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Instruction is Contextual: An Examination of McNair Programs for STEM Scholars and Recommendations for Curricula Based on the *Framework for Information Literacy in Higher Education*

Abstract

The Ronald E. McNair Postbaccalaureate Achievement awards help prepare high achieving but economically disadvantaged and underrepresented minority students for graduate research. This paper discusses the results of a survey of the 2016-2017 institutional recipients of these awards, about curricula and pedagogy employed in their program's research course, especially elements specifically created to assist students in Science, Technology, Engineering and Math (STEM) fields. This paper also reviews librarian-led instruction for McNair scholars in STEM at Rutgers University during 2016 and 2017, designed using the Framework for Information Literacy in Higher Education, that explores the disciplinary as well as societal, ethical, and financial contexts of research that are relevant to McNair scholars.

Introduction

The new *Framework for Information Literacy* provides an opportunity for academic librarians to broaden the scope of their instruction; to collaborate more closely with faculty, and to incorporate important disciplinary and social contexts of research. At the same time as the adoption of the Framework in January of 2016, the author was invited by Rutgers University's Ronald E. McNair Postbaccalaureate Achievement Program (McNair program) to assist with curriculum design and teaching of their Science, Technology, Engineering, and Mathematics (STEM) students in their Summer Institute's research course. This was a credit-bearing class, during which the students in were in residence, and were also working intensively with faculty mentors, graduate student mentors, the Writing Center, and McNair Program administrators. The students in this course all produced a 15 to 20 page research paper or proposal, with most of them participating in their faculty mentor's current research. In 2016, changes were made such that the Rutgers Instructional Design Librarian and the author (the Chemistry and Physics Librarian) were now responsible for redesigning the curriculum, as well as the full time instruction of students in this class. This provided an opportunity to strengthen the program instruction for STEM students through the use of the Framework. The instruction was supplemented with lectures from invited librarian colleagues who shared their expertise in citation management tools, research reproducibility, open access, and copyright. This paper, however, will not attempt to describe the entire research course, but it will outline curricular additions that the author created specifically for the STEM students, as they relate to the Association for College and Research Libraries (ACRL) *Framework for Information Literacy in Higher Education*.

While developing additions to the curriculum for the STEM students, the author sought to determine what other McNair programs were doing to address the different disciplinary requirements of STEM research. A literature review revealed that most of the existing research about the McNair program consists mainly of cases studies focused on the perceptions of graduate student satisfaction. Little information was found describing programs for STEM students, or about the efforts of librarians within the program. This led to the development of a survey of the recent institutional McNair grantees, in order to get a better picture of STEM curricula within McNair programs, and science librarian participation in these programs. Before delving into the literature and survey specifics, however, a brief description of the McNair program follows.

The Ronald E. McNair Postbaccalaureate Achievement Program

The Ronald E. McNair Postbaccalaureate Achievement Program was created in 1986, and was named in memory of McNair, an accomplished Black physicist and astronaut, who died in the explosion of the space shuttle *Challenger* in January of that year (NASA 2017). The McNair program is part of the United States Department of Education's TRIO Programs, formed in 1964 as a result of the federal Economic Opportunity Act. TRIO was originally comprised of three programs- Upward Bound, Talent Search, and

Student Support Services- which were initiated in 1964 through 1968. Since then TRIO has grown to include eight programs in total, that are intended to benefit promising students from "disadvantaged backgrounds" (US Department of Education 2017a).

The aim of the McNair program is to increase the numbers of high achieving minority students in graduate school, ultimately resulting in the attainment of a doctoral degree (Seburn, Chan, and Kirshstein 2005, 1). In order to be eligible for the program, students must be first generation college students and economically disadvantaged, and/or from a minority population that is typically underrepresented in graduate programs (Seburn, Chan, and Kirshstein 2005, 2). Through a competitive grant application process, institutions of higher education are awarded funding to provide programming that will prepare these students for graduate school (US Department of Education 2017b).

The Ronald E. McNair Postbaccalaureate Achievement Program has been a federally funded grant initiative for just over 30 years now. In that time, it has assisted over 97,000 high achieving students from populations that are traditionally underrepresented in academia, in the pursuit of graduate education (Seburn, Chan, and Kirshstein 2005, 3; U.S. Department of Education 2017c). Clearly this program is sorely needed, because as of 2015, of full time faculty at US degree granting institutions, only "six percent were Asian/Pacific Islander males, four percent were Asian/Pacific Islander females, three percent each were Black females and Black males, and two percent each were Hispanic males and Hispanic females" (NCES 2017). This disparity is especially apparent in science and engineering, where there are even smaller percentages of most minority doctorate holders in these fields (NSF 2017). It is all the more necessary, therefore, to ensure that McNair scholars, especially those in STEM fields, are fully prepared to conduct research. Following is a review of the literature reporting on the outcomes of McNair programs to this end.

Literature Review

Although there is a body of research concerning the McNair program, it is smaller than one would expect given the length of time it has been in existence. A review of the literature reveals that most of the research consists of case studies at institutions funded for McNair programs, and has focused on student perceptions of the effectiveness of the program in preparation for graduate school. Three studies addressed the assessment of the McNair program from the perspective of STEM majors, and two of these found that the opportunity to conduct research and the guidance of a faculty mentor in their fields were key to graduate success (Fifolt, Engler, and Abbott 2014; Lam, et al. 2003). A small longitudinal study published in 2016 assesses the success of former McNair scholars in STEM as graduate students, and finds that although the McNair program generally prepares these students for graduate school, achievement of a doctorate may be hampered by larger societal issues such as bias and stereotype threat (Bancroft, Benson, and Johnson-Whitt, 15).

While not focused specifically on STEM students, other studies acknowledged that discipline-specific content and differences between STEM and non-STEM fields of research needed to be addressed by the McNair programs at their institutions (Vaughan 2017, 24; Willison and Gibson 2011, 160). Additionally, a small case study by Posselt and Black (2012) utilizing a social theory framework finds that by helping first generation students to assimilate disciplinary norms, the McNair program increases students' chances of success in graduate school.

The experience of conducting research within a discipline and the guidance of a faculty mentor were pointed to repeatedly as key determinants of enrollment in graduate school, both for McNair programs and for other formal undergraduate research experiences (Bauer and Bennett 2003; Fifolt, Engler, and Abbott 2014; Grimmett, Bliss, and Davis 1998; Lam, et al. 2003; Thomas 1994). Seymour et al. (2004) did a thorough review of the literature pertaining to undergraduate research programs, in preparation for their study of science students' participation in undergraduate research at four liberal arts colleges. Although they note some deficiencies in much of the research described in the literature, they conclude that most studies are nonetheless beneficial to faculty participating in undergraduate research programs, because faculty tend to trust accounts of experiences from their peers (497). In their own study of undergraduate research, Seymour et al. report that students were "overwhelmingly positive" about the research experience, and derived benefits such as "'thinking and working like a scientist'… and clarification/confirmation of career plans including graduate school" (493). These findings appear to corroborate the studies about McNair programs. However, the authors also find that although undergraduate researchers gain confidence in their abilities, their research experiences sometimes fail to develop "…a better understanding of how to approach a research issue in different ways; how to work from the relevant literature to identify, choose, draft, and refine new research questions; and how to develop methods and procedures to address those questions…" (Seymour, et al. 2004, 513-514). As librarians routinely help students with these very issues, it leads one to question the extent of librarian involvement in these programs.

Reports of librarian involvement in undergraduate research programs, including McNair, have been limited. Two essays by academic librarians relate efforts at mentoring McNair students, and although they don't mention STEM students specifically, they acknowledge disciplinary differences being addressed by subject specialists (Riley and Wales 1997, 8; Scripa et al. 2012, 10). Stamatoplos (2009) proffers that the lack of librarian involvement in undergraduate research programs may be due to the existence of these programs outside of regular undergraduate curricula. He states, "Undergraduate research programs and evaluative studies frequently note the value of independent faculty-mentored research in learning the use of information skills and resources within a discipline. Explicit mention of libraries and information professionals, however, is virtually absent" (239), and he calls upon academic librarians to become more involved in mentor-guided undergraduate research (245).

Survey Methodology

Because of the lack of librarian involvement being reported in the literature on McNair programs, the survey was designed to determine not only the types of resources and methods being used to teach STEM students in a research course, but to also find out what kinds of disciplinary faculty, including librarians, were instructing them. The survey sought input in four main areas: cohort numbers (three questions); curricula and pedagogy (six questions); types of instructors employed (three questions); and program assessment (two questions). An additional two questions allowed respondents to provide contact information and other comments. Please see Appendix A for survey questions.

The survey was open to the 151 institutional recipients of the McNair Postbaccalaureate Achievement Awards from the 2016-2017 academic year (US Department of Education 2017c), and asked questions about the most recent cohort of McNair scholars in a research course. The survey was conducted through the author's institutional subscription to Qualtrics. The survey consisted of 16 questions, although participants may not have seen every question, due to branch logic. Upon obtaining Institutional Review Board approval, the survey was distributed in October of 2017, and remained open for responses for three weeks; this was after the conclusion in June of the final year of the previous three-year grant award.

The survey was distributed by e-mail to the 151 institutional recipients of McNair Program awards for the 2016-2017 academic year. The e-mail was addressed to the McNair program administrator or director, or when this information was not available online, to a generic McNair or TRIO e-mail address for the institution. Weekly reminders were sent to encourage participation. Responses were anonymous, but allowed respondents to opt-in to being quoted by providing their contact information. Of the possible 151 responses, there were 25 completed surveys, once partial results were removed. One possible reason for the low response rate may have been that the McNair program personnel responsible for the previous year's instruction were no longer at the institution; this was found to be the case in several instances when e-mails were returned. Other possibilities are that the program did not offer a research focused course, that the cohort had few or no STEM students and the administrators felt that the survey was not relevant to them, or it may be possible that grantees felt that sharing their program details might give others a competitive advantage in upcoming grant proposals. Adjustments for nonresponse were not made due to the anonymous nature of the survey, and the limited number of participants who self-identified. Although this sample cannot be considered representative of this cohort, useful information was gleaned from the responses gathered, which may be helpful to those seeking to develop a curriculum or improve their offerings for a McNair program or other research course.

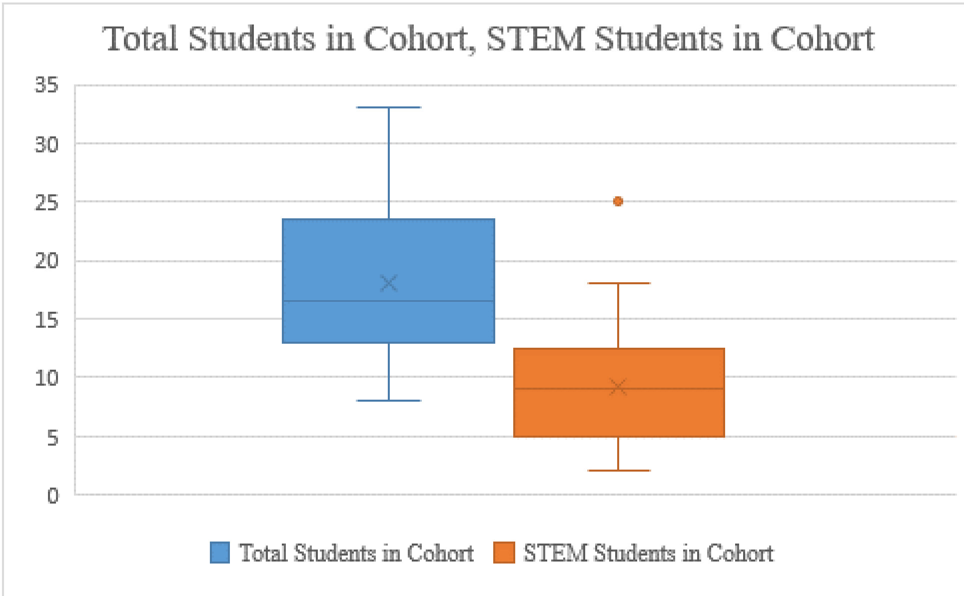
Analysis of Results

Cohort

Survey participants were asked for the number of students in their most recent cohort, as well as the number of students in that cohort with STEM majors. Twenty-two of the participants answered the cohort question, or 14.5% of the total number of grantees; and 25 (16.6% of grantees) answered the question about STEM student numbers. The size of the cohorts ranged from eight students to 33; the average cohort size was 18, the median was 16.5, and the mode was 13.

There were two instances of an entirely STEM cohort, these cohorts numbered 13 and 25. The number of STEM students in a cohort ranged from 2 to 25, the mean, median, and mode were 9. STEM students made up 50% of the cohorts on average. A box-whisker plot of summary statistics is provided in Figure 1.

Figure 1. Numbers of Total Students and STEM Students in Cohort



Informational Resources

When asked about reading materials, all of the 25 respondents indicated that students were provided with reading materials such as textbooks or articles as part of their McNair research course. Responses showed that there was an almost equal number of programs providing reading materials that included some content addressing STEM subjects, as there were programs providing materials without STEM content. Two of the programs, in addition to the two all-STEM cohorts, indicated that STEM students were provided with completely different reading materials than their non-STEM counterparts.

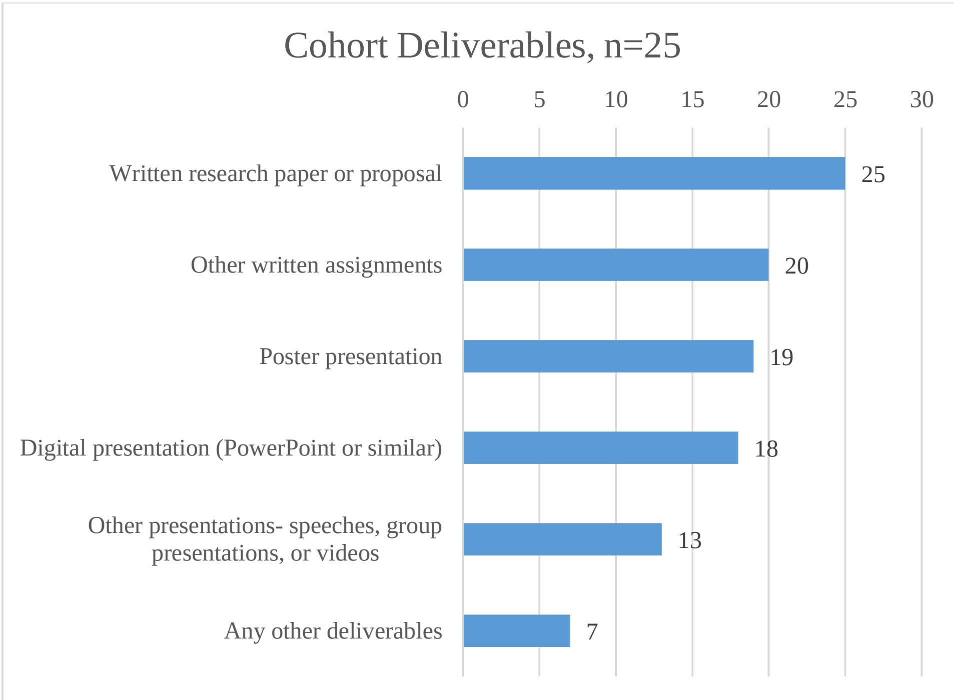
Only two respondents provided information about the reading materials given to their STEM students. Nevertheless, these examples were well-chosen resources. These STEM-specific resources included "The Whitesides Lab" case study; *Mathematics Into Type* by the American Mathematical Society; the *Scientific Style and Format Manual*; *On Being a Scientist: A Guide to Responsible Conduct in Research*; and the article "Teaching Scientific Ethics Using the Example of Hendrik Schon".

Deliverables

Information was sought about the kinds of deliverables required by all McNair scholars, as well any that may have been required of STEM students only. All 25 of the respondents indicated that a research paper or proposal was compulsory for their research course. There were four responses that indicated that different deliverables were required of their STEM students, however on closer examination of text responses, only one of these was a deliverable, a scientific poster. The other differences included continued work in a lab with their mentor after the end of the research course; and attendance at a special STEM seminar series.

There were 25 responses to the follow-up question about other types of deliverables, in addition to the research paper. Possible choices were: a written research paper or proposal; other written assignments; a poster presentation; a digital presentation such as a PowerPoint; other presentations such as speeches, group presentations, or videos; and any other deliverables. A summary of deliverables is shown in Figure 2. Respondents were also given the opportunity to describe other deliverables required by their students. The most frequently occurring written deliverable, in addition to the research paper, was a personal statement, required by six of the study programs. The second most common deliverables were literature reviews and annotated bibliographies, occurring five times each. Required by four of the study participants' programs were research proposal segments, curriculum vitae, reflective writing, and short essays. Other deliverables were digital portfolios, Institutional Review Board documents or grant proposals, abstracts, outlines, and a synthesis matrix.

Figure 2. Types of Deliverables Required by all Students



Instruction

Study participants were asked if any instruction was provided exclusively for STEM students. Possible responses were that all students received the same instruction; different instruction was provided for STEM students; and that the cohort was all or mostly STEM students. Nearly two-thirds (16) reported that all students received the same instruction, but six programs indicated that STEM students received some different instruction, with an additional three programs that were made up of all or mostly STEM students.

The six respondents who indicated that STEM students received different kinds of instruction cited special seminars and workshops, information about grant proposals and funding, instruction in lab techniques, ethics in science and Institutional Animal Care and Use Committee (IACUC) reviews, and reading and writing a scientific paper.

In an attempt to further differentiate disciplinary instruction, participants were asked about the disciplines of the instructors for their McNair scholars, as well as the percentages of time each spent teaching. Possible choices were instructors from the humanities, social sciences, or STEM fields; from a campus office such as the Office of Academic Affairs, from the library (i.e. a librarian), or another area not listed. There were twenty-five responses to this question; the number of instructors per program ranged from one to five, with a mean of 2.52, and a median and mode of 2. Results are summarized in Figures 3 and 4.

Figure 3. Instructors by Discipline

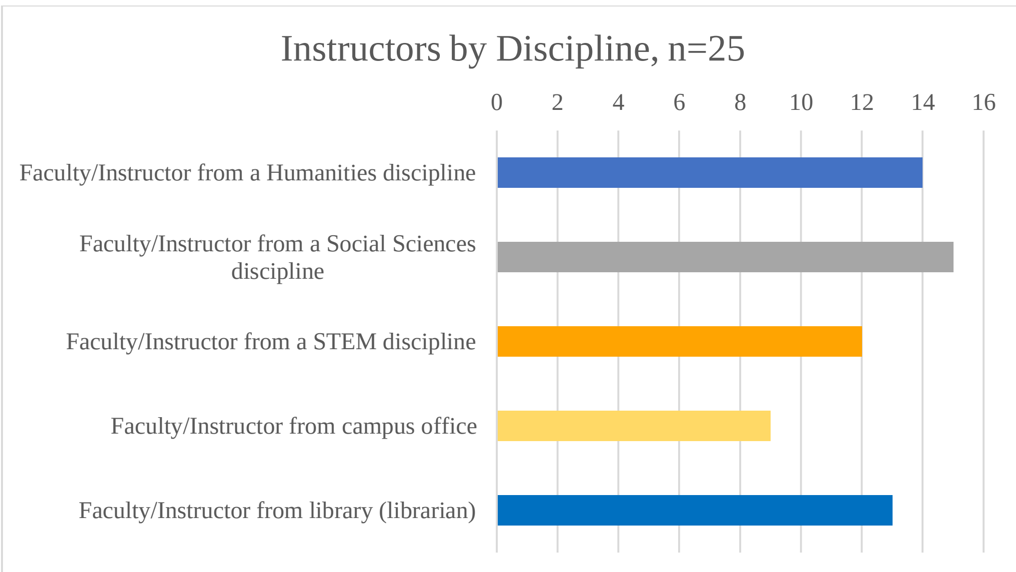
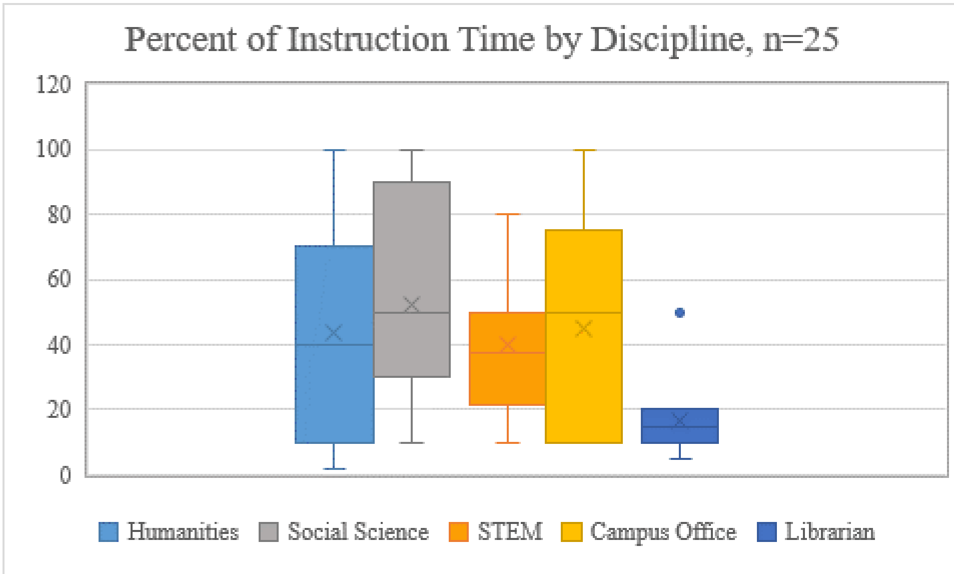


Figure 4. Percent of Instruction Time by Instructor's Discipline



Fifteen of the respondents indicated that librarians spent time teaching their McNair scholars, although as indicated in Figure 4., the total percentage of time tended to be lower than other instructors. Study participants were asked for the titles of the librarian instructors, to get a sense of their disciplinary backgrounds. The most frequently reported titles were more general, such as Instruction Librarian, rather than ones indicating a disciplinary concentration. Some STEM titles included Agriculture Librarian, Life Sciences Librarian, Physics Librarian, and Engineering Librarian. One respondent stated that as a small institution, their librarians are not differentiated by discipline.

Program Assessment

All twenty-five of the respondents indicated that they assessed their programs. A variety of assessment methods were used, the most popular being a single survey, used in 18 programs. Most programs used one method for evaluation, however there were six programs that used two assessment methods, and one program that used three methods. This respondent reported using a pre- and post-survey, a mid-summer focus group, and a one-year post review, all conducted by an external evaluator.

As a follow-up question, survey participants were asked if they made any modifications to their curriculum, instructional methods, personnel, or informational resources as a result of student feedback. The most often cited modifications were to curricula, followed by additional other changes, instructional methods, personnel, and information resources. From text responses to this question, the most common additional modifications were reported as minor adjustments (4), adding STEM content (2) and a STEM instructor (1), more discussion oriented activities or improved communication with students (3), adding online content (2), and modifying scheduling of instruction and lab time.

Discussion of Program Attributes and STEM Components

The average percentage of STEM students in programs that responded to the survey was 50%, and is in fact considerable in comparison to the percentages of minorities with graduate degrees in STEM fields (NSF 2017). However, looking at the responses gathered about instructional materials and deliverables, about half of the respondents indicated that there were no special reading materials provided for STEM students, and half said that the reading materials provided addressed some disciplinary differences. Two responses indicated that reading materials for STEM students were provided by or suggested by faculty mentors. The survey responses that were received about the STEM-specific reading materials described carefully chosen resources that address issues such as scientific ethics and reproducible research. Increasing the discipline specific content available for reading and discussion by STEM McNair students seems like a relatively easy way to improve program offerings for STEM scholars. There was in effect no difference in deliverables reported for STEM and non-STEM students in any of the responding programs, although the quantity and kinds of deliverables themselves were impressive. It may be that there were differences in format based on disciplinary norms, although this would need to be conveyed through instruction for the STEM students.

The amount of customization of instruction for STEM students reported by programs was low. Nine of the twenty-five respondents (36%), including the two all-STEM and one mostly STEM cohorts, indicated that there was some customization of instruction for STEM students. The percentages of STEM students in programs providing customization ranged from 38% to 78%, and a chi square analysis indicated that customization of instruction for STEM students was dependent on the number of STEM students. Due to the low response rate, however, this cannot be generalized as representative of all of the McNair programs. As was noted previously about STEM reading materials, it may be that some programs are relying on faculty mentors to provide instruction relevant to their discipline. This can be an effective way to deliver personal guidance to STEM students, but given that faculty are often pressed for time themselves, it might be beneficial to supplement this with classroom discussion around research reproducibility, ethics, and other topics in information literacy relevant to STEM students.

The disciplinary backgrounds and types of instructors in McNair programs varied. The most often cited instructors were from the social sciences (15 programs), followed by humanities (14), librarians (13), STEM (12), and a campus office (9). Almost all programs used more than one instructor, and as was shown in the analysis, the amount of time by the types of instructors were greatest for social science and humanities instructors, followed by instructors from a campus office, a STEM discipline, and finally a librarian. Librarians were typically used as “guest speakers”, spending an average of 16.8% of the total instruction time with students. Notable was the fact that among librarians, there was a high number of STEM librarians involved in McNair instruction, second in number to more general titles. This would seem to indicate, at least among the survey respondents, that there was an awareness of disciplinary differences for STEM students that could be addressed by STEM subject librarians. Given that students in undergraduate research programs struggle sometimes with how to approach their research, how to develop a research question, and how to work with the relevant literature (Seymour, et al. 2004, 513-514), it would seem that there is a need to increase the amount of information literacy instruction being provided by librarians generally.

Twelve programs, or about half of all respondents, had STEM faculty or instructors part of the time. The percentage of STEM students in a cohort with STEM instructors ranged from 25% to 100%. The amount of time STEM instructors taught in these programs ranged from 10% of the time, to 80% of the time. The average percentage of time STEM instructors taught in programs was 40%. Where STEM instructors spent a higher percentage of time teaching, this might be viewed as compensating for a lack of STEM-specific instruction. As noted before, it may be that some programs are relying upon STEM faculty mentors to provide a sufficient amount of discipline-specific guidance. However, it should also be noted that when assessing their programs, two made adjustments by adding more STEM content, and one added an additional STEM instructor, which points to some awareness of the necessity for disciplinary support for STEM students. Greater integration of discipline-specific information literacy instruction into the programs, as well as collaboration between librarians and faculty mentors, could assist McNair students in their development as researchers.

Recommendations for inclusion of STEM instruction based on the ACRL Framework for Information Literacy in Higher Education

In January of 2016, the ACRL *Framework for Information Literacy in Higher Education* (ALA 2017) replaced the sixteen-year-old *Competency Standards for Information Literacy in Higher Education*, which consisted of five standards with performance indicators and outcomes of achievement for the information literate student (ALA 2000). It also supersedes a mirroring set of standards created in 2006, *Information Literacy in Science and Engineering/Technology* (ALA 2006). The new Framework is constructed instead of threshold concepts organized in six frames, with knowledge practices and dispositions that allow for the inclusion of "social and political aspects of information literacy" (Foasberg 2015, 699), as well as economic influences on and disciplinary contexts in information.

ACRL's reframing of information literacy coincides with the latest definitions of science literacy by the National Academies of Sciences, Engineering, and Medicine. Their 2016 report reevaluated the concept and practices comprising science literacy, finding that "More than just basic knowledge of science facts, contemporary definitions of science literacy have expanded to include understandings of scientific processes and practices, familiarity with how science and scientists work, a capacity to weigh and evaluate the products of science, and an ability to engage in civic decisions about the value of science." (S-1) This definition acknowledges that science literacy, like information literacy, has disciplinary and societal contexts (National Academies of Sciences, Engineering, and Medicine 2016, S-3). It also defines aspects of science literacy as being the "identifying and judging [of] scientific expertise, and dispositions and habits of mind", including the "cultural understanding of science" (S-2), in addition to other criteria. This bears a striking similarity to concepts presented in the Framework.

The Framework, however, while embracing these different contexts and dispositions, differs significantly from the former Standards in several ways, one being that it does not provide prescribed outcomes for the student learner (Oakleaf 2014, 510). As a tradeoff for the greater flexibility to include community contexts in information literacy, librarians and disciplinary faculty must now take an extra step to devise their own outcomes as to the achievement of information literacy within the Frames. Without attempting to debate the merits of either the former Standards or the new Framework, below are some possible interpretations and applications of the Framework as they relate to STEM information literacy instruction, though they are certainly not exhaustive. Curriculum additions for STEM student researchers which were created using these interpretations of the Framework, with specified outcomes and learning objects for measuring achievement of threshold concepts, are then presented.

Interpretations and Applications of the Framework for STEM Disciplines

"Authority is Constructed and Contextual"

Disciplines, through both methods and traditions, have differing ways of approaching and understanding research in their fields. The research literature reflects these differences, and the authority of scholars is granted to them from within their communities of research. Metrics vary from discipline to discipline, and are necessarily compared only within disciplines, reinforcing the notion of context.

As students become familiar with the literature within their discipline, they learn who are the authorities in their fields. Because authority is sometimes interpreted by metrics and scholarship, students can discuss the use and purpose of tools such as impact factors, H-indices, and altmetrics, with the understanding that these tools have limitations and may be interpreted with bias. This supports the knowledge practices of using research tools as indicators of authority; recognizing authority within a domain while allowing for conflicting views and accepting challenges to this authority; and acknowledging that measurements of authority may be presented in new and changing formats (ALA, 2017).

"Information Creation as a Process"

Information may be used and interpreted at various points in the research process. The Research Data Life Cycle is an example of information creation as a process; it is also evident in the Scientific Process, and the Engineering Design Cycle. These concepts can be used to demonstrate to students in STEM fields how and when information is created and shared, and how it is used to create new knowledge. Students can relate their use of different kinds of research data, from raw data to cleaned data to analyzed data; along with reasons for preserving and sharing, or not sharing, their own data. Through a discussion of data management and the preparation of Data Management Plans, students acknowledge that they are part of the research process, and that although similarities exist in the phases of the research life cycle across domains, they still retain discipline specific norms, even between STEM fields that are closely related (Eekels and Roozenburg 1991).

“Information has Value”

Information has value when it is paid for as well as when it is freely accessible. Information production costs can be counted in both funding and intellectual expenditure of time and effort; potential gains obtained through the use of information may be realized in financial rewards as well as through benefits to society as a whole; for example, when an invention is patented. Equity in the distribution of information can be addressed when the value of information is acknowledged.

Within a discussion about the search process for literature sources pertaining to their research, students can consider the costs associated with producing and obtaining this information, and come to understand the economy that supported its publication and dissemination. They recognize that library resources, such as subscriptions to journals, are paid for with tuition funding, and aren’t free to everyone; and that even sources found through Google Scholar that appear to be free are often linked back to subscribed library resources.

Students can learn about commercial publishing practices, and the costs associated with publishing. The creation of scholarship is paid for by the time expenditure of the author and peer reviewers, as well as the financial support of a funder and/or institution. Students can discuss open access publishing, and the costs in volunteer time that are associated with it. Students also can be made aware of copyright issues and “pirated” articles. Disciplinary differences exist in the adoption of open access publishing practices (Bjork et al. 2010), and students can reflect on how these may influence future choices about their own publishing practices.

As an exercise, students can be asked to identify how they found an article relevant to their research, and to make a list of the costs associated with that article, from the researching, writing, and reviewing by others, through publishing, indexing, searching, and downloading. Students then identify groups who might not be able to access that article, and why not. Peers can lead a discussion of the results with the class. Particularly relevant to this discussion is the knowledge practice that states students will "understand how and why some individuals or groups of individuals may be underrepresented or systematically marginalized within the systems that produce and disseminate information" (ALA 2017).

"Research as Inquiry"

Beginning with a foundation of the results of research as expressed in the scientific literature, new hypotheses are formulated and science progresses through the results of additional experimentation, and the reproduction of those results for validation. New discoveries are made by design as well as through circumstance. The uncertain nature of the research process is acknowledged as necessary.

Students relate the iterative process of scientific investigation to the process of writing about their research. They understand that the process of experimentation leads to necessary revisions in assumptions and methodology, which in turn is reflected in the creation of a written research product. As part of the process of creating a research paper, students can be asked to write an abstract for their papers early in the research process, after examining abstracts from journal articles relevant to their research. As the students near the completion of their research papers, they will see the need to make revisions to their abstracts based on the outcomes of their research (Annesley 2010).

"Scholarship as Conversation"

Emphasis is placed on acknowledging the contributions of others in the research process, and that scholarship is built upon the previous work of others. By contributing to scientific discourse through experimentation and publication of results, students become part of the scholarly conversation.

Giving credit and the proper citation of sources naturally occurs when discussing "Scholarship as Conversation". An exercise in role playing ethical scenarios can also be used to teach this frame, as well as the frame "Information Creation as a Process", where the data lifecycle and the need for the accurate reporting of research data can be discussed. After reading about ethical dilemmas, students can act out a situation in which they as graduate students might be faced with an ethical dilemma.

"Searching as Strategic Exploration"

The discovery and application of new information becomes part of the research process, creating new understanding and ideas. This is mirrored in scientific research when unexpected results are produced during the course of experimentation, or when methods are modified to achieve desired results.

The sciences rely more heavily on research published through journal articles rather than in books due to the pace at which new discoveries are made, the development of new technologies which assist in discovery, and new media which speed the dissemination of results (Varmus 2009). Students can be shown techniques for finding and searching not just for articles, but for identifying journals with scopes that are relevant to their research, and browsing within a journal as a form of serendipitous discovery. This can be tied to the previously mentioned discussion of impact factors, and article citation metrics. Because the Frames are interrelated, several can be easily incorporated into a single lesson.

Table 1. below describes curricular additions created for McNair students at Rutgers, with a focus on STEM differences. These include learning outcomes and learning objects, which have been designed specifically to address the various contexts of STEM information literacy in research, although they are adaptable to other disciplines as well. Lessons emphasizing the different disciplinary norms of STEM research, as well as social, financial, and ethical contexts, include: searching the primary literature, journal and author metrics, the ownership and cost of information, data sharing, and ethics in research. Although the first frame, "Authority is Constructed and Contextual", is a guiding theme for these STEM curriculum additions, the lectures and assignments taken together reference all six frames. These curricular components may be of use to those who teach STEM students in any undergraduate research course, or to librarians seeking to incorporate new lessons for STEM students based on the Framework.

Table 1. STEM Curriculum Additions based on the Framework

Frames	Curriculum Addition	Learning Outcomes	Learning Object
Authority is Constructed and Contextual; Information Creation as a Process; Information has Value; Scholarship as Conversation; Searching as Strategic Exploration	Searching in journals is described, and research articles are identified as primary literature in science. Journal and author metrics and altmetrics are discussed with respect to disciplinary differences, and their relevance to early career researchers. Journal Citation Reports, SCImago Journal Rankings, and Google Scholar Profiles are presented. Interpretations and controversies surrounding these metrics are discussed.	The student will be able to identify journals with high impact in their discipline. The student will be able to find a Journal Impact Factor or SCImago Journal Ranking. The student will be able to find h-indices using Google Scholar. The student will understand how to interpret these metrics.	A written assignment describing a search for three journal titles relevant to their research, and Journal Impact Factors or SCImago Journal Rankings for these titles; the h-index of a well-known author in their field from their Google Scholar Profile; a brief discussion of author level and journal level metrics, including their interpretation within and outside of their discipline.* *Reflects assignment as modified for 2018
Authority is Constructed and Contextual; Information Creation as a Process; Research as Inquiry	Read “The Abstract and the Elevator Talk”. Write a preliminary abstract and present it to the class as an elevator talk. At the end of the course, make any needed revisions based on the outcomes of research.	The student will be able to write a succinct abstract appropriate for the publication practices of their discipline.	Preliminary and final abstracts are compared at the end of the course.
Authority is Constructed and Contextual; Information has Value; Research as Inquiry; Scholarship as Conversation	The publication process is reviewed. Open Access publishing and differing disciplinary practices and attitudes toward it within the sciences are presented.	The student will be able to identify the creators, distributors, and funders of information, and who has access to this information.	In a written assignment, the student selects an article and identifies the costs associated with it, both financial and intellectual. The student names groups with

	Access to information as a commodity is discussed.		access to the article and without access. * *Reflects assignment as modified for 2018
Authority is Constructed and Contextual; Information Creation as a Process; Information Has Value; Research as Inquiry; Scholarship as Conversation	The Research Data Lifecycle is described and the reasons for sharing data are discussed. Funding agency requirements for data sharing are outlined.	The student will be able to identify a funding agency for their discipline, and create a Data Management Plan for their current research that meets the agency's requirements. The student will demonstrate understanding of the future impact of research data by planning for sharing and preservation.	A Data Management Plan that describes the student's anticipated or actual research data, and outlines appropriate methods of providing access, policies for reuse, and plans for preservation, per agency requirements.
Authority is Constructed and Contextual; Information has Value; Research as Inquiry; Scholarship as Conversation	Read "What is Ethics in Research & Why Is It Important", "Twenty Questions: Ethical Dilemmas for PhD Students". Discuss ethics in the protection of human and animal subjects; and codes of conduct in professional organizations. Discuss ethics as it relates to reproducible research and the research life cycle. Review Retraction Watch website.	The student will identify a professional organization in their discipline with a code of conduct, and/or an institutional body that ensures the ethical conduct of research relevant to their work. The student will develop awareness of ethical situations involved in conducting and communicating research.	Written identification of an ethics review board for their discipline, and a professional organization with any disciplinary codes of conduct. Students role play in groups a situation representing an ethical dilemma for a graduate student conducting research, and the class identifies the ethical principal in question, and its possible effect on the researcher and/or subject.

Learning Outcomes

The evaluation of the learning objects demonstrated that by the end of the course, most students had grasped the threshold concepts being presented, and had developed some of the appropriate knowledge practices and dispositions. The STEM lesson which proved problematic for some students was the data management plan assignment. A few of the students' data management plans reflected what has been found to be the attitude of some faculty toward them, that while they "appreciate the benefits of sharing research data, on an individual basis they may be reluctant to share their own data" (Van den Eynden and Bishop 2014, A-4). Indeed, upon discussion with some of the STEM students about their data management plans, it seemed that their interpretations of the necessity to manage their data for future access and preservation was reflective of that of their faculty mentor's lab group. This points to the need for closer work with faculty in the McNair program, and in discussions with faculty generally about data management. Future plans include coordinating this lesson with the faculty mentors, and in doing so, creating additional opportunities for awareness of data management best practices for both faculty and students.

Conclusion

The new ACRL *Framework for Information Literacy in Higher Education* presents opportunities for librarians and faculty to incorporate broader contexts relevant to students as they interpret and conduct research. Societal, ethical, financial, as well as disciplinary contexts of research are important to those from economically disadvantaged and minority populations, who are underrepresented in graduate school and academia, especially in STEM fields (NCES, 2017; NSF, 2017). As the survey of recent McNair cohorts indicates, efforts are being made to address the different research contexts of these STEM students, but that there are also opportunities to expand these efforts.

The existing literature about McNair and other undergraduate research programs finds that research within a discipline alongside faculty contributes significantly to graduate student success (Bauer and

Bennett, 2003; Fifolt, Engler, and Abbott 2014; Grimmett, Bliss and Davis 1998; Lam, et al., 2003; Thomas, 1994), and the Framework recognizes the need for librarians to integrate information literacy collaboratively with faculty as well. The previous ACRL *Standards for Information Literacy in Science and Engineering/Technology* tacitly recognized that disciplinary contexts guide information literacy instruction, and this continues to be the case. The Framework allows that in addition to disciplinary differences, there are social, economic, and other dimensions to information literacy, and that these aspects within communities must be considered (Foasburg 2015). Because the McNair program prepares high achieving but traditionally underrepresented and economically disadvantaged students for graduate school, it is essential that disciplinary and other contextual aspects of information literacy are integrated into the research process, both for the short term and long term success of the students. Programs like McNair are helping to increase the number of underrepresented STEM doctorate holders, and librarians can contribute to this effort by working with faculty and undergraduate research programs to provide appropriately framed information literacy instruction.

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Appendix A

McNair Postbaccalaureate Achievement Awards
Survey of Program Administrators

Please enter your responses about the cohort of McNair scholars for the 2016-2017 academic year.

Please answer the following questions concerning classroom instruction of McNair scholars in a research-focused course.

1. Please enter the name of the research-focused course required of your McNair scholars.

Name of research course
Not Applicable- no research course was provided

[If no research course was provided, skip to end of survey]

2. Please enter the number of total students in your 2016-2017 McNair Postbaccalaureate Achievement Program cohort.

3. Did you require that your 2016-2017 cohort of McNair scholars produce a written research product, such as a research proposal or research paper?

   Yes
   No

4. For your research course, what deliverables are produced by all of your McNair students? Select all as appropriate. For anything not listed here, please briefly describe in the text box provided.

   Written research paper or proposal. Please enter minimum number of pages required
   Other written assignments. Please describe briefly.
   Poster presentation
   Presentation (PowerPoint or similar)
   Other presentations, such as speeches, videos, or group presentations. Please describe briefly
   Any other deliverables

5. How many of the 2016-2017 McNair cohort were STEM (Science, Technology, Engineering, and Math) majors? For this survey, do not count Psychology as STEM.

   Number of STEM students_______
   No STEM students
   I don't know

[If no STEM students, skip to Q10]

6. If STEM students produce different deliverables than the non-STEM students, please describe them here. If there are no differences in deliverables, select Not Applicable.

Not Applicable
Text box

7. Please say if your STEM students were provided with reading materials (i.e. textbooks, articles, or other works) for use in your research course. If your students were provided with reading materials and were all or mostly STEM, please select the last option and briefly describe the materials used. Please select only one answer.

   No reading materials were provided for use in our research course.
   All students use the same materials, with no disciplinary distinctions in content.
   All students use the same materials, but these contain some content addressing STEM disciplines.
   STEM students use different materials. Please describe briefly below the resources provided specifically for STEM students.

8. Did your 2016-2017 McNair scholars in STEM majors receive any instruction that was different from the instruction of non-STEM students? Please select one answer.

   All or most of the 2016-2017 McNair students were STEM majors
   Yes, the STEM students received some different instruction than non-STEM students
   No, both STEM and non-STEM students received the same instruction

9. Please describe briefly any instruction that was specifically for the STEM students in your 2016-2017 McNair program. If all or most students were STEM, please select Not Applicable.

   Not Applicable
   Instruction specifically for STEM students

10. What kinds of faculty or instructors are responsible for the formal instruction of your McNair 2016-2017 students in the previously named research course? Do not include mentors. Please select as many as applicable.

    Faculty/instructor from a Humanities discipline, such as English?
    Faculty/instructor from a Social Sciences discipline, such as Anthropology?
    Faculty/instructor from a Science or STEM discipline, such as Chemistry or Engineering?
    Faculty/instructor from an academic office, such as the Office of Academic Affairs?
    Faculty/instructor from the Library (i.e. Librarian)?
    Other Faculty/instructor not previously mentioned?

11. Please enter the percentage of time each kind of instructor spent teaching your McNair students during your research course. Total should equal 100.
    (Preselects answers chosen in Q10)

    Faculty/instructor from a Humanities discipline, such as English?
    Faculty/instructor from a Social Sciences discipline, such as Anthropology?
    Faculty/instructor from a Science or STEM discipline, such as Chemistry or Engineering?
    Faculty/instructor from an academic office, such as the Office of Academic Affairs?

Faculty/instructor from the Library (i.e. Librarian)?
Other kinds of faculty or instructors not previously mentioned who provide *classroom instruction in research* to your McNair students? Please enter their titles in the box below.

12. If librarians teach your McNair students, what are their titles? Some examples are: Instruction Librarian, Biology Librarian, English Librarian, Senior Librarian.

    Librarians' titles:
    Not Applicable
    I don't know

13. Do you assess your students' satisfaction with the McNair program?

    No – if no skip to question 15
    Yes
    If yes, please describe your assessment methods. For example, if you used an anonymous online or paper survey.

14. If you assessed McNair student satisfaction, have you modified any of the following in your research focused course as a result of feedback: the curriculum, instructional methods, personnel, or informational resources?

    No
    Yes
    If yes, please describe the changes you made as a result of student feedback

15. Is there anything else you would like to say about the McNair program at your institution?

16. If you would like the opportunity to have your responses cited in a peer-reviewed article, please provide your contact information below. You will be asked to review any content to be attributed to you before submitting it for publication. If you do not provide this information, all responses to this survey will remain anonymous.

    Name:
    Title:
    Institution:
    e-mail address:

Thank you for participating in this survey!