

The Master Course Design Process Explained Using General College Botany as a Case Study

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Abstract: This paper describes the master course design process at the largest institution of higher education in Colorado, USA. The master course design process demonstrated principles of backwards design and employed a team-based approach to course development. The course map was the primary vehicle for communicating the design of the course during development and later for accountability. This case study presented the redesign of General College Botany. The General College Botany curriculum employed authentic assessment and provided an andragogical learning environment. The central authentic assessment in the course was a term-long research project. Other assignments included wiki-building discussions, traditional quizzes, and at-home labs. The accounting of this process and the assignments described for an online science course provide a template for other institutions to follow when considering the implementation of master courses in higher education settings. As botanical curricula continue to be cut from degree programs and the need for remote learning becomes imminent in the modern world, the scaling of educational resources is facilitated by master course design. Master course design promotes accountability and standardization while also affording a well-researched, constructive, and blended learning environment. Evaluative results showed that the master course increased student success and retention in the course.

Keywords: master course, backwards design, botany, andragogy

This paper describes the master course development process at the largest institution of higher education in Colorado, U.S.A. Master courses facilitate the expansion of educational resources with minimal additional inputs as enrollment increases. In a traditional education design, each course is designed by the instructor who will teach it. This takes time and results in variability between sections of the same course. This variability reduces the equitability of the educational experience.

One goal and motivation for master course implementation is the standardization of the educational experience for students. Given ever-increasing enrollments in online higher education, more instructors are required to facilitate many sections of the same course. It is more equitable to employ master courses that equalize the educational experience across all sections of the same course. In the Colorado Community College System (CCCS), courses follow prescribed course competencies associated with the Colorado Common Course Numbering System (CCNS). The CCNS drives the curricular alignment throughout degrees programs. However, at the course level, the educational experience may be highly variable. A master course goes further than adherence to the CCNS. The master course directs the learning outcomes, assessments, instruction, and learning activities. When designed following principles of backwards design, andragogy, and employing authentic assessments, master courses can afford high quality learning experiences.

The master course development of General College Botany (BIO221) in Colorado is the subject of this case study. The accounting of this master course development process is not present in the current literature. The choice of botany as the case study was a strategic move to increase the conversation about declining botanical education in our world. Plants are essential to our survival and to our ability to mitigate climate change impacts. If any reader is trying to implement a master course,

herein lies a description of this master course development process and a sample botany curriculum to employ.

Literature Review

Instructional innovations in botany courses

Today hardly a botany course is listed in the course catalogs of the institutions of higher education across the globe (note international authorship of this literature review). Botany course availability is in decline (Drea, 2011; Nichols, 1919). As a result, there is great concern for botanical literacy (Hershey, 1996; Uno, 2009) and botanical blindness (Wandersee & Schussler, 1999). While disinterest in botany education may stem from its relative inaccessibility, declines in students' botanical interest also may be attributed to the failure of botanical educators and curricula to communicate to students why botany is relevant to their lives and the functioning systems of the planet (Hershey, 1996, Wandersee & Schussler, 1999).

Realizing that student understanding of the dynamic relationships between organisms, environments, and humans was not being served by a traditional lecture model, Zangori and Koontz (2017) reduced lecture time in their upper division undergraduate botany course to make room for student discussions on peer-reviewed literature. This instructional shift intended to infuse a systems perspective into a botany course. Through pre- and post-test analysis, they found that the systems approach revealed the relevance of discreet biological phenomena to each other. Student responses at the end of the semester demonstrated stronger learning outcomes and a departure from an egocentric perspective of plant physiology being facultative only to the well-being of humans.

Goldberg and Ingram (2011) found that a combination of active learning techniques and mini lectures promoted student engagement. It also promoted higher order cognitive learning outcomes. Between two samples of students, one semester with active learning instructional techniques and another semester with lecture alone, end-of-semester exam scores revealed that active learning students demonstrated stronger application of course content. Student responses indicated that they preferred learning activities that required research and creativity (Goldberg and Ingram, 2011).

Lord, Shelly, and Zimmerman (2007) described peer-led team instruction as an example of how inquiry-based, student-centered learning environments encourage scientific literacy. In peer-led team instruction, students present self-chosen topics within the learning outcomes to their peers. Students are responsible for managing an inquiry-based learning activity for their peers.

Zhonghua (2005) questioned the use of traditional behaviorist instructional practices. Instructional transitions towards constructive approaches like the examples explored here shift the learning experience from teacher-centered to student-centered. Zhonghua (2005) discussed how teaching method, specifically teacher-centered surface approaches to instruction correlated with lower quality learning outcomes due to the instructional focus on knowledge transmission rather than skills development in students. In conclusion and to offer a solution, Zhonghua noted alternative student-centered activities, including interactive teaching and learning sessions, discussion-questioning, independent learning tasks, and community activities.

Silva et al. (2016) asked botany students to define what it means “to give classes.” They asked, “how should a course in botany be taught?” Students responded noting that classes should be theoretical followed by practical. The authors related this by describing how teachers are theoretical and students are practical. In this way, the social ecology of the classroom becomes an important dimension in quality instruction and learning outcomes. They concluded that teachers should work with students to understand how teaching should be executed.

With a goal of increasing students' practical skills, Marshall (2016) reported on the use of digital herbaria specimens to increase achievement of learning outcomes. These efforts were meant to increase the multimodal study resources available to students. Marshall concluded that there was a positive and direct relationship between student exam scores and the frequency with which they accessed the digital herbaria specimens in practice quizzes, but it was not clear if this achievement gap was an outcome of student study behaviors or the utility of the tool.

Although the aforementioned authors, and many other scholars, demonstrate a constructive growth mindset regarding the continuous improvement of instruction, Hershey (1996) suggested that research chauvinism might diminish the teaching drive of many higher education faculty. While education theorists have promoted a transition from traditional behaviorist to constructive instructional approaches, no similar transition has occurred to favor teaching efforts among tenure-track faculty who teach and conduct research.

Given the long road of botany decline throughout the 20th and into the 21st centuries, we need a new approach for providing quality botanical education. Even in an institutional and cultural climate that does not favor botany, quality botany instruction and curricula can be offered. In this paper, I describe the master course design process for general college botany at a regional community college system. By establishing a constructive, student-centered approach that is deliverable to the masses, master course development can potentially bolster declines in botanical education and increase students' practical skills in and motivation for botany.

Master Course Design

In the era of mass education, and considering the modern standards-based educational movement, a master course design strategy in academic contexts facilitates quality education opportunities for large numbers of students (Franetovic & Bush, 2013). Master course implementation ensures reliability and repeatability in the learning experience (Franetovic & Bush, 2003). Master course development follows principles of a backwards design (Wiggins & Mctighe, 2005). Backwards design is now popular in course design at all academic levels. Educators use the backwards design process to 1) identify learning outcomes that will provide a foundation for the next course level, 2) design assessments to measure student attainment of these learning outcomes, and 3) create an instructional framework to facilitate student achievement of these learning outcomes (Wiggins & Mctighe, 2005).

Course learning outcomes can map college courses to degree schedules. When developing learning outcomes, educators seek to describe the knowledge a graduate might gain throughout the degree program (Cydis et al., 2015). From this guiding perspective of the learning outcomes, the course map iterates the instructional and evaluative plan for a course. A collection of course maps within a degree program illustrates how students will achieve the knowledge implied by the degree.

The utility of course design frameworks has been tested in case study contexts (Davis, 2018; Swan et al., 2012). Davis (2018) studied student learning outcomes before and after master course implementation. This research indicated that master courses have the potential to increase student success rates, although the results were not statistically significant in two of three courses investigated. Swan et al. (2012) found that using the Quality Matters (QM) framework (described below) improved student learning outcomes. Despite the increasing prevalence of backwards design and master courses in higher education, characterization of the master course design process itself is not readily available in the current literature (Jacoby, 2017).

Case Study: Colorado Community Colleges Online

The Colorado Community College System (CCCS) is the largest system of higher education in Colorado, serving 144,000 students annually at 13 colleges. The CCCS is governed by the State Board for Community Colleges and Occupational Education (SBCCOE). The CCCS vision is “that Colorado community colleges are unsurpassed at providing quality educational opportunities for all who aspire to enrich their lives” (“About CCCS,” 2016). Colorado Community Colleges Online (CCCOOnline) was created in 1998 to serve students with online education opportunities. In 2012, annual enrollment was 50,000 in 230 courses (“CCCO Strategic Plan,” 2013/2014). The CCCOnline courses are transcribed by the student’s home college within the CCCS. Each home college within the CCCS is independently accredited by the Higher Learning Commission.

The CCCS serves 40% of all Colorado resident undergraduates and 48% of all undergraduate students of color in Colorado. Thirty-five percent of CCCS students are students of color, 55% are female, and 56% are under 25 years old. On average, student wage potential increases by 17% after a student attends CCCS, even without attaining a degree. Tuition costs are approximately \$3,900 per year. The CCCS’s total economic impact is \$3.01 billion annually, or equivalent to 55,800 jobs created (“CCCS Fact Sheet,” 2016).

An overarching goal for the CCCOnline’s course development is to have 100% of CCCOnline courses Quality Matters certified. Quality Matters (QM) is an international organization that provides guidance to higher education and K-12 institutions to ensure quality in online education. The QM certification uses a faculty-centered, peer-review process for course design. With 900 institutional subscribers, QM is recognized as the leading quality assurance organization for online education (“Quality Matters,” 2016). All CCCOnline administrative leaders and many faculty members have participated in Quality Matters training, and some are certified peer-reviewers.

The QM program is similar to the Higher Learning Commission’s Academic Quality Improvement Program (AQIP), which is described as an accreditation program in which reviewers “act more like consultants than gatekeepers” (Cullen et al., 2012, p. 86). The rubrics employed in the QM process provide important guidance for the CCCOnline master course template discussed later in this paper. In addition to the courses being certified by Quality Matters, numerous CCCOnline courses have won national merit awards (“CCCO Strategic Plan,” 2013/2014).

Most of the courses offered are guaranteed transfer (GT) courses. To identify GT courses, the CCCS provides a title for a course, the credit hours, the course description, and the course competencies (“CCCS,” 2016). GT courses are guaranteed to transfer to any institution of higher education in Colorado. The GT transfer program illustrates how backwards design is inherent to modern higher education planning and development. By standardizing the learning outcomes in lower division courses, students can move between institutions and continue to succeed in their associate- and baccalaureate- level degree programs.

Methodology

Given that instructors may lack the skills to develop a quality online learning experience (Allen & Seaman, 2016), the master course design process employed a systems approach in which a team of professionals with varying skills worked together to build a course following principles of modern education theory. Puzziferro and Shelton (2014) and Chao et al. (2010) emphasized the importance of a team-based approach because the skills required to design and implement online courses are inherent to different professional credentials. The team included a subject matter expert (SME), an instructional designer (ID), and the program chair (PC). The SME had the biological knowledge to construct a logical and engaging instructional sequence while the ID had the technological and design skills

required to build an online course. The PC oversaw all the courses within the life science department and could therefore assess the alignment of the course map with the whole biology degree program. The PC also had leadership training and specific knowledge of the administrative culture of the institution.

Regarding training and professional experience required for the master course process, the SME is usually a professor who already teaches courses in the discipline. All educators in higher education hold a terminal degree in their discipline. In preparation for the master course design, the SME completed a self-scheduled, asynchronous orientation, in which the course development process was described and the roles for each of the team members were defined.

The IDs held terminal degrees related to instructional design and information technology. The IDs designed courses for every discipline. The ID selected for a particular course design was a matter of availability, not one of differentiated skill. This cross-discipline strategy created design continuity in the student learning experience across degree programs. All IDs were trained to build courses according to the master course template, which was based on the quality criteria outlined by QM.

Backwards Design and the Course Map

The backwards design process involved identification or development of the course competencies and learning outcomes, followed by the design of the assessments. The final step involves designing the instructional environment and learning activities. This process makes the learning outcomes transparent for the students and their future employers and educators (Villarroel et al., 2018; Wiggins & Mctighe, 2005). Implementing the concept of backward design has been important to standardization and accountability within the CCCS and within the Colorado higher education system. It guarantees that the learning activities promote knowledge attainment in the CCNS-specified course competencies. The alignment identified through backward design ensured that a course provided a specific learning experience that could be sequenced into a degree, career, or technical education program. The course competencies for General College Botany are noted in Table 1 alongside the numbers used in the Colorado Common Course Numbering System (2016). After the SME reviewed the course competencies, she developed the course map for Module 1 (Table 2).

Table 1. The Colorado Common Course Numbering System (CCNS) for course competencies of General College Botany.

CCNS #	Course Competency
1	Describe terminology, experimental methodologies, and general concepts related to botany.
2	Analyze scientific sources.
3	Apply basic concepts in botany in new contexts.
4	Analyze the role of botanical research and its impact on society.
5	Demonstrate proficiency in common laboratory techniques used in botany, including but not limited to microscopy, dissection, specimen identification and use botanical keys, etc.
6	Employ the scientific method to investigate questions in botany.
7	Convert quantitative and qualitative data into a variety of formats including graphs, tables, charts, and illustrations.
8	Interpret data from a variety of formats, including graphs, tables, charts, and illustration.

9	Communicate scientific information clearly and logically, in oral presentations and in writing.
10	Describe the biochemistry, cellular structure, morphology, and physiology of plants.
11	Explain the development and evolution of plants through geologic time.
12	Explain the role of plants in the environment and the impact on humans.
13	Examine contemporary theories of plant evolution.

Table 2. The course map for module one.

Element	Module 1: Two course weeks
Module Outcomes	Learning outcomes mapped to corresponding competency (noted here numerically in parentheses, see Table 1 for detail) Recognize that plants play a central role in global biological processes as primary producers (1) Recall the steps of the scientific method. (6) Design a botanical experiment according to the principles of the scientific method. (1) Label all the common structures of a plant. (1) List commonalities among all living organisms. (1) Demonstrate a working knowledge of academic integrity and experimental design. (8)
Topics	Scientific process; nature of life; general biology of plants
Reading	Chapters 1-2
Exploration concepts	Explore the scientific process Review the attributes of living organisms Introduce the world of plant biology
Lab concepts (F)	Review of botanical structures and experimental design
Assignment #1 (F)	Adaptive learning assignment in textbook
Discussion #1 (F)	Student introductions; academic integrity
Discussion #2 (F)	Scientific method and experimental design
Final paper (S)	Introduce final research paper including a preview of learning outcomes for the course Identify topic, provide three reference citations for possible use in final project
Exam/quiz (S)	Module quiz

Evidence of backwards design can be seen in the module 1 course map depicted in Table 2. The numeric parenthetical notation following the module outcomes map the structure of the module to the course competencies. This process ensured that the learning activities designed for the course promoted student attainment of those education goals expressed in the CCNS for General College Botany (BIO221). Each of the modules addressed specific CCNS course competencies, instead of following a sequence of learning objectives presented in a primary text for a course. In this way, once designed, the instructor may use any text with the master course.

Once the SME mapped the course competencies to each module, the SME wrote learning outcomes that aligned to the competencies and the specific activities within the course. For example, the course competency “employ the scientific method to investigate questions in botany” was addressed in module 1 with the learning outcome “recall the steps of the scientific method.” Each competency appeared at least once in the course, and some were repeated in numerous modules.

The course map included estimated learning time calculations for each course event, whether it was instructional time, reading time, learning activities, lab, or assessments. Learning time, historically referred to as seat time, is a concept that is waning in popularity (Cullen et al., 2012). However, it still plays an important accounting role, as it equates to the credit hours assigned to each course. Learning time calculations provide accountability and standardization for students who are planning their academic time.

The master course development team’s kick-off meeting played a role in the formative assessment of the SME’s development of the course map. The development of the course map was the first proof that the SME could conceptualize the course design. If the ID and PC on the team found that the SME did not develop the course map to meet the master course standards, additional mentoring would have ensued until the SME finalized the course map, and the entire team confirmed the course map as the design blueprint for the master course.

Master Course Development Process

Once the team approved of the course map, they began the development of the master course. The SME designed the assessments first, then the instructional materials, and finally, the learning activities for each module. After designing each component, the team communicated via email, phone, or virtual meeting space. The ID and PC reviewed the work of the SME to ensure that it followed the course map.

With the course map guiding the process, the SME developed the modules in text documents. The team reviewed the module documents before each was built in the Learning Management System (LMS). The LMS is a digital platform through which academic courses are hosted. Once the ID built each module in the LMS, the SME and PC reviewed the design work of the ID to ensure that all learning objects followed the course map, contained no content errors, and met QM standards.

As a final step, the SME and PC conducted a review of the entire course in the LMS. Upon acceptance of the final review, the SME taught one pilot section of the master course in the subsequent semester. Once assuming the faculty role, neither the SME nor other faculty were permitted to change the contents of the master course. Any master course modifications that arose in future semesters were handled through written request to the ID team. These modifications were then reviewed and either implemented or denied. Instructors could not request modifications to their course sections only as that would negate the logic of the master course, one rationale for which is the equitability in standardization.

Regarding the change management process, the master course was curated in the Learning Management System (LMS). Each semester, one instructor set the dates for the current term. From this term master course, every instructor’s course was duplicated. With this template, instructors added any instructional materials they authored including instructional essays and videos, announcements, discussion posts, and grading comments. When an error in the master course was detected, the instructor submitted an Instructional Technology (IT) help ticket. IT corrected the error in all the duplicated shells and in the master course.

Results and Discussion

The success of the master course implementation was evaluated by comparing pass rates and withdrawal rates for the seven semesters before the course redesign and for the two semesters after the redesign. A Pearson chi-square test is a statistical tool to determine whether a statistical relationship exists between two categorical variables. Following the methods of Davis (2018), who also considered pre-master course and post-master course student success rates, a chi-square test (SPSS, 2015) calculated whether the master course was related to student success or course completion rates.

These data tell a compelling story. The pass rates were higher after master course implementation. The course withdrawal rates were lower. The average enrollment per course increased by 27%. Despite a decreased instructor-student ratio, more students completed the course, and they achieved greater success after the redevelopment effort. These results were statistically significant.

The master course students had significantly higher pass rates (73.2%) as compared to students before master course implementation (54.2%). Students were more likely to pass the master course $X^2 (1, N = 187) = 5.905, p = .0029$. The master course students also were more likely to stay enrolled in the course $X^2 (1, N = 187) = 4.145, p = .046$. Fewer master course students (10.7%) withdrew from the course as compared to 23.7% of students in the course before master course implementation. These data suggest that the redesign was successful in terms of facilitating student learning and encouraging course completion (Figure 1).

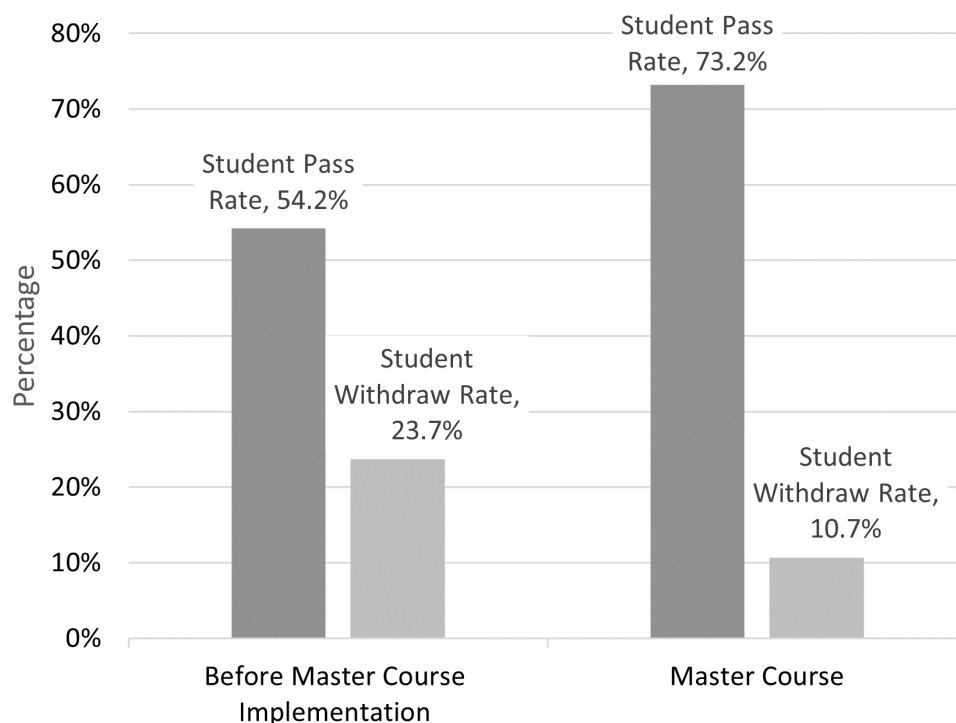


Figure 1. Student data before and after master course development. More students completed ($X^2 (1, N = 187) = 4.145, p = .046$) and passed ($X^2 (1, N = 187) = 5.905, p = .0029$) the master course than before the master course implementation.

In future investigations, assessing the grade point averages of students might shed more details on student success. Looking at the detailed grade point average would indicate student success in different assignment types. This could create evidence to fuel continuous course improvement. Administering a pre- and post-course surveys that query student interests and motivations around the topic might shed some light on how the course facilitated learning, in the perspectives of the students.

Authentic Assessment

Assessment of learning gains leads the backwards design process, but the credibility of web-based assessments is challenging to manage in asynchronous learning environments. Before the master course implementation, the course relied heavily on traditional assessment methods, like closed response quizzes. In this and other courses, issues of integrity were raised. Virtually any test question written by a textbook publisher can be offered as practice quizzes on the Internet on instructors' webpages and on websites like Quizlet ("Quizlet," 2016). This is a concern for the accountability of traditional multiple-choice assessments. Without direct supervision, it is impossible to know if a student used resources to complete the assessment. Furthermore, scholars argue that traditional assessments measure only information recall and lack the capacity to measure a student's ability to use the information gained in the learning experience (Wiggins, 1990; Zhonghua, 2005).

In the online environment, authentic assessment offers student-authored assessment that alleviate cheating concerns and engage students in self-directed learning. Authentic assessments require students to employ new knowledge. Authentic assessments might involve procedural task completion. They may also involve learning demonstrations, for example, the evaluation of information, novel writing tasks, and tests of validity (Villarroel et al., 2018; Wiggins, 1990; Zhonghua, 2005). Authentic assessments require a transformation of knowledge, which is a step beyond tests of recall (Herrington et al., 2014; Villarroel, 2018). Instead of simply identifying and recalling the learned knowledge, the knowledge must be applied to novel contexts. In blended learning contexts, authentic assessment provides authoring opportunities that increase student engagement and validate student identity. Authentic assessments can provide artifacts of student achievement that demonstrate student knowledge in contexts applicable beyond the classroom. They can demonstrate student performance in simulated professional tasks, critical thinking, judgment, and innovation in the field of study to future educators and employers (Herrington et al., 2014).

The major authentic assessment for General College Botany was a final research project. Students explored any topic of professional or personal interest within the parameters of the course learning outcomes. Intentional dialogue about the learning outcomes of a course lead to student awareness, utility, and reflection of the learning experience (Cydis et al., 2015). The entire process modeled thesis writing or peer-reviewed literature writing. Biology majors may become practicing scientists who will engage in research, produce a thesis or dissertation, and publish peer-reviewed articles. Modeling this process while addressing the knowledge base of the course learning outcomes afforded students the opportunity to explore the rigor required to pursue a degree and career in the biological sciences.

Andragogy

In addition to meeting the tenets of authentic assessment, the final project met the principles of andragogy, or adult learning. Adult learners have many tasks to pursue in life and limited time to enact learning experiences. Being able to choose a topic within the learning outcomes framework affords the opportunity for intrinsic motivation. Adult learners bring prior knowledge to learning tasks which they should be encouraged to employ, and they like to gain practical knowledge that can be applied to

solve real-world problems (Merrill, 2002). Therefore, learning experiences must reflect the life goals of students (Knowles et al., 2011). The final research paper appeared to meet the motivational needs of adult learners by providing them with the opportunity to explore the botanical sub-context of their own interest (Hershey, 1996; Wandersee & Schussler, 1999).

Cognitive Development Through Social Engagement

Learning involves social, cognitive, and emotional development (Bangert, 2008). A community of inquiry in a text-based learning environment involves three interdependent components: social, cognitive, and teaching presence (Garrison et al., 2000). Collaboration enhances learning by engaging participants in a meaningful discourse and reflection about their mutual learning goals. The final research project had several checkpoint assignments throughout the semester to facilitate growth in research and writing through a community-based framework (Table 3). These included collaborative assignments in which students practiced their research and writing skills and shared them with their peers to solicit feedback. The checkpoint assignments also included written assignments submitted to the instructor who provided individualized feedback for improvement. This collaborative framework fostered critical thinking through self-reflection and interactive discourse (Garrison et al., 2010).

Table 3. Final research paper authentic assessment assignments model the process of scientific research.

Assignment Type <i>F - formative</i> <i>S – summative</i>	Brief description of the assignment	Estimated learning time (hours)	CCNS #
Module 1: Discussion #2 (F)	Scientific method and experimental design	3	3, 6
Module 1: Project (F)	Intro to final research project; Identify topic; provide three reference citations for possible use	2	2, 6
Module 2: Discussion #2 (F)	Introduction to peer-reviewed literature; Submit one reference and annotation for final paper; propose a tentative topic	3	2, 6
Module 2: Project (F)	Annotated bibliography including five total references, three of which include annotations State topic and competency met by topic; Instructor provides feedback on topic selection and reference formatting	3	2, 6
Module 3: Project (F)	Research paper outline; Detailed instructor feedback provided	3	6
Module 4: Project (F)	First draft of research paper; Detailed instructor feedback provided	10	1, 2, 3, 4, 6, 9

Module 5: Discussion #2 (S)	Present your final paper topic in summary; Post the abstract, the reference list, and at least one relevant image for the final research topic; students review each other's work	3	6, 9
Module 5: Final Research Project (S)	Final draft of research paper	4	1, 2, 3, 4, 6, 9

In some modules, the discussion facilitated the written assignments. For example, in Module 2, students shared one citation and annotation in discussion. Then, by the end of the week, they submitted three annotations to the instructor as their written assignment for the module. The feedback students received in discussion helped them to achieve full credit in the written assignment.

In other modules, students worked directly with the instructor to achieve continuous improvement. The students submitted a total of five assignments, including citations, an annotated bibliography, an outline, a first draft and then a final draft. Along the way, the instructor and the student discussed the project, which facilitated both academic growth and their interpersonal relationship. Through repeated feedback and dialogue on these related assignments contributing to the final project, students were able to invest themselves in continuous improvement and thus engage a growth mindset. Most students who completed the five assignments achieved full credit on the final drafts of their papers. Sachar (2020) reported similar conclusions indicating that feedback, revision, and an emphasis on self-improvement led to writing achievement among students.

Other Assessments, the Lecture Content, and Learning Activities

In addition to the final research paper, there were several other recurring activities in the botany course. The online discussion is currently favored as the primary surrogate for attending class (Palloff & Pratt, 2013). Online discussions are typically one to two weeks long. The discussion prompts in the online discussions guided students in writing their *original post*, which is their authentic contribution to the discourse. Students could participate in discussion 24 hours per day, within the specified assignment due dates. The exceptions to these gated discussions were ungraded, open forums in which students could ask questions and/or share social messages throughout the semester. Open forums had no deadlines and no points. There were two discussions associated with each module. It is typical for the first discussion in the first module of an online course to be a student-introduction discussion. Introductory discussions build community among the students and the instructor of the course. This first discussion created a bridge to facilitate social and cognitive development.

One challenge of the online classroom is that it may leave students feeling lonely if there is not an intentional effort by the instructor to encourage social interaction (Palloff & Pratt, 2013). Therefore, it is important that the instructor imparts a sense of caring and open communication that can then be modeled by the students in the community. An exemplary instructional strategy involves instructor response to every single student introduction post. In subsequent discussions, the instructor participates daily but may not respond to every student.

The second discussion of Module 1 was associated with the final research paper project described above. Students reviewed the learning outcomes and identified potential topics for their research. By sharing their thoughts on final paper topics, they continued to get to know each other and found allies in the course who were pursuing similar degrees and/or interests. This fostered

professional networking and social interaction. Later in the semester, students with similar paper topics chose to review each other's work. Alternatively, students chose to review the work of students pursuing different topics to expand their own knowledge of botany.

Subsequent modules had one collaborative wiki-building discussion crafted around the learning outcomes, and one discussion that addressed a component of the final paper. The development of wikis is an emerging concept in education built upon constructivist principles of learning. A wiki resource is a knowledge base to which all community members contribute.

"Knowledge is no longer acquired in a linear manner. We can no longer personally experience and acquire all the learning that we need in order to act. We must derive our competence from forming connections with other people. Blogs and wikis are ideal tools for this and what we see in these tools are examples of networks of growing knowledge and understanding" (Rennie & Morrison, 2008, p. 11).

In addition to a wiki discussion, each module had a second discussion that supported the final project above (Table 3). In these discussions, students shared references, reviewed each other's writing, and shared conclusions and images that described their research. Students could choose wiki topics that also supported the knowledge development required for their research efforts when the learning outcomes for the module intersected with the learning outcome chosen for their final projects.

General college botany had one lab credit. Students performed at-home laboratory experiments using lab kits mailed to their homes. These labs were analogous to the labs conducted in the face-to-face classroom. The kits contained the supplies needed to safely perform the labs at home. There was one rubric for all lab assignments that provided an evaluative framework for lab reporting. Students followed the lab procedures, collected data, answered questions, and reported the results in a common template built from the rubric criteria. Students synthesized these lab experiences in written lab reports that included photographs to authenticate their work process. The lab component facilitated practical learning, a student-identified important component of all botany courses (Silva et al., 2016)

Conclusion

This paper described the master course development process for a general college botany course. The master course design process employed backwards design and involved a team-based approach. Authentic assessment and andragogy were the guiding theoretical scaffolds for the course design itself. The case study of General College Botany illustrated how a master course can provide an authentic, constructive adult learning experience that promotes accountability through standardization. Evaluative results showed that the master course increased student success and retention in the course. Master courses in botany have the potential to enhance botanical literacy in the modern world.

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