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SYMPOSIUM

A Creative Model for an Interdisciplinary Approach to Service-Learning

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Synopsis The biological sciences are inherently interdisciplinary and important advances in biology cannot be made without collaboration. Despite the increasing emphasis on interdisciplinarity in higher education, science courses only rarely extend to content outside of the STEM discipline. Classes are typically taught by one faculty member in one discipline. To demonstrate relevance while addressing genuine community needs, faculty can use service-learning in their courses. Service-learning is an experiential learning strategy where students learn course content and additional relevant skills through completing service with a community partner. Community needs are frequently beyond the scope of a single course or discipline. In order to better meet community needs, an interdisciplinary collaboration provides a more comprehensive experience that highlights the application and interconnection of course content. This article presents a generalisable model for successful interdisciplinary collaborations. While the nature of course scheduling, academic department structure, and faculty workload can be barriers to collaboration between faculty, they are not insurmountable and accomplishable within this framework. The benefits to the students and the community far outweigh navigating these challenges. Using an interdisciplinary approach in teaching will not only enrich course content and expand student learning in multiple areas, but also increase collaboration within the academy while better meeting community needs.

Introduction

Service-learning, an intentional teaching and learning strategy that integrates meaningful community service with academic instruction and reflection, has been adopted by colleges and universities to better engage students in civic life while promoting authentic learning. Service-learning on college campuses was further supported by its identification as a "high-impact" educational practice by the American Association of Colleges and Universities (Kuh 2008). This pedagogical approach requires students to be "active" in their learning which ultimately increases students' engagement and positively impacts their success. Traditionally, colleges that employ service-learning seek to connect a specific course with a community partner in which the class engages in meaningful service that addresses a need of the community partner and becomes the means by which the course content is covered (Bringle et al. 2004). Students ascribe meaning to their service by critically reflecting upon their experiences throughout the class. By doing so, they connect their service to their learning, deepening their understanding of the course content (Eyler and Giles 1999). Service-learning is usually offered in the context of a single course because "academic work traditionally segments knowledge into specific disciplines. . ." (Culhane et al. 2018). Meanwhile, interdisciplinary service-learning courses, in which courses from different disciplines work together with a common community partner on a common shared project that addresses a genuine community need and the content needs of both classes, are rare.

Higher education is recognising the value of interdisciplinary education, with many institutions offering degrees in Interdisciplinary Studies or Interdisciplinary

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Science, and this is echoed by Nicholas Zeppos, the Vice Chairman of the Association of American University's Board of Directors:

> "Universities should also give students time to mix academically, so they can interact with a variety of disciplines, thinkers, and makers….[this will lead to] future teachers collaborating with future policymakers, English majors learning alongside engineers, and musicians studying molecular biology…Graduates leave more well-rounded, with a diverse set of technical and people skills" (Zeppos 2018).

Zeppos's comment speaks to the advantages of interdisciplinary education outside of academia, with students gaining valuable transferrable skills that can serve them well in the workplace. Therefore, creating courses which foster interdisciplinary thinking among students provides a great benefit to them. It provides an opportunity to answer complex problems that span multiple disciplines where "new knowledge structures are established by the integration of different disciplinary perspectives, theories, and methods" (Godemann 2006). Service-learning courses, which rely on diverse perspectives to engage with and understand a given problem, are therefore a natural fit for interdisciplinary courses. Service-learning aims to deepen students' understanding of the content through a real-life experience. Similarly, interdisciplinary collaboration can result in students enhancing their understanding of their own discipline by gaining exposure to the methodologies of another discipline. Among the advantages of utilising an interdisciplinary approach are that students learn that knowledge is not compartmentalised, but rather knowledge is transferable and cumulative (Garkovich 1982).

Further, it is rare in today's society to find people that work solely within their own discipline without the benefit of engaging with people from other disciplines. Indeed, many important scientific discoveries were made possible because of the integration of ideas from many disciplines. For example, the discovery of the three-dimensional structure of DNA was possible only because of the integration of data obtained through techniques used in chemistry and biology labs. In order to address today's complex issues and challenges, academia needs to appreciate the value of interdisciplinary learning and recognise the boundaries of a single academic discipline. Marcketti and Karpova (2014) argue that higher education institutions need to "decrease the gap between real-world and academic environments" and call for interdisciplinary learning experiences to increase transferable graduate skills and thus their employability. One of the ways to address this gap is to utilise interdisciplinary service-learning in college courses. There are very few examples in the literature reporting successful interdisciplinary collaborations between a STEM discipline and a non-STEM discipline. Additionally, it is difficult to find good models of interdisciplinary service-learning which have emphasis on service and learning. Furco (1996) explains the importance of providing a "balance between learning goals and service outcomes." This reciprocal approach intentionally benefits the provider as well as the recipient of the service (Sigmon 1979; Furco 1996). Examples of interdisciplinary service-learning that are in the literature are typically between two STEM disciplines. Often these examples either do not include all of the elements of service-learning or focus on student learning without taking into account genuine community needs.

The following article describes a creative model for an interdisciplinary approach to service-learning and provides a framework for future development and application. It illustrates a unique interdisciplinary partnership, where a common service-learning project was undertaken between students in a graphic design course and students in a genetics course. The uniqueness of this partnership was twofold; the combination of the classes and the nature of the service project. Two very distinct courses, housed in two separate schools within the university, were partnered to work on a project that would not have been able to be completed within the auspices of one class alone. Students in each of the classes relied on the education of their own discipline and collaborative interactions in and outside of the classroom in order to engage in meaningful service. The service addressed the needs of a community partner while promoting student-centered learning and development of professional practices unique to each discipline. It is important to note that while service-learning projects are vehicles in which course content is delivered, all of the course content does not need to be addressed by a single service-learning project. In interdisciplinary service-learning projects, the amount of course content addressed by the project can differ for each of the partnering courses, as described in this article. The details of this particular project, including possible assessment strategies, and impacts on the community partner and students, are described. In addition, a generalisable framework that can be used to develop other interdisciplinary service-learning courses is explained.

Developing the model: gaming in science

Interdisciplinary service-learning and projects, especially ones involving such different academic majors as biology and graphic design, allow for cross collaboration that would not typically happen in an undergraduate setting, but this approach mimics collaborations that happen more commonly in the workplace.

During the Fall 2016 and 2017 semesters, a 200-level genetics course collaborated with a 300-level graphic design course on a project for the Education and Community Involvement Branch (ECIB) of the National Human Genome Research Institute (NHGRI). A common service-learning project was undertaken between students in these classes with the goal being to create interactive games about the novel genome editing technique, CRISPR, for middle school students. At the end of each semester, selected games were chosen for additional review and possible distribution to middle schools through the ECIB.

The ECIB's mission is to "develop education and community engagement programs to enhance the public's understanding of genomics and accompanying ethical, legal, and social issues. . . [and to develop] resources for the public" (Education and Community Involvement Branch 2020). By collaborating with ECIB to create games about a current genomic technique, students in both classes were addressing the need of their community partner. The process by which students created the games facilitated student learning of the objectives of each class. While the genetics students were not experts in the field of gene editing, by working on this project, they came away with a solid understanding of the fundamental components of CRISPR. Similarly, the design students, while not yet professionals in their field, utilised the professional graphic design process to create a game design that communicated the content correctly for the target audience.

CRISPR, which stands for **C**lustered **R**egularly **I**nterspaced **S**hort **P**alindromic **R**epeats, allows researchers to edit a particular sequence within a genome, and is derived from bacterial immune systems. Bacteria utilise this system to recognise foreign DNA, fragment it, and store the fragments in their genetic memory (Jansen et al. 2002; Mojica et al. 2005). The basic CRISPR/Cas9 gene editing system consists of three components: guide RNA, Cas9, and the donor DNA. The guide RNA, as the name suggests, recognises the DNA sequence to be edited and guides the other components to the site. Cas9 is an enzyme which functions like molecular scissors to cut the DNA at a precise location, defined by the guide RNA. The donor DNA provides the template that will replace the sequence of DNA that is to be edited (Cong et al. 2013; Zhang et al. 2014).

The design of the guide RNA and the exact mechanism of this technique are more complex than described here, but to achieve the goal of the project, the genetics and design students needed to convey just the basics of this technique to their target audience of middle school students. The middle school science curriculum, as envisioned in the Next Generation science Standards, anticipates that by the end of eighth grade, students will understand that:

> "Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual (e.g., human skin color results from the actions of proteins that control the production of the pigment melanin). Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits" (National Research Council 2012).

The middle school students, depending upon their grade level, would have a basic understanding of genetics, including the structure of DNA and the process by which proteins are made. They would not necessarily be able to understand the complexities of CRISPR, but they would be familiar with DNA and RNA, which would provide a foundation for understanding the basics of the CRISPR/Cas9 editing system, which in turn would be communicated through game play. Therefore, it was essential for the games to make the complicated science of CRISPR accessible in multiple ways, through text, visuals, and game play.

Interdisciplinary approach to the project

The scope of the project required the expertise of students from both disciplines working together to achieve the common goal of creating an interactive, functional, innovative, and engaging playable game that could lead to further classroom discussion about the application of CRISPR and genetic technologies in general. The creation of a game, even one that conveyed scientific concepts, was well beyond the learning objectives of the genetics course. Similarly, understanding the science content by itself was outside of the purview of the design class. Only by combining the two classes, collaborating, and drawing upon the expertise of students from each discipline, could the outcome be successfully realised. Students in the two classes were partnered so that one biology student was paired with one design student, resulting in 20 pairs of students, and ultimately the creation of 20 unique games each semester.

The genetics students and design students each approached the project from different perspectives, rooted in their disciplines' own specific research process. Science, derived from the Latin word *scio*, meaning *to know*, aims to understand the living world, whether at the atomic level, molecular level, or ecosystem level. In order to understand the world around them, scientists ask questions and design experiments to answer those questions. In their science courses, students learn that the key to creating a good, solid experiment is to start with a valid scientific question, which leads them to develop a hypothesis, a tentative, testable answer to the question. Through experimentation and analysis of the data, the hypothesis is either supported or disproven. If the hypothesis is disproven by the data, the experimental process is repeated. Design education, on the other hand, focuses on solving complex human-centered design problems using design thinking and professional production practices, including brainstorming strategies, research, testing, and analysis, to create design solutions. Both disciplines rely on iterative cycles of experimentation and analysis to achieve a final product or to draw final conclusions.

The two groups of students, who would not have shared a classroom otherwise, worked together to communicate the science of CRISPR to middle school students in a visual way. Genetics students contributed valuable insight into the science behind CRISPR and the understanding of DNA in general, and helped to incorporate this content into the game narrative. Design students were primarily responsible for the research and development of game visuals and the aesthetic decisions designed for the target audience of middle school students. In an effort to create a realistic outcome that met ECIB's community education need, joint collaboration was essential. Through the experience, students developed a deeper understanding of the methodology of the other discipline in the context of a real-world experience, and developed professionalism and industry knowledge through community-engaged problem solving. Furthermore, the students became teachers in their own right; the genetics students taught the designers the basics of CRISPR, while the design students taught the genetics students the basics of graphic communication.

The process of game design

Each pair of students had to first determine for themselves what scientific content they wanted to incorporate into their game, taking into consideration the target audience and the learning objectives of their game. Some pairs opted to focus on the applications of CRISPR in animals or plants, while others chose to focus on the ethical issues of this technique. Visiting speakers came into the classroom to provide specialised background and rationale in areas of middle school curriculum, education strategies, and game mechanics. This knowledge helped inform game concepts as they worked to integrated learning objectives and game play. Each pair then wrote a creative brief outlining how their unique design strategy was informed by and addressed the target audience, science content, and learning goals of the game. Design students illustrated their scientific understanding, aiming to break down the information to the appropriate level, making sure to cross-check with genetics students for accuracy and communicability. Their illustrations became a mutual starting place for game concept exploration, the ideation of possible narratives, and the functionality of their game concepts (Fig. 1). Through critical and reflective activities, students worked to evolve their game into a feasible and functioning concept. A variety of games were generated from ones that included the whole class to single and multiplayer games (Fig. 2). The most successful games were ones that considered budget, could be played without technology requirements, opened classroom discussion, and included an element of competition while meetings established learning objectives.

Experimentation and analysis of results are essential parts of both the scientific method and the design process. Through the iterative processes that resulted in the final game design, students could see, in the context of a real project, how the scientific and design processes complemented one another. Students informally tested their prototyped games with their peers, relatives and friends, faculty, target audience, and scientists at ECIB in order to obtain valuable feedback that they used to improve the game. By the end of the semester, students had produced high quality prototypes that had been tested on a variety of audiences. In order to truly fulfill the mission of a service-learning class, to provide a need to a community partner, the games would need to be available to middle school audiences. As of this writing, some of the games that were produced each semester are undergoing additional revision, with the goal of making them available to the target audience next year.

Impact on student learning

A space was provided for students to engage in experimentation and receive feedback from multiple perspectives, which strengthened their overall project. This type of learning is reflected in the experiential learning cycle (Kolb 1984). In experiential learning, the four-part learning cycle consists of (1) concrete experience, or encountering a new experience or situation, (2) reflective observation, (3) abstract conceptualisation, and (4) active experimentation. In the model presented in this paper, Kolb's learning cycle is manifested by (1) collaborating with a completely different discipline (concrete experience), (2) reflecting on the joint meetings and collaboration in general (reflective observation), (3) visualising the scientific concepts, and testing different game ideas, examining the playability, narrative, learning objectives and design for the different game ideas (abstract conceptualisation), and (4) presenting the games to the community partner and our university community as a whole (Fig. 3).

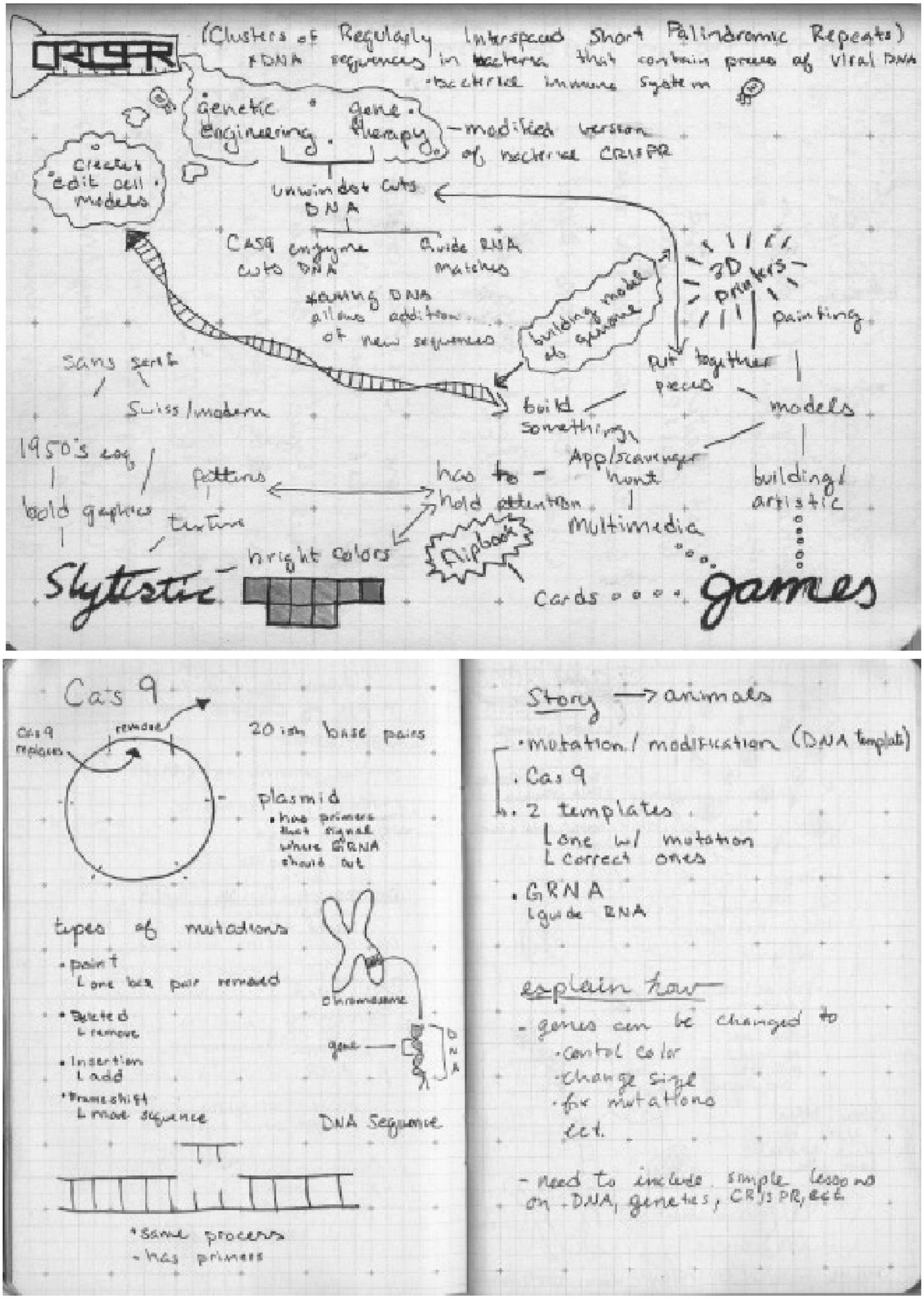

Fig. 1 Illustrations of the scientific concepts incorporated into the games. Design students illustrated the scientific concepts that the genetics students communicated to them.

This experiential approach provides students with an opportunity to interact with a community partner, addressing the needs of that community partner. In turn, the student acquires real-life experience. The type of learning that students are acquiring, as evidenced by the quotes below, is the higher-level learning, the applicability of one's work in the classroom to other situations.

> "This was a lot different than other client work that I have done in other classes. This felt more real – like there was more at stake and I really had to stretch my brain to understand what I was working with in order to design any part of it. As a designer that's pretty important" – Design student.
> "I had a really great time working with them [the design students]. The overall experience was really, really stressful honestly because a lot of explaining had to be done. This really gave me a better understanding of how to explain complex material to people outside my field." – Genetics student

Interestingly, while the design students reflected on their real-life experience, the genetics students' comments tended to reflect their exposure to a completely different discipline, which for many students was eye opening. While the nature of a designer's work is to visually communicate content from a variety of fields, student scientists often tend to view other non-science disciplines as less rigorous or worthy than their own discipline. By participating in the design process, the science students could witness firsthand the iterative process that designers go through, much like the iterative process of scientific experimentation.

For many of the science students, this was their first time learning about CRISPR. The challenge of having to learn a complicated topic and then present the content to non-science majors well enough so that the content could be visualised in the game was daunting. Furthermore, students struggled with the best way to communicate the complex concepts involved in CRISPR to an audience with a limited background in DNA and genetics. Many groups addressed this by identifying the vocabulary and concepts that needed further explanation within the confines of the game itself and creating a glossary of terms to be used by students playing the games (Fig. 4).

> "My concern is probably I did not explain CRISPR well enough for [my partner] to understand it. So I think that reflected how the game looked/played out." – Genetics student

The nature of the assignments for each class led to some inequalities between the classes. This project was a semester long project for the design students, but only 10% of the total grade for the science students. As such, it was a challenge to get the science students to feel an equal sense of ownership in the projects. Despite talking with students over the semester about feeling a sense joint ownership, this feeling persisted. While some students recognised the value of a multidisciplinary project, they did not view the game that was created as theirs, but one their partner created.

> "It was difficult working with non-biology majors. I was able to present my partner with the content and basic information about CRISPR and I felt that he was able to…make a playable and enjoyable game out of it. He had great ideas" – Genetics student.

Here too, the science student clearly viewed the game as the design student's creation. While the science student provided the content, they did not feel that they had contributed to the design aspect of the game. Likewise, the design students often felt that they could not contribute to the scientific aspects of the game because they lacked the necessary background knowledge.

In the creation of the games, non-science students (who are a subset of the general public) became well-versed in the basics of CRISPR and its applications. While time did not allow for testing of the games on middle school students during Fall 2016, some games from both classes were tested on the target audience in October 2017.

Impact on the community partner is ongoing. Service-learning is distinguished from volunteering based on fulfilling a need of the community partner. In this case, the need, as defined by our community partner, was educating the public about genomics, and was fulfilled in some ways by the creation of the games themselves.

> "We needed creative ways to convey complex scientific topics and the project gave us more than we could have ever expected. I found that the students' perspective was invaluable. This resulted in a variety of approaches and outcomes…..I can see using this approach to develop resources for other genomics-related topics that have been difficult to explain to the public (ex. testing, consent, risk assessment)" – Dr. Carla Easter, chief of ECIB.

The nature of this project is a longer-term investment than typical service-learning projects, which are completed within a semester. This project results in a tested educational game; however, in order to produce games that are classroom ready, students need to commit to further refined vetting processes both on and off campus with faculty, our community partners, and educational game experts. We continued the partnership between our classes and the NHGRI in the Fall 2018 and Fall 2019 semesters and refined the process to include additional interaction throughout the semester with middle school teachers. The teachers not only informed our students about the middle school science curriculum, but also helped to facilitate the testing of the games in their classrooms. At the end of the Fall 2019 semester, the teachers chose several games to test in their classrooms.

Fig. 2 Examples of student work. Different types of games were generated by the pairs of students from board games, to card games, to games that involved physically acting out the bonding between base pairs. Furthermore, some pairs created competitive games while others chose to create collaborative games.

Generalisable model

For successful integration of interdisciplinary service-learning, the following steps are recommended and based on the experience of implementing this method. These five recommendations were developed in order to aid other faculty in developing successful interdisciplinary service-learning courses. Recommendations are discussed in terms of which are believed to be fundamental to the success of the project and which could be customisable to individual classes.

1. **Finding a community partner**. To get started, speaking with someone in your institution's Service-Learning or Community Service office to identify potential community partners is a good first step. Once a community partner is identified and presents their tangible needs, it can be determined which courses and student learning objectives may be the best to address these needs. Faculty of those courses can begin to collaborate and determine how to best integrate service-learning via an interdisciplinary approach.
2. **Overlapping class time and shared meeting space.** The partnership between the classes is the key to success. While each class will have their own individual learning objectives, they should share common service-learning objectives. A time and place to meet (virtual or face to face), conducive to both classes, instructors, and client alike, is essential to promote collaboration and communication.
3. **Organized partnerships.** Pairing and setting the trajectory for inquiry and learning with deadlines to drive progress helped to keep all students focused on research, process, and outcomes of their project. We found that one-on-one partnerships formed between genetics and design students made assessment easier; however, this is not an essential element of the model. Larger group sizes could work just as well, but may present a challenge in terms of grading and individualised feedback opportunities.
4. **Joint ownership of the project.** The project completed for our community partner was far too large and complicated for a single student to accomplish

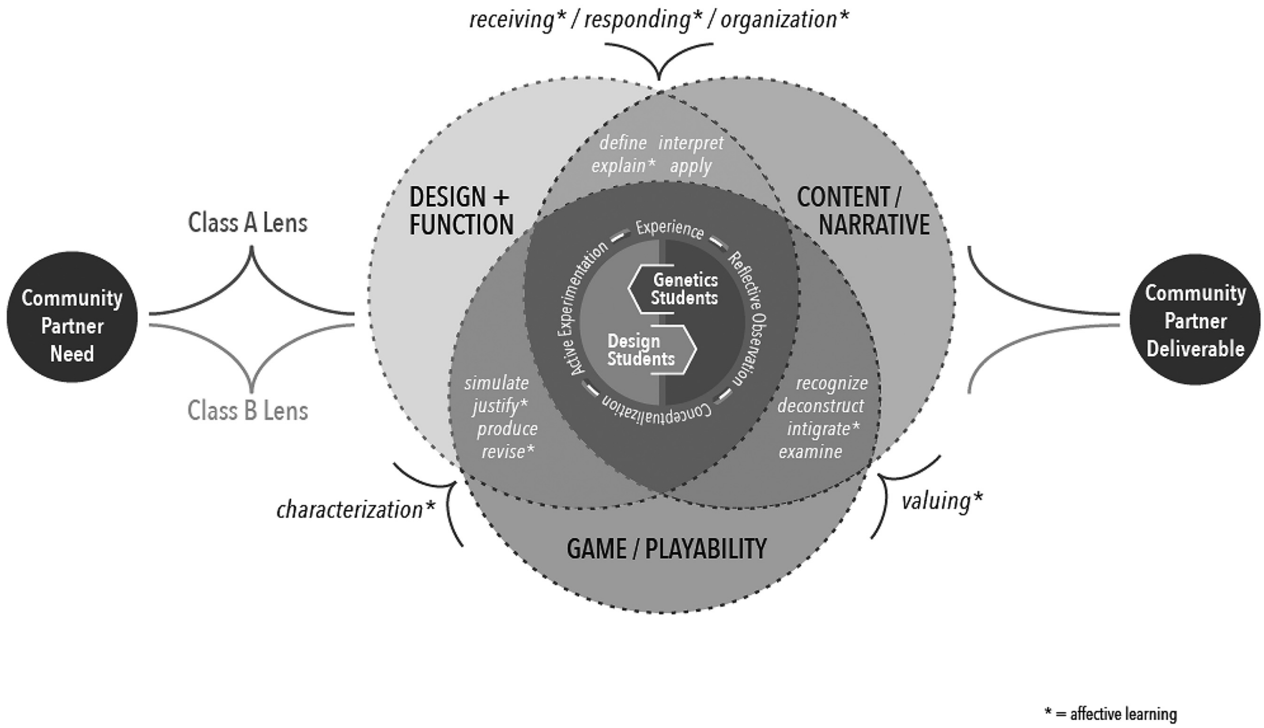

Fig. 3 The adaptation of Kolb's learning cycle to this multidisciplinary service-learning project. The community partner's need was addressed by both the design and genetics classes working together towards a common, shared goal. While the pairs of students worked together to design one game, the design students took the lead on the design and function aspects of the game, while the science students lead on the content and narrative of the game. The production of a functional, playable, engaging game relied on the interplay between the design and the content.

during the course of one semester. Students needed their partnering student in order to bring specialised knowledge to the project. Joint ownership of a common project between a pair of students can be cultivated in several ways, but it is essential that all students approach the project on as equal footing as possible in order to help foster this sense of joint ownership throughout the game design process. In the context of an interdisciplinary project, having content experts address both classes simultaneously is one way to even the playing field. A shared budget with which to create the game can also foster a sense of joint ownership between the students, especially if the weight of the project is different in each class.

5. **Assessment strategies.** Various types of assessment that could be done for an interdisciplinary project are outlined below, along with examples of assessment types. These assessment types range from smaller individual course assignments to common assessments of the learning process in general. It is recommended that the community partner also provide feedback to incorporate into student assessment.
   a. **Course-specific assignments and rubrics.** The actual assignments differed for each class as they were dictated by each class's course objectives. For the project described here, designing the game was a full semester project for design students, whereas game associated assignments were 10% of the total course grade for genetics students, reflecting the alignment of this project with each class's course outcomes. While each course should have some course-specific rubrics, the end products should be assessed with the same rubric.
   b. **Critical reflections**. Ongoing critical reflections throughout the semester are a key component in service-learning and help to link the content and service pieces together. Through these reflections, students demonstrated their knowledge of content and their application of content to the process by documenting the process of specific aspects of the project, completing a certain avenue of research, or documenting changes based on their observations or other research findings. Reflections can be written journal entries, class discussions, or many other formats.
   c. **Common learning objectives—assessing the effectiveness of the project in overall student learning.** The nature of this project allows for assessment of student knowledge at a variety of different levels. For example, pre- and post-tests re-

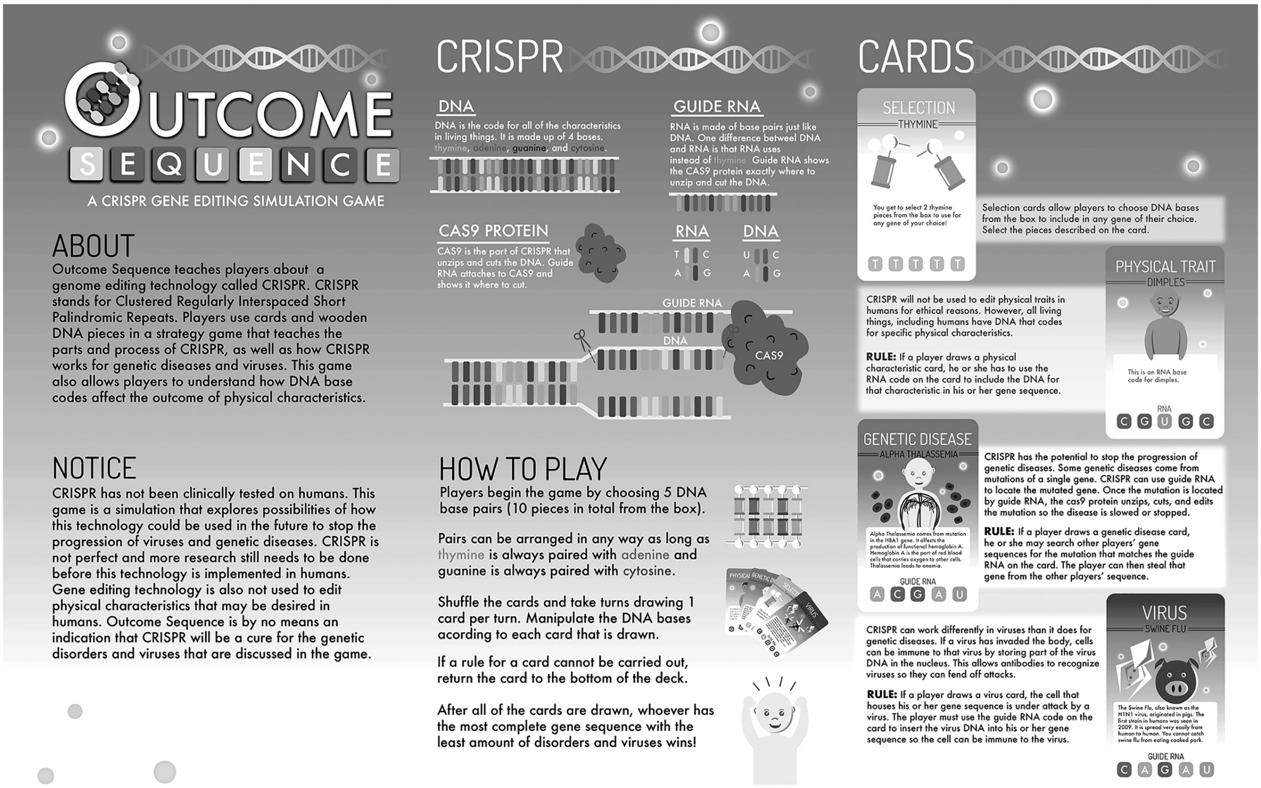

Fig. 4 Examples of instructional aids created by students. Some of the games relied heavily on the use of metaphors to communicate the science behind CRISPR. To ensure that teachers were communicating the metaphors correctly, some students included a teacher's guide to the game that included questions the teachers could use to generate classroom discussion.

garding aspects of CRISPR can be used to assess the learning gains in science content among middle schoolers, genetics students, and design students. Knowledge of the scientific and design research processes as well as service-learning outcomes could be assessed with the Student Assessment of Learning Gains (SALG) instrument (Seymour et al. 2000). While these types of overarching assessments may not be necessary for the courses, they provide data on the effectiveness of the courses as a whole and are instrumental in guiding faculty in further refining their courses.

Extending the model

This collaborative model can be applied in many different contexts. Many faculty may face institutional or administrative hurdles when attempting an interdisciplinary approach. Barriers to proposing or developing new courses or splitting teaching load for "team teaching" can quickly put a stop to collaboration; however, this model circumvents those challenges. This model requires matching existing courses with relevant community partners to address their needs. Since there is a partnership between the two classes, each instructor has their own responsibility for delivering content and assessing their own class. Additionally, this pedagogical approach allows instructors to creatively meet existing course outcomes without proposing new courses.

There are myriad combinations of courses which this model could be applied to. A few additional examples for your consideration that have been experimented with by the authors and other collaborators are as follows:

- Designing for a Target Market and Conservation Biology: The authors experimented with applying the model to new courses during Fall 2020. Although there were many challenges due to the COVID-19 pandemic, the biology students were able to complete on-site outdoor work, as well as collaborate with the design students on projects communicating conservation. All students presented their projects to the nature center and community via a webinar. The joint ownership over the project and presentation stressed the required collaboration. Unfortunately, one aspect of the model that was not able to be employed was the overlapping class time and space. This made the timing of collaboration much more difficult for some students. The overlapping time would also have allowed for presentations by outside experts to enhance the learning experience, as described in the gaming model. Incorporating these two components would have greatly improved the projects, as well as the student experience.

- Literature (Ecohorror) and Conservation Biology: In this example, students in each class completed service projects at the same site based on the community partner's needs, but mainly worked independently due to the SARS-CoV2 pandemic and interaction between the two classes was mainly online. Several assigned readings were shared between the two courses and students communicated with each other through reflection essays and responses. The specific combination of Ecohorror and Conservation Biology allowed for the further exploration of topics related to environmental racism and environmental justice, eco-anxiety, and what organisms/landscapes are "worthy" of conservation efforts. Using the proposed model for this course collaboration could increase the impact for the community partner and deepen student relationships between the courses as they reflect on their shared experiences.
- History and Biodiversity: Students collaborated to collect data for a report about a local historical site to document the cultural history and natural history (Johnston 2017). The history students focused on the cultural history and the Biodiversity students participated in a BioBlitz citizen science project with community members helping to identify organisms. Discussion and reflections in the Biodiversity course allowed for the exploration of some difficult topics related to the historical legacy of racism that would not have been otherwise covered. Using the proposed model for this collaboration could deepen the student engagement and ownership of the research project while allowing greater exploration of the historical context and natural history of the area.
- Journalism and Evolution: Students could collaborate on creating content for a wide range of audiences based on the needs of a relevant community partner. The community partner could range from a local non-profit newspaper or non-profit online news site to a school district looking to develop content or curriculum. Using this model would deepen the evolution students' understanding of important concepts by requiring a deep knowledge of the material in order to teach the journalism students and collaborate on the written end product. Journalism students could help to teach the evolution students about communicating about science at an appropriate level for the audience. This is similar to the genetics students teaching the difficult topic of CRISPR to the design students and the design students working to translate it into a product.

Conclusion

This article attempts to illustrate that interdisciplinary service-learning between a STEM and non-STEM discipline provides a great benefit to students and the community. It not only offers an opportunity to address complex problems that span multiple disciplines, but allows students to employ different disciplinary perspectives (Godemann 2006). By utilising an interdisciplinary approach, students will be challenged to reach outside of their comfort zones. Each student can become personally invested in the project through a different lens, but they come together under a common goal outlined by the community partner. The unique multidisciplinary nature of these projects allow students to "mix academically" (Zeppos 2018) with students from other disciplines. This deepens students' understanding of their own discipline content through "real-life" experiences while enhancing their understanding of the methodologies of another discipline. The collaborative, interdisciplinary elements of joint projects add layers of communication and mutual learning that help to prepare students for the demands of their future professional work lives. Most importantly, this approach reinforces that generating knowledge does not take place in silos, but rather knowledge is transferable and cumulative (Garkovich 1982). In conclusion, using interdisciplinary service-learning enriches course content and expands student learning in multiple areas while increasing collaboration within the academy and better meeting community needs.

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Data Availability

Participants of this study did not agree for their data to be shared publicly, so supporting data is not available for sharing.

References

Bringle RG, Philips MA, Hudson M. 2004. The measure of service learning: Research scale to assess students' experiences, Washington, DC: American Psychological Association, p. 230.

Cong L., Ran FA, Cox D, Lin S, Barretto R, Habib N, Hsu PD, Wu X, Jiang W, Marraffini LA et al. 2013. Multiplex genome engineering using CRISPR/Cas systems. Science 339:819–23.

Culhane J, Neiwolny K, Clark S, Misyak S. 2018. Exploring the intersections of interdisciplinary teaching, experiential learning, and community engagement: A case study of service learning in practice. Int J Teach Learn High Educ 30:412–22.

Education and Community Involvement Branch. 2020. National Human Genome Research Institute, March 14, 2021 in Bethesda, MD(https://www.genome.gov/about-nhgri/Division-of-Policy-Communications-and-Education/Education-and-Community-Involvement-Branch).

Eyler J, Giles DE. 1999. Where's the Learning in Service-Learning? San Francisco, CA: John Wiley & Sons, p. 315.

Furco A. 1996. Service-learning: A balanced approach to experiential education. Expanding Boundaries: Serving and Learning, Washington, DC: Corporation for National Service, p. 2–6.

Garkovich L. 1982. A proposal for building interdisciplinary bridges. Teach Socio 9:151–68.

Godemann J. 2006. Promotion of interdisciplinary competence as a challenge for higher education. J Soc Sci Edu 5:51–6.

Jansen R, Embden JD, Gaastra W, Schouls LM. 2002. Identification of genes that are associated with DNA repeats in prokaryotes Mol Microbiol 43:1565–75.

Johnston G. 2017. BioBlitz!!! Stevenson University, March 14, 2021in Owings Mills, MD(https://www.stevenson.edu/academics/undergraduate-programs/history/blog-news-events/bioblitz-at-baxter).

Kolb DA. 1984. Experiential Learning: Experience as the Source of Learning and Development, 1st ed. Upper Saddle River, NJ: Prentice Hall, p. 19–38.

Kuh G. 2008. High-Impact Educational Practices: What they are, who has access to them, and why they matter, Washington, DC: Association of American Colleges and Universities, p. 9–11.

Marcketti SB, Karpova EE. 2014. Getting ready for the real world: student perspectives on bringing industry collaboration into the classroom. J Fam Cons Sci 104:27–31.

Mojica FJ, Díez-Villaseñor C, García-Martínez J, Soria E. 2005. Intervening sequences of regularly spaced prokaryotic repeats derive from foreign genetic elements. J Mol Evol 60:174–82.

National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, Washington, DC: The National Academies Press, p. 158–9. https://doi.org/10.17226/13165.

Sigmon RL. 1979. Service-learning: Three Principles. Synergist 8:9–11.

Seymour E, Wiese D, Hunter A, Daffinrud SM. 2000. Creating a Better Mousetrap: On-line Student Assessment of their Learning Gains. Paper presentation at the National Meeting of the American Chemical Society, San Francisco, CA. Available online https://salgsite.net/about.

Zeppos N. 2018. Slow Food? Let's Try Slow College. CNN, June 3, 2019 in Atlanta, GA(https://www.cnn.com/2018/03/01/opinions/the-case-for-slow-college-zeppos-opinion/index.html).

Zhang F, Wen Y, Guo X. 2014. CRISPR/Cas9 for Genome Editing: Progress, Implications and Challenges. Hum Mol Genet, 23:R40–6.