Strategic Master Plan for CNS Undergraduate Curriculum

21st Century Curriculum Implementation Task Force

The College of Natural Sciences
The University of Texas at Austin

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Executive Summary

Current degrees in the College of Natural Sciences are organized primarily around content knowledge within a series of courses. The content knowledge builds and overlaps between those courses, but this overlap is often not well coordinated throughout the degree plan. Moreover, former students tell us that the lasting impact of their degree is more likely to be the broader skills they obtain while studying this content knowledge rather than the specific content knowledge itself. The manner in which these critical skills can be obtained within our current degree plans are not obvious to either students taking the courses or to the faculty teaching them. As a result, it is difficult to define outcomes from specific degrees and/or to determine key differences between degree options beyond required credit hours or course numbers. To address these problems, we propose that all CNS degrees intentionally address both a set of essential skills for scientists and mathematicians and critical discipline content knowledge. This will require the following action items:

- ***Define essential skills needed for each CNS degree***
- Define critical discipline content for each CNS degree
- ***Map outcomes of degree-required courses accordingly for each CNS degree.***

In addition to discipline-specific content, degree plans should be organized to develop higher-level "essential skills." The 21st Century Curriculum Implementation Task Force identified the following set of essential skills that are fundamental to all scientifically literate citizens and future scientific leaders, both in academia and industry disciplines:

- ***Effective communication***
- ***Information literacy***
- ***Computational/technological literacy***
- ***Self-directed learning***
- ***Teamwork***

All CNS degrees should be organized around a common set of principles. These principles will offer structure in the process of defining outcomes, curriculum mapping and navigating through the degree plans. These principals will also ensure that degrees are organized to meet all categories of requirements. Rather than being addressed through additional course mandates, both critical content and essential skills will be incorporated into existing course. Additional requirements such as state core and flags must also be satisfied with overlapping degree coursework.

The following five-step action plan lays out a recommended pathway for departments to achieve the goals of defining critical concept knowledge in the discipline, incorporating essential skills into the curriculum, and utilizing degree design principles.

1. *Select department lead; set a goal end date*

2. *Identify degree outcomes*

3. *Inventory discipline concepts and essential skills*
   Each department will identify a set of discipline-specific concepts that all majors are expected to learn. Clearly defined learning outcomes for each course will ensure all degrees encompass the critical discipline content and will improve consistency of replicate courses and the vertical alignment of course sequences. Degrees within the same discipline should share common critical discipline concepts.

Departments will incorporate the essential skills into the required coursework for each degree plan, though the manifestations can be unique to each discipline. As students move through a degree plan, instruction should incorporate activities designed to continually reinforce and enhance the level of these skills.

4. *Map curriculum*
    a. *Standardize learning objectives and vertically align course material*
    b. *Implement instructor communication across cohort courses*
    c. *Offer state core/flagged courses within the major*

5. *Request resources to support curriculum work*

Throughout all phases of the curriculum work, the TIDES STEM Instruction Consultants will play a key role in helping faculty implement changes. The consultants will serve as both a curriculum resource and a project manager. The consultants can also help identify ways to implement changes within courses themselves. Depending on the level of prior degree plan updating, the timeline for this process and the resources used to implement changes may vary by department. Many departments have already begun the work of rewriting degree plans to a certain extent, and this progress will be acknowledged and incorporated into this work.

The work of curriculum mapping and reform should be periodically reviewed by a CNS faculty committee constituted for this purpose. After the process of curriculum reform has been running for some time, the membership of this committee should include faculty who have played leadership roles in this process in their own departments. Ultimately, the success of curriculum reform will depend on implementation, and, specifically, on the ability of faculty and their departments to develop and institute educational mechanisms that achieve the skills and knowledge goals set forth in the revised curricula. Careful thought needs to be given to how students attain both content knowledge and essential skills as they move through the curriculum in different ways. Implementing these changes will better prepare graduates for post-baccalaureate success, and increase transparency of intended outcomes in CNS courses and degree plans at large.

The Vision

(Below excerpted from 21st Century Report)

Degree plans are the ultimate drivers of the student learning process because they define what is required and expected of all students. Degree plans shape the instructional mission of the College by defining what educational experiences and which courses must be provided by our faculty. Although the content of courses and the manner in which they are taught are critical, the degree plan should be a framework for achieving student outcomes.

To achieve our vision of undergraduate education, we must have a substantive change in our existing curriculum and curricular review process. No longer will a course-driven curriculum, divorced from a larger College vision, be suitable. To successfully engage students in independent thinking, deep conceptual understanding, experiential learning, and collaborative and creative work, we need a shared vision for excellence across all majors that (a) defines the learning outcomes expected of each student and (b) clearly demonstrates how these outcomes are to be accomplished within each degree.

Efforts at the University to embed flags into the curriculum took a step in this direction, but flag requirements were laid upon an existing set of course requirements rather than serving as a master plan for how specific outcomes would be accomplished within the unique context of each department. Moreover, they placed the burden on the student to navigate how they will obtain the flags rather than having these outcomes clearly embedded in the required curriculum.

Students need to be able to look at any degree plan in the College and recognize why they are completing each specified requirement. Faculty need to be able to understand how courses fit into degree plans and how adding, changing, or removing courses will affect the undergraduate experience. A common degree plan format aligned with an overarching set of desired outcomes would ensure that all students, faculty, and advisors recognize the desired learning outcomes and their manifestation in the degree requirements.

Recommendations

1. Define and Incorporate Critical Discipline Concepts into Degree Plans

A bachelor's degree from CNS is intended to create science mastery in students, both from the perspective of scientific content and the practice of science. Each degree carries a different suite of learning objectives specific to a discipline, and yet our departments all strive to design the best pathway to guide their students towards those learning goals. Course plan organization, prerequisites and degree requirements are tools we use to organize our degrees, and here we explore techniques we can use to improve that organization.

Toward this goal, the 21st Century Curriculum Planning Implementation Task Force recommends that each department, for each degree plan, identify a set of critical concepts in the discipline (i.e., "content knowledge") that all undergraduates pursuing that degree plan are expected to learn. These should be defined as outcomes for the degree. In addition, each department should identify how these learning outcomes are to be attained within the degree (e.g., which courses or other degree requirements). These learning outcomes are expected to differ across different degree plans offered by the department (e.g., Chemistry BS vs Chemistry BSA; Human Biology BS vs Cell Biology BS). However, the outcomes for a given degree plan should be general enough to be achieved by any of the allowed paths through that plan.

Learning outcomes should be stated in more general terms than learning outcomes for a particular course. Our College will also define essential skills that every CNS degree plan should address in the context of the respective discipline. This innovation will be addressed in the next section.

The 21st Century Curriculum Planning Implementation Task Force recommends that each department incorporate these outcomes into a curriculum map (See Appendix A for a template). Departments may use the suggested format or choose a different one as long as the map includes all critical concept learning outcomes and essential skills (addressed in the next section), how they are addressed in the curriculum, and to what degree they are addressed in the curriculum. The Implementation portion of this document offers a step-by-step process for completing the curriculum map.

The very process of completing a curriculum map often spurs curriculum improvement. To determine "where" a critical discipline concept learning outcome is accomplished—and to what degree—requires a clear understanding of the courses offered for the degree and how they interrelate, or not. Gaps and redundancies in topic coverage can be revealed, along with lapses in vertical alignment among sequence courses. Courses that may be amenable to more innovative pedagogy and assessments can be identified and modified to satisfy more flags or the newly defined essential skills addressed below. Some courses might be combined or eliminated. ***Departments should identify where experiential learning in the form of research, mentoring, internships, and others can both fit in and or substitute for other courses within the curriculum.***

Upon completion, the curriculum maps will be made publicly available. They will be a valuable resource for students to use when deciding on a major, selecting courses, and building four-year plans. Advisors can use them to provide more major-specific guidance. Departments can use them for ongoing improvement.

We have identified three primary focus areas where individual departments can make concrete improvements to degree organization while designing curriculum maps, enhancing the learning experience for students and also easing the burden on individual instructors by building more open channels of communication. These focus areas are:

1.1 Standardization of learning objectives and vertical alignment of course material. Learning objectives should be established and coordinated for each course. Course objectives should be vertically aligned across different courses in the curriculum to ensure that students acquire the knowledge required for successful progression through the curriculum and to eliminate repetition of material between courses where it is unnecessary. Establishing and coordinating learning objectives will also allow departments to identify gaps in the curriculum that require new courses, existing courses that could be combined, and extraneous requirements that can be eliminated. ***Defined learning outcomes will also make it easier to determine what traditional courses might be replaced by experiential learning courses.***

1.2 Instructor communication across cohort courses. A large fraction of students in a particular major and cohort will follow a stream of courses within a semester, and from one semester to the next. Courses that have particularly strong links should have learning objectives that align and complement each other. For example instructors teaching physics lecture and lab courses covering the same material taken concurrently should communicate directly. This communication will be facilitated and tracked by "course coordinator" described in the **Implementation Techniques** section below.

1.3 Availability of state core/flagged courses being offered within a major. Each student is required to fulfill both a list of state core required courses and courses carrying flags. Students often must resort to courses outside of their major and even outside of CNS to fulfill these requirements, making it more difficult for them to enhance their in-degree curriculum. Applying the relevant flags and state core status to existing courses can make a tremendous impact on student satisfaction and learning. Note that adding a flag to some courses may not require any changes to the curriculum; many unflagged courses may already meet the flag and/or core requirements and simply need to be identified.

<u>**Implementation Techniques**</u>

Designating course coordinators: We recommend that a faculty "course coordinator" be designated for courses to ensure consistency across instructors and vertical alignment within the major. At a minimum, a course coordinator should be designated for any course that is 1) a required course at the base of the major, 2) part of a strongly linked sequence, or 3) taught by multiple instructors. A course coordinator will facilitate discussion among instructors to designate agreed-upon broad-level learning objectives. Published learning objectives help faculty members who are new to the course, as well as helping to ensure sufficient standardization across different offerings of the course. Learning objectives provide clarity about expectations to both students and instructors, as well as allowing instructors for courses that are next in line to easily find out what background their students will have when entering their course. This organization sets the stage for instructors of vertically-aligned courses to communicate and eliminate redundant material, or to coordinate their efforts.

Biology may serve as a useful example for efficient standardization and communication of learning objectives. In several biology courses, the course coordinators facilitate the communication between instructors all teaching the same course. This reduces variation in topics, grading, and learning outcomes, regardless of the particular professor teaching during any given semester. Instructors talk with one another to coordinate learning objectives. The designation of course coordinators greatly increases communication among instructors, and in some cases, has led to increased alignment between courses and their prerequisites.

We recommend that even smaller, advanced courses have clear learning objectives published. This allows the instructors teaching courses that feed the advanced classes to know what their current students will need to tackle once they leave, and it allows students to see that what they are currently learning will apply to their next course.

Specifically, course coordinators must facilitate an annual review of published learning objectives with all instructors of that course for the coming academic year. If the course is part of a sequence or a prerequisite for other courses, they must also meet with the appropriate course coordinators to verify and adjust vertical alignment. These findings and adjustments will then be reported to a standing curriculum committee comprised of a subset of course coordinators that are selected by the chair of the department. In turn, the alignment committee will annually report their findings to a college-wide review committee.

Identifying course overlap and sequencing: Lack of communication between instructors within a discipline or across disciplines can detract from student learning. In some departments, there are disconnects or a lack of communication between instructors teaching related courses (e.g. lab and lecture courses).

We recommend that departments work to identify (1) “linked” courses that tend to have strong overlap in their student populations in a given semester and (2) “sequence” courses that tend to be taken in series by a large student cohort. While some course links may be obvious (corresponding lab and lecture courses), some are not, such as those that span departments (e.g. “Physics 302K: General Physics 1 Mechanics” and “M408C: Calculus 1”) or even Colleges (e.g. “CH 353: Physical Chemistry” and “CHE 353: Transport Phenomena”). This information can be obtained from student enrollment data available to CNS with assistance from the Office of Data Reporting and Analysis and TIDES.

Instructors and/or “course coordinators” for each set of “linked” or “sequence” courses should be invited to meet with one another to compare notes on topics and learning objectives for each course within the sequence. These meetings can be informal or take place with the aid of a STEM Instruction Consultant that can aid in drafting a plan to prioritize the development of key student skills identified by the instructors over the course sequence.

The committee believes that such communication can reveal differences in priorities for student learning objectives for lower and upper division service courses taken by students outside of their home department (for example mathematics courses commonly taken by chemistry and physics students). Such information can be used by instructors to better align course focus and method of instruction to the knowledge base of students entering a course sequence while simultaneously ensuring that students leave a course with key skills needed to successfully tackle the next node within a course sequence.

2. Define and Incorporate Essential Skills into the Curriculum

A college education should enhance critical thinking, communication, and other high-level skills. However, there is growing evidence that many American university graduates lack such skills and therefore cannot meet the demands of rapidly changing workplaces and civic realities brought on by scientific and technological innovations (CLA+ National Results 2013-14; College Learning for the New Global Century, 2007). As the world becomes more globalized and innovation accelerates, our degree plans must continue to evolve as well, and incorporate skills that will enable students to adapt to a changing world. Current degree plans are all too often a collection of isolated courses that have accumulated over time, rather than an intentional, cohesive pathway to intended learning outcomes. Accordingly, one of the central recommendations of the Report of 21st Century Undergraduate Education Group is that curricula should be strategically re-envisioned.

In addition to achieving discipline-specific content outcomes, degree plans should be organized in a way that develops a set of higher-level skills. Based on surveys of CNS graduates and their employers, as well as reports by the Howard Hughes Medical Institute and the Association of American Colleges & Universities, the 21st Century Curriculum Planning Implementation Task Force identified a set of essential skills that are fundamental to all scientifically literate citizens and future scientific leaders, both in academia and in industry disciplines.

The manifestation of essential skills can be unique to each discipline, while the underlying skills remain consistent across CNS disciplines. As such, the committee recommends the following as a minimum set of skills to ensure that students possess scientific literacy skills upon graduation:

- ***effective communication***
- ***information literacy***
- ***computational/technological literacy***
- ***self-directed learning***
- ***teamwork***

The committee recommends that each degree incorporate these skills into the required coursework for each degree plan. Additionally, rather than flagging a single class that addresses these skills, all CNS graduates should have repeated significant experiences with these skills upon completion of their degree. As students move through a degree plan, instruction should incorporate activities designed to continually reinforce and enhance the level of skill. While there may be some overlap with flags and core curriculum requirements, these skills are viewed as separate in that they will be acquired through discipline-specific CNS courses and in greater depth. For example, a single writing-flagged English Composition course would not be sufficient to satisfy the requirement for training in effective communication. Rather, this skill needs to be addressed in upper-division, discipline-specific courses for students to have sufficient experience with scientific research communication.

2.1 Definitions of Essential Skills

2.1.a. Effective Communication**:** Effective communication encompasses the ability to produce stylistically appropriate written and oral reports within a student's discipline of study. To acquire this skill, students should practice making persuasive, evidence-based arguments using appropriate scientific sources and learn to make and use figures and graphics effectively. Students should be able to produce both written and oral reports that are scientifically accurate and reflect the common practices of the discipline in terms of style and substance. Students' reports should emulate materials produced by experienced researchers in their discipline. What is deemed stylistically appropriate and relevant in terms of written and oral reports is different for each discipline of study, which is why it is crucial that each department incorporate within their own coursework courses that specifically instruct students on the appropriate communication methods within their discipline. Equally important to communicating within their scientific field, students should learn to communicate with diverse groups, including those outside of the discipline and those who are not scientists or mathematicians. We must instruct our students how to effectively communicate scientific research to the public in order to improve the translation of research to the public.

2.1.b. Information Literacy**:** Information literacy includes the ability to locate appropriate information, evaluate both information and information sources critically, read and interpret primary scientific literature, and synthesize information in the service of decision making. This skill is likely to be taught in the same context as the previous skill, as both must be present in effective communication. Information literacy is crucial to scientific literacy as this skill enables students to use critical thinking skills to identify first what information is relevant to the discipline and then to identify scientifically valid sources of information. It is not sufficient for students to simply read information given to them, but students must be active participants in the process of identifying primary sources of relevant information to the discipline. Students should be instructed on methods of identifying sources and tracing citations within scientific literature in order to ensure an understanding of the requirements for scientific validity. Additionally, students should gain experience reading information from this literature as well as interpreting and synthesizing this information for the purpose of presenting the information in a literature review or other synthesized form of document. Students should also be able to reference multiple sources in the context of a single discipline-specific argument and compare and contrast conflicting ideas in the broader scientific literature.

2.1.c. Computational/technological Literacy**:** Computational and technological literacy includes the ability to organize and interpret data and apply computational skills to solve problems. While students are already required to obtain a core mathematics credit, as well as a quantitative reasoning flag, it is possible that the courses may be taken in departments other than the student's home department. As such, it is important to ensure that students are learning the specific quantitative skills required by their discipline in order to conduct scientific research in the field. For some departments, these quantitative skills may be acquired through the current quantitative reasoning flag, but efforts should be made to verify the courses that students are taking to meet these requirements include the discipline-specific requisite knowledge. Additionally, students should gain computational skills through experiences with computer software or programs which are primarily used in the field of research. While some fields may have multiple computational programs that are widely used, students should be exposed to at least one program within their coursework. Developing skills using at least one program will provide a learning experience that students can transfer to the process of learning subsequent computational programs.

***2.1.d. Self-directed learning*:** Each student should gain practice in self-directed learning. Through this experience, students should demonstrate the ability to execute an independent and original project culminating in a product, such as a written document, oral presentation, or physical object. The creation of this project will likely rely on a synthesis of all previously listed skills in order for the project to be effectively completed. Students will need to utilize effective communication skills, information literacy, and computational/technological literacy in order to evaluate and present their project in a meaningful way. The final result of this learning can be presented in whatever manner is deemed as most appropriate by the discipline. There is potential for this skill to be accomplished within a course bearing the independent inquiry flag so long as students present their research. Self-directed learning involves work on a project that allows students to progress through all parts of the research process from generating an idea or concept to completing the work and presenting independently. A key feature of this skill is that students learn to innovate, create, or conduct original research projects within the discipline of their field with maximal freedom to create something original. *This skill is tied closely to the deep incorporation of experiential learning into CNS degree plans.*

***2.1.e. Teamwork*:** Finally, students should acquire skills that foster effective teamwork, including the ability to resolve conflicts, plan and coordinate group efforts, and communicate effectively with teammates. While teamwork is a required component of several of the core academic requirements, the skills gained through teamwork are of such importance that it should be used as frequently as possible, and this skill should be reinforced and enhanced as students proceed through a degree plan. Whether students transition into careers after graduation or continue in their academic pursuits, they will be required to actively engage with others in their field. Thus, students should have experience working through discipline-specific problems in order to develop skills in teamwork within discipline- specific research contexts. These skills will include the ability to plan and coordinate the division of responsibilities in the group and to resolve issues that may arise from conflicts within the group without the need for outside intervention.

2.2 Essential Skill Implementation Techniques

Each department must determine how to best incorporate essential skills into their degree plans. Although strategies will inevitably vary between departments, we recommend that all departments adhere to the following guidelines:

- Skills should be incorporated into existing courses rather than being addressed through additional course requirements. If a new course is required to address these skills, it must replace existing courses rather than be added into the existing course sequence.
- Avoid creating a second set of *de facto* flags in which each competency goal is met by completing a particular course. Instead, skills should be acquired organically throughout the curriculum.
- Skill training should be recurrent, as skills are most effectively learned through distributed practice across time. Ideally, each skill should be addressed in multiple courses so that skills can

be developed, refined, and reinforced across the curriculum.

Appendix B lists the essential skills and priority student-learning outcomes associated with each skill. These outcomes can be mapped into the curriculum along with the critical concepts, core courses, flags, and experiential learning components.

When new educational objectives are implemented, there is often conflict between the goal of achieving broad impact and the goal of maintaining simple, navigable degree programs. There is the danger that degree programs will become more complex, and students will struggle to meet the requirements or delay graduation. In recommending that the prescribed skills become an "organic" part of the curriculum, as opposed to a checklist of flags, we are advocating that departments structure their curricula to maximize student exposure to relevant training mechanisms without imposing new requirements for students. Degree plans should be designed so that students receive significant training in each area as they progress naturally through their degree program. However, this need not be a one- size-fits-all system. As departments establish and publicize course-level learning objectives, students will be able to choose paths that might emphasize one set of skills over another. While every student should have exposure to all skills, not every path through every degree needs to have identical outcomes.

3. Degree Design: Common Frameworks and Guiding Principles

To facilitate the process of defining outcomes, curriculum mapping, and navigation through the degree plans we propose a shared set of degree principles. Degree plan alignment with an overarching set of principles would ensure that all students, faculty, and advisors recognize the desired learning outcomes and their manifestation in the degree requirements.

CNS Degree Principles should be considered within the multiple types of degree courses, including:

- **State Core**
- **Major Science (also referred to as Departmental Core)**
- **Advanced Science or Minor**
- **Breadth in Science or Arts**
- **Electives**

3.1 Guiding Principles

CNS degrees should be organized around the following principles. Degrees should:

1. Be no more than 120 semester credit hours.
2. Have defined outcomes that satisfy the core competencies.
3. Include a substantial experiential learning component.
4. Have nearly complete overlap between all degree options in a field of study for the first 2 years.
5. Incorporate the quantitative reasoning flag, independent inquiry flag, and two writing flags.
6. Allow for a minimum of 15 semester credit hours of free elective credit.

3.2 Common Framework

There are several categories of coursework that fall within degree requirements (See Appendix C). These categories are visually outlined in Appendix C. The categories are as follows:

3.2.a State Core: The Core consists of both the requirements set by the Texas Higher Education Coordinating Board as well as those specific to UT Austin. In total this is 42 hours of course work. However, effectively for all CNS majors it amounts to only 27 hours as course required for the majors can also satisfy core requirements. For some areas (like Mathematics), the Science and Technology portion of the core will not be covered within the degree requirements.

3.2.b Major Science: This is the bulk of the major and should contain all the required science and mathematics courses that are common to all degrees in the major. This includes introductory work that might be in other disciplines. This portion of the degree should be 48 hours of course work. For some areas (such as Mathematics), some coursework may need to be designated to cover the Science and Technology portion of the State Core even it is not directly related to the discipline.

3.2.c Advanced Science or Minor: For B.S. degrees, this portion of each degree would contain 15 hours of additional science within the discipline allowing students to specialize in a particular area as well as gain more in depth experience within the field. This portion likely includes at least 3 hours of laboratory work. For BA/BSA degrees this 15 hours is the concentration outside of the major. This could be a minor, certificate, or 15 hours within a field of study (that is not in CNS, Engineering, or Geosciences).

3.2.d Breadth: For B.S. degrees, there are an additional 12 hours of course work in the sciences that can be used in several different ways. This coursework can provide additional depth in the field, can be used to for breadth in other sciences areas, or can be used to create more elective hours. For BA/BSA degrees these 12 hours provide breadth in the arts with students taking courses in fine arts, humanities, social science, and/or language and culture.

3.2.e Elective Hours: Each degree should leave 18 hours at minimum for free electives. Students should be able to explore topics of interest across campus with no restrictions on which courses they can take to satisfy the degree plan.

3.2.f Flags: In addition to the core requirements, the University of Texas at Austin also requires students to take courses that carry specific "skills and experience flags." The flags are:

- *Cultural Diversity in the US (CD)*
- *Ethic and Leadership (EL)*
- *Global Culture (GC)*
- *Independent Inquiry (II)*
- *Quantitative Reasoning (QR)*
- *Writing (W)*

Ideally students could take courses in their degree that carry the necessary flags such that they do not have to use their elective hours to meet this requirement. This is important both for streamlined degree plans and effective advising. From a degree plan standpoint, all CNS degrees should seamlessly incorporate as many flags as possible so that students moving through their degree naturally acquire the flags without needing to select specific courses. In the sciences, this means ensuring students have the quantitative reasoning flag, the independent inquiry flag, two writing flags, and ideally the ethics and leadership flag. These would ideally be placed within the Core-required science coursework portion of the degree also known as the “Core Science.” Students would need to acquire the other flags outside of CNS. For example, they could meet the “Cultural Diversity in the US Flag” and “Global Cultures Flag” in their State Core. If this is not possible, students would need to satisfy these requirements in breadth courses or electives. Finally, while the College should move towards incorporating more courses that carry the ethics and leadership flag, students in many majors will need to meet this requirement outside their science coursework.

To ease pressure on students’ need to fulfill these flag requirements, departments can broaden offerings of courses that carry flags within the major(s) they offer. Currently there are majors courses that already fulfill or could be easily adapted to fulfill a flag requirement, but the official flag approval for the course has not been pursued. Departments should ensure that faculty apply to have courses flagged where appropriate. While some flags will be easier to fulfill than others, every effort should be made to strengthen the offerings within each department, taking pressure off students to find courses outside the department that qualify. This is particularly true for the Independent Inquiry flag that would be best satisfied by students within their degree required coursework.

One way to expand flag offerings would be to increase offerings of the SIAD (Scientific Inquiry Across the Disciplines) courses currently taken by FRI students. This course can fulfill multiple degree requirements while instilling a strong sense of the scientific process and reasoning central to a CNS degree.

Another potential challenge for CNS students is the “ethics and leadership” flag. The vast majority of our students fulfill the requirement through classes taken outside of CNS, with little in the way of direct guidance provided by CNS in this endeavor. This should not be the case as ethics and leadership are both key tenants that should be naturally interwoven into any degree program within CNS. As such, we strongly recommend that both CNS and individual departments work together to implement methods that make the satisfaction of the “ethics and leadership” flag a natural component of any degree plan offered by CNS. Two potential methods for achieving this goal would be to: (1) modify one of the existing courses within a degree plan to satisfy this flag; or (2) to guide majors that follow a specific degree plan towards courses outside of CNS that satisfy this flag yet have strong ties to topics of direct relevance to the student’s chosen degree plan.

Importantly, to implement method (1) above, either 1/3 of a 3-credit hour course or 1/6 of two 3-credit hour courses taken in sequence would need to be dedicated to ethics and leadership to qualify for the flag. A representative example of a course sequence within CNS that meets this requirement is BIO 375, Conservation Biology, offered in the Option I: Ecology, Evolution and Behavior Biology B.S. program. Departments that elect to follow this route would be offered reasonable support by CNS to assist their faculty in modifying one or more of their current courses to meet this flag requirement.

While the expansion of ethics and leadership within some degree plans may be straightforward to implement, the committee recognizes that this may be difficult to achieve for other degree plans. As such, the committee also suggests that departments within CNS be allowed to partner with other departments outside the college to identify specific courses of direct relevance to CNS majors that satisfy the “ethics and leadership” flag. Once identified, such courses could reserve a specific number of seats or potentially expand their enrollment to accommodate CNS majors. An example of this is RS373M, “Biomedicine, ethics and society”, which is planning to reserve 225 seats out of 300 for biology majors.

Implementation

The following action plan describes a recommended pathway for departments to achieve the goals of defining critical concept knowledge in the discipline, incorporating essential skills into the curriculum, and utilizing degree design principles. The action plan consists of five steps, outlined here and described in more detail below. Throughout all phases of the curriculum work the Department will be supported by a STEM Instruction Consultant. The consultant will serve as both a curriculum resource, as well as a project manager.

1. Five Step Action Plan

1.1 Select Department Lead and Set a Goal End Date

Each department will identify a faculty point person who will coordinate the degree plan analysis and reorganization. This person may already serve a role in the department such as the undergraduate coordinator or member of the UG SEC. The department lead will coordinate the efforts to revise the degree plan with the input of the undergraduate studies committee and/or other faculty in the department. The Department Lead will work closely with a STEM Instruction Consultant to manage the curriculum reform project.

1.1.a Department Lead Compensation: The Committee recommends that the Department Lead receive a workload reduction for this task that is proportionate to the expected time required to carry it out (see section 1.5 Establish timeline for changes). The department lead may then identify 3-4 dedicated faculty who will form a curriculum revision committee to oversee this process for a given degree. The committee can propose changes to the degree to be brought forward for discussion to the department's faculty.

1.2 Identify Degree Outcomes

There are two main tasks in identifying outcomes for each degree. First, faculty should identify critical concepts in the discipline. These are the content or discipline specific outcomes associated with each degree. For some disciplines, there are recommendations from national committees (*e.g.,* HHMI, ACS, ASBMB,…). Second, faculty need to agree upon their discipline's essential skills. While the implementation task force has recommended a set of essential skills that would ideally be included in all degree plans, each department's curriculum revision committee should determine whether each of these competencies is appropriate for the specific department. Departments should define these outcomes in discipline-appropriate terms. If a department believes there are other important essential skills, they should identify outcomes for those areas as well. Departments should strive for consistency across the essential skills, department goals, and student learning outcomes.

Finally, for both the critical concepts and essential skills departments should determine the depth of coverage of these requirements. For example, departments should decide if a single course exposure to a concept or skill is sufficient, or if it requires repetitive exposure throughout multiple courses.

1.3 Inventory of Discipline Concepts and Essential Skills

After degree outcomes are identified, the department can complete an inventory of existing course work. The inventory should note which courses cover which outcomes in terms of both discipline concepts and essential skills. Ideally, departments would identify multiple faculty to assist with the inventory of select courses. The faculty lead and the STEM Instruction Consultant can provide materials to assist in the inventory and analysis process. This process should prioritize the central courses of the degree plan that all students are required to take. Optional elective courses can be mapped if time permits.

1.4 Curriculum Mapping

The goal of this process is to identify where in the curriculum students will acquire particular outcomes. The first task is to identify what redundancies and/or gaps exist within the current curriculum. Using the current degree plan(s) for the department, and the curriculum competency identifications from the inventory process, the Department Lead or the curriculum revision committee should determine what essential skills, flags, and content are currently being covered in the degree. Students should be able to satisfy the essential skills, flags, and critical content without supplemental coursework outside of the degree. If a course does not offer an essential skill, flag, or critical content, it should be removed, combined, or revised in a new degree plan.

Current plans should also be considered alongside degree design principals. For example, said principles state that all degrees should include a substantial experiential learning component. A department should specifically address where experiential learning courses can fit within degree requirements and/or where they can be expanded to replace current requirements. It is imperative that degree design principals be intra-curricular and imbedded within degree requirements to serve a broad and inclusive student population. Additionally, departments should assess their prerequisite policies. Prerequisite courses should not impose excessive rigidity on students' degree plans.

If students are expected to achieve a flag or skill through an elective, this should be clearly communicated within the degree plan. For example, if students are expected to meet the Cultural Diversity in the United States flag through one of their electives that is not offered by the degree major coursework, this should be made clear to the students in the degree plan so that students can plan accordingly. Students should not be expected to take courses that simultaneously satisfy multiple flags, as few of these courses are consistently available to students. To ease pressure on students' need to fulfill these flag requirements, departments can aim to broaden offerings of courses that carry flags within the major(s) they offer. Currently there are majors courses that already fulfill or could be easily adapted to fulfill a flag requirement, but the official flag approval for the course has not been pursued. Departments should ensure that faculty apply to have courses flagged where appropriate. While some flags will be easier to fulfill than others, every effort should be made to strengthen the offerings within each department, taking pressure off students to find courses outside the department that qualify. This is particularly true for the Independent Inquiry flag that would be best satisfied by students within the coursework required by their degree.

We strongly recommend that CNS and individual departments think about which existing courses could qualify for the "Ethics and Leadership flag." If no existing courses currently qualify for a given area, we recommend that either the department or CNS offers a general one credit course tentatively titled "Ethics and Professional Development in STEM" to satisfy the mandated training requirements (however, 1/3 of a 3-credit class can also be dedicated to ethics to qualify for the flag). This could be a different course offering for physical science students than for biological science students, as different implications of professional ethics apply in different areas of research.

Another way to expand flag offerings would be to increase the number of SIAD (Scientific Inquiry Across the Disciplines) courses offered. This course, currently taken by FRI students, can fulfill multiple degree requirements while instilling a strong sense of the scientific process and reasoning central to a CNS degree.

The Department Lead and faculty should identify any gaps in current degree plans in content, skills, or flags and consider embedding this content within existing courses. Departments should also identify which currently offered courses are not meeting any of the listed content, skills, or flags and determine if these courses could be substantially revised or removed from the inventory. **If a course does not fulfill a specific departmental goal within the degree sequence, the department should offer the course as an elective, revise the course to meet departmental goals, or remove the course from course offerings.**

The end goal of this work is for each department is to have created degree plan sequences, or maps, for each major option which ensures students will receive experience with all essential skills, flags, and content through the required and/or recommended courses. The amount of change to existing degree plans to achieve this goal will differ widely by department. Completed degree plan maps should be made available publicly via the department website so current and future students and advisors can easily determine what sequence of courses to take. They should also be available to all advisors.

While departments can designate the amount of freedom students can have in fulfilling their degree plan requirements, students in each department should be given a clear outline of which courses are recommended to accomplish each skill. If students have autonomy to select from a variety of courses to satisfy a portion of their degree plan requirements, but these courses are identified as places that students should gain specific flags or skills, students should be explicitly informed which courses will satisfy these requirements.

1.5 Timeline and Supporting Resources

The process of curriculum reform may require new resources to help departments incorporate new skills into the curriculum. Throughout all phases of the curriculum work, the TIDES STEM Instruction Consultants will play a key role in helping faculty implement changes in their particular courses. The consultant working with each department will serve as both a curriculum resource and a project manager. The consultant can also help identify ways to implement changes within existing courses and help with the creation of any new courses necessary to meet departmental goals.

The work of curriculum mapping and reform being done in the various departments should be periodically reviewed by a CNS faculty committee constituted for this purpose. This committee should look at the materials created by the departments as part of the reform process (*e.g.,* curriculum maps, plans for improvement, revised syllabi), make assessments of departmental progress, and (where appropriate and possible) make suggestions for possible improvements. After the process of curriculum reform has been running for some time, the membership of this committee should include faculty who have played leadership roles in this process in their own departments.

While the STEM Instruction Consultants will play a key role in helping faculty make necessary curricular changes through workshops and one-on-one consulting, it will still be a large task for the faculty. The

Department Lead in conjunction with the Department Chair should identify a timeline for completion of the curriculum work and affiliated degree plan updates and any resources that will be required for implementation. Depending on the level of prior degree plan updating, the timeline for this process and the resources to implement changes may vary by department. Many departments have already begun the work of rewriting degree plans to a certain extent, and this progress will be acknowledged and incorporated into this work. For departments who have not already begun the work of organizing degree plans, we anticipate this effort will take one year to complete.

Ultimately, the success of curriculum reform will depend on implementation, and, specifically, on the ability of faculty and their departments to develop and institute educational mechanisms that achieve the skills and knowledge goals set forth in the revised curricula. Meeting these goals will require redesign of some existing courses and development of new courses, but may also involve establishment of programs that are not course-based, such as independent research streams, internship programs, learning assistant programs, or design competitions. The faculty who lead these efforts will need support in various forms, including protected time, staff support, or additional training. Departments may request such support from the dean's office. After a department has completed curriculum redesign, it should submit a proposal to the dean's office identifying the resources needed to support specific implementation-related activities, such the development or redesign of a course. Reasonable requests might include teaching relief or summer salary for a faculty member, support for a graduate assistant, and/or funds for attending a training workshop. Each proposal should clearly identify a specific implementation-related project and describe how it supports the goals of the redesigned curriculum. It is likely that departments will need to undertake multiple such projects and may include multiple requests in a proposal to support these efforts.

Appendix A: Sample Curriculum Map

The following is a template for curriculum mapping. Departments may use this format or choose a different one as long as the map includes all critical concept learning outcomes and essential skills.

Department Course Map Worksheet

Degree plan: ______________________________ Circle: BS BA BSA

Key and Description of Learning Objectives for Checklist

Flags (Code):
Cultural Diversity in the United States (CD)
Ethics & Leadership (EL)
Global Cultures (GC)
Independent Inquiry (II)
Quantitative Reasoning (QR)
Writing (WR)

Each flag must be represented at least one time within each degree plan

Learning Objectives for flags can be found here: https://ugs.utexas.edu/flags/students/about

Flag designations can be found in the course schedule for the current semester

Essential Skills:
Essential skills should be covered multiple times across courses at increasing depth.

Essential Skills (Code)	Student Learning Outcomes
Effective Communication (EC)	a. The ability to formulate and express in writing an evidence-based argument using scholarly sources and a designated style of source citation b. The ability to write clear, concise, stylistically appropriate written reports c. The ability to deliver professional, persuasive, and evidence-based oral presentations d. The ability to use figures and graphs appropriately to support an argument e. The ability to translate scientific research to a broader general audience
Information Literacy (IL)	a. The ability to identify appropriate sources of information. b. The ability to accurately evaluate information sources quality/potential for bias c. The ability to read primary scientific literature d. The ability to interpret and synthesize primary literature into a literature review e. The ability to compare and contrast conflicting findings within the literature

Computational/ Technological Literacy (CTL)	a. The ability to explain and interpret the results of mathematical models/computations in specific settings where context provides meaning including drawing inferences and recognizing sources of error b. The ability to apply different mathematical and statistical methods to make decisions and identify, clarify, or solve real-world problems c. The ability to organize, process, represent, and interpret numerical data using discipline-specific technologies (e.g., scientific instruments, databases, software)
Self-Directed Learning (SDL)	a. The ability to attain a discipline-specific goal (e.g., complete a project, acquire a new skill, learn a new topic) outside of class that requires independence, planning, and minimal supervision b. The ability to design, execute, and present information gained through the learning experience. c. The ability to be persistent and respond productively to mistakes/failure d. The ability to analyze and critically evaluate one's own work to identify limitations and areas for future improvement
Teamwork (TM)	a. The ability to analyze a problem and devise a solution through collaboration in a group b. The ability to plan and coordinate with group for maximal cooperation, efficiency, and effectiveness c. The ability to apply effective conflict management strategies d. The ability to communicate and work effectively with people different from oneself

Departmental Learning Objectives

Table should be filled in by department

Concept	Code	Student Learning Outcomes

Worksheet

Semester																		Count by Objective/Skill
Course																		
Credit Hours																		
Course Name																		
Flags	CD																	
	EL																	
	GC																	
	II																	
	QR																	
	WR																	
Essential Skills	EC																	
	IL																	
	CTL																	
	SDL																	
	TM																	
Learning Objectives (dept specific)																		
Count per course																		

Semester																		Count by Objective/Skill
Course																		
Credit Hours																		
Course Name																		
Flags	CD																	
	EL																	
	GC																	
	II																	
	QR																	
	WR																	
Essential Skills	EC																	
	IL																	
	CTL																	
	SDL																	
	TM																	
Learning Objectives (dept specific)																		
Count per course																		

Appendix B: Core competencies and Student Learning Outcomes Table

Core Competency	Student Learning Outcomes
Concept Knowledge	Specific knowledge relevant to the discipline
Technological and Methodological Literacy	a. The ability to explain and use discipline-specific tools (e.g., scientific instruments, databases, software) for collecting, processing, analyzing, and displaying information b. The ability to apply the processes of science to identify and analyze problems and decisions, explore options and alternatives, solve problems and evaluate outcomes using discipline-specific tools and methodologies c. The ability to formulate research questions/hypotheses, design/ implement projects (e.g., experiments, computations, computer programs), examine evidence, and reach conclusions. d. The ability to identify and use ethical practices in the discipline
Quantitative/Computational Literacy	a. The ability to explain and interpret the results of diverse mathematical models/computations in specific settings where context provides meaning b. The ability to apply different mathematical and statistical methods to make decisions and identify, clarify, or solve real-world problems c. The ability to organize, represent, and interpret numerical data in several ways using discipline-specific software (e.g., graphs, tables, dynamic visualizations) d. The ability to reason with numerical data, including drawing inferences and recognizing sources of error
Information Literacy	a. The ability to define the nature and extent of information needed to solve problems in the discipline b. The ability to access diverse sources of information on STEM-related topics effectively and efficiently. c. The ability to accurately evaluate information source quality/potential for bias d. The ability to understand and critically review discipline-specific primary literature

Effective Communication	a. The ability to formulate and express in writing an evidence-based argument on a STEM-related topic using scholarly sources and a designated style of source citation b. The ability to write clear, concise, professionally-formatted laboratory reports c. The ability to write and deliver professional, persuasive, and evidence-based oral presentations on STEM-related topics d. The ability to use technology to communicate effectively in various settings and contexts
Self-Directed Learning/Habits of Mind	a. The ability to select, manage, and assess one's own learning activities outside of class b. The ability to attain a discipline-specific goal (e.g., complete a project, acquire a new skill, learn a new topic) outside of class that requires independence, planning, and minimal supervision c. The ability to be persistent and respond productively to mistakes/failure d. The ability to analyze, reconsider, and question one's experiences, values, beliefs, and decisions within a broad context of issues and content knowledge
Teamwork	a. The ability to analyze a problem and devise a solution through collaboration in a group b. The ability to apply group processes that affect team cooperation, efficiency, and effectiveness c. The ability to apply effective conflict management strategies d. The ability to communicate and work effectively with people different from oneself

Appendix C: Common Framework