What to expect in Research

11th Grade Parents

FULTON COUNTY SCHOOLS
INNOVATION
ACADEMY

Agenda

- Pinnacle Project
- Research
  - Pinnacle Project
  - The Research Class
  - Exemplar Projects
  - Opportunities

Questions

What is the IA Pinnacle Project?

Similar to a Capstone Project

Choose a topic they are passionate about

Investigate a problem or research a gap

Find a solution or answer their research question

Research Course

IA Research is a course in which students experience research through the lenses of both the scientific method and design thinking. Over the course of the year students will frame, execute and communicate their independent research through IA's Pinnacle Project using industry best practices.

Students can work independently or with partners or small groups and are encouraged to take the opportunity to have community and expert mentors guide them through the chosen content area.

Research- Two Main Approaches

Design Thinking Approach

- What problems are happening in the local/global community?
- How can things be improved?

1. Create a problem statement
2. Understand the problem
3. Develop a prototype revolving around a solution

Scientific Method Approach

- What has not been studied yet?
- What do you want to investigate that no one has before?

1. Create a research question
2. Understand body of knowledge
3. Create a method designed to find an answer

Research

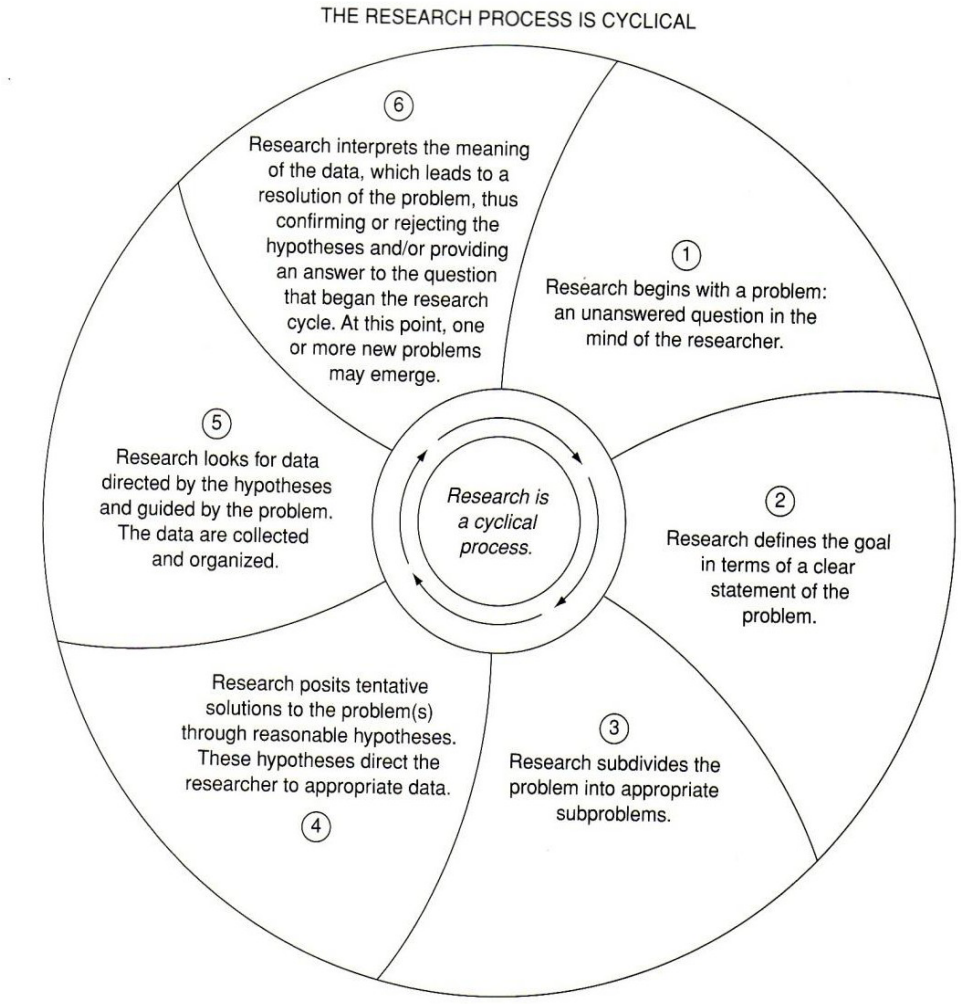


FIGURE 1.1
The research cycle

Figure 1: Research Cycle (Ormrod, Leedy, 2016)

Examples from Research-Pinnacle Projects

How to Lead an Innovation Academy Club

Gavin Grubbs

Research Question: How can Innovation Academy students increase membership and engagement in clubs at Innovation Academy?

Abstract and Background:

Since Innovation Academy (IA) is a new school, all clubs are brand new. The students of IA have made new clubs from scratch, which can make them unstable and without vision.

Many clubs outside of IA have been created and led affectively, which can be used to help teach the students of IA how to lead their clubs. Though, IA is different than a normal high school, which can affect how to lead a club affectively at IA.

Also, since clubs have leadership, meetings, and outside activities, businesses could be used as a good model for how to run a club. Businesses can also show how to promote or "sell" a club, and how to keep "customer retention rate" high with club members.

Hypothesis

My hypothesis is that the business practices would provide the best results because it is something new and it will try to help the culture of the club. I believe that both techniques will help improve the club with how well they are run and the engagement of its members.

Background Literature Review

I have read multiple books and articles on how to lead a club and have read multiple books and conducted interviews on how to lead a business. There were multiple things that I found throughout my research that were similar in both clubs and businesses. The most recurring idea is of a mission statement or purpose, almost every article, book, and interview talked about finding or creating a mission statement or purpose and building the whole club or business around it. Also, I found that one of the largest parts of creating a club and being a great leader is to have conviction and passion for what you do; This will overflow into your work and really thrust your club into the spotlight (Mohler, 2012).

Another way to make your club stand out is finding your club's niche and promoting it, this can be done by asking the members what they want in the club, as the purpose of the club is for the members (Patin-Sauls, 2023). Finding out what the members want in a club can help a leader to create goals for the club and a vision for it to follow, which will bring passion into the members and direction for club decisions (Mohler, 2012). This all and more will be talked about in my IA Club Guidebook (Linked at the bottom of the Digital Portfolio) which will also have details on IA specific club tips and information to help club leaders not miss deadlines and to be prepared for noticeable club events.

Method and Process Steps

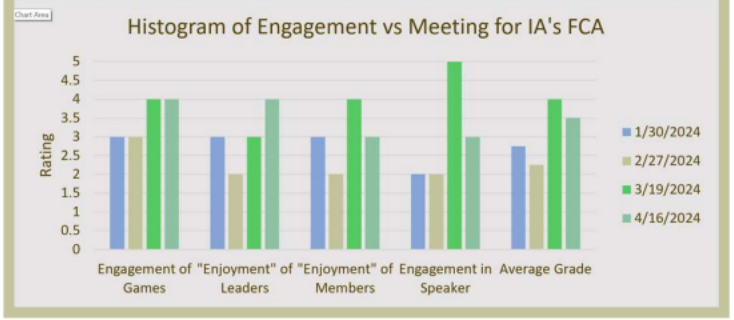
I have conducted research on how to lead clubs and businesses to be able to find strategies and models on how to lead an Innovation Academy club. I have implemented these models and techniques from my research into the club meetings of Fellowship of Christian Athletes (FCA) to see what techniques helps the club's engagement and membership.

The first club meeting of the year, I took data on how "engaged" were the members during the games, during the talk, all out of 5. I also took data on how many people there were, of how the leadership felt about the meeting, how they looked during the meeting, how much work they had to do, and how much work I had to do before the meeting, still out of 5. I did not change anything so this could be the "base meeting".

The second meeting of this year, I added the techniques from my research on how to run a club. I added time for normal members to add their thoughts of the reason of the club and anything that we could add to our club. This was to increase engagement of the club members and to be able to add their ideas to make the club better. I still gathered the same data as before.

The third meeting of the year, I added techniques from my research on businesses. I focused on how to lead people and how to make a good culture for FCA. I worked with the leadership team and added a mission statement for FCA, which can help a club stay on track by putting all actions of the club through the lens of its mission. We decided that the purpose for our FCA would be around training our members in the Bible and making a community for the Christians of IA.

I used evaluative research methods to find the difference between the different methods and techniques. I used qualitative and quantitative data gathered throughout the observational study to conclude which is the best technique, and what mix of techniques would provide the best results in a club.



Results

At the start, the data showed a decrease of enjoyment in the members of the club, though that came back up as the meetings continued. Overall, the later meetings had a higher grade of engagement then the previous meetings and had similar numbers of people. Though there were many outside variables could have produced these results. An example is that on March 19th the speaker for the meeting was exceptional, which inflated all the data. Also, the ratings are made by opinions and were made in an unscientific environment, making each rating unsound. This makes the data unreliable, even though the data loosely supports the hypothesis.

Conclusion

The Experiment I have conducted here is too short and has too many confounding variables to be able to make any conclusions. The one thing that can be concluded from this experiment is that there are many different variables in created a successful club. Though this study was not made to find answers, it was test what I had found in my literature review. In this the experiment was a success, because it showed me that adding business and club suggestions can increase effectiveness of a club and has given me examples of how they can be implemented to be added to my IA Club Guidebook (Linked at the end of the Digital Portfolio).

Next Steps

Next steps for future research would be looking in how different confounding variables affect the engagement and membership of a club. This can be used for later to better test how leading a club at IA would change based on techniques based on other clubs or businesses. I will use this information from this project to lead IA Fellowship of Christian Athletes, IA Robotics team, and to help teach new leaders in my Scout Troop, Troop 143.

Citations

Mohler, A. (2012). *The conviction to lead: 25 Principles for Leadership That Matters*. Baker Books.

Patin-Sauls, J. (2023). *A+ Club leadership: A Comprehensive Guide to Starting and Running a Successful High School Club*.

Wickman, G., & Winters, M. C. (2015). *Rocket fuel: The One Essential Combination That Will Get You More of What You Want from Your Business*. BenBella Books, Inc.

NEXT GENERATION OF SUSTAINABLE HOUSING

HOW CAN PLASTIC WASTE BE EFFECTIVELY REPURPOSED TO PROVIDE SUPPORT FOR SUBSTANTIAL HOMELESS POPULATIONS, CONCURRENTLY MITIGATING THE IMPACT OF WASTE ACCUMULATION ON VALUABLE ECOSYSTEMS?

By: Anushka Goray

Introduction

In 2024, with global recycling rates at just 9%, urgent action is needed to tackle environmental degradation. Bridging environmental studies and humanities, this research explores methods of repurposing plastic to provide accommodations for the homeless, mitigating the waste's impact on ecosystems. Ultimately, the objective is to transform waste into resources, drawing from initiatives like plastic blankets to envision larger-scale solutions like housing construction. Through a multidisciplinary approach and 3d modeling technology, this study intends to formulate practical strategies to address homelessness and environmental issues simultaneously.

Background

Through our understanding of sociology, It's become apparent that the growing issue of homelessness in our society has fueled violence and deepened socioeconomic barriers. As my awareness of this issue deepened, I became determined to focus my project on improving the lives of homeless individuals or creating better living conditions for them. During my research, I stumbled upon an episode of "Liv and Maddie," where the characters ingeniously used recycled items and scraps to construct a temporary shelter. This inspired me to explore whether similar approaches could be implemented in our own homeless communities.

Materials

- Data from research
- 3d modeling software

Hypothesis/ CFS

Considering the time constraints, the main criteria of success for this project is: Could this model successfully be implemented as a viable temporary home specifically in the Atlanta area and provide a higher quality of living for these individuals? Success is determined by whether the shelters can withstand environmental disasters frequent in Atlanta and can effectively sustain necessities required for modern day living (Wi-Fi, electric appliances, comfortable living space).

Replicable methods/ Initial Research

Case Study

To understand the severity of the damage caused by plastic pollution, I created case studies of locations with the most plastic pollution and provided an in-depth analysis detailing examples of plastic pollution's impact on biodiversity loss, ecosystem instability, and future health risks. In my report I included before and after images to show true nature of damage.

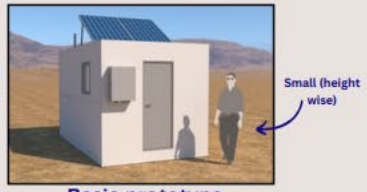
Content analysis

To better understand why homelessness was so prevalent within certain areas, I used the content analysis method to analyze several reports which discuss the predictive indicators for homelessness. I then cumulated this research to create comprehensive labeled maps of the areas with the largest homelessness populations to determine whether there was a correlation among certain socioeconomic/geographic factors and a rise in homelessness.

Interviews

To understand the broader implications of my research and its potential future impact on communities, I interviewed a sociologist who provided valuable insights into economic and social dynamics at play. This interview illuminated potential challenges and financial obstacles I may face in actually implementing/ constructing this housing solution, while also highlighting the versatility of my designs to suit other climates such as those of South Asia. Furthermore, the sociologist pointed out that given the latest developments in funding for such projects, there's a possibility that this initiative could generate employment opportunities for individuals as it gains momentum.

Results/ Data Visualization



Basic prototype

As I was researching existing solutions, I found a prototype by Otahlo, a company with similar goals. However, their prototype is still quite rudimentary and inflexible. This prototype is crucial as it provides a foundation for me to adapt their initial design to suit Atlanta's environment. Here are the key components I considered in creating my preliminary model:

- Natural disasters: Through my research, I discovered that Atlanta is highly susceptible to thunderstorms because of hurricanes along Georgia's coast. Taking this into consideration, I designed a house with a vented structure, allowing floodwaters to pass beneath the living area. Moreover, I incorporated angled roofs to prevent rainwater accumulation and protect the structural integrity of these temporary structures.
- Power: As part of the commitment to environmental sustainability, the houses will be powered by solar panels installed on the roof. Given Atlanta's abundant sunlight, these panels are expected to generate sufficient energy to support all household functions. However, given the expense of solar panels, alternative options such as hydro or nuclear energy are viable energy sources that balance affordability and efficiency while also minimizing environmental impact.

Latest Iteration

Conclusion

From initial research to the final model iteration, it's evident that these sustainable houses offer an avenue to a higher quality of life for homeless individuals. By granting them shelter stability, we enable them to focus on addressing other vital needs, such as pursuing education and strengthening their financial stability. Additionally, by constructing these houses from environmentally degrading plastics such as PVC, we can significantly mitigate the adverse impact these materials have on the environment/ biodiversity. This not only addresses immediate housing needs but also sets a precedent for sustainable material repurposing, fostering a more conscientious approach to design and resource utilization for the future.

Future steps

Since the project currently only showcases a digital model, the next steps involve creating a physical prototype of the sustainable house. With an extended work period and more experience in 3D modeling software, I can develop a more interactive model that comprehensively illustrates the layout and construction of the home beyond a basic functional demonstration. Given the complexity and costliness of transforming plastic materials into construction materials, the plan is to collaborate with the company Othalo, who is in the process of patenting the technology for this purpose. Collaborating with Othalo could pave the way for obtaining student grants to build these sustainable houses in Atlanta and beyond.

Citations/ acknowledgement

- 1. Konings, M. (2021). What Does Money Do? The Critique of Capitalism between Political Sociology and Political Economy. Labour/Le Travail, (88), 143+. https://link.gale.com/apps/doc/A719997970/WHIC?u=inn_aca&sid=bookmark-WHIC&xid=fa9a5f7f
- Finding a firmer future; Lauren Davidson meets an entrepreneur trying to solve both pollution and the housing crisis. (2016, November 27). Sunday Telegraph [London, England], 21. https://link.gale.com/apps/doc/A471681818/GIC?u=inn_aca&sid=bookmark-GIC&xid=a5146ac7
- Turner, Steve. "Case study 7: primary health care in homeless shelters in Lodz, Poland." WHO Regional Publications, European Series, World Health Organization, 2003, p. NA. Gale In Context: Global Issues, link.gale.com/apps/doc/A159179667/GIC?u=inn_aca&sid=bookmark-GIC&xid=2a1389c2. Accessed 24 Jan. 2024.

- Thank you to all of my interviewees and teachers for all they have done in supporting my project.

DEGRADATION OF 3D PRINTED BIOMATERIALS UNDER PHYSIOLOGICAL CONDITIONS FOR THE REGENERATION OF KIDNEY TISSUE

Adya Srinivasan

Abstract

This study explores the degradation behavior of 2% calcium alginate bioink under simulated physiological conditions representative of reduced kidney function to address the organ shortage crisis through advancements in 3D bioprinting for kidney tissue engineering. The research aims to determine the effect of an environment that mimics acidosis pH, temperature, and pre-urine concentrations of a patient with compromised renal function on the degradation rate of calcium alginate, a popular bioink. The experimental design includes the comparative analysis of bioink degradation under controlled lab conditions and simulated physiological conditions over a 24-hour period. The results indicate a significant increase in the degradation rate under simulated physiological conditions compared to the control. This rapid degradation suggests that while 2% calcium alginate exhibits favorable mechanical properties for bioprinting, its rapid biodegradation under disease-mimicking conditions may render it unsuitable for sustained kidney tissue regeneration, which ideally requires a degradation timeline that matches the rate of tissue formation and integration. This study contributes to the field of regenerative medicine by highlighting the influence of specific physiological variables on biomaterial performance, suggesting the need for further research to tailor bioink properties to align with the dynamic environment of human kidney tissue more closely. The findings serve as a basis for future investigations into alternative bioinks that can better withstand the specific challenges of the renal environment, potentially leading to more effective solutions for kidney regeneration and a reduction in transplant waiting lists.

Background

The organ shortage crisis is a rapidly growing global issue, with the demand for organ transplants surpassing the available donors. Kidneys, in particular, have seen a surge in demand, contributing to the expansion of renal (kidney) transplant waiting lists worldwide. This issue is the motivating factor behind many techniques and ideas in regenerative medicine, a field that aims to apply engineering and life science principles to promote regeneration and restoration of diseased and injured tissues or whole organs. One approach is the idea of 3D bioprinting an organ or kidney tissue structure with the ability to stay viable in a patient body. 3D bioprinting is essentially 3D printing with "bioinks" or biologically derived materials [1]. By using biomaterials and specific printing techniques, scientists can generate a structure made of biocompatible materials that maintain cells and allows them to grow and regenerate as in vivo, in human system, organs or tissue systems [2]. Though this sounds promising, there is one major issue in the technology: finding the right bioink for the structure and measuring its properties. One of the most versatile biomaterials used in the field includes calcium alginate because of its availability/low cost, biocompatibility, and similarity to human tissue [3][4][5][6]. More specifically, a 2% calcium alginate composition has been proven to display the best mechanical properties after 3D bioprinting [7]. There is also a gap which lies within the existing research to identify how in vivo conditions of a patient struggling from reduced kidney function impact bioinks.

Methodology

Quantitative experimental methodology was chosen to examine the effect of independent variables (physiological conditions: acidosis pH, temperature, and solution that mimics human body pre-urine) on a dependent variable (the degradation rate of the bioink, measured by mass over time.)

1. Preparation of Calcium Alginate Solution:
   - Dissolve 8g of sodium alginate in 400ml of distilled water in a 1000ml large beaker.
   - Place a magnetic stirrer at the bottom of the solution in the beaker.
   - Stir at a speed of 500 until all the sodium alginate powder is dissolved.
2. Preparation of Calcium Chloride Solution:
   - Purchase a 0.8M calcium chloride solution.
   - Prepare 600ml of 0.8M calcium chloride solution in a stock beaker.
3. Formation of Calcium Alginate Beads:
   - Employ manual extrusion using a syringe to drop formed sodium alginate hydrogel into the calcium chloride solution.
   - Remove beads from the solution, rinse with distilled water, and pat dry on a paper towel.
4. Setup of Degradation Experiment:
   - Place weighed beads in separate Petri dishes at a constant mass of 7.5g as the initial timepoint.
   - Label petri dishes as control and test.
   - Submerge beads in their respective solutions: distilled water for control and a 1:1 ratio of artificial urine and pH buffer solution for test.
   - Incubate test dish in an incubator at 37°C.
6. Data Collection:
   - After 24 hours, remove beads from each Petri dish, drain liquid, and dry beads on a paper towel.
   - Measure the mass of beads after 24 hours.
   - Repeat the procedure three times for a total of three experimental trials.
7. Data Analysis:
   - Calculate the degradation rate of each sample using mass measurements at initial and final timepoints.

Research Question + Hypothesis

What effect does an environment that mimics physiological conditions of a patient struggling from reduced kidney function have on the degradation rate of a calcium alginate-based biomaterial?

Null Hypothesis: There is no significant difference in the degradation rate of 2% calcium alginate bioink at physiological conditions that mimic the human kidney environment of a patient with reduced renal function when compared to the bioink under conditions that do not mimic the human body circumstances.

Alternate Hypothesis: The bioink comprised of 2% calcium alginate will have a different degradation rate at physiological conditions that mimic the human kidney environment of a patient with reduced renal function compared to bioinks under conditions that do not mimic human body circumstances.

Results

$$Degradationrate(t) = (Wo - Wt)/Wo \times 100\%$$

Figure 1: Formula used to calculate degradation rate from the initial and final mass collected.

Table 1: Average (mean) change in mass of control and treatment sample for all trials at the initial and final timepoints.

	0 Hours	24 Hours
Control Sample	7.50g	7.48g
Treatment Sample	7.50g	2.90g

	0 Hours	24 Hours
Control Sample	0%	0.27%
Treatment Sample	0%	61.34%

Table 2: Average (mean) degradation rate of control and treatment sample for all trials at the initial and final timepoints.

Results + Discussion

Observations

The researcher's results reveal significant differences in degradation rates and kinetics between the treatment and control samples, suggesting a significant impact of the treatment on the degradation process.

At the 24-hour time point of data collection, the researcher observed a decrease in the mass of the treatment group and the control, however, the treatment group displayed a much more significant decrease (Table 1). The degradation rate was also seen to be significantly different. The treatment sample, which was placed in an environment that mimics that of human body temperature, acidosis pH, and pre-urine concentrations, had a much higher degradation rate after 24 hours (Table 2).

The observed difference in degradation rate of the treatment group highlights that under physiological conditions, biodegradation occurs much quicker, underscoring a potential impact in regenerative medicine and healthcare in the future.

Implications

Though the difference in degradation rate of the treatment group is significant, that does not mean it is ideal for the regeneration of kidney tissue for clinical applications. Ideal degradation of a biomaterial is determined by comparing the measured degradation to the rate of tissue formation and cellular ECM replacement in the target tissue. For kidney tissue, full tissue replacement falls under two to three weeks [11]. To analyze if the degradation rate of 2% calcium alginate under physiological conditions (the treatment group) falls under this time frame for tissue replacement, the researcher compares the treatment group's degradation at 24 hours to the expected rate of tissue regeneration. As displayed in Table 2, the average rate of degradation for the treatment sample after 24 hours is 61.34%, therefore, the researcher can infer that the 100% degradation would occur long before the 2-week mark, not falling in between two to three weeks of tissue regeneration. Therefore, this suggests that 2% calcium alginate does not act as a viable biomaterial under the physiological variables tested in this study in regard to biodegradability helping to inform future research. By identifying that this biomaterial may degrade too quickly in vivo, this study helps scientists save time in the future and focus on other biomaterials for the creation of a kidney scaffolding.

Conclusion

The findings from this study have allowed the researcher to conclude that under simulated physiological conditions, the degradation rate of 2% calcium alginate is too quick for the formation of a kidney scaffold. Kidney tissue formation will not be able to replace the synthetic biomaterial scaffold to make a functional structure. This suggests that integrating a scaffold made of 2% calcium alginate, though it has the best mechanical properties, cannot be used for an effective kidney scaffolding under the physiological conditions mimicked by acidosis pH buffer, body temperature, and biomolecules found in pre-urine concentrations.

In terms of the discipline of biomedical engineering and regenerative medicine, this research contributes a narrow gap in the field as it examines degradation of a 2% calcium alginate under physiological conditions in the lab that mimic that of a patient with reduced kidney function. Though other studies measure degradation rate of calcium alginate concentrations, no study focuses on the specific conditions studied in this research. This new knowledge stands to steer future research of 3D bioprinting technologies towards more personalized medical applications. By tailoring the bioinks to degrade at rates congruent with the body's natural tissue formation, this study supports a shift towards treatments that are regenerative.

Limitations + Next Steps

Some limitations to this research include the fact that the physiological conditions, despite being carefully manipulated to mimic the in vivo environment, cannot fully replicate the dynamic and multifaceted nature of the human body. Also, this study focused on purely biomaterial-based hydrogels to test degradation. However, during the process of building a kidney scaffold, kidney stem cells will be incorporated into the biomaterial hydrogel before implantation in the human body which may impact the degradation kinetics of the bioink. In addition, due to resource, time, and lab availability constraints, this study's timeframe was limited to 24 hours which may not fully capture the long-term degradation kinetics relevant to kidney tissue regeneration, and because only 3 trials completed, there is not a viable statistical test that can very these results statistically significant.

Moving forward, the next steps of the research involve extending the duration of data collection and observation to capture long-term degradation trends. This will help to further solidify the difference in degradation rates between biomaterials placed under conditions that mimic physiological environments and biomaterials in lab settings. It will also be imperative to test a broader range of bioinks, biomaterial concentrations, and hydrogel combinations to verify the most effective bioink formulation for kidney tissue scaffolding. Additionally, future studies should attempt to integrate a more comprehensive range of physiological variables, such as the presence of immune cells or blood flow dynamics, to simulate the in vivo environment and strengthen the findings for future implications more closely. Ultimately, a long-range goal for this discipline includes in vivo studies with patients which would be essential to validate the findings of this research and to take the crucial steps from the laboratory to clinical application, helping to solve the organ shortage crisis and growing transplant waiting list.

References

[1] A. S. Mao and D. J. Mooney, "Regenerative medicine: Current therapies and future directions," Proceedings of the National Academy of Sciences, vol. 112, no. 47, pp. 14452–14459, Nov. 2015, doi: https://doi.org/10.1073/pnas.1508520112
[2] O. Ramadan and M. Zourob, "3D Bioprinting at the Frontier of Regenerative Medicine, Pharmaceutical, and Food Industries," Frontiers in Medical Technology, vol. 2, Jan. 2021, doi: https://doi.org/10.3389/fmedt.2020.607548
[6] A. Kostenko, C. J. Connon, and S. Swioklo, "Storable Cell-Laden Alginate Based Bioinks for 3D Biofabrication," Bioengineering, vol. 10, no. 1, pp. 23–23, Dec. 2022, doi: https://doi.org/10.3390/bioengineering10010023.
[7] F. Abasalizadeh et al., "Alginate-based hydrogels as drug delivery vehicles in cancer treatment and their applications in wound dressing and 3D bioprinting," Journal of Biological Engineering, vol. 14, no. 1, Mar. 2020, doi: https://doi.org/10.1186/s13036-020-0227-7
[8] D. R. Sahoo and T. Biswal, "Alginate and its application to tissue engineering," SN Applied Sciences, vol. 3, no. 1, Jan. 2021, doi: https://doi.org/10.1007/s42452-020-04096-w
[9] T. A. Becker, D. R. Kipke, and T. Brandon, "Calcium alginate gel: a biocompatible and mechanically stable polymer for endovascular embolization," Journal of Biomedical Materials Research, vol. 54, no. 1, pp. 76–86, Jan. 2001, doi: https://doi.org/10.1002/1097-4636(200101)54:1%3C76::aid-jbm9%3E3.0.co;2-v.
[10] S. James and M. Moawad, "Study on composite hydrogel mixture of calcium alginate/gelatin/kappa carrageenan for 3D bioprinting," Bioprinting, vol. 31, p. e00273, Jun. 2023, doi: https://doi.org/10.1016/j.bprint.2023.e00273
[11] M. Takasato et al., "Kidney organoids from human iPS cells contain multiple lineages and model human nephrogenesis," Nature, vol. 526, no. 7574, pp. 564–568, Oct. 2015, doi: https://doi.org/10.1038/nature15695

Opportunities for Pinnacle Project

- Grants procedure
  - Students can apply for a grant
- School IRB (Institutional Review Board)
  - Replicates the IRB process that university students and professionals encounter
- Leverage for college/job interviews
  - Students learn so much from Pinnacle Project
- Students should consider publishing
  - Journal of Emerging Investigators
  - Many others

Questions?