Physics Problem-Solving Methodology in Application to Non-Physics Problems

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Abstract

The physics curriculum trains students in problem-solving, teamwork, and particularly in higher-level coursework, systems-thinking. Within the program, the scope of such problems is focused on physical systems. As evidenced by my experiences outside of the physics program, such a skillset proves useful in application to non-physical systems, specifically within the realm of social issues.

Acknowledgements

As trite as it is, they say, “it takes a village” and I’d be remiss in not thanking my unique BYU village: Professor Todd Manwaring for introducing me to the world of social impact. Your incisive approach to systems-thinking trained me in dissecting social issues and seeking evidence-based solutions. Professor Romeri-Lewis, thank you for inspiring me to be a passionate voice for the voiceless and wherever I may be, to be a changemaker. And to Dr. Leishman, for inspiring the confidence in me to see my degree through at a time when I faced seemingly insurmountable challenges.

Table of Contents

List Of Images

Introduction

The physics curriculum develops a rigorous set of problem solving skills, with a very specific scope. Students learn to analyze and understand physical systems as well as how to model them. I chose to pursue a degree in Applied Physics, as it gave me the leeway to enrich my education with courses in international development, social innovation, and international relations. I was exposed to a diversity of thought and societal issues that I would have otherwise never learned of to the kind of depth such coursework did. In doing so, I had the opportunity to utilize the skills gained in my physics program and apply them to unique social issues. In my physics coursework, I learned rigorous problem-solving skills, effective teamwork, and how to interpret and model data. I hope to illustrate how such coursework prepared me to be effective in the fields of international development and social impact as well.

This writeup will consist of essentially two parts: 1) a summary of internships and work experiences I had throughout my undergraduate career that highlight the use of my physics skills for problems with a decidedly social emphasis; 2) a thesis focused on the potential and need for physics problems-solving skills to be applied to social issues.

Problem-Solving Methodology Comparison[1]

Physics Framework

In approaching a physics problem, students are trained to turn to a familiar pattern in framing, and in turn solving a problem. Though exact wording and details may vary, in framing a problem, students:

1. draw a diagram
2. define known variables
3. delineate what is known and what one is trying to find
4. assess which equations will be needed.

Following this outlining of a problem, there are a variety of strategies used in solving one. Typically one begins by solving symbolically. This approach reduces the risk of calculation error as every added step increases the odds of some element of user error. Following a symbolic solution, you plug in your known variables and calculate a result.

[1] David Morin, "Strategies for solving problems," in *Introduction to Classical Mechanics: with Problems and Solutions*, (Cambridge, UK: Cambridge University Press, 2007), 1-18, https://scholar.harvard.edu/files/david-morin/files/cmchap1.pdf.

For some systems this approach is enough. However, as coursework evolves, so too, does the complexity of the systems. Students encounter systems in constant change, or with limiting cases. In these instances, one may find it useful to solve numerically in order to hone in on a quick approximation. One must also test these limiting cases to verify the validity of a solution. For example, as an electrical system is in operation, the movement of electrons produces electrical energy, however, some of this energy is also converted to heat. As the system heats up it affects things like resistivity and conductivity. Early in a physics student's coursework they may ignore such effects, however, as one gains further mathematical tools one can take such effects into account. Or for an example of limiting cases, we can consider a mass hanging from a string. The mass is swinging in such a manner that it traces out a horizontal circle as shown in Fig. 1. We can derive the relationship between the angular frequency and the angle of the string as such: $\omega = \sqrt{\frac{g}{l \cos\theta}}$, where ω is angular frequency, g is gravity, l is length of the string, and θ is the angle the string makes with the vertical. There are two limiting cases one should consider in this example: $\theta = 0°$ and $\theta = 90°$. In the first instance, the result is $\omega = \infty$, meaning the ball would have to swing infinitely fast in order to maintain a horizontal position. In the latter case, the result is $\omega = \sqrt{\frac{g}{l}}$, which is the same as that of a simple pendulum. Thus we see the importance of considering limiting cases in order to fully grasp the nature of a system.

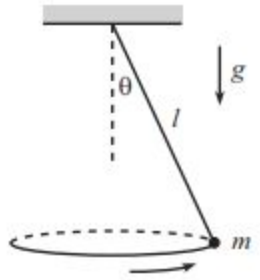

Figure 1.[2]

Social Impact Framework

In approaching a social problem, students are trained with a similar methodology. While the steps in this process are not a perfect one-to-one with those in the physics framework and differences in terminology further mask such resemblance, the similarities will be made apparent. One of the most commonly-taught methodologies in the social impact space is that of human-centered design (HCD) or design thinking (terms often used interchangeably). This process is illustrated in Figure 2. In the following section, I will outline this process using the example of homelessness as a social issue.

[2] Morin, *Introduction to Classical Mechanics, 4.*

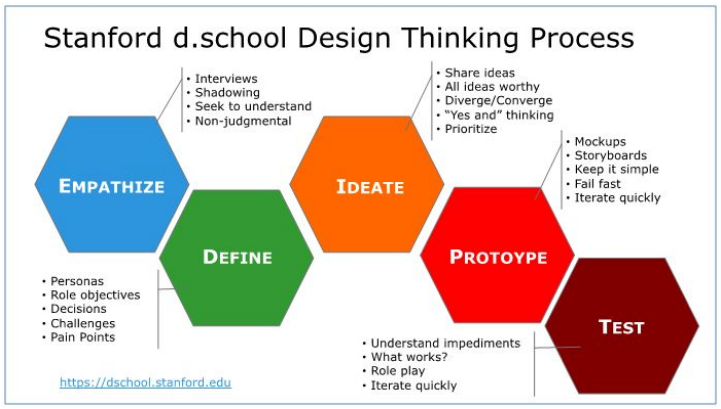

Figure 2.[3]

The first step is to empathize. At this stage it's crucial that one gains an understanding of the problem that centers around the user. It's all too easy to come into a problem with preconceived notions of the issue and its solution. One way to circumvent this is through user research such as interviews or shadowing. By asking a user for their own perspective we understand their needs rather than our conceptions of their needs. In the example of homelessness, suppose we assume that one of the leading causes is drug abuse. In that case, our solutions will likely entail some blend of rehabilitation and treatment. However, using HCD we interview several unhoused persons and come to learn that for many of them drug abuse was in fact a symptom of homelessness rather than a cause. For some it was the loss of a job, for others it was coming out as LGBTQ+ and being kicked out of home, for others yet it was due to untreated mental illness. By utilizing HCD, we've now established a variety of causes worth exploring. Following is an example of a product called the PlayPump that highlights what happens when we fail to incorporate user experience.

The PlayPump is a water pump/drill mechanism designed for use in sub-Saharan Africa in water-scarce regions. The initial design was essentially a merry-go-round playground toy for children to play on that in the process of their playing would operate the pump, producing water. What ended up happening however, is that the pumps weren't placed optimally and in some instances would have required 24 hour operation in order to provide for a village's daily needs. The children often wouldn't play on the merry-go-round more than an hour or two a day which left the women of the village operating these merry-go-rounds for hours on end. Had the engineers stopped to consult with villages and their needs, they may have learned that those responsible for procuring water would have preferred not walking in a circle ad nauseam when there are already existing technologies that are far less labor-intensive. So where this may have

[3] Stanford Design School, *Stanford D.school Design Thinking Process*, February 18, 2018, http://www.theagileelephant.com/what-is-design-thinking/.

seemed like an intriguing engineering challenge that was probably quite enjoyable to design, it ultimately ended up being a marked failure.[4] In both physical and social issues it can be useful to step back and assess things rather than diving in with our assumptions. Our assumptions can guide us, but it's important that we keep an open mind to possibilities we hadn't considered.

The next step is to properly define the problem. Just as in physics, scope is important. Are we looking at something on the subatomic level requiring the inclusion of strong/weak forces? Or perhaps looking at a body so large that gravity of nearby celestial objects becomes relevant. In the case of our social issue, are we looking at homelessness in the world or homelessness on 9th East? Picking the appropriate scope helps craft an appropriate response. Just as calculating the gravitational pull on an electron would likely be fruitless, designing a solution to end homelessness in Provo wouldn't include the same scale of response as ending homelessness in the state of California.

As a part of this definition, one useful tool is the ecosystem or stakeholder map. An example of a stakeholder map for the issue of homelessness is given in Figure 3. In such a map, it's useful to diagram all of the stakeholders, those that are affected or have an effect, of the issue. In the case of homelessness we may want to consider landlords or construction companies. Why is there a housing shortage? What role does public policy play? How does this involve voters or policymakers? How are police or hospitals or other public services involved? Are there charities filling a role? This charting is analogous to a free body diagram. As we map out all of the relevant forces acting on a system, we can determine which are relevant and which can be ignored (e.g. gravitational force on an atom may not be as relevant as electromagnetic forces on said particle). In the case of a social issue, charting out these relationships can help illustrate what needs are met and unmet, as well as what areas of focus will be most useful. Coupled with the information gathered from user experiences, we begin to uncover root causes of the issue.

[4] Tamara Guirao, Marie Vandendriessche, Karen Oliveira, and Esther Ortiz, "The Story of PlayPumps: Merry-Go-Rounds, Water, and Failures in Development Aid," United Explanations, accessed July 14, 2020, http://unitedexplanations.org/english/2012/03/22/the-story-of-playpumps-merry-go-rounds-water-and-failures-in-development-aid/.

Figure 3.[5]

As may have become clear in the last section, the ecosystem map starts to uncover root causes and direct our research. There are many techniques for discovering root causes, but the idea is to keep peeling back layers of an issue until a root cause is discovered. One common method is "The Five Whys." Following is an example conversation using the five whys:

Social Worker (SW): Mary, why are you homeless?

Mary (M): I can't afford my rent.

SW: Why can't you afford rent?

M: My husband left us. My job isn't enough to support the family.

SW: Mary, I know this is personal, but why did your husband leave?

M: He developed a drug and alcohol addiction which he chose over his family.

SW: Why did he turn to drugs and alcohol? Has this always been a problem?

M: No, he just couldn't handle the grief anymore.

SW: Why was he grieving?

M: Our son passed away last year and it broke my husband.[6]

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[5] Abigail Stewart-Kahn, "Image Result for Stakeholder Map Homelessnes,". accessed July 1, 2020, https://www.pinterest.com/pin/252483122842321304/.

[6] Kimberly Patch, "4_kimberly-patch_student-Presentation.pdf," Northeastern Seminary, n.d, accessed July 15, 2020, https://www.nes.edu/media/2889/4_kimberly-patch_student-presentation.pdf.

This example focuses on an individual family, but it's useful for broader issues as well. As we start to uncover the root causes we may ask, is it more useful to look at crime data? At housing law? At policing practices? There are myriad ideas and at this point we are still defining our problem. Similar to a physical system, it's useful to determine what kind of problem we're dealing with. Are we looking at thermodynamics? Kinematics? Electromagnetics? Just as in physics, by setting up our problem correctly, we direct our later efforts in solving it.

The next step is ideation. Ideation is the part of the Human Centered Design process in which you generate ideas. It is crucial that we maintain a solutions-agnostic approach throughout this process. Students are wedded to the social issue, not a solution! What are the data telling us? At this point we've started some preliminary research and we're starting to make sense of it. During this step we brainstorm ideas that focus on the root causes we've uncovered. We don't have to spend too much time on this step as we'll be returning to it again. The whole HCD process is iterative, and especially this part of it. As we ideate solutions, we test them, providing further information on our issue. This may allow us to redefine elements of our ecosystem map or uncover new relationships, which in turn shifts the focus of the solutions we craft. Similar to physics, it's important that we not be too beholden to our hypothesis (or solutions in social impact parlance), but rather allow our research to provide new insights into our hypothesis. Drawing from historical examples like Millikan's oil drop experiment, one can see the merit in not letting ourselves cling to our hypotheses. In the original oil drop experiment, Millikan's value for the charge of an electron was off by some amount due to the fact that he was using an incorrect value for the viscosity of air. However, we saw a slow creep from Millikan's value to today's accepted value because of scientists' reticence to deviate too far from Millikan's results.[7]

Lastly we prototype and test. Though this is the "final" step in the process, it should be remembered that the whole HCD process is iterative. Testing a solution on a small-scale gives immediate feedback that we incorporate back into our definition and conception of an issue. This process repeats itself as we take in new data. This could be likened to using numerical approximation techniques like Euler's method. Rather than solving an arduous differential equation, it can be useful to approximate as we hone in on a solution. In testing our intervention it's also useful to consider limiting cases just as we might do in physics. Suppose up to this point we've considered a fairly homogeneous population of white, middle-aged men. How does our solution differ if our population includes homeless women? Or LGBTQ+ teenagers? Non-English speaking refugees? Just as in physics such exercises can be a useful means of evaluating the limits of one's intervention.

[7] "Oil drop experiment," Wikipedia, last modified June 11, 2020, https://en.wikipedia.org/wiki/Oil_drop_experiment.

In addition to the similarities in the problem-solving methodologies themselves, the kind of systems-thinking that proves useful in physics is equally useful for social issues. In the previous section on the physics framework we discussed the complex interplay of an electrical system. Another example of complex physical systems that bears striking parallels with social problems are nonlinear systems. Tiny changes in initial conditions lead to drastically differing outcomes. These complex systems are referred to as "wicked problems" in the social impact space. Wicked problems are defined as "problems that are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize," and that due to, "complex interdependencies, the effort to solve one aspect...may reveal or create other problems."[8] As soon as you implement a solution, it permanently alters the landscape of the problem. Circling back to the example of homelessness, it's difficult to separate the issue of homelessness from mental health issues, drug addiction, poverty, and much more. And any attempts to ameliorate any one of those issues will alter your solutions to your chosen problem. These tiny changes in one system can drastically alter the landscape of our system and in turn, how we craft our response. Suppose your organization has designed an intervention that addresses the economic elements of homelessness by means of a $500 per month stipend. Once you implement this, you've altered the economic state of the region. Perhaps landlords in the region will start charging $500 more per month for housing or homeless services will start charging for what they offer. Like a nonlinear system, any further interventions must now incorporate the new set of initial conditions.

Applications of the Framework

Some of the most useful skills I gained in my physics training proved to be equally applicable in tackling social issues. In particular, I wish to highlight that the many lab courses I had taught me effective teamwork and communication. Also, while the problems being tackled in these experiences weren't particularly rigorous from a mathematical perspective, having such broad exposure to mathematical tools proved extremely helpful. I was able to perform data analytics for a variety of interesting problems. Having spent a summer in the Acoustics Research Group I also learned valuable skills for contributing to a research project. This proved especially helpful in my work with GTCI. Lastly, as discussed above, while the nature of the problems is different from those in physics, the problem-solving skills I gained there proved indispensable in approaching these social issues. Details on some of the most relevant projects are given below in chronological order.

[8] Australian Public Service Commission, "Tackling Wicked Problems : A Public Policy Perspective," June 12, 2018, https://www.apsc.gov.au/tackling-wicked-problems-public-policy-perspective.

Reasons to Stay

My involvement in this project began in an Intro to International Development (ID) course (IAS 220). Over the course of the semester, we designed an ID project using the Human-Centered Design (HCD) process. Our team began with exploratory research into the issues besetting Kosovo (found here). Our initial inquiry looked at public health, education, gender issues, youth unemployment, governance, and geopolitics. Following this background research, we held focus groups and surveys with locals in Kosovo to assess the most pressing needs. As a part of this, we used the "Five Whys" and found the overwhelming response to be that economic youth development was needed. After a series of brainstorming sessions in which we considered the data gathered from our interviews as well as our background knowledge, our project proposal (found here) was a business incubator with a focus on teaching entrepreneurial skills to college-age adults (an outline of our project can be found in the presentation linked here). Our reasoning was, such skillbuilding would empower Kosovar youth to pursue their own business ventures given their intimate knowledge of the region's needs. As a part of our proposal there was to be regular impact evaluation in order to gauge the efficacy of our program (outlined in the proposal). This would entail gathering data on project outcomes and conducting analysis on said data.

VentureUP

In the summer of 2017, I moved to Kosovo and helped to launch the aforementioned Reasons to Stay project with the organization VentureUP. In my work there, I authored the grant proposals found here and here. These projects had a specific emphasis on social ventures, whether as a business with a social angle or a non-profit. I remained in Kosovo through December 2017 helping to develop the program outlined in said proposal. As a part of this, we added new workshops and gathered data on what was attracting students and what was leading to successful ventures. I helped to assemble a data pipeline that would allow for regular impact evaluation. Unfortunately, my time at VentureUP was cut short as I returned to Provo to finish my schooling, so I didn't have the opportunity to see this pipeline put into action.

GTCI

Global Truth Commission Initiative (GTCI) is a global dataset on truth commissions (TC) in which we gathered hard-to-find data on TC processes in 30+ post-conflict societies on 250+ qualitative variables. This data was to be used by researchers and policymakers in the transitional justice space (in-depth description can be found here). Due to this data being qualitative in nature (level of training of officiants, gender of participants, etc.) I learned to scale such variables to

allow for data analysis. Due to my connections in the Balkans, I played a role in gathering data regarding Yugoslav Truth Commission efforts. During this time, I relocated to the Balkans, networked with civil society organizations and policymakers, and gathered data for the GTCI dataset (data gathered can be found here). During the fall semester of 2017, I presented a lecture to the GTCI group regarding the Yugoslav Wars and TC efforts in the region (slides here). Prior to my involvement in the GTCI project, I also helped contribute to group work in a class on Women, Peace, Security, Transitional Justice & Rule of Law in which we produced a proposal for a Yugoslav TC (slides here).

Incorporating our research, we then designed a Truth Commission as part of a document containing recommendations for the government of Colombia. As a part of this process, we invited student volunteers to participate in a mock TC. We utilized aspects of HCD and incorporated their feedback into our final recommendations. We also included the feedback gathered from those involved in the Yugoslav TC (those I interviewed).

Social Innovations Solution Competition 1 - RefugeeChain

In this case competition, we were given one-week to analyze a need and craft a solution regarding any element of the refugee crisis.

We interviewed refugees and several individuals working for non-profits involved with the crisis. In seeking to dig out root causes we found that one looming issue is a lack of identity. Meaning when refugees flee, they often leave behind personal documents: bank accounts, deeds for property, academic credentials, etc. These documents may be destroyed in a disaster and it may prove impossible to verify such identifiers if the issuing organization's have also been damaged or destroyed in war. In bumping shoulders with STEM majors every day, I was familiar with popular tech solutions like blockchain and big data. Exposure to such ideas helped us to craft a solution that incorporated these powerful tools.

Thus, our solution was to utilize blockchain as a secure, immutable identifier for refugees. This served a dual purpose in providing individuals with a means to preserve valuable documents while also granting us access to useful data. Anonymizing this data could provide crucial insights into the demographics and movement patterns of refugees. This could inform policymakers and allow them to predict influxes based on historical movement data as well as what preparations are needed to receive refugees.

Much of our thought process and brainstorming can be found here. Our final presentation can be found here.

Social Innovations Solution Competition 2 - The Other Side Academy

The Other Side Academy (TOSA) helps to rehabilitate ex-convicts, felons, and drug addicts into society. They do so by, "offer[ing] vocational training, education, peer counseling and mentoring, leadership training and transitional services."[9] One of their most popular programs is a moving company which is run, managed, and operated by their students.

This competition followed the same format as the last. In this case, we were again given one week to craft a solution for The Other Side Academy. TOSA wanted to expand into a new program that would provide growth and experience for their students similar to that of their moving program. This tight timeframe required us to condense the Human Centered Design steps more than is usual, but ultimately our solution was awarded 2nd place and was implemented by TOSA.

In our initial meetings we brainstormed ideas (some of which is captured here) on industries with little to no barrier to entry (i.e. low startup costs). We also interviewed ex-convicts and drug addicts about the sort of skills they would have found useful or that they would want to learn in a similar type program. We took special note of the needs of female students since the existing business is a moving company (the heavy lifting while still certainly possible is more difficult to the average woman). It also needed to have a high profit margin to generate revenue to cover the other services TOSA provides (counseling, housing, etc.). Throughout this process, we ideated dozens of options. We bounced them off the people we had surveyed and continued to refine our options until one emerged as the strongest contender.

Our solution was a painting company that could be packaged with the moving company. After settling on this idea we divvied up the various aspects (breakdown found here) of the business that we felt were most relevant to the organization. We researched TOSA's mission, their goals and sought to align our solution with this. We were careful to note that we weren't just being asked to produce a money-making branch, it had to align with TOSA's values and further their mission.

Finally, we presented our findings to the board of TOSA (slides here). After the first round of judging we were invited back as finalists in which we addressed questions raised in the first round (licensing requirements, breakdown of costs, typical workday, etc.). A detailed response can be found here. Lastly, in order to address the financial questions raised, using regional data on pricing, I created an excel spreadsheet to conduct a breakeven analysis in program

[9] "How It Works: The Other Side Academy," accessed July 17, 2020, https://www.theothersideacademy.com/how-it-works.html.

profitability. A second spreadsheet included a bid estimator for a foreman to calculate rough estimates on job bids. These sheets can be found here.

Table of Experiences

I was involved in additional projects in which such skills were utilized. I've listed the projects and any relevant skills in the table below. Where possible, I've included documentation for these projects in the Appendix. The projects are presented in reverse chronological order.

Date	Project Title	Skills Used
4/2019 - 9/2019	Ballard Brief	Data Analytics
11/2018	TOSA Case Competition	Teamwork HCD Data Analytics
4/2018 - 9/2019	Teaching Assistant for *Do Good. Better - Social Innovation* course	Recruited 6 students from the physics department to sign up for this course (one of which applied these skills in the TOSA case competition) Taught the social impact problem-solving framework to students. Lectured on the design-thinking process.
2/2018	RefugeeChain Case Competition	Teamwork HCD Data Analytics
1/2018 - 4/2018	Givv Consulting	Advised on a new direction for their business that incorporated blockchain technology Teamwork Website Design (coding)
9/2017 - 12/2017	VentureUP	Grant Writing
5/2017 - 2/2018	GTCI	Data Collection HCD Teamwork

		Research
1/2017 - 4/2017	Reasons to Stay	Data Collection HCD Teamwork Project development

Table 1.

Proposal

I want to prelude my thoughts for the following section by saying this isn't derived from a rigorous, comparative analysis between BYU Physics and any other program. Rather, I'm drawing from my own personal experiences as an Applied Physics major. Thus, while many of my observations are anecdotal, I do feel that they reflect on attitudes I found prevalent during my years as a student.

David Hume, renowned Enlightenment philosopher, wrote at length of the distinction between *is* and *ought* statements and the challenges in distinguishing between the two.[10] He warns of the dangers in deriving what *ought* to be from what *is* without challenging our assumptions. For example, suppose we start with a premise (*is*-statement) that human females evolved to nourish children. We then posit (*ought*-statement*)* that women should stay in the home and raise children. This is just one example of how failing to question our assertions can lead to misguided conclusions. Science, rationality, and logic are exceptionally good tools at telling us what *is*. But determining what *ought* requires value statements and an ethical foundation from which to draw such postulations. The physics curriculum in particular, is extremely adept at training students in problem solving, rationality and the like. However, when such skills are divorced from ethical principles or understanding of the societal context, scientists may face significant challenges in their work.

Course Outline

One proposed approach to bridging this gap between *is* and *ought*, is a lecture series course that touches on various social issues, housed within the physics program. President Worthen has emphasized experiential learning, and in light of recent events, there's a particular pressure for students to receive further exposure to topics like race, gender, etc. In my personal dealings within the physics program, I found that there was a certain lack of awareness regarding the value of the social sciences (our very language in referring to them as soft or squishy sciences

[10] David Hume, *A Treatise of Human Nature*, (Cabin John, Maryland: Wildside Books, 2007).

reflects this). By housing the course within the physics program, it lends it a legitimacy that may not otherwise be afforded such a course outside of the STEM field.

For each week of the semester, the course could focus on a different social issue/topic. The topics could span such issues as race, gender, or socioeconomic status, or could even expand into international topics like climate change, or the refugee crisis. As the semester progresses, more complex issues could be addressed like intersectionality[11] or white-saviorism[12] (white-saviorism is a common critique leveled at missionary work or voluntourism; it's not that these programs are inherently bad, but without proper cultural context and understanding they can result in more harm than good). Perhaps there could even be a week devoted to learning about Human Centered Design or social impact methodologies.

In preparation for each week's lecture, there could be assigned readings that prepare the student to think critically and analyze an issue. The lecture itself could be presented by a rotation of BYU physics grads or professors with relevant experience). Assuming this course is housed in the physics program, I think it would be especially important to present statistics and data surrounding these many issues. Having had many conversations with my fellow physics students about these topics, data is a powerful tool in opening people's hearts and eyes. Each week, students could also be asked to submit a brief one-page response paper. Such an assignment will help students to articulate their thoughts and to analyze these issues critically.

The final assignment for the semester could be a more substantial paper or a brief presentation. The paper could be 3-5 pages synthesizing some of the ideas of the course and expanding on an issue. Similarly, the 3-5 minute presentation could be a deeper analysis of one of the issues discussed or even the intersection of multiple ideas/issues. For example, the course might discretely touch on issues pertinent to race and public health. An interested student could seek to understand racial disparities in health outcomes and explain this in a paper/presentation.

Benefits

Over the course of my Applied Physics career, I enriched my education with courses on global women's issues, international politics, race and ethnicity, international development and more. While I certainly don't expect every student to share the same broad range of interests as me, I think there was great value in the multi-disciplinary experiences I had. These courses have

[11] Intersectionality is a theoretical framework for understanding how aspects of a person's social and political identities might combine to create unique modes of discrimination and privilege.
[12] White saviorism refers to people from the Global North (Europe, North America, Australia) going in to "fix" the problems of struggling nations or people of color in a self-serving manner or without understanding of the region's history or needs.

shaped me, informed my worldview, and exposed me to a whole slew of challenging problems to which I could apply my physics skills.

It's possible that having a lecture series as described above could inspire some students to pursue an Applied Physics capstone with a decidedly social impact. Perhaps a capstone that uses machine learning to combat human trafficking, or a PlayPump 2.0 that incorporates the needs of the end user. It may also demonstrate to physics majors the myriad problems to which they can apply their problem-solving skills.

The BYU Mission proposes that:

> "All instruction, programs, and services at BYU, including a wide variety of extracurricular experiences, should make their own contribution toward the balanced development of the total person. Such a broadly prepared individual will not only be capable of meeting personal challenge and change but will also bring strength to others in the tasks of home and family life, social relationships, civic duty, and service to mankind."[13]

I think it bears mentioning that my experience was that most of my fellow students are well-intentioned, and that any ignorance I encountered, stemmed from a lack of exposure, not from bigotry. As students gain a broader understanding of societal issues, their more holistic *is*-s will enable them to construct better-informed *ought*-s. The proposed course would expose students to issues in a manner that helps them to achieve the BYU Mission in more diverse contexts.

Conclusion

In the coming century, we will see the development of advanced artificial intelligence and synthetic biology. We have already seen the rise of unchecked social media platforms eroding the integrity of democratic institutions the world over.[14] And we're currently witnessing centuries-long scars of racism reach a boiling point in the George Floyd killing. Regardless of one's opinion on these matters, it's become increasingly apparent that these issues will come knocking at our doors, and making sense of all the information available can be a daunting challenge. My experience with the Applied Physics program has shown me that the physics skills I've gained are transferable to these challenging issues. I'm confident that the intersection of my

[13] "BYU Mission Statement," accessed July 23, 2020, https://aims.byu.edu/byu-mission-statement.
[14] Tucker, Joshua A., Yannis Theocharis, Margaret E. Roberts, and Pablo Barberá. "From Liberation to Turmoil: Social Media And Democracy." *Journal of Democracy* 28, no. 4 (2017): 46-59. doi:10.1353/jod.2017.0064.

Applied Physics curriculum, exposure to social impact frameworks, and awareness of sociological methodologies prepared me to tackle a broad range of problems.

Facing the panoply of research questions of the next century without a basic framework to evaluate societal impact presents harrowing possibilities in potential implementation and outcomes. Especially, in a period of rapid technological advancement, it is crucial that students enter the workforce willing to question the implications of their work. My time at BYU has convinced me of the goodness of my fellow students and professors, and I am confident that given the proper tools in their physics' toolbox, that they can be forces of good in the world.

Appendices

Reasons to Stay

Research Report - research on various social issues Kosovo is facing
Powerpoint - final presentation on our project proposal
Final proposal - in depth project proposal outlining our business incubator idea

VentureUP

Version 1 - grant proposal regarding a social venture branch of the business incubator
Final Version - a later version of the above proposal

GTCI

Mentored Research Letter - an outline of what our research entailed
Data Collected - data I collected while living in the Balkans
Yugoslav War and TRC - a lecture I gave regarding te Yugoslav War and current truth commission efforts in the region
Recommendations for a Yugoslav Truth Commission - a proposal for a Yugoslav TC that incorporated our findings over the course of the semester with particular emphasis on gender

RefugeeChain

First Iteration of Pitch Deck
Second Iteration of Pitch Deck
Final Iteration of Pitch Deck
Meeting Notes (shows evolution of ideas, research direction, etc.)

TOSA

Brainstorm - notes from initial meetings as we sorted through several business ideas
Painting Outline - this is a breakdown of tasks after we settled on the painting business
Questions to Resolve - following our first presentation several questions were raised that we addressed in the next iteration of our pitch deck
Pitch Deck - Powerpoint presentation given to judges with the culmination of our work
Appendix - a catch-all for anything that didn't fit in our slide deck that was pertinent to the implementation of our idea and an understanding of our process

Financials - two sheets. Break even analysis for the business and a bid estimator for jobs.

Ballard Brief

Focus Group Report - transcription of focus group responses. This data was then scaled and analyzed for insights regarding the Ballard Brief product.

Do Good. Better

Behavior Change Slides - lecture I gave on behavior change in the context of the social impact framework
Social Innovator Roles Slides - lecture I gave on how to apply the social impact framework regardless of industry or location

Givv Consulting

Unfortunately, Givv Consulting has closed so I no longer have access to all of the work we did for them. I've tried to include the files I still have access to.

Midterm presentation (work our team had accomplished in the first half of the semester). I was responsible for the research on sliding scales as well as the coding of the following website.
Index - a list of our team's work from the Midterm to the final
Gamification Research - research I compiled on gamification to increase employee's charitable donations
Gamification Blog Post - blog post synthesizing the above research