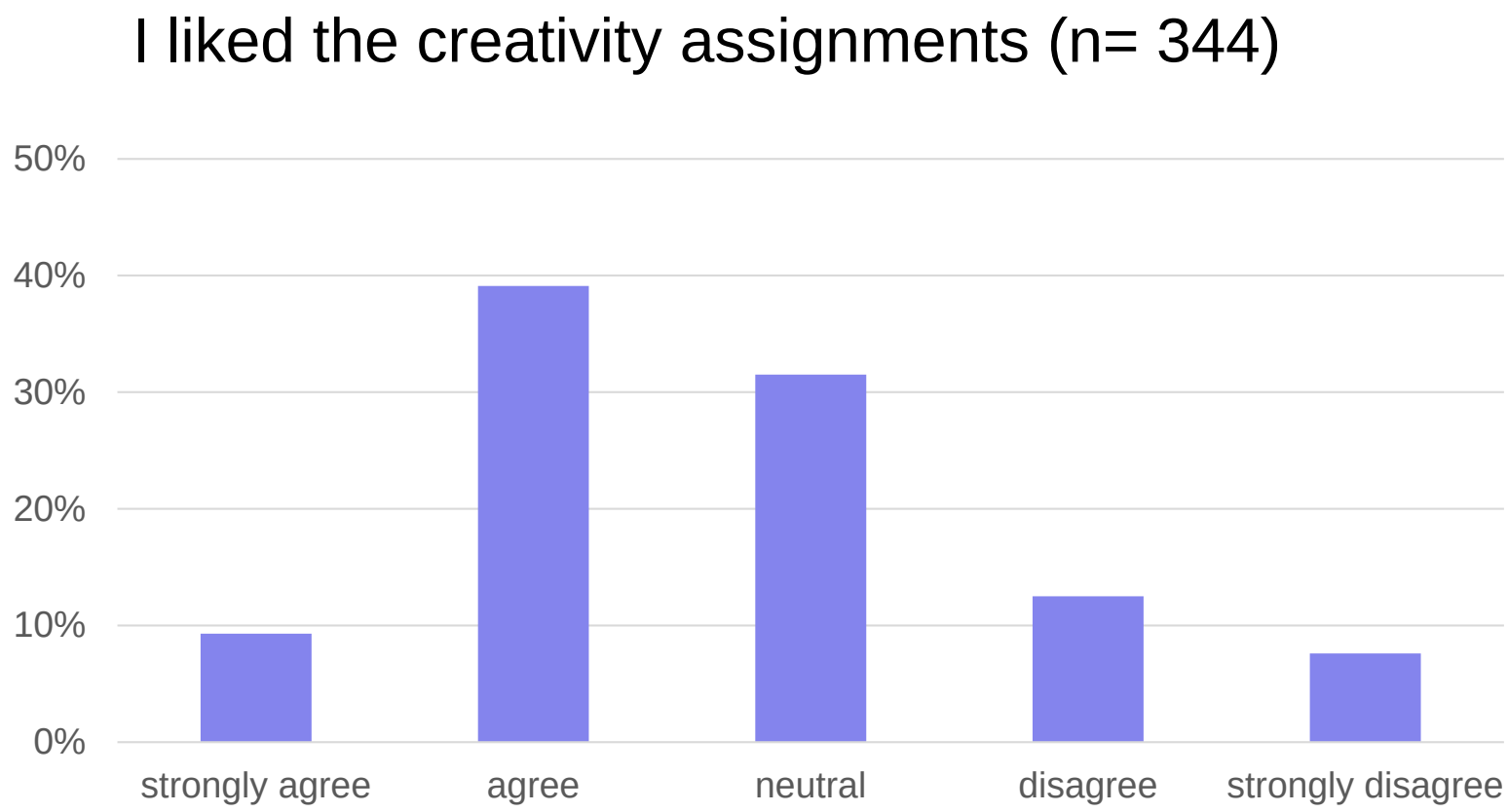
Story

Continued…

Feeling like he was breaking through to something he called up his good friend Doc Hudson, a former retired racecar from back in the day. After explaining his thoughts and actions to Doc, Doc said that what he is thinking about is called vectors. Vectors, he explained, is a quantity having direction and magnitude so as to determine the position of one point of space relative to another space. This works on the race track because as a racer you want to go from the starting line (point A), to the pit quarters (point B), and then finally to the finish line (point C). This creates a triangle of sorts, Doc further explained.

Astonished and excited, Lightning McQueen was now more determined and confident than ever that he had the edge he need to win the race. Come race day, he flew past his competition and won the gold piston cup. He was pleased to know that knowing about vectors can really be beneficial to his career, and would be sure to implement his knowledge to future races.

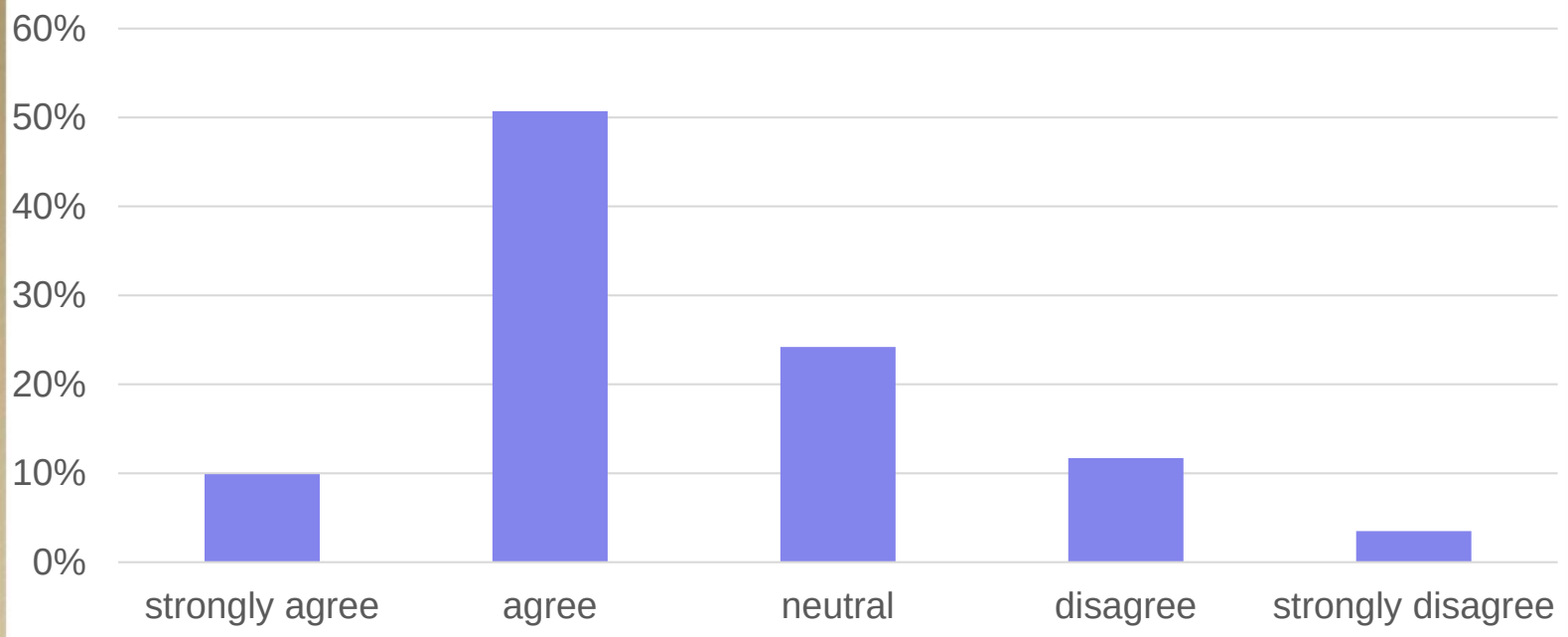
Quantitative Results of the Study



Quantitative Results of the Study

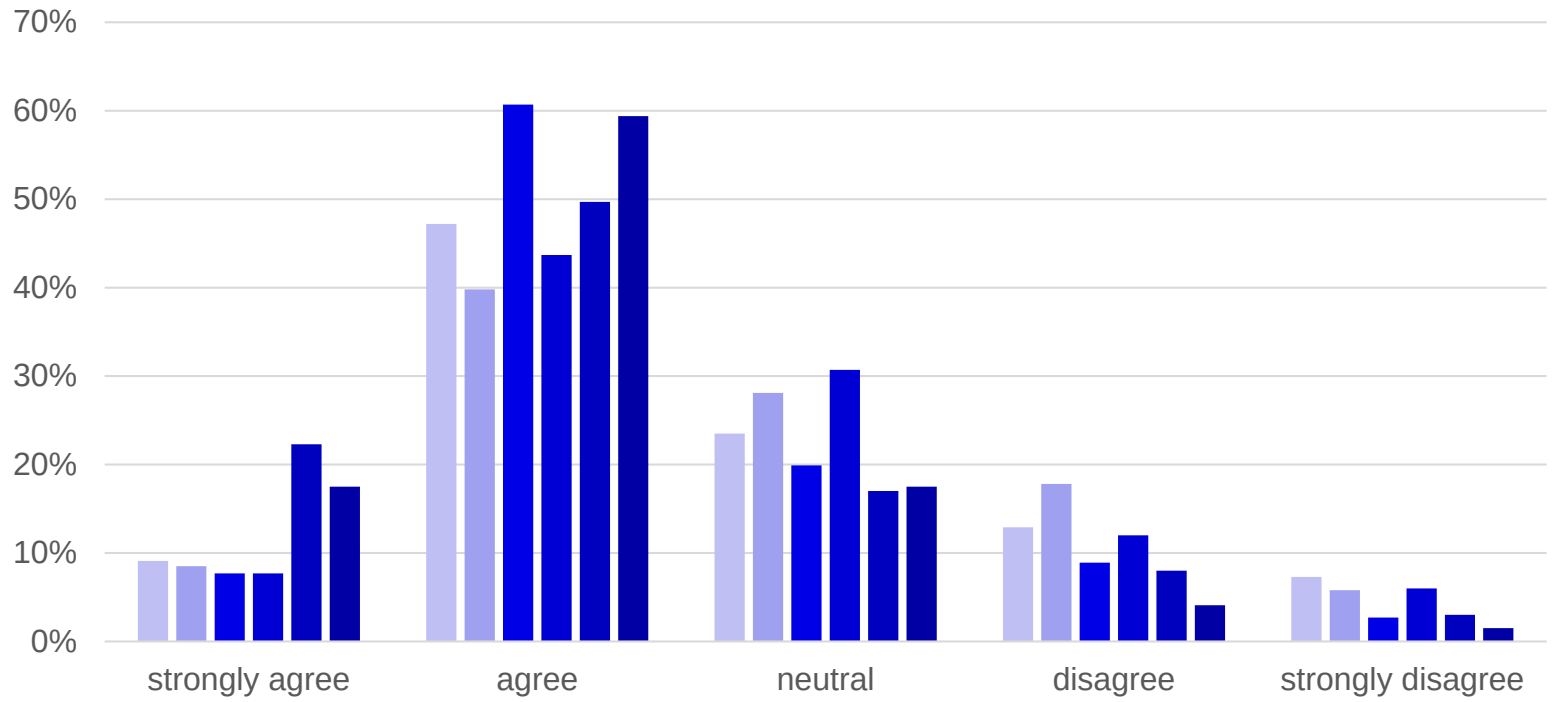
Bringing in Own Perspective

When I worked on the creativity assignments, I was creative. (n= 344)



Quantitative Results of the Study

Understanding and Learning Physics

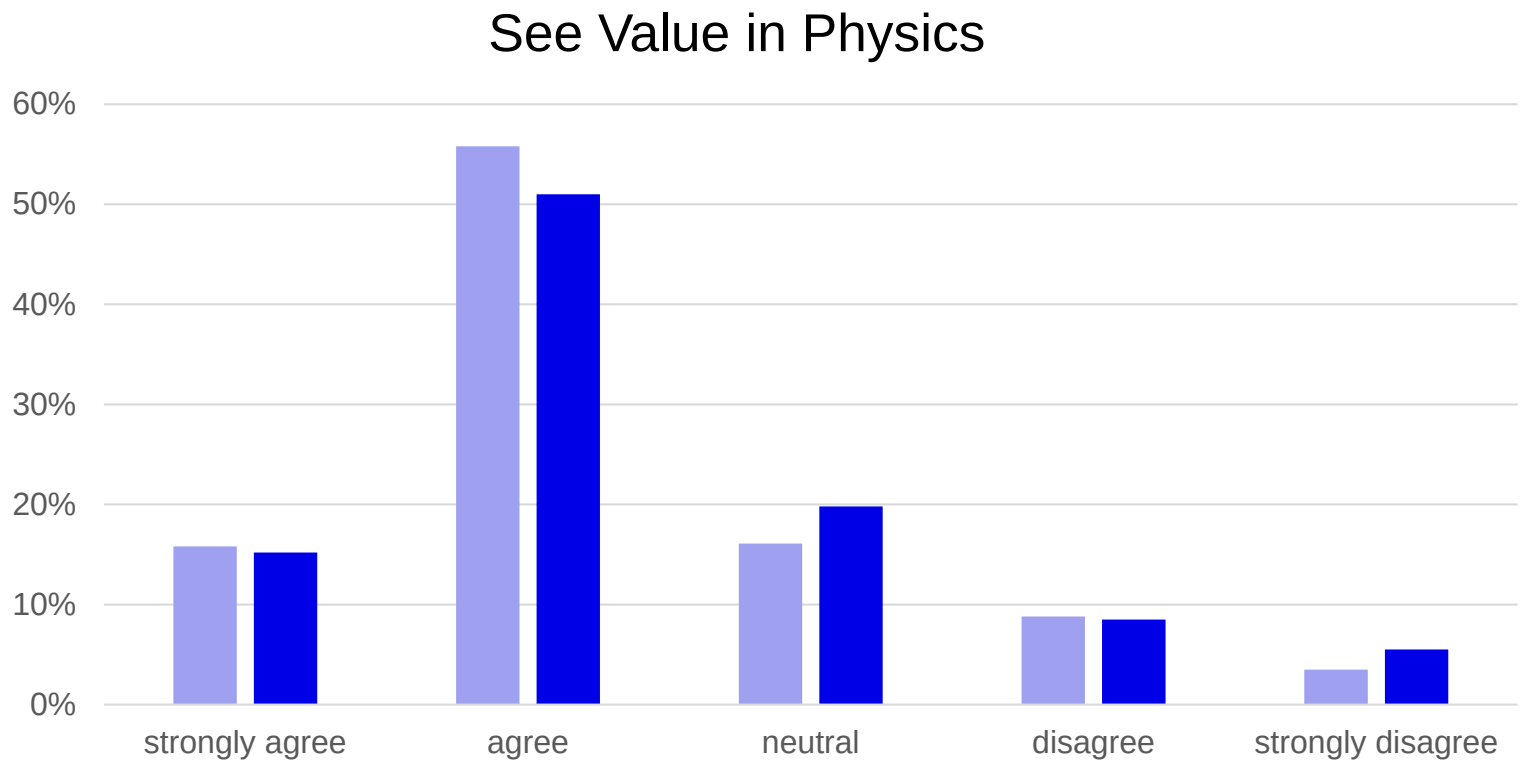


(n = 344)

From left to right:

- The creativity assignments helped me to make sense of the physics topics.
- The creativity assignments help me to understand the physics.
- I could learn through this task [explaining something].
- I could learn through this task [writing a story].
- I could learn through this task [creating a word problem].
- I could learn through this task [working on a calculation].

Quantitative Results of the Study

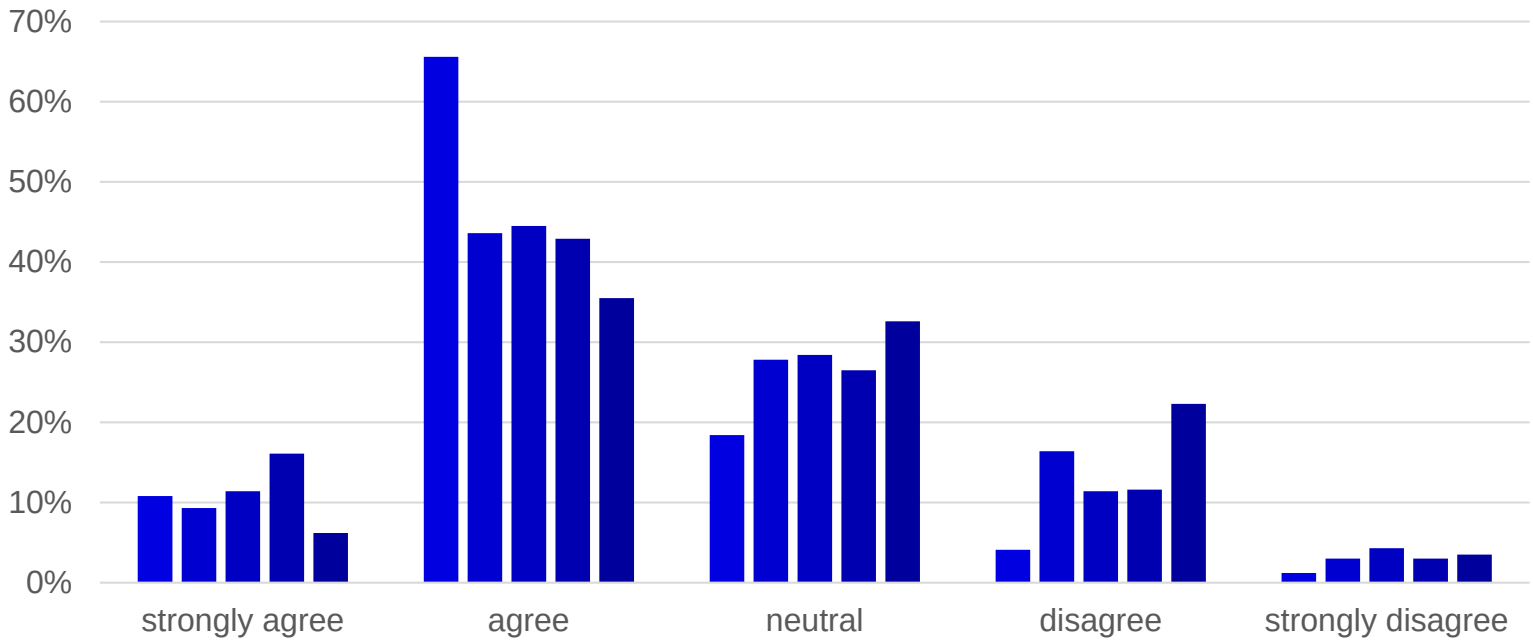


(n = 344)
Left bar:
Through the creativity assignments, I see how the physics can be used.

Right bar:
The creativity assignments helped me to see where the content plays a role in real life.

Quantitative Results of the Study

Communication about Physics



(n = 344)
From left to right:

- I used specific physics terminology in the creativity assignments.
- I could learn through this task [explaining something].
- I could learn through this task [writing a story].
- I could learn through this task [creating a word problem].
- I could learn through this task [working on a calculation].

What are the benefits of writing texts in college physics classes?

- Besides the physics contents, the students also practice how to communicate about physics
- The students can bring in their own background, perspective, personality, and interests into the science classroom
- The (non-physics major) students see the value of physics for their own life and field of study
- Addresses the lack of multicultural awareness in science classes

Thank you for your interest.

Please contact me if you are interested in collaboration.

elmar.bergeler@txstate.edu

Appendix

Creativity Assignments to Create Own Texts

- Describe and explain a physical concept from the lecture from the last two weeks to a novice or classmate in a short text (roughly a third of a page). You can pick any fact you want (law, rule, principle, definition, ...) from the lecture. Write it in your own words, but feel free to introduce one or two words of the specific physics terminology, if useful.
- Reflection about own learning: In the last week's class, what was the hardest content to wrap your head around it? (Roughly a third of a page or longer, reflect, why was it the hardest?)
- Create a word problem to a topic from last week.
- Give an example where the newly learned physical concept plays a role. Write a short text (roughly a third of a page) in your own words, but feel free to introduce one or two words of the specific physics terminology, if useful.
- Illustrate (depict, or symbolize) a physical concept, fact, rule, law, definition, or application from the last week's lecture. You can do that for example by drawing a scheme or diagram where you add the formulas and key words into the image.

Creativity Assignments to Create Own Texts

- Give an example where you might need the newly learned physical concept or fact in your future career and explain how you use the new fact/law/formula.
- Write a short story about how someone could have discovered a new physics law, fact, rule, or physical concept. The physics law, fact, concept, or rule should come from a recent (within the last two weeks) lecture of PHYS 1315. Though, your short story should be fictional. (roughly a third of a page or longer)

References

- Hill, C. (2015). Solving the Equation: The Variables for Women's Success in Engineering and Computing, http://www.aauw.org/research/solving-the-equation
- Hodson, D. (1993). In search of a rationale for multicultural science education. Science Education. 77(6), 685-711.
- Larke, P. (2013). Culturally Responsive Teaching in Higher Education: What Professors Need to Know. In Integrating Multiculturalism into the Curriculum. (Edts: S. Mayo; P. L. Larke). Peter Lang Publishing, Inc., New York
- Meyer, X., & Crawford, A. B. (2011). Teaching Science as a cultural way of knowing: Merging authentic inquiry, nature of science and multicultural strategies. Cultural Studies of Science Education 1-23
- National Council of Accreditation of Teacher Education. (2011) Unit Standards in effect 2008, Standard 4: Diversity from http://www.ncate.org/Standards/NCATEUnitStandards/UnitStandardsinEffect2008/tabid/476/Default.aspx#stnd4