Inclusion in neuroscience through high impact courses

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A R T I C L E I N F O

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A B S T R A C T

Recognizing that STEM disciplines, including neuroscience, have a long way to go to attract and retain diverse talent, educators can take action by being more intentional about their departmental curricula, course design, and pedagogical strategies. A deep body of research suggests that one way we can promote inclusion is through the use of high impact practices (HIPs). These active learning teaching practices promote deep learning and student engagement and have been shown to have a positive differential impact on historically underserved student populations. Here we describe the characteristics of two different types of HIP courses, makerspace classes, and course-based undergraduate research experiences (CUREs). In addition, we provide ideas for how these courses can be structured to help all students engage and learn. With experience overseeing a large campus-wide program introducing these course types to the curriculum, we also provide insights about faculty experiences and assessment. We propose that including these types of courses in a curriculum can engage a more diverse group of students to choose neuroscience as a major and as a career.

A growing interest in neuroscience has led to the expansion of undergraduate neuroscience programs across the U.S [1,2]. As neuroscience programs proliferate and continue to gain popularity, it is important, perhaps now more than ever, to think carefully about not just what students will learn in these programs, but how we will welcome them into the discipline, help them learn, and support them enough to help them be retained. The recent 'Talking About Leaving Revisited' report highlighted that poor instructor pedagogy and ineffective curricular design were the top two negative reasons for why students left science, technology, engineering, and math (STEM), and top negative issues even for students who remained [3]. We do know that when evidence-based pedagogy and curricula are utilized well (including active learning, deliberate practice, and inclusive interactions with students) achievement gaps are narrowed failure rates are decreased, and retention improves [4,5]). With this knowledge in hand, it is crucial, now more than ever, to take action.

As faculty design and revise neuroscience curricula, there is an opportunity to avoid getting bogged down in what Petersen et al. call the "tyranny of content coverage", and think about how we can ensure that all neuroscience students have opportunities to deeply learn some concepts and competencies [6]. Notably, this work has already begun in the neurosciences. In 2017, the Faculty for Undergraduate Neuroscience (FUN) met and mapped out fundamental principles that promote core competencies in neuroscience education [1]. Inclusion should not be an after-thought but should be the lens we take as we plan the course structure and all of our interactions with students [7,8]. Indeed, the 2017 FUN meeting principles highlighted this directive and stressed "the ongoing need to make diversifying the student body that is attracted to, and successful in, neuroscience programs a primary goal in developing neuroscience curricula." [1]. As important as the core competencies, inclusion should be integrated into courses.

In this article, we'd like to suggest approaches around making (designing and prototyping objects) and research that support diversity and inclusion in the neurosciences and provide some guidance for implementation. These approaches fall under the category of high impact practices (HIPs), which include opportunities to engage in research, service learning, first-year seminars, and collaborative projects [9]. Kuh's work [9] demonstrates that HIPs are beneficial for all students and that these learning opportunities can be especially beneficial for underserved students (also see work by Brownell and Swaner, 2010). Unfortunately, underserved students have traditionally had less access to these opportunities. Thus, we and others believe an inclusive curriculum should strive to include or require as many HIPs as possible [8,10].

HIP learning experiences described by Kuh [7] are different from

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traditional lecture-heavy classes in that they:

1 Require significant time and effort on the part of our students, moving them past rote learning of textbook material;
2 Promote learning beyond the walls of our classroom, so that the knowledge our students gain can be applied in a meaningful way;
3 Provide opportunities for meaningful interactions between faculty and students that highlight the collaborative nature of teaching and learning
4 Allow students to learn from a diverse group of other people who might not have the same views or experiences;
5 Create opportunities for frequent and substantive feedback to students so that they learn the value of iteration and develop feelings of competence.

As demonstrated by these characteristics, the focus is less on "what do I want students to know?", so that the coursework can be designed around different questions: "what skills will students develop?", or even "who do we hope our students become?" [11]. When executed well, HIPs create opportunities for all students to experience deep learning, where they are challenged to reflect on their assumptions and beliefs and integrate their learning across more than one area of study. Neuroscience as a subject area is a perfect fit for implementing HIPs, in part, because it draws from many different subject areas, including both STEM (e.g., Biology, Chemistry, Engineering, Computer Science) and the Arts and Humanities (e.g., Psychology, Sociology, Philosophy, Linguistics), thus providing an opportunity for integration.

We focus on two types of courses that can be incorporated in any neuroscience discipline and align with the characteristics of HIPs. Both also meet the principles and core competencies outlined by the 2017 FUN meeting for neuroscience educators to focus on curricular changes that can diversify and retain learners in the neurosciences [1]. The first type of course we describe, a makerspace course, teaches design-thinking and making to a non-engineering population. The second type of course, a course-based undergraduate research experience (CURE), teaches through novel research with students. CUREs move well beyond traditional labs, in which students follow step-by-step instructions or guided inquiry exercises without novel discovery. Makerspace courses do not yet have a substantial foothold in higher education, whereas CUREs have gained a lot of traction in many STEM disciplines and have become integrated into some university-wide programs such as the Freshman Research Initiative at UT Austin [12]. Both of these course types can be implemented in either introductory or upper-level neuroscience curricula.

Our university, UNC-Chapel Hill, has university-wide programs for both makerspace and CURE courses (QEP.unc.edu), and we've been directly involved in running programs for faculty professional development and/or teaching these courses [13]. At UNC-Chapel Hill, faculty are incentivized to spend a great deal of time developing these courses through year-long faculty learning communities (FLCs) with an associated stipend for effort. Through our experiences working with several faculty cohorts over the past few years, we believe similar incentives and training would work at other institutions as well. In FLCs, faculty reflected on numerous topics, such as their perceived ability to implement making or research in their courses, to evaluate what has worked/not worked in their own and colleagues' courses, to discuss issues around collaboration and inclusion, to assess learning, and much more. Ultimately, the framework for discussion often revolves around the defining characteristics of makerspace and CURE courses that we discuss below.

1. Makerspace courses (making)

1.1. Background

Many institutions of higher education, libraries, and museums have opened up collaborative spaces, called makerspaces, that have a variety of tools for designing and prototyping objects [14,15]. These tools can range from 3D printers, laser cutters, electronics, sewing machines, metalworking stations, to scissors, cardboard, and legos. Makerspace courses encourage students to use design-thinking and making as a way to reinforce disciplinary learning, as well as integrate ideas from other disciplines. Instructors might begin planning making for their neuroscience courses by thinking about the teaching tools or models they would use in their classrooms if they had access to them or to think about concepts that are difficult to learn. Is there a making activity that could aid students in understanding particular concepts? For example, the "hands-on" approach could help students gain a deeper understanding of the structure and function of neurons if they are asked to use various materials to demonstrate terms like cell body, axon, dendrites, and synapse (e.g., students have to determine what part of one neuron should touch another to make a synapse). Beyond building a neuron, this kind of activity can also explore ideas around creativity and privilege in resources, as described in the "Making a Neuron" activity.

A diverse student population can be impacted by makerspace courses because all students are welcome to enroll. At some institutions, the makerspaces are part of an engineering school, but these tools need not be sequestered in engineering programs that may not have as diverse a student population as psychology and neuroscience disciplines. At UNC-Chapel Hill, makerspaces are open to all students and located around campus in main buildings, within dorms, and on mobile carts. Because these kinds of courses are not widely known and offer great promise for how diversity can be leveraged, below we provide what we see as essential characteristics of makerspace courses [16], adapted from the definition of CUREs [17].

1.2. Characteristics of a makerspace course

Use of design-thinking and making processes. We like how IDEO, a great resource for design thinking states, design-thinking "allows people who aren't trained as designers to use creative tools to address a vast range of challenges" (*IDEO Design Thinking | IDEO | Design Thinking*, n.d.) IDEO describes the process around: framing a question, gathering inspiration, ideation, prototyping, user feedback, iteration, implementation, and communicating [16] It is important to note that these may be steps of a process, but the process is not necessarily linear. For example, the designer may come back to gathering inspiration at any point. It is possible for students to participate in all aspects of this process, but they may only be able to meaningfully participate in some steps more than others (*e.g.*, they may spend more time on revising designs and only get to do one prototype or they may spend more time prototyping if they are trying multiple materials for a proposed design). In this way then, design thinking is not linear, as there are multiple entry and exit points to the process.

Discovery. The work is not predetermined by the instructor, so students make choices and produce novel objects. For example, as students work through the design process of modeling an ion channel receptor, they may discover new materials or designs that work best for an object that were not apparent to the student or instructor until the process began. As another example, if students were building a model to test a novel scientific hypothesis, they may discover that their model supports or discredits a hypothesis. Perhaps most famous in the biological world is the way in which Watson and Crick discovered the structure of DNA by making models and fitting them together. What discoveries are awaiting in neurobiology that can be modeled this way, and by whom? Students might propose designing a new kind of co-culture dish for cellular studies or model a circuit that degenerates during neurodegeneration.

Broadly relevant or important work. There are many opportunities for objects to have importance beyond the classroom. For example, students may design objects that can be used for education in informal settings or schools (*e.g.*, modeling how a brain changes during Alzheimer's Disease), test hypotheses such as structure function ideas in neuroscience *e.g.*, the function of a brain area during injury), or prototype objects that can be useful in healthcare or communities (*e.g.*, helmet designs to prevent concussions). The object being made could be something developed in collaboration with a community partner to meet a need, and thus would be both a service-learning and makerspace course (*e.g.,* a model to educate patients about how antidepressant drugs work). When students find relevance in their design and making work, they may begin to take on a creative and maker mindset. Perhaps we can create "maker identities" for students, analogous to how we try to create science identities for students earlier in their education [18].

Collaboration. Students can collaborate in all or just parts of the making process with peers and instructors. A group may make one object together or critique an individual's designs, prototypes, and presentations. In doing so, students can learn skills to evaluate and offer constructive feedback. By seeing different designs from peers, neuroscience students have an opportunity to think metacognitively about the diversity of thinking and how diverse teams can yield more creative outcomes when bolstered by feedback. This, in turn, may cultivate agency and autonomy for students and create a sense of ownership in their learning. An example of how collaboration can lead to innovation is highlighted above in the "make a neuron" activity, and instructors may find specific examples in neuroscience illustrating the power of collaboration. For example, Andrew Huxley has written about the trials and errors of his well-known collaboration with Alan Hodgkin, on the road to their fundamental and Nobel prize-winning work on nerve cell excitability [19]. An instructor may find their own research experiences captivate students, if, for example, they discuss how collaboration worked to build a research paper with co-authors.

Iteration. The design and making process provides many opportunities for iteration as students move from ideas, to prototypes, to final products. As such, the instructor needs to provide enough uncertainty in the project so that students can discover weaknesses/failures in designs and prototypes and try again with improvements. For example, the initial material selected by a student might not provide the stability they thought it would, or a student might create an educational object, try it with a sample audience, and discover the audience misunderstands. Students will need to reflect, perhaps collaboratively, and make adjustments. In so doing, students learn how resilience and failure are part of success. These experiences can be used to highlight the process of iteration many neuroscientists have moved through, for example, the experiments conducted by Hubel and Wiesel to describe receptive fields in the visual cortex. It was only after some failed experiments that they "accidentally" happened upon the solution that led to this discovery [20]. Authentically building this resiliency mindset into a curriculum may contribute to a more diverse group of students persisting in STEM.

1.3. Getting started with a makerspace course

Students may think that they are not good at making or designing things, based on their past experiences. They may not understand what creativity is and is not [21]. This might even come in the form of students saying "I'm not a creative person" [22], echoing the "I'm not a math person" type declarations seen in quantitative fields [23]. Past experiences might have involved a lack of resources, activities lacking structure, or a notion that there is a "correct" way to make or do something, leaving little room for creativity. Whatever the experiences, learning histories, or skill levels our students bring to the classroom, makerspaces courses can invite all students into the design and making process.

An introductory making activity may help students explore ideas around why they might not see themselves as creative or a "maker". The first activity described here includes a significant amount of self-reflection and provides students the opportunity to explore their prior knowledge and misconceptions about making and design. It also sets the stage and models some of the kinds of characteristics students will experience throughout the semester (*e.g.,* collaboration and iteration.)

Time and resources may limit an educator's ability to get started with a makerspace course. If an educator can't offer a semester-long project because they can't provide much class time or aren't ready to make a leap yet, mini-making – smaller projects that promote curiosity – are a good entry point. Larger projects can stem from these in the future. Mini-making ideas can be inspired by Dr. Eric Chudler's website "Neuroscience for Kids" [24] and adapted for undergraduate students. While many institutions have invested in makerspaces with equipment such as 3D printers and laser cutters, we reiterate that the same outcomes can be achieved with low-cost supplies, like cardboard, scissors, etc. on mobile makerspace cart.

1.3.1. Making a neuron

This activity was adapted from the mobile activity described by Sandra M. Lawrence [25]. To modify it to a neuroscience class, students are asked to model neurons with their group demonstrating their understanding of the terms cell body, axon, dendrites, and synapse. As homework before class, students were asked to bring a list of 3 things that made them feel included in a learning environment and 3 things that made them feel excluded in a learning environment. They wrote their responses down on an index without their name on it, and these were collected at the beginning of class.

Students should take a seat at a table to form groups of 4−5. Each table has a paper bag on it that contains materials to make a neuron. Some groups ("high resource groups") receive bags containing many materials such as tape, glitter glue, fancy pipe cleaners, scissors, and colored paper. Other groups are given fewer materials and tools. The "low resource group", for example, receives only a white piece of paper, a piece of twine, and a few paper clips. Additionally, the high-resource groups receive a diagram of a neuron with step-by-step instructions about what to do, while other groups have no instructions or diagrams to guide them.

As students work on this assignment, it usually becomes apparent to the low resource groups that other groups have received more resources and tools. The high-resource groups sometimes notice but often do not. Once students have had a chance to present their neurons to each other, group and whole-class discussions help to reflect on the design and making process.

These discussions are structured by the instructor to highlight the idea that simply having access to tools and materials for making and design does not ensure that students actually engage in a creative or discovery process. Students in the low resource group usually express how they had to be more creative and collaborative than other groups. This is highlighted by the "high resource group". With a diagram, step-by-step instructions, students are assembling an item, rather than designing an item. This process highlights the need for students to assume project ownership to move towards developing a sense of maker identity (rather than following a recipe).

To thread the value of privilege, diversity, and inclusion into this activity, students are asked about how they feel about noticing the differences in their bag of tools. Students in the "low resource groups" usually express some frustration and a sense of unfairness. When asked if they asked the higher-resourced groups for help, the answer is usually no. When the high resource (privileged) group is asked if they thought to share, they often remark they didn't even notice they had more than others, and they assumed everyone had the same. The instructor can help students see the value of collaboration in design, and the need to not make assumptions about the resources and experiences their peers bring to the process. Finally, students are given one index card that another student brought to class to reflect on what makes other students in their class feel included and excluded. A writing activity or class discussion can give students an opportunity to reflect on these responses. Slides that you could use to facilitate this activity can be found in the supplementary materials.

1.4. *Structuring semester-long making and design activities*

Educators looking to implement making into a neuroscience curriculum may need a few ideas for inspiration. We've listed a few below, but the possibilities are endless. An example syllabus for a makerspace class can be found in the appendices.

- Create educational objects for a hands-on museum exhibit centered around a particular theme, such as neurodegenerative disease.
- Take on a particular research problem, such as how concussions can be prevented, and ask students to prototype designs for helmets
- Create puzzles and board games to understand principles such as spatial summation
- Design escape rooms or boxes that utilize students' understanding of a neuroscience concept to create thrilling and accessible entertainment. An example of an escape box activity created by students in a makerspace class can be found at https://neuralconnections.wixsite.com/outbreak
- Create models to learn about neuroanatomy (see Fig. 1)

So how do you ensure these classes promote inclusion? As many have pointed out, a structured class is an inclusive class, and this is also true of makerspace classes [e.g., 4,6,17,18,26,27]. These courses will mirror other project-based courses in that the instructor needs to provide enough structure to help students get started and move their projects along but provide enough flexibility and uncertainty for project ownership to develop. Projects that are too open-ended can put some students at a disadvantage, such as students that have trouble setting and keeping their deadlines. Along with the design and making process, some parts may need to be more prescribed (*e.g.,* students only have access to a particular material or tool) versus parts that are highly open (*e.g.,* selecting any object to design as long as it teaches a neuroscience concept to 7th graders).

Structure vs. ownership is a balance the instructors will continually explore, and one that was the basis of many conversations in the maker FLCs at UNC-Chapel Hill. Let's examine other parts of a makerspace course that require the instructor to consider more structure, to ensure the course is an effective, inclusive HIP. We'll consider deadlines, feedback, reflection, and collaboration in the next few sections.

1 *Structuring Time and Deadlines.* We can't assume everyone has experience structuring time in long-term projects, so it's more inclusive for an instructor to set deadlines for students to complete their project in stages. For example, students might have a deadline for selecting a topic, doing some research, creating a timeline for the project, and submitting a prototype object. To address the possibility that work for the project would interfere with student work/family responsibilities, it would be more inclusive for the instructor to set aside some days in the class schedule for project working and collaboration.

2 *Structuring Feedback from the Instructor*. Instructors can help students understand how formative feedback can improve their process. This means that feedback to students should be constructive, focused on improvement, and for multi-step projects especially, should help students prioritize crucial aspects of the project that will keep them on track.

Rubrics are one tool that instructors can use to provide feedback and make grading less biased. Rubrics also provide students with clear expectations. Whenever possible, rubrics should be provided to students so that they have a clear picture of what they are being asked to do when a project or assignment is introduced. With semester-long projects, rubrics can be provided along the way as students complete smaller pieces of the larger assignment. Rubrics might include an outline of what students should know or understand, what they should be able to do, or what questions need to be answered. At UNC-Chapel Hill, our instructors personalized rubrics for their projects, and they included measures around areas such as disciplinary content, accuracy, aesthetics, presentation, collaboration, effort, and specific making competencies [28, 29]. There is not a universal rubric that will work, so instructors are encouraged to think about the specific learning goals of their project and align them to these. In Table 1, we list a few maker-specific competencies as outlined by a project through the University of Texas Arlington Libraries, and Fig. 2 offers a framework for designing your class.

3 *Structuring feedback from peers*: When structured carefully, peer feedback can be immensely helpful for students. The advantages for students include getting feedback from multiple sources, appreciating another point of view, and self-reflecting on one's own work in the process [30]. Students will also develop their communication and collaboration skills. Peer feedback could be structured by the instructor to provide a rubric for students to follow. Ideally, these rubrics will pose questions that cannot simply be answered with 'yes' or 'no' but instead direct students to process the work more deeply. For example, instructors might ask 'what is the purpose or main idea of the project', 'what do you like about the project thus far?', 'what do you think can be improved?' 'what questions do you think users

Fig. 1.

Table 1
Maker Competencies as outlined by the University of Texas Arlington Libraries, in collaboration with other university partners.

UTA Maker competency number	Competency. The "Maker-Literate" student should be able to:	Sub competencies
1	Identify the need to invent, design, fabricate, build, repurpose, repair, or create a new derivative of some "thing" in order to express an idea or emotion, to solve a problem, and/or teach a concept	a. recognize unmet needs that may be filled by making b. tinker and hack to learn how things are made and how they work c. evaluate the costs and benefits of making as an alternative to buying or hiring d. investigate how others have approached similar situations
5	Assess the availability and appropriateness of tools and materials	a. research various equipment and materials to determine limitations and suitability for a specific application b. choose the most appropriate tools and materials (physical, digital, and rhetorical) for the job c. acquire the necessary tools and materials d. investigate alternate tools and materials when a desired tool or material is not available e. fabricate necessary tools, reimagine material choices, develop alternate workflows, and/or revise project scope when alternative tools or materials are not available
6	Produce prototypes	a. determine the method of creation most suited to the project b. gain confidence with technologies and processes required for creation c. specify functional requirements for prototype vs desired finished product d. divide design into individual components to facilitate testing e. document design process
7	Utilize iterative design principles	a. apply measurable criteria to determine whether creation meets needs b. revise and modify prototype design over multiple iterations c. gather prototype feedback and input from stakeholders and mentors d. rework design to include insights from feedback take intelligent risks, use trial and error, and learn from failures
10	Collaborate effectively with team members and stakeholders	a. listen to others b. learn from and with others c. communicate respectfully and clearly with team members and stakeholders d. follow through on team commitments and responsibilities e. practice accountability both personally and with team members f. appraise contributions to the success of the team

will have interacting with the object?' The Center for Teaching and Learning at Washington University in St. Louis has a useful guide with practical advice for engaging in peer feedback [31].

4 *Structuring opportunities for self-assessment through reflection*: Self-assessment helps students understand how their work meets the standards set forth by their instructor or their collaborators and can be key to helping them appreciate the process of iteration. Creating opportunities for reflection throughout the design and making process provides an opportunity for students to not only practice this skill but to see their own growth over the semester [[32]]. One way to implement and structure self-assessment is for instructors to include it as a course learning outcome and align activities to this outcome. For example, a "making journal" is one way to provide opportunities for reflection. In the journal, students can be asked to reflect on what has worked for them and just as importantly, what has not been working. Students might reflect on strategies for working through those aspects of their project that are difficult, or how they came to an "aha" moment. The journals can include sketches and photos too. Prompts for reflection might also ask students to discuss their goals and how they will know that they have met those goals, how they will manage their time effectively, or what aspect of the project they are having the most difficulty with. Thus, rather than a simple inventory of what they did, the making journal can become a structured record of what students plan to do before they begin, how things are going during the making and design process, and an evaluation of what was learned once a task is complete. cited as important to any experiential learning activity [33].

5 *Structuring Collaboration:* Without structuring collaboration, inequities, and feelings of exclusion can arise. The opening activity, making a neuron, can be utilized as an introduction to group work with time to reflect on the process of collaboration together. If students will be in semester-long groups, group contracts are recommended to promote inclusiveness. These contracts can help guide issues around outside classwork time, dividing work equally, and individual strengths/weaknesses before problems arise. Documents can have team agreements that are signed with explicit guidelines for how the group will deal with members who violate the disagreement. Faculty can provide a basic scaffold to students that students can adapt. These documents can be living documents and amended as needed.

Along with scaffolding dates that groups need to have certain work done, an instructor can also set dates for routine group reflection. These can be simple forms that students complete about what is working and not working. Not only do these regular check-ins help student groups function more effectively, but they help an instructor monitor the work and intervene if needed.

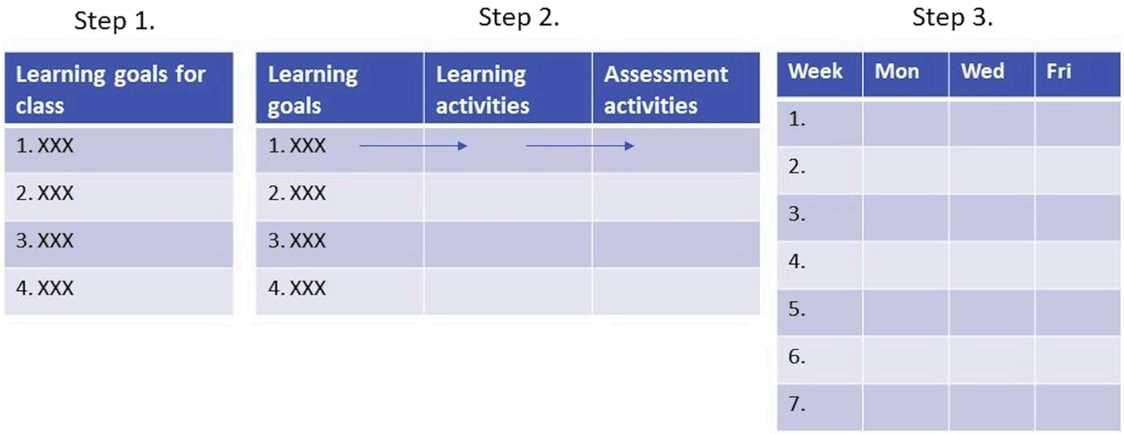

Fig. 2.

2. CUREs (Research)

2.1. Background

CUREs allow students to perform novel research in a collaborative setting with peers and instructors [17]. One way to think of CUREs are as lab courses that get away from “recipes” for students to follow. For example, rather than students following a lab manual through guided inquiry about neurons and nerve signals, students participate in novel research that contributes knowledge to a field. In traditional labs, hundreds of students have repeated the same methods, collected the same data, and made the same discoveries already known to the instructor. In contrast, students in CUREs have the opportunity to participate in authentic science, making discoveries unknown to them and their instructors. CUREs offer a way for more students to access research than one-on-one mentored experiences because all that is required of a student is to enroll in the course [34]. Students need not have the know-how to navigate approaching a research mentor. Furthermore, students interested in obtaining research experience do not have to wait for a slot in a research lab to open up. To date, much more has been published about CUREs than makerspace courses regarding their value in diversifying science and their outcomes [34,35] faculty can find more guidance on designing CUREs through various publications and networks, such as CUREnet. In addition, The Journal of Undergraduate Education (JUNE) is an excellent resource for creating a CURE course for neuroscience students. Once an instructor decides they want to use this approach, we recommend reading Fear of the CURE: A Beginner’s Guide to Overcoming Barriers in Creating a Course-Based Undergraduate Research Experience [36]. We’ve listed references to a few published studies about neuroscience CUREs in Table 2 that can help give specific ideas in neuroscience, but there are many more available in other biological disciplines.

The characteristics of a CURE have already been well defined [17]. Below we will reflect on each characteristic based on what we’ve learned by running a university-wide CURE program across disciplines.

Table 2
Examples of Neuroscience CUREs.

Title of paper	Citation
Versatile Undergraduate Neurobiology Course-Based Research Experiences Using Open Access 3D Electron Microscopy Image Volumes	[37]
Classroom-Based Research Experiences to Support Underserved STEM Student Success: From Introductory Inquiry to Optogenetics in the Embryonic Chicken	[38]
A course-based undergraduate research experience examining neurodegeneration in *Drosophila melanogaster* teaches students to think, communicate, and perform like scientists.	[39]

This can be helpful as neuroscience programs incorporate CUREs more widely.

2.2. Characteristics of a CURE class

Use of Scientific Practices. We find that most faculty are comfortable with the use of scientific practices from their current or past work, but they have often never explicitly taught these skills to students in a course. Instructors usually find they want to spend a few weeks teaching skills (such as PCR, microscopy, or statistical software) before starting the research. Yet, we often find ourselves encouraging instructors to teach skills while simultaneously narrowing down research questions. We nudge instructors towards starting the research project early because we want students to take ownership of their project immediately. The sooner students begin the project, the sooner they can encounter the other aspects of a CURE and build a science identity.

Discovery. Labs are common in STEM. Yet it is often the case that students are discovering something novel *only* to them: The instructor usually knows the outcome because it is a recipe or guided-inquiry experience that has been repeated by students year after year. Working with faculty, we have observed novelty can be the hardest part of designing a CURE. Faculty are used to knowing the answers to questions that students ask, and this kind of uncertainty disrupts the traditional dynamics for educators. Questions then arise. What kind of project can create new knowledge, within the short time of a semester? How can the project be sustained so that it continues to be novel to students semester after semester? There is no one right answer here, but we recommend instructors consider these questions and plan immediately, before getting too far into course design.

Broadly relevant or important work. Students create new knowledge in these courses, and they will find even more meaning when they can see the impact of their work on either the scientific community or a local community. As such, when faculty are designing a CURE, we have found it useful to remind them that the final assessment provides an opportunity to highlight their work beyond the classroom through a publication or a presentation to a community group. At the very least, a campus forum in which students present their research to peers, faculty, and staff from across campus in a celebration of research is warranted. At many institutions, these poster sessions are often designed for independent research only. At UNC-Chapel Hill, these events were enlivened by the addition of CURE course students presenting their findings together in small groups sometimes with posters but also with webpages and interactive demonstrations as well.

Collaboration. Neuroscience is a collaborative field, and there are many opportunities for students to collaborate. They may be in semester-long groups or they may have individual but related projects in which they can critique each other along the way and practice communicating about their process and findings as they go. When planning a CURE, we recommend listing all the steps of the research process that will occur and making a plan to see if students can collaborate at each step. Don't leave it to chance that students will know how best to collaborate on each step, provide structure and scaffolding for the collaboration. The more structure provided, the more inclusive collaboration will become [8]. As noted above when discussing making and design, there are many examples of collaborative work in neuroscience that can be discussed to highlight the benefits of collaboration, and for inclusion, it is best to highlight a diverse group of scientists collaborating on ideas together. New hashtags on social media and databases are rapidly helping science provide stories of diverse scientists [40]

Iteration. Real science involves failure and repetition, and this is an essential part of a CURE. If everything worked and students followed a simple recipe, it wouldn't be a CURE. But what is there is so much failure that the whole class never produces data? This happened to our colleagues at UNC who were teaching a CURE for the first time in a biology course. Even without producing data, many outcomes were achieved, such as an increased ability to navigate scientific obstacles and an increased sense of belonging [41] These findings reinforce the idea that the point of a CURE is to teach students how science works and give students the *opportunity* to discover something new. Producing novel findings doesn't always happen in the first semester of a newly designed course and that is okay. Faculty can practice their growth mindset around iteration of their own course, learning from mistakes one semester to enhance the experience for students the next semester.

2.3. Getting started with a CURE course

Educators will find a variety of ways to begin a CURE class, but we encourage jumping right in with helping students discover all characteristics of a CURE right away. We advocate for doing, not telling. Below is an idea that can work in a neuroscience course.

2.3.1. Conducting a taste test

For this activity that one of us, Viji Sathy, designed, students are asked to work in small groups to design and conduct a taste test with peers in the class (those not in their group). Let the students help design the questions, such as can students discern between two types of cheese crackers? Can blindfolded students discern the flavor of different color skittles? Students are asked to construct a brief paper-and-pencil survey for the taste test that is reviewed by the instructor to encourage a mix of closed-ended responses for easy analysis. After collecting the survey data, students work together to analyze the data. This is an opportunity for the instructor to walk through how categorical data can be presented in a bar chart for instance, as well as scale-level questions can be presented via means and standard deviations. The final portion of this assignment includes a short write-up including their key findings, which also serves to provide a baseline writing sample. The instructor can use the activity to reflect on parts of the scientific process (from design through communicating ideas), and the ideas of discovery, collaboration, iteration, and relevance of research demonstrated or not demonstrated by the exercise.

2.4. Structuring semester-long research activities in CUREs

Many of the considerations for managing a semester-long collaborative CURE project are similar to those we discussed with makerspace courses. It is key to structure the deadlines, feedback, self-assessment, as much as possible, while leaving open the opportunity for students to still find uncertainty and opportunity to iterate within the research itself. It is important to note that an instructor will feel more like a coach at times, helping students see that setbacks are a normal part of science. The importance of structure becomes more and more evident as the courses scale-up through multi-section introductory courses and multiple instructors and/or TAs may be involved. At UNC-Chapel Hill, we have utilized a graduate research consultant (GRC) program, that has helped many of our faculty new to CURE succeed. In courses utilizing GRCs, these graduate students are usually hand-picked because they know the area of research/skills well and can help guide individual students and groups through the process. They are paid a modest stipend ($1000) and are not allowed to be used for grading.

There are many examples of CUREs that relate to neuroscience in the literature already (see Table 1), and there is no limit to what area of research can be chosen and what techniques are used. They may involve screening chemicals for new effects on neurons or animal behavior, knocking out gene function in animal models to understand neurodegenerative disease, or analyzing microscopic images to understand neuron structure and function under different conditions. Sometimes faculty find an extension of their own research that lends itself to many students working over many semesters. Other times, faculty find a CURE helps them think through new research ideas because the research they are familiar with is cost-prohibitive or involves too many skills for a semester project. An example of a semester-long student research project, which stemmed from work by students in a Makerspace class, is shown in the supplementary materials.

3. Evaluating impact

Our society struggles to show diverse role models in science, and neuroscience is no different, as seen by the call for a #BlackinNeuroWeek on Twitter by Black neuroscientists hoping to connect with one another and a larger community through #BlackinNeuro. The reason for diverse role models is much larger than a lack of highlighting BIPOC. As the organizers of #shutdownstem (http://www.shutdownstem.com) wrote, "Those of us who are not Black, particularly those of us who are white, play a key role in perpetuating systemic racism. Direct actions are needed to stop this injustice. Unless you engage directly with eliminating racism, you are perpetuating it" ("Why Black lives matter in science," 2020). Thus, we believe that educators using inclusive teaching methods and curricula engage intentionally in acts that are anti-racist. We suggest that HIPs, such as makerspace courses and CUREs are part of society's solution for inclusion.

When utilized in introductory curricula, both makerspace and CUREs may represent a point of entry into neuroscience for students who might not see a path in STEM that interests them. Why? They may have had only exam-based assessment opportunities, labs with 'recipes' and little deep thinking, few opportunities to see how science moves beyond the lab, or not knowing all the different careers a 'scientist' can have. In intermediate and upper-level curricula, allow students with more disciplinary knowledge in neuroscience to test hypotheses and develop their science identity more deeply. Thus, CUREs may be a useful strategy to attract talent from a diverse group of students, as well as help retain students within a STEM major and career.

In our assessment of these types of courses, we see that students generally indicate experiencing aspects of these high impact experiences such as discovery, collaboration, and iteration [42]. We routinely ask all students engaged in these CUREs to complete surveys comprised of established scales such as the Laboratory Course Assessment Survey (Corwin et al., 2015) and Project Ownership scale [43] In the area of making, scales have been developed by campus experts based on the Remake Learning Cross-Cutting Competencies [44] and maker literacies piloted in partnership with institutions, some which are listed in Table 1 [29]. These scales address areas such as the development of confidence and persistence in making as well as design thinking [45].

In addition, students comment on the rewarding and challenging aspects of making (makerspace course) or research (CURE). Their qualitative remarks in addition to traditional measures such as the LCAS and Project Ownership Scale are reflective of the experiences we want to offer via curriculum to cultivate inclusive STEM education:

Meeting my classmates and working as a team with them to create our project was very rewarding. We faced many challenges and frustrating moments but in the end, we created a tool that we all worked so hard on, and were excited to share. [Makerspace course student]

This was a fun way to instill the knowledge I needed on the topic in order to create a product that was going to be helpful to other students when they learn the subject. I believe that if I didn't have a strong grasp of the topic, it would have been much harder to create the product in the first place. [Makerspace course student]

I loved using the skills I learned during class to conduct my own research. [CURE student]

Being given the chance to present my work at the QEP Exposition exposed me to the research environment, which was an area that I was considering for my career but didn't have enough experience to really say whether I liked it or not. When I presented for the first time, it was an incredible experience! [CURE student]

When curriculum and courses are carefully designed and faculty are supported in integrating HIPs, we not only offer our students opportunities to engage deeply in neuroscience but to discover a pathway to seeing themselves in a discipline that they may not have considered a home for their talents. By building inclusive courses and curricula, we can reach students where they are and invite them to see what our discipline has to offer. And not just some students. All students.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.neulet.2021.135740.

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