PURM
Perspectives on Undergraduate Research & Mentoring

Systematic and Scoping Reviews with Undergraduates

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Introduction

As undergraduate teaching faculty, it is essential that we explore new and innovative avenues for developing successful research programs. Research is a demanding process that can require extensive amounts of time and funding; nevertheless, undergraduate research experiences are in high demand since they can be helpful for student advancement in their prospective careers (Nielsen-Gammon et al., 2009). Furthermore, student participation in undergraduate research experiences increases retention of minority students in academic programs (Lopatto, 2007; Russell et al., 2007), and promotes greater academic success (Fechheimer et al., 2011). As junior faculty, it is exceptionally difficult to create traditional research experiences for students due to limited available resources and heavy teaching loads (Sharobeam & Howard, 2002), thus alternative avenues must be explored. Here, we describe how systematic and scoping reviews provide a cost-effective means for engaging a large group of undergraduate students in a research project and a sustainable and productive route for maintaining scholarship in a highly competitive academic environment.

Types of Reviews

Qualitative and quantitative reviews provide a "snapshot" of the current knowledge on specific topics, offer novel insights into topics, find inconsistencies in a research area, and thereby play an important role in the research process (Palmatier et al., 2018). All reviews share the important characteristic of focusing predominantly on the assessment of published original work. Thus, materials included in reviews are often subjected to scrutiny through peer-review and include primary research evidence. There are many types of review papers that offer different perspectives on a research topic and below we outline the general information about key types of reviews and their potential usefulness as an avenue for engaging undergraduate students in the research process.

Narrative Review

The narrative review, also known as the literature review, is the general term for a critical appraisal of the literature on a topic. This type of review does not include a systematic process for identifying eligible studies or analyzing data collected, but rather uses convenience or time restricted gathering

of materials to be included, which may result in omission of certain parts of the relevant literature (Grant & Booth, 2009). Thus, the less stringent requirements of a narrative review lend it to be a useful research project in undergraduate course-based settings, such as research methods or capstone courses. While this type of review is effective for engaging students in finding and scrutinizing literature, the narrative review does not require extensive collaborative effort; therefore, it may not be the most useful review type for an authentic research project with a large group of undergraduate students to conduct as a team. Overall, the narrative review lacks the data analysis element and team effort seen in more structured review types, such as the meta-analysis discussed in future sections.

Systematic Review

A systematic review uses a methodical approach for searching, analyzing, and synthesizing research evidence (Grant & Booth, 2009; Munn et al., 2018). Further, this approach can be complex and is typically conducted by a team of researchers. This contrasts with a narrative review which is a more appropriate project for an individual or small group in a writing course. Executing a systematic review is usually completed following guidelines outlined by the Cochrane Collaboration (Green, 2008) and the NHS Center for Reviews and Dissemination (Centre for Reviews and Dissemination, 2009). The steps for completion of a systematic review are described by the investigators in detail and often include registering with an online database such as PROSPERO to secure the research question (National Institute for Health Research , 2011). In contrast to a narrative review that can include a more subjective assessment of a topic, a systematic review uses a specified protocol to objectively analyze a body of literature to answer a specific question. It incorporates three central components: a clearly defined and formulated research question, critical appraisal of evidence collected, and synthesis of the evidence presented in the included studies.

A systematic review of the literature includes qualitative analysis of the data collected and can include quantitative meta-analysis (see below). The basic steps for completing a systematic review are: 1) completion of a multi-database search using a comprehensive list of terms related to the research question with or without the help of a librarian, 2) screening all abstracts using eligibility criteria by two independent reviewers, 3) completion of a full-text review of included studies by two independent reviewers, 4) critical analysis or data extraction from selected articles, and 5) completion of systematic review and/or meta-analysis. For a more detailed discussion of the step-wise methods for successfully executing a systematic review please refer to a review by Khan and colleagues (Khan et al., 2003) and Cochrane Collaboration (Green, 2008).

Importantly, a systematic review research project would provide a large group of undergraduates with a collaborative and extensive research experience while also familiarizing students with subject-based literature and specialized language. Reviewing article abstracts and full texts for specific inclusion and exclusion criteria teaches students to use the scientific method, thereby offering students an authentic research experience. The analysis element of a systematic review, while qualitative, still provides avenues for students to utilize and learn critical thinking in a team environment. Allowing undergraduates to participate in a systematic review project will increase exposure to research in a potentially less intimidating manner than a traditional research experience, such as in the community, clinic, or laboratory.

Meta-Analysis

A meta-analysis is a statistical method that combines quantitative research evidence from multiple studies to examine the overall impact of the results (Grant & Booth, 2009). A systematic review of the literature is completed prior to a meta-analysis to identify eligible studies. For a meta-analysis to be a valid and original investigation, the studies must be sufficiently similar in the outcomes measured and how the findings are presented. Analyzing literature at this level is extremely stringent

and requires a trained team of researchers, potentially undergraduates, for successful project execution. Including a meta-analysis as part of an undergraduate research project, when possible, would be of great benefit to the students and the research mentors as the learning opportunities are copious, and differing perspectives are valued. The incorporation of quantitative analysis often warrants inclusion of experts in statistics, providing an additional avenue for collaboration across fields.

Systematic Scoping Review

A systematic scoping review, also known simply as a scoping review, shares central methodological qualities with a systematic review — including the screening processes as described above — but is unique in that it often does not include a specific research question (Peters et al., 2015). A scoping review is a preliminary investigation that assesses the size and scope of the literature base on a research topic and is often followed by one or more systematic reviews with specific research questions. A scoping review can be used to assess and clarify definitions or define a concept using the literature, and they are often useful when comprehensive reviews of the literature on a topic have not been completed previously.

Along with systematic reviews and meta-analyses, systematic scoping reviews have the potential to impact our understanding of important and highly valued aspects of society such as: healthcare standards (Sofaer & Strech, 2012), teaching and mentoring practices in classroom and research settings (Khalaf, 2018), retail practices that benefit businesses while also promoting health in the human population (Blake et al., 2019), criminal justice reform (Belur et al., 2018) and experimental methods for studying human health and disease (Mohammadzadeh et al., 2018). Importantly, the very broad, comprehensive, and tiered nature of these reviews makes them an ideal project for a large team of undergraduate researchers. In the next section, we describe our reasons for choosing to conduct a systematic scoping review with our undergraduate team of 25 students.

Why We Chose a Systematic Scoping Review

With our low student to faculty ratio, we were searching for a project to engage a large number of students in the research process. The systematic scoping review offered a route for the faculty to mentor large numbers of undergraduates in a research project. The project also offers a number of other benefits: the opportunity to publish in fields inside and outside of the immediate area of study, identification of gaps in knowledge in a research field that can lead to novel questions for future research projects, and an avenue for maintaining productive scholarship in academia while under extreme time and resource constraints. Furthermore, the systematic scoping review process overcomes other barriers associated with traditional research in other settings, including inexperienced student researchers in a high-risk location, such as the hospital, a large student to research faculty ratio, and extensive university certification requirements.

A systematic scoping review project provides opportunities for practicing the same skills required in other research settings including: critical thinking and problem solving, time management, motivation, planning, and team collaboration (Landrum & Nelsen, 2002; Lopatto, 2007). Further, this type of review fosters the evolution of the initial research question as the project progresses, which allows novice undergraduate researchers to actively engage with the research process. This promotes the use of problem-solving and communication skills for students and progression of the research project. Therefore, we identified the systematic scoping review as a good investment of time and effort for both faculty and undergraduate researchers, and as a result we have successfully mentored more than 25 undergraduate students in this research process over the past 12 months.

Learning Goals for Student Researchers

Systematic scoping reviews are an ideal research experience for an effective undergraduate team-

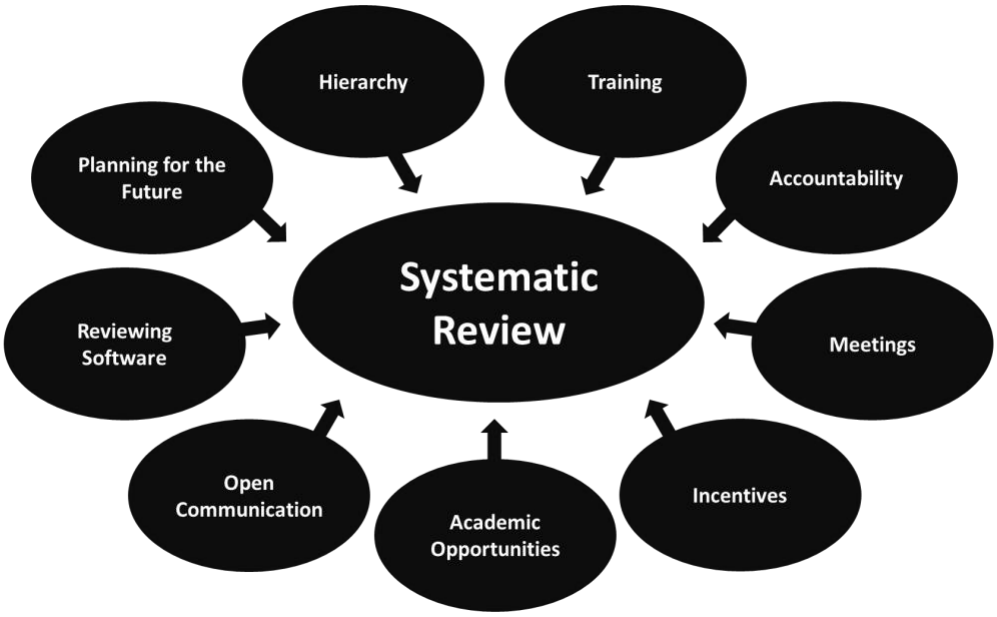
oriented learning environment in any discipline or area of study. Based on our experience conducting a systematic scoping review, we have compiled a list of learning goals for students that participate in this type of project:

- Students will develop the necessary literacy skills to be able to independently search databases for literature pertaining to their given field.
- Students will gain a greater appreciation for the scope of scientific literature, increasing motivation and inspiring new questions for future careers.
- Students will learn how to effectively work in a team environment while also gaining potential avenues for the development of leadership skills through the recommended hierarchy described below.
- Students will gain experience in qualitative and quantitative data analysis and interpretation.

Initial Challenges of our Project

Based on our experience, we have identified some key tips that could help others in review design, specifically aimed at allowing undergraduates to learn the methodology of a systematic review and streamline the project launch. First, a precise question and specific criteria are essential for an effective database search. Our initial question was very broad, and we struggled with a cumbersome number of hits following our librarian-lead electronic database search. We had over 200,000 abstract hits with many of these irrelevant to our topic of interest. After fine tuning our question and search terms list, we reduced our abstract hits to approximately 26,000. We suggest having a collaborator that is an expert in the chosen research field to assist in developing the search terms list and creating a narrowed research question to improve the output from the electronic database search.

Figure 1. *Tools for successful systematic scoping review (A pictorial display of the necessary components for conducting a systematic scoping review with an undergraduate student team*)



We quickly realized that with over 25 undergraduates working on the research team, there were significant challenges to overcome, including: keeping students engaged in the online process, training the students efficiently and effectively, and ensuring all students understood the project

guidelines. The next section details methods for successfully overcoming these challenges and conducting a systematic scoping review with an undergraduate student research team.

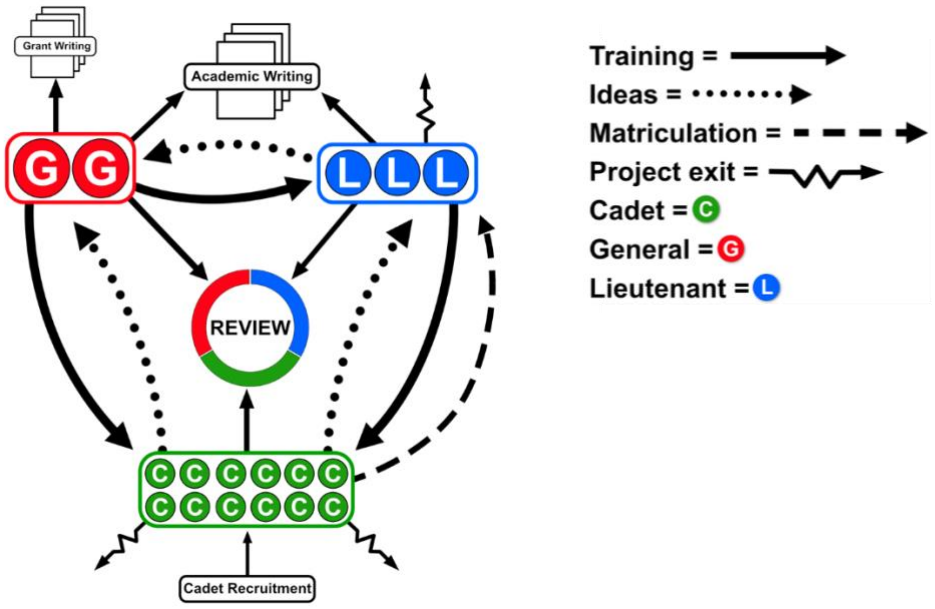
Methods for Successfully Executing a Systematic Scoping with Undergraduates

The flexible nature of systematic scoping reviews allows for research to be conducted semi-independently. To maintain consistency and sustainability, it is essential to have an organized team of trained researchers utilizing appropriate software, with faculty and senior students planning ahead. To maintain retention and morale among the team, accountability, incentives, meetings, and open communication are necessary. Finally, academic opportunities, such as authorship and conference attendance, serve as the main method of recruitment and retention (Russell et al., 2007). These methods contribute to the overall success of our systematic scoping review, which is summarized in Figure 1.

Hierarchy

Successful incorporation of undergraduates into the research project is enhanced by using a team hierarchy, as shown in Figure 2. This idea stems from the notion that students learn well through collaboration and reciprocal learning, as indicated by the theoretical framework on social constructivism (Amineh & Asl, 2015). As part of the team hierarchy, students simultaneously act as both mentors and mentees, allowing them to practice collaboration and leadership while cultivating project progression. Not only are undergraduates involved in the project, but there are also opportunities for graduate students or post-doctoral researchers to be incorporated. Individuals entering the project typically begin with varying levels of research experience and education, but these benchmarks are not an indicator for determining which level of the hierarchy a person belongs to. Team members enter the project as cadets and can be promoted to the lieutenant position through hard work and dedication to the project, as described in the next sections. Additionally, the team hierarchy also provides faculty more time to complete service, teaching, and other research obligations. Below, we use a militaristic naming scheme to describe the roles of the different members of our team: cadets, lieutenants, and generals.

Figure 2. *Systematic scoping review team hierarchy*



Notes: The relationship between the team members and their corresponding roles that contribute to a successful review process. solid arrows indicate training methods for new cadets that enter the projects.

Spherical dashed arrows indicate the flow of project ideas and input between all team members. Rectangular dashed arrows indicate the development of cadets and matriculation to a lieutenant leadership position within the project. Jagged arrows indicate the exit of team members from the project, either from lack of interest or incompetence (cadets) or matriculation to higher education/entrance into the workforce (lieutenants). Both lieutenants and generals have opportunities for writing project-related publications. Generals reside over administrative tasks (e.g., grant writing).

The Cadets

Containing the largest number of students, this rank is the entry level position within the hierarchy. For entry, cadets do not need to have any prior research experience and can be at any stage in their college career. The main roles of trained cadets are to review abstracts and full text articles and assist with data collection during the data extraction phase of the project. The cadets are also required to attend team meetings and communicate directly with their peer mentors — the lieutenants (see the *Meetings* section). It is important to remember these students are experiencing research for the first time and the online literature-based research experience may not appeal to them. Thus, instability within this group is expected and members may choose to no longer participate in the research project. Setting firm expectations and deadlines for the cadets creates an efficient team. Additionally, having a plan for when to remove cadets is essential and should be communicated during training (see the *Accountability* section). If cadets' express interest in being part of the team but have not completed project tasks for one month, it may be the time to remove these cadets to enhance productivity and make way for new recruits. In contrast, cadets who exhibit dedication and enthusiasm for the project are encouraged to assume leadership positions on the team.

The Lieutenants

The lieutenant positions are usually filled by upper level undergraduate students – juniors and seniors – and graduate students. To join this rank, students must have previously served as cadets, completed 10% of the current stage of the project, and/or been self-identified or chosen by the faculty as a leader. The main roles of the lieutenants are to help with data collection and to train new cadets. Lieutenants have an additional responsibility of resolving conflicts when the two independent reviewers disagree on inclusion of an abstract or full text article. The lieutenants can reach out to cadets who may have challenges with the reviewing process and act as mentors which helps to tailor the research experience for novice student researchers. Furthermore, the lieutenants are important for completion of weekly email progress reports, developing methodology, data analysis, and manuscript preparation. Overall, the uniqueness of this position lies in students acting as both mentors and mentees, resulting in training in leadership and research. This position holds value for students by allowing them to practice vital skills that will support their success in the future.

The Generals

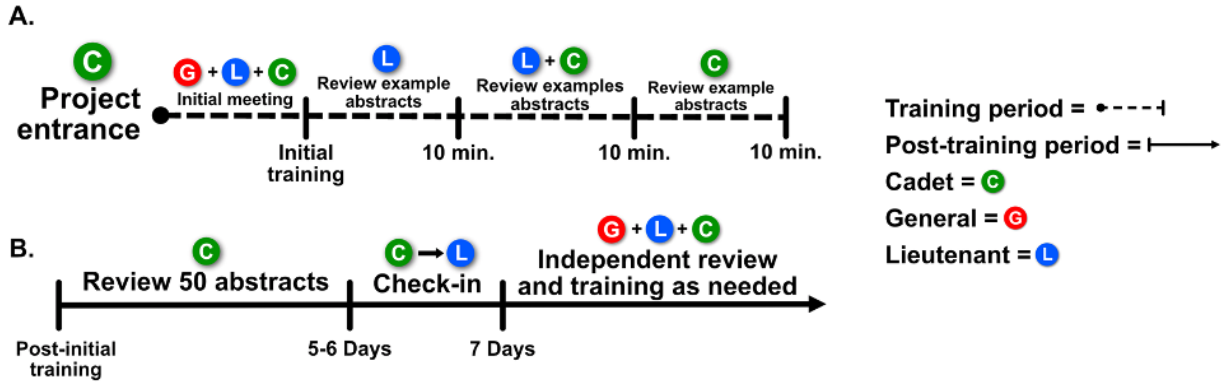
Consisting of faculty, the generals plan major meetings (see the *Meetings* section), drive the project ideas forward, set expectations for project completion, and act as a resource for all members of the team. To help the cadets and lieutenants discuss challenges within the project, the generals should also assist in data collection. The generals meet with each new cadet, ensuring that they understand the goal of the project and, more importantly, their role on the team. Follow-up training is facilitated by lieutenants who help to manage day-to-day questions regarding the research process. The generals spend significant time ensuring all members of the team are held accountable and continue to successfully move the project forward.

Training

Training of cadets by the generals and lieutenants is essential for project success. See Figure 3 for a schematic of training. Generals should meet with each new cadet and at least one lieutenant to

discuss the expectations and methods for reviewing the literature. By incorporating a lieutenant in the meeting, each cadet has a peer mentor to serve as a point of contact regarding project tasks and act as an accountability partner (see *Accountability* section). Further, it provides an opportunity to build comradery. At each new step in the process, the generals and lieutenants plan and implement a training program to ensure that team members can successfully complete the next task (see *Meetings* and *Planning Ahead* sections). Upon entry to the program, each cadet is assigned a lieutenant as their mentor who will provide the majority of the training. Before any training begins, each new cadet is given a pre-test to assess baseline skills, including critical thinking and topic literacy. Following this, lieutenants begin training by reviewing the inclusion and exclusion criteria, as well as any specific definitions needed to understand and sort abstracts. Lieutenants then give a brief tutorial of the software used (see *Review Software* section) and review four to five abstracts while discussing the thought processes with the cadets. Next, cadets review four to five abstracts with lieutenants providing guidance, as cadets verbalize their thought process during the completion of this task. It is imperative during this abstract training process that lieutenants choose a breadth of abstracts that range in difficulty, as well as eligibility based upon pre-established inclusion criteria. This ensures cadets are exposed to a range of abstracts varying in difficulty on inclusion and exclusion criteria. Finally, the cadets will review abstracts on their own for approximately 10 minutes while the lieutenant is present so that cadets may have access to a more experienced reviewer to ask questions if needed.

Figure 3. *Cadet training timeline*



Notes: This figure illustrates the standardized process used for the training of newly recruited cadets. The training period, indicated by the dashed line (part A.), consists of 10-minute increments of observational (left), guided (middle), and independent (right) cadet training for abstract review. The post- initial training period, indicated by the solid arrow (part B.), consists of an independent introductory period for cadet abstract review. After this period, the cadet checks in with their lieutenant to discuss any problems or questions regarding the review process. Once the cadet has been trained and feels comfortable reviewing on their own, they may move on to full independent review with continued trainings.

Cadets are then able to review freely without any oversight from lieutenants but are encouraged to ask questions as they arise and discuss common and potentially confusing patterns in the literature with their lieutenant and other cadets in their mini-team (see *Meetings* section). After reviewing their initial 50 abstracts, cadets are requested to check-in with their lieutenant to discuss any questions or concerns and to provide more interaction, as the nature of this type of project can be solitary at times. At quarterly full-team meetings, the entire review team gets together to actively engage with one another to discuss the literature and provide individual viewpoints. In addition to planned small group breakout activities, a period of abstract and full-text review practice and discussion in full-team meetings is useful for identifying key issues and for providing students a platform to share perspectives. Additional trainings are implemented as different steps in the process are conducted,

including review of full text articles for inclusion and exclusion, data extraction and analysis, and writing up of results for publication. We advise that cadet recruitment should occur primarily in the abstract review phase to allow students to become comfortable with the research question and reading the literature. These trainings further encourage students and faculty to share their successes and failures within the research project, thereby building comradery among the team.

Accountability

This type of project includes significant time spent on completing work independently, using computer-based and online software. While the flexibility of this project format is often a perk, the intrinsic motivation needed to complete long-term goals can be considerably higher than research completed in a face-to-face format. Although accountability is not absent from other types of research, establishing clear and consistent expectations is even more essential to maintain the necessary level of productivity in virtual research projects. Periodic check-in points and open communication (see *Communication* section) are the most beneficial methods for ensuring accountability within a large research team with varying experience levels.

We use a graduated approach to teaching and learning to successfully incorporate new students into the project and facilitate the progression of motivated cadets into the lieutenant position. The social constructivist theory suggests that the scaffolded learning of cadets is rooted in the assistance from more experienced researchers on the project, the lieutenants and generals, to help cadets reach their full potential (Kim & Hannafin, 2011). As individuals enter the project, they will likely be less familiar with and slower at the review process than more experienced members. This dictates that expectations are set at a different level for new recruits than for veteran reviewers. We start by giving each recruit the initial weekly goal of reviewing at least 150 abstracts. Once the team is in the full-text review stage, the cadets will be given a weekly goal of three to five full-texts to review per week. These goals are based upon an expectation of completing an average of 30 minutes per day of reviewing for five days out of the week, with an average of one minute per abstract or approximately 10 pages of a full-text paper per day. As cadets become more experienced, students will become more comfortable with the methodology and the number of abstracts and full texts completed during the two-and-a-half-hour weekly requirement will increase.

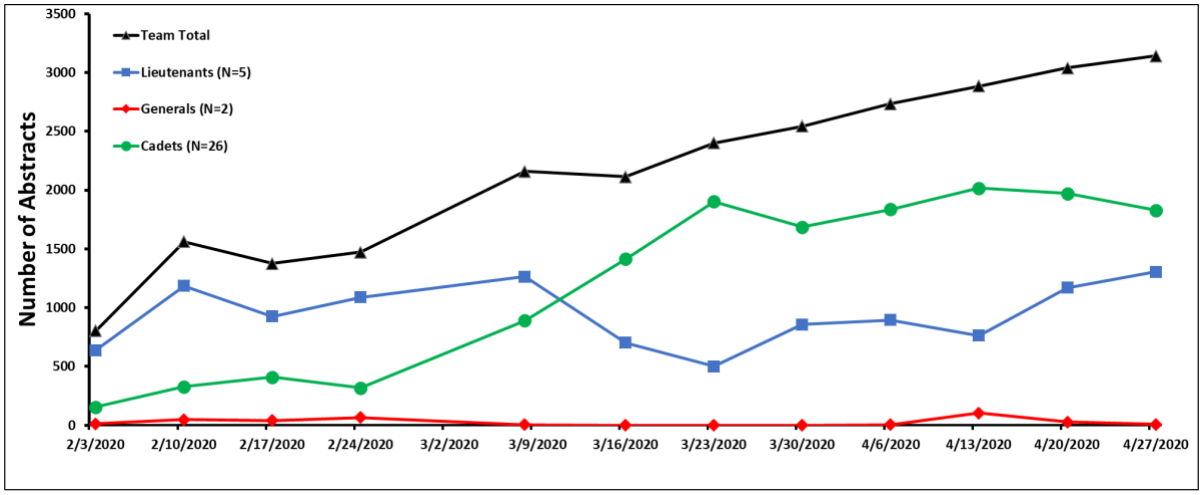
We have found that this two-and-a-half-hour requirement for experienced reviewers is ideal for moving the project forward and for giving individual members adequate exposure to the literature, without causing burnout or loss of reviewing quality. Students who choose to dedicate more time and exceed expectations will be recognized and rewarded (see *Hierarchy* and *Incentives* sections). Further, with these basic expectations, generals can determine project timeframes and work with lieutenants to prepare for the next stages of the project (see *Planning for the future* section below). We have found that holding students accountable for specific goals each week is key for maintaining productivity of team members, thus providing higher quality work.

Since team members are composed of faculty and students, time is typically a finite resource. All team members have their own outside responsibilities, such as classwork and paid employment, thus the expectations for achieving weekly goals are plastic. To maintain the needed flexibility, a running three-week trial window is maintained for cadets to meet expectations. This means that individuals who are unable to meet their weekly requirement can make up the total in the following two weeks. Cadets are required to communicate with their lieutenants and generals if they are unable to meet goals for a specific week (see *Open Communication* section). Those that are consistently unable to meet the weekly requirement are then scheduled to meet with a general for a discussion on time management and if the behavior continues, then the cadet is asked to leave the project. These guidelines are set in place not only to ensure productivity for the research, but also to

ensure fairness to the other reviewers and the research team. Maintaining project expectations is essential to having a productive, efficient, and high-quality research team.

To consistently monitor the team's progress towards completing the project, a lieutenant sends out weekly reports of each members' review numbers. Weekly updates allow lieutenants and generals to assess individual reviewers' contributions. Lieutenants can then encourage cadets who are meeting their goals or reach out to those who are not meeting expectations. Generals then follow-up with words of encouragement and congratulations for particularly productive cadets. This is helpful for maintaining comradery and motivation. Additionally, a graphical representation of the team's progress is sent out each week, showing the rate of completion for the team in its entirety (see Figure 4). Based on these reports, weekly lieutenant-general meetings (see *Meetings* section) occur to discuss any challenges or successes that need to be addressed among the whole team.

Figure 4. *Weekly abstract totals*



Notes: Weekly abstract totals are taken for each individual team member and a weekly graphical update is provided to the team. The data is plotted using the team hierarchy, general, lieutenant, cadet, and the team total as – red diamond, blue square, green circle, and black triangle, respectively.

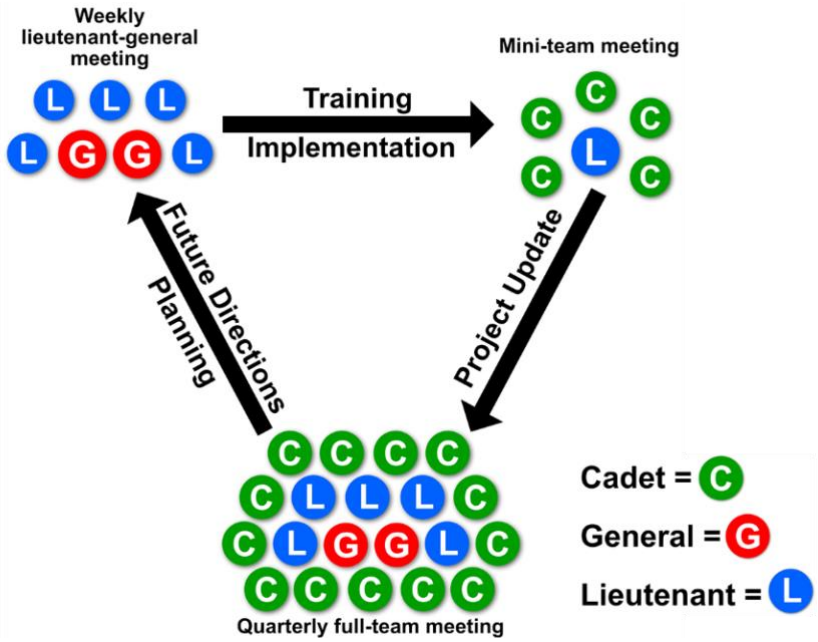
Meetings

Meetings are used to develop team ideas and to further project progression. These different meetings create a cycle of ideas fostering research skill development among all members. Mini-team meetings are imperative for ensuring continued focus on the goals of the project and the value of each team member's contributions. As the team is rather large, these mini-team meetings consist of a lieutenant and four to five cadets. The main purpose of mini-team meetings is to encourage further reviewing, provide a supportive and open setting to discuss issues or problems, and ensure all reviewers are engaged and active in the research process. These meetings are also useful for adjusting training protocols and providing cadets with more regular updates on the entire project. Generals often "drop in" on mini-team meetings to increase cadet engagement within the project. See the Appendix I for mini-team meeting notes created by lieutenants and cadets.

Weekly lieutenants-general meetings occur to discuss any major challenges with reviewers, inconsistencies among methodologies, weekly abstract review graph, and project progress (Figure 5). Quarterly full-team meeting agendas are also discussed and prepared so that lieutenants can assist generals in leading the meeting. These meetings are also open to all other members of the team, and cadets who attend these meetings and actively work to troubleshoot challenges, are often ideal candidates for future lieutenants (see *Hierarchy* section). Mini-team meetings and weekly lieutenant-

general meetings are then followed up by quarterly full-team meetings. These full-team meetings not only provide the necessary social aspect for maintaining accountability, but also an opportunity to address challenges, celebrate successes, and determine future goals and deadlines as a collective unit.

Figure 5. *Team meeting types*



Notes: This figure illustrates the cyclic flow of ideas within the review research team. Weekly lieutenant-general meetings (top left) focus around planning and considering future directions for the project. Min-team meetings (top right) occur as needed between cadets and their lieutenant during which training and implementation of the future project steps. Quarterly full-team meetings (both middle) occur to update existing team members of project progression and introduce future plans generated by the team.

As previously mentioned, most of this project is completed online and flexibility is a key component that allows various members to continue their involvement. In order to give a variety of options on time and location of meetings, resources such as Zoom, or GoToMeeting can be utilized to allow members to collaborate long-distance (see *Open Communication* section). The ability to work online allows multiple institutions to work together on a project simultaneously and allows students not on campus over summer to remain engaged.

Incentives

Motivation is key for the success of any research project. This is particularly true for online literature-based research, which include significant time working independently. It can be challenging to remain intrinsically motivated to complete deadlines, therefore offering extrinsic motivation can help keep students engaged. We offer gift cards and certificates of achievement at each quarterly full-team meeting to each cadet and lieutenant who has made the most significant contribution toward completing project work. Using gamification through the certificates and gift cards creates a friendly competition among our cadets and lieutenants, which increases productivity. This methodology has been utilized successfully to engage students in a variety of educational settings (Gressick & Langston, 2017).

In addition to providing rewards at our quarterly full-team meetings, our team has similarly utilized the weekly lieutenant-general meetings to provide a leadership incentive for cadets (see *Meetings* section). Cadets in attendance of these meetings have the opportunity to contribute ideas to the research, gain more detailed insights about the research process, and potentially create an avenue to become a leader on this project. Overall, offering rewards and leadership opportunities through meetings has proven beneficial to team motivation and morale. Academic opportunities are also a form of more long-term incentive for both students and faculty.

Academic Opportunities

The completion of a systematic scoping review can offer students and faculty the opportunity to present their work at conferences and to publish their findings. The prospect of publishing and/or presenting systematic scoping review projects can help motivate students who are members of the team. See Appendix II AAS Poster Draft for an example poster presented at a regional conference by our cadets and lieutenants. Findings from systematic and scoping reviews are broadly applicable, thus providing various opportunities for students and faculty to present at both the local, regional, and national levels. Importantly, large author lists are not uncommon in systematic and scoping reviews due to the high-volume workload (Morales et al., 2017), thus having a large team to complete these projects is effective and students and faculty alike can be recognized for their work.

Open Communication

Between meetings, open lines of communication allow team members of all ranks to share ideas. A shared drive enables all members of the team to work together efficiently on research documents and presentations, while housing them in a central and easily accessible location. Our university uses Teams and SharePoint by Microsoft, but other free applications such as Google Drive or Dropbox could be used as well. Teams and SharePoint allows students and faculty to simultaneously improve work, make changes on writing projects or posters, and collaborate from different locations. Centralized emails help to keep all members up to date on the project progress.

In addition to cloud storage for easy access to project-related files, it is important for members of the research team to have easy access to each other throughout the week. For brief group correspondence that does not require extensive time and discussion, messaging services like GroupMe or collaboration software such as Slack are helpful. These services are either free to users or offer a free base package that is sufficient for teams that do not match the numbers or complexity of some company department teams. These services provide faculty and students privacy from sharing personal contact information with one another, since they are likely involved in curricular settings.

As discussed briefly in the *Meetings* section, virtual meeting solutions are especially useful when face-to-face meetings are logistically challenging to carry out. There are many services like Zoom and GoToMeeting that coincide nicely with the needs of online or virtual correspondence that are secure. The function and importance of strong communication and accessibility to both team files and members is magnified when considering that this project is completed entirely online by such a large research team.

Review Software

It is beneficial to use a specialized software to complete a systematic or scoping review. We currently use the e-software Covidence (Veritas Health Innovation, n.d.), a platform which our university utilizes for systematic and scoping review collaborations. Covidence allows the team to work on the project simultaneously, while also providing data on the total amount of abstracts and full texts reviewed by the team, as well as individual member completion rates. If a university does not provide access to paid systematic review software there are websites such as Rayyan QCRI (Ouzzani et al.,

2016) that are free to users. Generally, these e-software programs are relatively easy to use. However, it is essential to train the students in how to correctly use any software when conducting systematic and scoping reviews. While software training is a significant front-end time investment, when done properly, well-trained team members remove stress and unnecessary difficulty later in the research process.

Planning for the Future

Considering the number of opportunities that are offered to students in projects like a systematic or scoping review, it is crucial that the collaboration between generals and lieutenants is not wholly fixated on only active project tasks. It is in the interest of project momentum that meetings among upper-level team members address avenues for moving forward after ongoing efforts (i.e., abstract review onto full text or full text onto data extraction) are completed. Failure to consider upcoming objectives and implementation is an invitation for stagnation and frustration within the cadet ranks and a loss of research productivity. New cadets are of importance here, as they are very likely to have some expectation of a highly active and engaging research environment. Furthermore, as the project grows and its timeline begins to span across multiple semesters, existing lieutenants will matriculate to a higher level of education or enter the workforce, which may require them to relinquish their role. For this reason, it is important to plan future steps small and large. Lethargy of generals and lieutenants must be avoided and therefore prospective thinking and preemptive planning on the part of the project leaders is a crucial element to the success of this type of student experience.

Conclusions

Systematic and scoping reviews are a sustainable avenue for faculty of all disciplines to collaborate and mentor a team of undergraduate students with a continuum of research training and experience. Results from a survey on outcomes of undergraduate research determined that sustained long-term research projects, attending conferences, mentoring other students, and authoring journal papers, were associated with a positive research experience for undergraduate students (Russell et al., 2007). The methods described above for a mentored systematic scoping review clearly address each of these outcomes and all are integrated directly into our research project design.

Creating additional opportunities for undergraduates to conduct research, outside of the one-on-one mentoring on faculty research projects, is the goal of many educators and educational researchers. To meet this need, summer research programs, year-round research programs, and course-based undergraduate research (CURE) experiences have been created to increase undergraduate exposure to research (Bertrand & Slovensky, 2020; Bhatt & Challa, 2018; Butler et al., 2008). We propose that the systematic review project is an additional mode of research to be included in this programming.

Summer research programs offer invaluable exposure to research for undergraduates, but they also have significant challenges for both students and faculty. Students often struggle to learn the science literature, the context of their project, the research methods, and how to collect and interpret data all in a 10-week period (Kardash, 2000). Further, there are significant time and resource limitations on the faculty when mentoring a new undergraduate student in the laboratory (Kardash, 2000). We propose that beginning these types of review projects can overcome these challenges and would make an excellent research endeavor for summer research programs, with the great likelihood to continue after the 10 weeks. This would increase the research exposure time and would potentially allow students to contribute to the authorship on a publication, both of which are associated with positive undergraduate research experiences (Russell et al., 2007). As systematic review projects are web-based, less resources are utilized during the training for this project. Further,

creating timelines with student help (see the *Meetings* section) increases student "buy in" to summer research projects by allowing the students assist in creating their own research experience (Butler et al., 2008). Integrating key aspects of summer research programs into a web-based research project would positively impact the research experience for both faculty and students.

CUREs have been an effective means for increasing exposure of groups of undergraduates to authentic research experiences (Corwin et al., 2015). Many traditional CUREs focus on a basic science question, such as engaging first year students in zebrafish CRISPR/Cas9 editing (Bhatt & Challa, 2018) or studying the plankton *Tigriopus califonicus* (Olimpo et al., 2016). Although we do not describe our project as a potential course, we propose that a systematic review project on a specific science topic could offer an authentic CURE for online students. CUREs contain activities such as collecting novel data, working collaboratively with peers, interpreting results, and reading and analyzing the current literature, which we demonstrate are essential activities in our methods to complete a systematic review project with undergraduate researchers (Corwin et al., 2015). Note that CURE is not a traditional term used in the non-STEM fields, but course-based undergraduate research is still present in courses sometimes called research methods or research based-courses. Further, activities associated with belonging in academia, such as presenting work at conferences and publishing academic papers, are incentives built into our methodology.

As illustrated by the following quotes from our undergraduate students, participation on a mentored systematic scoping review project directly ties into short- and medium-term learning outcomes associated with CUREs. These include but are not limited to the following: increased analytical skills, knowledge content, self-efficacy, and project ownership (Corwin et al., 2015) which encourage the development of key research-related skills, including: analytical assessment and field-based literacy (See *Learning Outcomes* section).

"[I have learned] the importance of defining terminology properly and consistently throughout the project's progression, and how deadline-sensitive the research has to be for the project to actually move forward."

"I feel as if I have gained a more abstract/open-mind when regarding research and undergraduate researchers. I am able to reflect on my personal experience in research and appreciate the soft skills I have learned and how they apply to interview skills and graduate school. I feel like I have also learned to correctly dissect an abstract and, in the future, a full paper to understand the key concepts efficiently."

"I've learned how to analyze an abstract by pinpointing specific topics; thus, being able to understand the overall purpose of the project. Additionally, because of the limited time strain, I was able to work efficiently. This has helped me to be more productive in finishing a required amount in a certain time. Moreover, because [our generals] were able to describe what goes on behind the scenes of a research project, I was able to better grasp what has to happen in order for research to be accurately conducted."

"As a lieutenant, I have gained useful tools for implementing effective teamwork, collaborating with my peers and faculty, and strengthened my ability to communicate and plan effectively. I also gained valuable insight into the research process."

"I never knew that a web-based project would rely so heavily on teamwork. I can honestly say that I have learned a new appreciation for collaboration and how to implement effectively from a distance."

As evidenced by the student comments above, the learning outcomes discussed, including developing time management, teamwork, and leadership skills, and understanding different kinds of scientific literature and research projects are achieved with systematic review projects. Further, we have seen improvements in our student's critical thinking and problem-solving skills, their ability to interpret the scientific literature, and their overall outlook on a web-based literature project. Our evaluation is currently anecdotal, but our future goals include developing and validating evaluation methods for assessing these important outcomes of our undergraduate students research team, as is recommended by Corwin and colleagues (Corwin et al., 2015).

In a time when research funding is scarce and sustainable productivity in scholarship is essential, faculty should consider creating a line of research that is flexible, productive, and sustainable by leading to new research questions. This type of project can be executed through entirely virtual means providing opportunities for students that have ever increasing home and work demands. Further, it provides a route for maintaining productive scholarship in times when forced social distancing (such as during the COVID-19 pandemic) is necessary for safety.

Overall, our article describes how to implement systematic and scoping review projects effectively to create an opportunity that benefits undergraduate researchers and faculty alike, while producing novel research that is both productive and sustainable.

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