Research that Reflects Values: Finding a Way for Students to Influence Universities' Technological Research Projects

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Lauren Murphy

Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Joshua Earle, Department of Engineering and Society

Introduction

Hypersonic flight vehicles are complicated technologies that have grown and advanced since their introduction to the world in 1949. Everything from long-range missiles to the Apollo space capsules travels at hypersonic speeds (Anderson, 2012). Hypersonic flight is defined as any vehicle that reaches a minimum Mach number of five, which translates to speeds of 1375 m/s to 1700 m/s depending on target elevation (Kirtskhalia, 2012). Additional physical phenomena are associated with these high velocities. This means that in order to design and create a flight vehicle capable of reaching beyond hypersonic levels, extensive testing of the temperatures, pressures, shocks, and material reactions is required. All current methods of testing in this extreme environment are extremely costly.

A possible solution to the high costs associated with hypersonic testing that the University of Virginia (UVA) is currently investigating takes testing from the ground to the sky – or more accurately above the sky – with miniature satellites called CubeSats. The Hypersonic ReEntry Deployable Glider Experiment (HEDGE) CubeSat is the focus of my senior capstone project, and it has the goal of creating a new, cost-effective method of conducting hypersonic tests. It is being developed by the University of Virginia's entire Spacecraft Design class. Pressure and temperature will be collected as this spacecraft re-enters the earth's atmosphere at hypersonic speeds, and it will be sent back to the ground for collection and analysis. The information gathered will then be used to help design hypersonic flight vehicles (Goyne, 2022).

This is a common-type project with a common problem. When reading my brief and simplified project explanation above, one might nod their head in curious understanding, form a few questions in their mind, or simply move forward with their lives away from the topic. It may be unique in technical details, but the story is one seen everyday across the country and across

the globe. There is a problem that must be solved, and universities jump on the opportunity to devise a solution in the name of technical progress (Harabi, 2006). Its commonality often prevents deeper thought into the more complicated nature of this and similar projects. The HEDGE *is* a positive step forward in technological progress, but the human and societal aspects behind it are not as straightforward. Notably, leaders and professors of the university decided to pursue this project without any input of the student body or regards to their values.

My research addresses problems regarding students' right to belong to a university that reflects their values and concerns over universities acting without the consent of its students. This is specifically with regards to technical and research projects. I also endeavor to answer the following questions: Should students have a voice in the creation of new technological projects, even when they are not involved in the project? If so, what practices are used now regarding the issue? And how can universities ensure in a reasonable, applicable, and appropriate way, that students have a voice?

There are four key aspects to answering these questions. The first is the ethical and logical foundations of what university and student relationships should be. The second is how projects get started and the accessibility students have to this decision process. The third is determining how much students want to influence projects and be a part of the decisions. The last is an analysis of the effects student influence might incur.

Multiple methods were employed in this study. The first was finding and synthesizing literature. Topics researched included ethical frameworks, community, hypersonic weapons, university research applications, and more. This data helped to answer the above research questions. Polling was also used. Twenty-five undergraduate students from the University of Virginia with various majors were asked questions about their understanding of university

projects and their opinions on topics regarding student input. One professor was also interviewed, and I asked questions regarding the process of starting projects through a university. Each section goes into further detail of how the research was conducted.

Highlighting the Problem

HEDGE is a great example that shows the disconnect between students and projects that raises concerns over respecting student values. At first glance, it may seem like a harmless engineering project, but its implications travel into ethically complicated ground. The US military is heavily involved in hypersonic research and the weapons it can help design. This year alone, the Department of Defense increased its budget for hypersonic research by hundreds of millions of dollars, making it the leading investor in the field (Gould, 2022). Their main goal is to develop hypersonic missile prototypes (Sayler, 2023). Hypersonic missiles are an increasingly deadly weapon compared to conventional missiles. First, they travel significantly faster, making it more difficult to detect and shoot down. Second, they can maneuver on unpredictable paths, which makes tracking much harder. This, coupled with the fact that they have the capacity to become nuclear capable, shows the great destruction these devices can cause (Yoksoulian, 2022). Views on this type of technological capability are justifiably widespread. Many support them, many do not, and many sit somewhere in between. With this singular example, students may start to wonder how their support of a university translates into real-world consequences. Not only is there a theoretical relationship between military use of hypersonic missiles and the HEDGE project, but ties have already been made between the two. Professor Goyne, the leader of the project, has stated that the US Navy is looking to be a potential customer. This includes potentially sponsoring the project upon completion of the critical design review presentation – a

presentation displaying the fully finished CubeSat concept and explanation as to why it will likely succeed.

The ethics and necessity of improving technological weapons and military scope in general is a complicated topic with too many factors for any one person to fully understand. While it is an interesting topic of debate, the goal of this paper is not to try and answer where the line of ethical versus unethical is drawn in military operations. HEDGE, along with the controversy it carries, is used not as a topic of debate, but as a representative of a larger and broader issue at hand: universities decide on projects without consulting the general student body or accounting for their values.

Technological Citizenship

The first step in this research project was to find an answer to the first part of the question: should students have a voice in the creation of new technological projects? To answer this, I conducted research by examining scholarly articles and writings from established professors in the Science, Technology, and Society (STS) field of study. The goal was to generate a logical, philosophical, and ethical solution that can answer this question of opinion with rational reasoning. The final verdict from this data, explained in detail below, is yes, and it hinges on the idea of Technological Citizenship (TC).

TC argues that a new method of technological accountability should be put in place, guided by the ordinary people who are a part of the community the technology is created in or created for. It is based on the principle that technology has the power to shape societies in the same way that legislative acts can, yet there is no dedicated legislative body to monitor and keep the increase of innovations in check (Andrews, 2006). For example, discrimination is a very

powerful force in the social fabric of the United States. Laws can and have been put in place to mitigate its presence in places such as the workforce, but an algorithm used to give credit scores still discriminates against people of color in the lending market (Martinez and Glanz, 2018). Whether accidental or on purpose, this technology and many others like it, are ingrained in society with few options to mitigate the harm they might cause. In many cases, people ignore technological consequences because they trust technologic experts. However, they fail to realize that differing interests, differing traditions, and design errors may be ingrained in the technology (Feenberg, 2011). Experts are human. They too can be unaware of certain effects, make mistakes, or can have unethical motives. Building off the structure of political citizenship, TC presents a set of rights and responsibilities that should be granted to everyone in a community that interacts with a technology. These rights include information access, participation in decisions, and informed consent. Responsibilities include reaching technological literacy, engagement, and protecting the civic good (Andrews, 2006). With these rights and responsibilities in mind, technologies can be monitored. The end result is more ethical technologies.

Applying this logic to the issue at hand, it is clear that some degree of TC should be granted to students. When students choose a university, they actively attach their names to it and the values it holds. Thus, the students are deeply rooted in the realm of these research technologies and must be given opportunities to hold the university accountable. Two important aspects of a community are belonging and communication (Chowdhury, 2019). If universities want to claim they make up a community, both of these aspects must be met with respect to TC. Further, most universities have mission statements that, by their nature, would support student influence of technological projects. The University of Virginia states they are defined by "a free collegial exchange of ideas [and] values of honor, integrity, trust, and respect" ("Mission

Statement of Virginia", 2014). A true free exchange of ideas would include student to professor interactions regarding these projects, and trust and respect would apply to the values students hold. While university research and technical projects may not directly affect most students, there are still important human and social components regarding students when it comes to the development and research of these technologies.

Technological Citizenship serves two key functions in this essay. The first is as a finding and result in itself, answering the first part of the research question. This is displayed above and summarized as follows: students *should* be able to influence technical projects because TC demands it and TC works to make better and more ethical technologies. It also serves as the framework for which all subsequent research will be based. Without proper reasoning for *why* students should have influence, it would be hard to argue what actions should be taken to ensure they have influence. Making a recommendation will therefore be looked at from the aspects of Technological Citizenship, how those aspects would be received, and what effects they might ultimately cause.

What is in Place Now

It is important to analyze the current systems to ensure any change can realistically build off of these foundations. To answer the second part of the research question about the systems that are currently in place, multiple methods were used. These mostly involved using the University of Virginia as a specific case study, and it stands as a representative for similar universities doing controversial studies across the country. While there are some limits to this – not all universities are highly ranked public schools with UVA's specific mode of working – I still believe that the general themes are applicable across the board. In the US alone, over 250

universities are considered Research Universities alongside the University of Virginia. These are institutions that focus on graduate and professor level research, and most have a sizable undergraduate population (State University, 2013). An emphasis on the HEDGE project is also used as a representative of most research and technical projects. I analyzed access to information, polled students about their knowledge, and interviewed a professor about the process of starting a project.

Finding information on different research projects was possible, but not convenient. To analyze this, I conducted online searching with three other undergraduate students to decrease bias. We paid attention to the amount of effort that went into our research and the information gathered out of it. Any logical search inputs along the lines of "list of UVA research" or "what research is UVA conducting" generally led to three types of web pages. The first was overviews and goals of research through different departments. For example, the medical school's page often came up explaining how it "supports and promotes basic, clinical, and translational investigation" (Office for Research, 2023). The second type included news articles about progress or successes of different projects. These types of articles were also often linked in the main pages of overviews. The last type included statistics on research being conducted. One page, with big graphics and no supporting details, had the number of money granted in research, departments involved in research, and similar "fast facts" (Research, n.d.). With more digging through attached links, redirects, and individual lab pages, I could finally form a picture of some of the research being conducted. Not all projects I found listed, however, had thorough information on what it was and its implications.

While this method of research isn't quantifiable and difficult to draw definitive conclusions on, takeaways can still be seen. This is especially considering all four students

involved had similar experiences. Overall, the rights of information access and informed consent given by TC is not reached. First, no information was obtained without proper digging. One has to have a specific project in mind before starting to research, which means that someone looking to share their opinions would already have at least a little knowledge on the project. HEDGE, for example, has considerable information on the internet. However without knowing specific keywords, there is very little to be found when searching for general technical projects. The average student who is unaware of a project or research, a large proportion of the TC community, would not know or ever know a project against their values is being performed. Second, because not all projects are explained in detail, TC is limited and only applies to those which are thoroughly explained. Third, no information was given on potential future projects. During the formation of projects is the key time for values and opinions to be heard, and it is the only reasonable time a project could be stopped. This is a violation of the second right, the right to participate in decision making. This prevents the responsibility of engagement from taking place. Information access is overall not completely restricted, but it does not allow for the proper implementation of TC.

A second method to analyze what is in place comes from student responses. Twenty-five students from the university of Virginia were polled the following questions. How would you rate your knowledge of current research projects being conducted at the University of Virginia? Have you heard about the HEDGE project? The average rating out of ten for the first question was a 2.96, a telling sign that students have very little knowledge about projects and their implications. While this may be an indication that students are not fulfilling their responsibility of reaching technological literacy as technological citizens, it seems to be a greater indicator that a violation of the rights to information and informed consent is present. This is based on the

discussion above. Similarly, only 16% of respondents have ever heard of the HEDGE project. Of those that have, 50% only know it by name. Only 8% of total respondents had a significant amount of knowledge on the project and its implications. Again, this shows that TC is not being granted to students.

Finally, I interviewed Professor Goyne about the process of beginning a research or technical project at universities in general. For over 20 years he has worked and completed research at UVA, with a focus on hypersonic propulsion. He is also the professor of the Spacecraft Design class. In this interview, the process he described was one where minimal decision making power was given to university leadership outside of the project's leaders. It starts with agencies, often the federal government, putting out proposals for needed new technologies. These are released to the academic community, where faculty can then write their own proposal for how they would go about approaching the problem. In the instance of a federal government proposal, the government then chooses which school and faculty will receive the grant or funding. After that, it is up to faculty members to recruit students to help go about the project (C. Goyne, personal communication, March 21, 2023). University input does happen on some level with regards to ensuring legal standards are met, but this does not include any opinion based input or thought on student body values. For example, universities' ensure researchers obtain approval from the Institutional Animal Care and Use Committee if the project deals with animals (Virginia Tech, n.d.). However, there is no discussion with the student body regarding their values and thoughts on the ethics of animal testing.

When looking at the issue from a strict TC framework, UVA and similar universities must change their ways. With regards to HEDGE, knowledge about the project was not readily available to students, and there was no method for anyone outside of the class to impact the

course of this research. Even students in the Spacecraft Design class had no choice on the matter. Being technological citizens was never an option, and this was not the only instance. For fiscal year 2022 alone, the University of Virginia obtained two new military research grants (US Department of Defense, 2022), which likely violate some students' values too. All or almost all other university projects fail to meet TC standards too.

What Students Want

The next step of my research process was finding out just how much students want TC rights and would fulfill TC responsibilities. Technological citizenship in theory is a great way to hold technologic innovations in check, but it requires full participation and enthusiasm from the community. This is difficult to achieve in practice. Evaluating the want that students have for TC was composed of two types of research. This first was evaluating views on military spending – a telling sign on if students would support a project like HEDGE – through article research. The second was from polling students on what their beliefs are regarding TC.

The HEDGE project continues despite the high probability that most students do not support this type of increasing military power. A plurality of individuals aged 18 to 29 believe that the military budget should be cut back, and only 18 percent believe it should be expanded (Kafura, 2020). The correlation between support of military financing and support of military advancement is not direct, but this data still shows how important it is to find and consider opinions on the matter at hand. There are many more controversial topics that may have even stronger opposition than projects dealing with the military. Having proper TC would not only allow these views to come forward, but it would allow changes to projects so they better represent student values. In this sense, it seems as if students would want TC.

When asked about universities' obligation of respecting student values, a similar conclusion can be drawn. The following data was taken from the same poll discussed earlier. 84% of students believe that UVA does have an obligation to respect student values. 12% are undecided, and only 4% say that it does not. Considering the vast majority agree, this too seems to be an indicator that TC would be happily taken in by most students. With students able to influence and voice their opinions on all projects the university pursues, student values would be respected much more than is currently in place. This is especially considering another result found. When asked about whether or not students believe UVA *does* respect their values, only 41.7% said yes. 37.5% were undecided, and 20.8% said no. This shows how many students do, in fact, see a disconnect between what the university should and is doing. Having TC with respect to research and technical projects would help bridge this gap.

However, the research presented above does not tell the full story on student wants. Student and university relationships with regards to values, while applicable to the conversation to TC, does not directly correlate to TC. The polled students were also asked questions that more directly relate to TC and their responsibilities. When asked to "rate how much influence you believe students should have in deciding what projects the university pursues" out of ten, the mean was only a 5.58 and the median was 5. When asked to rate "how likely would it be that you voice your opinions / act on concerns you have about a new UVA project if the opportunity was there" the results were even smaller with a mean of 4.63 and a median of 5. There are many reasons a student may not want TC, such as not believing students have the knowledge to make such big decisions or not wanting to put in the effort. Regardless, a responsibility of TC is participation. With only about 50% of students inputting their values, chances are that the data would be skewed and not all values would be appropriately accounted for. For example, imagine

a project where 30% of students were strongly against it. Because those 30% feel strongly about the issue, they are the ones stepping up and using their TC. If these are the only voices heard, it may seem like the majority of the student body is against the project, when in fact 70% have no issue with it. This poor representation defeats the purpose of TC. It also hurts TC's legitimacy.

Effects of Change

An important discussion about effects of change rests on the importance of research and technical projects in general. To begin, research and technical projects help universities thrive. Universities with cutting edge project opportunities draw in top-notch professors. They then give students the most up-to-date, extensive, and quality education possible (Rosowsky, 2022). Further, high-level and groundbreaking projects give universities a better reputation and ranking. Research universities' goals are to discover new knowledge that can be implemented into the world, and their overall success rides on the success of meeting that goal (Brescia et al., 2014). If TC were implemented to the fullest extent, it is possible that some projects would get cut. This could easily lead to disgruntled professors who choose different universities, a fall in ranking as less knowledge is being discovered, and a loss of promising students because of the two former. While the values and opinions of students matter, a university will not be able to function if it cannot do research to its fullest potential. These effects are arguably too great compared to what is gained by TC.

Another reason projects are so important deals with the greater community of a nation and arguably all people of the world. New scientific findings and technological innovations are not sought for pure amusement, but for the goal of applying it to the world and helping human's progress. Universities are responsible for many breakthroughs in the fields of medicine,

information technology, energy, and more. All of these work to improve the general well-being and standard-of-living for those who access the new developments (Geiger, 1993). Vannevar Bush, the former director of the Office of Scientific Research and Development, set this precedent for universities in 1945 when he argued similar facts to the US government when proposing an increase in government research funding to universities. He also highlighted the importance that innovation has to the national economy (Bush, 1945). From this, it can be seen how universities have obligations to communities that reach further than the walls of the institution. Now when looking at granting TC to students, two more concerns can be seen. First, TC is supposed to apply to *all* in a community that the technology affects. Technological innovations have the potential to reach all corners of the earth, but there's no reasonable way to listen to everyone on earth's views on the topic. Going back to weapons development, for example, many students may not support it, but the nation as a whole may understand the need for it when looking at potential conflicts the US might face. Or maybe people in Ukraine are desperate for it as Russia continues their current invasion. All in all, putting the project decision making process into the hands of a small ill-representative portion of the population goes against the fundamental aspects of TC. Second, discovery and innovation is clearly very important to the world. Giving such a small group of people power over such crucial processes may bring about undue harm.

Recommendation

The goal of this research was to find a method to reasonably implement TC into the University of Virginia and all other similar universities. To do this, I had to balance the three major, and somewhat conflicting, points found in this essay. First, TC is an ethical way to hold technologies accountable and should always be implemented. Second, while students may value

the idea of TC, the implementation of it would be difficult and not properly representative. Third, the effects of TC could harm technological progress and a university's standing. To balance all aspects I recommend the following. At the very least, UVA and all other similar universities should have a clear and easy to find list of all technical and research projects that are being conducted. This would include information on the project, its funding source, and implications it can have in the world. I also believe that this list should have contact information of the project leaders, so if a student has a big enough concern with the project, they have the ability to reach out and have their voice be heard. While this doesn't directly count as TC, as there is no set way for a student to actually influence the work, it does allow for more discourse on the topics.

Additionally, I believe that universities would benefit from having student council members weigh in on prospective topics with the professors leading those projects. As it stands, projects are rarely vetted by the university itself and are largely in the hands of only the professors. With project topics run by student council, if only for questions and concerns with no approval or denial power, students' voices would be better heard. Professors could then go into a project with a better idea of how it will reflect on the student-body. Additionally, having this be the job of the student council would take much of the pressure off the everyday student to be well-versed on the wide range of topics studied. It would also ensure that views are more representative of everyone as opposed to only the students who speak up. These two methods are also limited enough that they would rarely cause any change. Universities thrive on their research standing. It is important that progress still be made relatively unhindered, but with the doors open for genuine input from students. I believe these two solutions acknowledge that.

One important note is that while this research focuses on the University of Virginia and more specifically the HEDGE project, findings such as information access, want of student input, and the possible solutions are applicable to all research projects or technical design projects. Other controversial topics, such as gene editing, animal testing, or technologies that contribute to climate change all benefit equally. Another important note is that while controversial topics will be the most influenced by this change, the processes and principles discussed above are applicable to all projects. There are no set guidelines of what defines controversial, and if students values are to be more respected, it would be up to them to determine this. This paper lays possible guidelines for *all* projects.

Bibliography

Anderson, J. (2012, May 30). Hypersonic flight. Retrieved from https://airandspace.si.edu/stories/editorial/hypersonic-flight

Andrews, C. (2006, March 20). Practicing Technological Citizenship. *IEEE Technology and Society Magazine*, *25*(1), 4-5. doi:10.1109/MTAS.2006.1607713

Brescia, F., Colombo, G., & Landoni, P. (2014). Organizational structures of knowledge transfer offices: An analysis of the world's top-ranked universities. *The Journal of Technology Transfer*, *41*(1), 132–151. https://doi.org/10.1007/s10961-014-9384-5

Bush, V. (1945). *Science, the Endless Frontier: A Report to the President by Vannevar Bush*, Director of the Office of Scientific Research and Development, July 1945. U.S. Government Printing Office. Retrieved from https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

Chowdhury, A. (2019, June 21). What does "community" really mean? Retrieved from https://www.disciplemedia.com/building-your-community/what-does-community-mean/

Feenberg, A. (2011). *Agency and Citizenship in a Technological Society*. Lecture presented at IT University of Copenhagen in Course on Digital Citizenship, Copenhagen. Retrieved from https://www.sfu.ca/~andrewf/copen5-1.pdf

Geiger, R. L. (1993). *Research and relevant knowledge: American Research Universities since World War II*. Routledge.

Gould, J. (2022, April 7). DOD seeks 'huge jump' in budget for Hypersonic Test Facilities. Retrieved from https://www.defensenews.com/congress/budget/2022/04/07/dod-seeks-huge-jump-in-budget-for-hypersonic-test-facilities/

Goyne, C. (2022). CubeSats at the University of Virginia [Powerpoint slides]. *Unpublished manuscript*, University of Virginia, Charlottesville, United States.

Harabi, N. (2006). Sources of technical progress: Empirical evidence from Swiss industry. *Economics of Innovation and New Technology*, *4*(1), 67–76. https://doi.org/10.1080/10438599500000015

Kafura, C. (2020). Republicans, Democrats Split on Increasing US Defense Budget. *The Chicago Council on Global Affairs*. Retrieved from https://globalaffairs.org/research/public-opinion-survey/republicans-democrats-split-increasing-us-defense-budget

Kirtskhalia, V. G. (2012). Speed of sound in atmosphere of the Earth. *Open Journal of Acoustics, 02*(02), 80-85. doi:10.4236/oja.2012.22009

Martinez, E. M., & Glantz, A. (2018, February 15). *For people of color, banks are shutting the door to homeownership*. Reveal. Retrieved from https://revealnews.org/article/for-people-of-color-banks-are-shutting-the-door-to-homeownership/

Office of the Executive Vice President and Provost. (2014). Mission statement of the University of Virginia. Retrieved from https://provost.virginia.edu/faculty-handbook/mission-statement-university-virginia

Office for research. University of Virginia School of Medicine . (2023, January 19). Retrieved from https://med.virginia.edu/office-for-research

Research. University of Virginia Vice President for Research. (n.d.). Retrieved from https://research.virginia.edu/

Research universities - faculty and students, beyond academics, the history of the research university, classifying and Ranking Research Universities. StateUniversity.com. (2023).

Retrieved from https://education.stateuniversity.com/pages/2366/Research-Universities.html

Rosowsky, D. (2022, March 2). *The role of research at universities: why it matters*. Forbes. Retrieved from https://www.forbes.com/sites/davidrosowsky/2022/03/02/the-role-of-research-at-universities-why-it-matters

Sayler, K. (2023, February 13). *Hypersonic Weapons: Background and Issues for Congress* (CRS Report No. R45811). Hein Online.

U.S. Department of Defense. (2022, March 3). Department of Defense Announces University Research Funding Awards. Retrieved from https://www.defense.gov/News/Releases/Release/Article/2953234/department-of-defense-announces-university-research-funding-awards/

Virginia Tech. (n.d.). *Research compliance involving animals, biohazardous agents and/or human subjects*. Virginia Tech Office of Research Compliance. Retrieved from https://www.research.vt.edu/content/dam/research_vt_edu/orc/files/iacuc-irb-ibc-printable.pdf

Yoksoulian, L. (2022, March 22). *Why is the use of hypersonic missiles in the Russia-Ukraine conflict significant?* Illinois New Bureau . Retrieved from https://news.illinois.edu/view/6367/1254629557