Systematic Literature Review Enhances the Professional Development of Undergraduate Students

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Abstract

The measured value of systematic literature review and research synthesis for contributing to the professional development of undergraduate students is largely unknown. As such, opportunities to develop these skills may be underutilized by educators. Using quantitative and qualitative methods we assessed how the level of participation in an out-of-classroom volunteer opportunity that focused on research synthesis could enhance the professional development of undergraduate students in ecology. We found improvements in participants' motivation to pursue careers in ecology and self-confidence as researchers, which are two key aspects of professional development. Systematic literature review and research synthesis are critical skills for success in environmental sciences, yet opportunities to develop these skills may be scarce. Developing these skills can impart significant benefits to the professional development of undergraduate students, and educators should not hesitate to offer opportunities based on literature review and research synthesis.

Keywords: undergraduate, motivation, confidence, professional development, literature review

Although formal courses provide foundational knowledge for undergraduate students, out-of-classroom experiences provide opportunities to develop complementary real world skills in more authentic contexts (Keown, 1984). These out-of-classroom experiences such as volunteer positions, field experiences, and self-directed research increase the chances of undergraduate students following a career in STEM fields (science, technology, engineering, and mathematics), improve their basic skills, and cultivate their identity as scientists (Kardash, 2000; Robnett et al., 2015). In ecology, field experiences are especially common. Numerous studies document the benefits of these field experiences; such as increasing the likelihood of students pursuing a career in ecology, instructing the use of field equipment and methods, and increasing student comprehension of course material (Keown, 1984; Lei, 2010; Lopatto, 2010; McLaughlin et al., 2018; Resasco, 2013; Switzer, 1995). Although field experiences benefit many aspects of student professional development, other skills such as quantitative analysis, science communication, and research synthesis are also central in the holistic career preparation of ecologists. In particular, skills related to research synthesis such as the ability to find, understand, and synthesize published data have been identified as critical components of environmental education programs (Monroe, 2012). While the myriad of benefits of field experiences for undergraduate ecology students have been well documented, there is a need to better understand the benefits or potential drawbacks of developing skills related to research synthesis. Especially central to research synthesis is the process of conducting systematic literature review and extracting key data from published studies, which from here on we refer to as “data compilation”.

For ecology undergraduate students, opportunities to engage in data compilation as part of a research synthesis project are less common than field experiences. Nonetheless, experience in data compilation is critical for developing skills such as how to find relevant publications, use criteria in systematic literature searches, and interpret the information in publications. Data compilation is also a key component of meta-analyses and other forms of research synthesis that create generalizations, resolve uncertainty, and identify knowledge gaps (Koricheva et al., 2013). Although systematic literature review and data extraction are vital skills for ecologists, it is largely unknown how undergraduate students perceive these activities. It is reasonable to hypothesize that undergraduate students would generally prefer field experiences over data compilation which could be perceived as repetitive and unengaging. If data compilation is perceived to be unengaging busy work it might decrease student interest and confidence, thus potentially deterring some students from pursuing careers in ecology (Motz et al., 2021). None-the-less, given its importance, thoroughly developing data compilation skills in a research synthesis framework could be a valuable opportunity for enhancing the professional development of undergraduate students. As such, it is important to assess how students perceive data compilation experiences to gauge its value in the process of professional development.

In this study we address the question: in what ways do data compilation experiences as part of research synthesis projects enhance and/or hinder undergraduate professional development? Similarly, how does the level of participation in these activities mediate these effects? We expected a priori that participating in data compilation would increase student confidence because it is perceived as an important skill for ecologists, increases student familiarity with ecological research, and ultimately results in an impactful final product. Previous research has found that student self-efficacy (i.e., one’s belief that they can successfully complete tasks specific to a field) is an important factor to their self-confidence in their ability to progress in STEM fields (Wofford, 2021). Given that data compilation is a critical aspect of research, we expected that improving these skills will increase students’ belief that they can successfully conduct research and thus their self-confidence. In addition to self-confidence as researchers, developing the motivation to pursue a career in ecology or other STEM fields is a critical aspect of undergraduate professional development. Motivation has been found to be improved by access to mentors, a student’s self-confidence, instructor feedback, and the perceived relevance of a task (Cromley et al., 2015; Hernandez et al., 2017). Therefore, we expected that a modest increase in motivation might occur in some students, likely as a result of increased self-confidence. However, we also expected a priori that participating in data compilation might decrease some students’ motivation to pursue a career in ecology or other STEM fields because data compilation requires spending extensive amounts of time performing tedious tasks such as systematic literature searches, reading many published studies, and taking detailed notes (Motz et al., 2021). Addressing this question will help elucidate the value of data compilation in research syntheses experiences for enhancing undergraduate professional development.

Methods

We used a combination of quantitative and qualitative methods to determine how data compilation experiences potentially enhance the professional development of undergraduate students. We surveyed the attitudes of eight volunteers who participated in an out-of-classroom data compilation project and assessed changes in their levels of motivation and confidence.

From September 2020 to August 2021 we conducted an ecological meta-analysis describing the difference in spatial extents at which habitat configuration and composition influences wildlife distributions. This meta-analysis required amassing a thorough compilation of data on movement behavior of 128 species of terrestrial mammals globally. To assist compiling and summarizing movement behavior data, we put out a call for volunteers among the undergraduate students in the University of Florida department of Wildlife Ecology and Conservation. Nine students responded and attended a virtual training on how to perform a systematic review of the primary literature early in January 2021. They were trained to use keyword searches in Web of Science and Google Scholar to systematically search for a given

species' movement behavior data. Specifically, volunteers reviewed all results in the Web of Science using the key word search species name AND "dispersal" AND "home range". If this search did not generate results, the search was broadened to include only "species name". Volunteers were assigned different species and independently read all relevant search results, and extracted key information that included homerange size, dispersal distance, dispersal type, study location, and sample size. The participants compiled this information into a summary report for each individual species. The number of publications pertaining to a given species on Web of Science and Google Scholar varied by species, but was often more than 50. Each volunteer worked remotely for approximately three hours a week on the project during the spring semester (i.e., January 2021 to April 2021). By the end of the semester, each volunteer completed zero to 36 species summary reports (mean (M) = 11; standard deviation (SD) = 10.7). Two of the nine volunteers did not complete any species summary reports.

To assess the contribution of data compilation to the participants' professional development, we invited volunteers to complete two surveys: one at the beginning of the semester and another at the end of the semester (Supplementary Information, Appendix A). In addition to non-sensitive basic student information (i.e., year in degree, department), the surveys contained three sections: section one) participant level of motivation to pursue STEM careers; section two) participant level of self-confidence as a researcher; and section three) participant overall reaction to and attitudes about the experience (administered only in the post-semester survey; Supplementary Information, Appendix A).

Both pre- and post-semester surveys contained identical versions of sections one and two. Section one contained eight closed-answer questions on a Likert scale of one to four (Likert, 1932), with higher numbers indicating greater agreement with statements expressing level of motivation to pursue graduate studies or a career in ecology or STEM (i.e., minimum 1 = "strongly disagree", maximum 4 = "strongly agree"). Section two contained 11 closed answer questions on a Likert scale of one to seven, with higher numbers indicating a greater level of agreement with statements expressing level of confidence as a researcher (i.e., minimum 1 = "strongly disagree", maximum 7 = "strongly agree"). This section was designed to measure the respondents' self-confidence in several research abilities, primarily those related to data compilation, but also their self-confidence in their ability to succeed as researchers in general.

Section three was included in only the post-semester survey and contained seven open answer questions regarding the participants' reactions to participating in the project. This section allowed for a qualitative assessment of student attitudes, in particular, what they learned and how they felt they benefited by participating in the project. This section also provided participants a chance to express any dissatisfaction with the experience and/or provide constructive criticism. The three sections of our survey were developed by the authors, but questions were closely modeled after similar Undergraduate Research Experience questionnaires with modifications made to focus on motivation and confidence (Grinnell College, 2009). Surveys were administered and returned by email. Participants were made aware that completing the surveys was voluntary and would not affect their participation in the ecological meta-analysis project. Eight of the nine volunteers returned fully completed survey responses at the start and end of the semester.

To quantitatively measure the effect of participating in a data compilation project on student motivation and confidence, we assessed sections one and two of the survey using first paired t-tests then linear regressions, namely one t-test and regression for each section of the survey. Each respondent that completed at least one species report served as one sample in the paired t-tests (N = 6), and all respondents served as one sample in the regressions (N = 8). We summed a participant's responses to all questions within a section (i.e., eight 1–4 questions in section one, and eleven 1–7 questions in section two). With these totaled scores, we used paired-sample t-test to determine if there was a significant difference between post- and pre-semester scores for a participant's motivation or confidence as a result of participating in data compilation activities. This was the primary quantitative analysis and served to indicate if a significant change occurred in the students from the start to end of the semester. Then, we used the difference between a student's summed pre- and post-semester scores within a section as the response variable in the two linear regressions. Positive values indicated an increase in overall motivation or in overall self-confidence from the start of semester to the end of semester. In both linear models, the number of species summary reports completed by a participant was used as the explanatory variable to represent the amount of time spent conducting research synthesis. We expected the relationship between motivation or self-confidence and the number of species assessed to decelerate rather than increase indefinitely. To model this relationship, we log transformed the independent variable (i.e., number of species assessed). The final model for section one took the form

$$\Delta motivation = \beta_0 + \beta_1 * log(S) + \epsilon$$

where S is the number of species summary reports completed, ϵ is the residuals in the model which are assumed to follow $\epsilon \sim N(0,\sigma)$ where σ is a measure of variability, and β_0 and β_1 are the intercept and slope of the relationship respectively. A similar model for section two contained $\Delta confidence$ as the response variable. We use a models' R^2, beta coefficients (β_1), standard error (SE), and their corresponding p-values to make inference on the extent that participants' change in interest or confidence was explained by their level of participation in research synthesis activities. We consider a β_1 p-value < 0.05 to indicate a statistically significant relationship between the amount of time spent engaging in data compilation activities and student motivation or confidence. Although eight or six is a very small sample size, there is no theoretical minimum for sample size in these sort of Ordinary Least Squares (OLS) analyses (van de Schoot and Miočevic´, 2020). A potential

issue of low sample sizes in OLS analyses is the high risk of type II error (i.e., failing to detect a relationship when one exists; van de Schoot and Miočevic´, 2020). As such, if our OLS analyses detects a relationship with these low sample sizes, that relationship can be considered relatively robust. However, sample sizes as low as eight or six can be heavily influenced by outliers (e.g., atypical students) or random chance and we still strongly emphasize caution in drawing inference from these OLS analyses alone. All analyses were done in R version 3.5.1 (R Core Team, 2018).

To complement our quantitative analyses, we also examined the effect of data compilation experiences on student motivation and confidence qualitatively through the open answer section of the post-semester survey. Because this section was only relevant to participants that completed at least one species summary report, the two participants that did not complete any reports were not able to respond to section three (however, they were able to respond to sections one and two). Therefore, we had a total of six respondents for section three whose responses we assessed with a thematic analysis approach (Akinyode & Khan, 2018; Lester et al., 2020). Namely, we reviewed their responses and looked for commonly expressed sentiments shared by multiple respondents. Because there were only six respondents in this section and their responses were written, extensive data preparation and transcription phases of thematic analysis were not necessary (Lester et al., 2020). Similarly, the thematic analysis did not require the aid of any software. Extensive coding was not necessary as student responses were brief (e.g., 1-5 sentences); however, memoing (i.e., recording our reflections) was employed while reviewing the responses (Lester et al., 2020). After an initial review and memoing of the responses, we reassessed them and grouped any of the shared or noteworthy sentiments expressed by the participants into hierarchical themes and sub-themes (Akinyode & Khan, 2018). Attention was given to identify what participants considered positive or negative aspects of the experience (i.e., what did they feel enhanced or hindered their professional development).

In accordance with our background in natural sciences, we approached this analysis in the post-positivist paradigm because we intended to elucidate the cause and effect relationship between data compilation and effective professional development leading to career preparation (Monroe et al., 2019). We attempted to remain as objective as possible. However, we recognize that our research is a case study within the complex phenomenon of professional development, and its results are meant to inform as best a possible via multiple methods rather than prove any conclusion definitively (Panhwar et al., 2017).

Our study was approved by the University of Florida IRB202100035.

Results

Both quantitative and qualitative surveys showed a positive effect of data compilation in research synthesis for improving students' self-confidence as researchers. The qualitative survey also showed a positive effect on student motivation to pursue STEM careers, but this pattern was not significant in the quantitative analysis. However, contrary to predictions, there was no quantitative or qualitative decrease in motivation.

Quantitative Assessment of Motivation

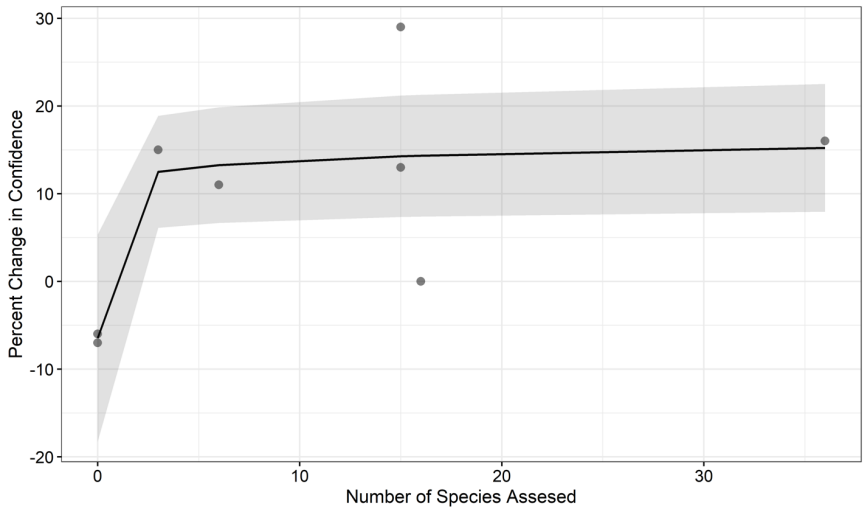
Paired t-test showed no significant difference between participating students' post- and pre- semester levels of motivation ($p = 0.74$). Linear regressions of responses to section one also showed no significant effect of the degree of engagement in data compilation on students' motivation to pursue careers in STEM fields ($\beta_1 = -0.021$ SE = 0.06, $p = 0.74$; model $R^2 = 0.019$). Across all eight respondents, the mean change in section one scores between the beginning and end of the semester was 0.2 (of a possible maximum of 32). However, all eight participants began with a high, almost maximal, amount of motivation. The maximum response for a given question was four, and 74% of all responses in section one of the pre-semester survey were four (23% three, 2% two; Appendix B). Participant motivation did not show significant quantitative decrease by the end of the semester after participating in data compilation activities. The internal consistency of section one responses was poor, with a Cronbach alpha score of 0.58 (Cronbach, 1951). However, this was surprising given that there was very little variation between responses. The relatively coarse scale (i.e., 1 to 4) of this section may have led to this low Cronbach alpha score. Similarly, some respondents indicating high motivation to pursue a career in ecology, but not other STEM fields in general might have lowered this section's internal consistency. Nonetheless, there was no quantitative evidence of a change in motivation to pursue career in ecology, likely because motivation was already high with little space for improvement.

Quantitative Assessment of Confidence

Conversely, a paired t-test showed a significant difference in the six participating respondents' levels of confidence between the start and end of the study ($p = 0.00012$). The mean level of overall self-confidence for participating respondents ($N = 6$) at the start of the semester was 58.5 (SD = 7.2) versus 66.5 (SD = 6.7) at the end of the semester (Appendix B). Furthermore, in the linear regression student confidence showed a significant quantitative increase with increasing engagement in the project ($\beta_1 = 0.67$, SE = 0.2, $p = 0.017$; model $R^2 = 0.64$). Of the eight total respondents, five had a 10–30% increase in confidence, one had no change, and two participants had a ~6% decrease in confidence (Figure 1). The participants that completed the most species summary reports generally had the greatest increase in confidence. However, as expected this increase in confidence plateaued. The only two participants to report a decrease in confidence were the two non-participating students that attended the initial project training, but did not complete any species summary reports throughout the semester. The specific questions that saw the greatest increase among all respondents were: "I am confident in my ability to synthesize scientific publications and extract key information" and "I am ready for a career in

Figure 1.

Change in Participant Confidence



Note. Model predicted change in confidence in relation to the number of species summary reports completed. Gray points are the real data values and each point represents one student. The relationship between dependent and explanatory variables were modeled with a logarithmic relation to account for a plateau in confidence. Values on the x-axis are back transformed to their original values for plotting purposes. Predicted values (solid black line) and 95% confidence interval (gray shading) were generated with the plot_model function of "sjPlot" in R.

ecology and/or wildlife management". Internal consistency of this section's question was suitable with a Cronbach's alpha score of 0.76 (Cronbach, 1951).

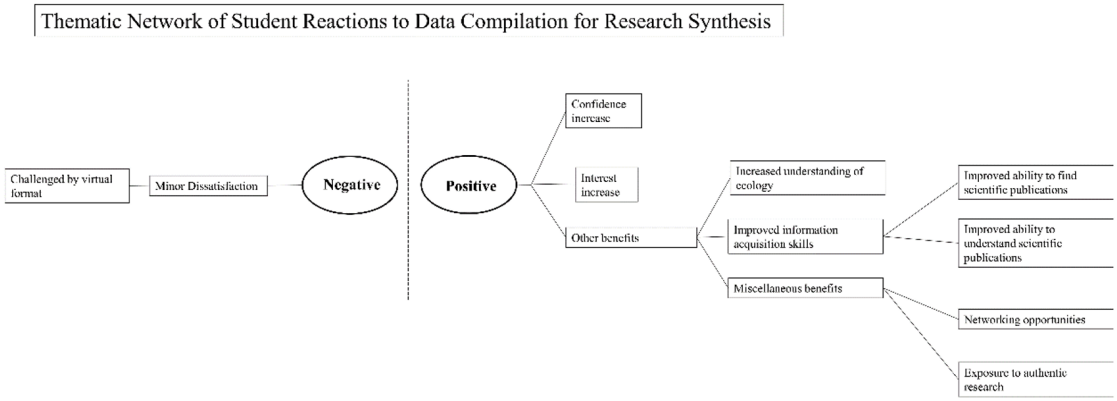
Qualitative Assessment

Although the quantitative results showed significant change in self-confidence and a positive relationship with the degree of participation in data compilation, the robustness of the analysis is limited by small sample size. However, this quantitative trend was supported by the qualitative results that also indicated the benefits of data compilation on student professional development, particularly by increasing student confidence. All six respondents to the qualitative section (i.e., the respondents that completed at least one species summary report) had expressed sentiments that fit into the theme of being more motivated to pursue a career in STEM, and also of being more confident in their research abilities (Figure 2). Specifically, all six participants indicated they were more or equally interested in pursuing a career in ecology, all felt more prepared for a career in ecology, and all would recommend other students to participate in similar data compilation experiences. For example, one participant noted "*I feel more interested in pursuing a career in ecology and wildlife because now I know more about the exciting and in-depth research that goes into this field*", and another that "*I feel much more prepared now for a career in ecology than I did previously. I am significantly more confident in my ability to conduct research and analyze scientific papers now than I was before*". Additionally, all six respondents expressed similar sentiments that participating in data compilation improved their information acquisition skills in one or more of the following ways: ability to use Web of Science and Google Scholar, identify relevant articles, understand the language used in scientific publications, navigate typical publication format, extract key information from each article, and compile key findings into a comprehensive understanding. In addition to improving the process of obtaining information from scientific publications, four of the six respondents expressed that they gained a deeper understanding of and interest in ecology. For example, one participant noted *"I also learned more about wildlife movement and the difference between species"*.

Some participants also mentioned benefiting from the experience in ways that are not specific to data compilation activities, but applicable to volunteering in general. For example, two respondents reported that they enjoyed seeing a "behind-the-scenes" look at how research is conducted, and also appreciated the opportunity to interact with other undergraduate and graduate students. Two participants felt the virtual format of the project was convenient and conducive to their success. One participant felt that the relatively hands-off style of this project compared to others they had participated in impeded their motivation to participate more. However, this was the only negative perspective of the experience and not specific to data compilation. Finally, some noteworthy positive responses include two students reporting they felt that participating in this data compilation experience was in some ways better than formal classes they had taken: *"I also found that this experience was very enriching unlike some of my other classes, and I felt a sense of accomplishment when working and completing the work for this project"*, and *"I've had to look through research for classes of course, but I haven't had to read through as many articles for class as I did for this [volunteer position]".* Overall, participants' qualitative reaction to data compilation was positive indicating an increase in motivation, confidence, and learning.

Figure 2.

Qualitative Responses Thematic Map



Note. Thematic network of themes and sub-themes emerging from participant survey responses. Reactions are divided into the two global themes of positive and negative reactions to the experience. Hierarchical sub-themes elucidate the specific ways in which participants benefited or were hindered by the experience.

Discussion

Although many undergraduate students in ecology are inspired by field experiences, success in ecology and related professions depends on more than field skills (Auker & Barthelmess, 2020; Gray et al., 2005). Searching, interpreting, and synthesizing peer-review publications are other key skills in professional ecology (Brownell et al., 2012). Results from our study demonstrate the potential benefits of developing these skills, in particular increasing student confidence. Specifically, based on participants' qualitative responses, we found that all student volunteers in a data compilation opportunity increased their ability to find information, navigate peer-review publications, and distill information into a communicable form. These abilities represent higher order learning on Bloom's taxonomy (i.e., analyze and evaluate) critical for university level learning (AAAS, 2011; Krathwohl, 2002). Overall, our pool of participants gained these important skills, increased their self-confidence, and had no decrease in motivation.

The improvements made by participants in this study may be especially important as most indicated this was their first experience with tasks related to data compilation or research synthesis. During the initial training at the start of the semester, many participants indicated they were not familiar with the general format of scientific papers, nor how to systematically search for publications. Even for students in their third year, these skills appeared to have not yet been developed. As the semester progressed, a noticeable improvement was seen in the speed and quality with which students completed species summary reports. These rapid improvements demonstrated that these skills can be developed in a relatively short amount of time, and thus potentially indicated that participants received little prior training in these skills. This lack of prior training exemplifies how data compilation and research synthesis opportunities are potentially underutilized for the professional development of undergraduate students.

Change in Motivation

Contrary to initial worries, professional development via data compilation activities did not come at the cost of diminishing participant motivation to pursue careers related to ecology. We predicted that the tedious nature of systematic literature review could make it an unappealing aspect of ecological science. However, no quantitative change was seen in participant levels of motivation. In fact, in the qualitative survey participants universally expressed an increase in motivation to pursue careers in ecology. However, based on participant comments, some of this increase came from networking with other students and a "behind-the-scenes" look at research, and these benefits are not necessarily unique to data compilation. Regardless, the tedious nature of data compilation did not diminish any participant's motivation to pursue a career in ecology. Participant motivation to pursue a career in ecology did not change greatly; however, we consider this a positive outcome as there was no decrease in motivation.

Our results mirror a similar study in which undergraduate students reacted positively (i.e., increased confidence and professional skills with no decrease in motivation) to a course focused on writing for science that was expected to diminish some students' motivation to pursue careers in STEM (Brownell et al., 2012). Despite the tedious nature of activities such as data compilation and writing for science, undergraduate students appear to remain motivated while developing these skills. The difference between these activities and other tedious activities that do diminish student motivation may be related to the authentic importance of these activities for a career in STEM. Studies have shown that similar activities that differ primarily in their authenticity elicit substantially different reactions for students (Simmons et al., 2008). Namely, students reacted positively to an authentic activity but more negatively to a simulated exercise of the same activity (Simmons et al., 2008).

Change in Confidence

Student success in ecology depends not just on their level of motivation, but also confidence in their skills as researchers (Nicholson et al., 2013). In this respect, we observed statistically significant improvements to student confidence that can likely be attributed to data compilation specifically. The only two respondents that showed a decrease in confidence over the semester were ultimately unable to participate in the project. Their decrease in confidence could be due to disappointment felt from not having time to participate in a project they were initially interested in, or general end-of-semester fatigue that was mitigated in the other participants by their involvement in the project (Young et al., 2018). The students that did participate showed a quantitative and qualitative improvement in their level of confidence, especially in skills related to data compilation, but also research in general. Improving confidence is a vital aspect of a student's professional development and promotes their ability to work independently (Hunter et al., 2006).

Although we recognize that this study contained a small sample size (eight respondents), it still provides a useful indication of the value of data compilation for enhancing undergraduate professional development. Additionally, achieving a larger sample size in this type of study may be unfeasible. Unlike attracting volunteers for field experiences, attracting a large number of volunteers to participate in the same data compilation project may normally be difficult. Some participants expressed at the start of the project that they wanted to volunteer in some sort of ecological study, but that the COVID-19 pandemic limited other available options. The research project of wildlife movement behavior was conducted remotely, thus was an option during the pandemic when other field options were more limited. Similarly, in our experience, it is rarely necessary to include more than one or two volunteers in most data compilation projects. The scope of the wildlife movement behavior project allowed for a less limited number of volunteers. These two factors make a group as large as eight a relatively large group for this sort of project, and an opportunity worth examining.

Summary

We found quantitative and qualitative evidence that data compilation experiences can develop skills that make students feel more confident and prepared for a career in ecology. Also, despite its apparent tedious nature, data compilation did not decrease participant motivation to pursue graduate school or careers in ecology. Overall, our results suggest data compilation can be an important complement to other professional development opportunities, and is potentially being underutilized throughout higher level education in favor of field experiences. We recommend that educators should not hesitate to offer opportunities in data compilation or other activities related to research synthesis as a means to prepare students for professions in ecology and other natural sciences.

References

AAAS. (2011). *Vision and Change in Undergraduate Biology Educaiton, A Call to Action*.

Akinyode, B. F., & Khan, T. H. (2018). Step by step approach for qualitative data analysis. *International Journal of Built Environment and Sustainability*, *5*(3), 163–174. https://doi.org/10.11113/ijbes.v5.n3.267

Auker, L. A., & Barthelmess, E. L. (2020). Teaching R in the undergraduate ecology classroom : approaches , lessons learned , and recommendations. *Ecosphere*, *11*(4). https://doi.org/10.1002/ecs2.3060

Brownell, S. E., Price, J. V, & Steinman, L. (2012). A writing-intensive course improves biology undergraduates ' perception and confidence of their abilities to read scientific literature and communicate science. *Advances in Physiology Education*, *37*, 70–79. https://doi.org/10.1152/advan.00138.2012

Cromley, J. G., Perez, T., & Kaplan, A. (2015). Undergraduate STEM Achievement and Retention: Cognitive, Motivational, and Institutional Factors and Solutions. *Policy Insights from the Behavioral and Brain Sciences*, *3*(1), 4–11. https://doi.org/10.1177/2372732215622648

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555

Gray, F. E., Emerson, L., & MacKay, B. (2005). Meeting the demands of the workplace: Science students and written skills. *Journal of Science Education and Technology*, *14*(4), 425–435. https://doi.org/10.1007/s10956-005-8087-y

Hernandez, P. R., Bloodhart, B., Barnes, R. T., Adams, A. S., Clinton, S. M., Pollack, I., Godfrey, E., Burt, M., & Fischer, E. V. (2017). Promoting professional identity, motivation, and persistence: Benefits of an informal mentoring program for female undergraduate students. *PLoS ONE*, *12*(11), 1–16. https://doi.org/10.1371/journal.pone.0187531

Hunter, A., Laursen, S. L., & Seymour, E. (2006). Becoming a Scientist : The Role of Undergraduate Research in Students ' Cognitive , Personal , and Professional Development. *Science Education*, *91*, 36–74. https://doi.org/10.1002/sce

Kardash, C. A. M. (2000). Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*, *92*(1), 191–201. https://doi.org/10.1037/0022-0663.92.1.191

Keown, D. (1984). Let ' s Justify the Field Trip. *National Association of Biology Teachers*, *46*(1), 43–48.

Koricheva, J., Gurevitch, J., & Mengersen, K. (2013). Handbook of Meta-Analysis in Ecology and Evolution. Princeton University Press.

Krathwohl, D. R. (2002). A Revision of Bloom ' s Taxonomy : An Overview. *Theory Into Practice*, *41*(4), 212–219. https://doi.org/10.1207/s15430421tip4104

Lei, S. a. (2010). Field Trips in College Biology and Ecology Courses: Revisiting Benefits and Drawbacks. *Journal of Instructional Psychology*, *37*, 42–48. http://go.galegroup.com/ps/i.do?id=GALE%7CA224405377&sid=googleScholar&v=2.1&it=r&linkaccess=fulltext&issn=00941956&p=AONE&sw=w

Lester, J. N., Cho, Y., & Lochmiller, C. R. (2020). Learning to Do Qualitative Data Analysis: A Starting Point. *Human Resource Development Review*, *19*(1), 94–106. https://doi.org/10.1177/1534484320903890

Likert, R. (1932). A TECHNIQUE FOR THE MEASUREMENT OF ATTITUDES. *Archives of Psychology*, *22*, 5–55.

Lopatto, D. (2010). Undergraduate Research as a High-Impact Student Experience. *Peer Review*, *12*(2), 27–30. http://content.ebscohost.com/ContentServer.asp?T=P&P=AN&K=52225829&S=R&D=a9h&EbscoContent=dGJyMMvI7ESeqK84yNfsOLCmr0uep7BSs6y4S7WWxWXS&ContentCustomer=dGJyMPGpt0mwrLdQuePfgeyx44Dt6fIA%5Cnhttp://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=5222582

McLaughlin, J., Patel, M., Johnson, D. K., & De la Rosa, C. L. (2018). The Impact of a Short-Term Study Abroad Program that Offers a Course-Based Undergraduate Research Experience and Conservation Activities. *Frontiers: The Interdisciplinary Journal of Study Abroad*, *30*(3), 100–118. https://doi.org/10.36366/frontiers.v30i3.424

Monroe, M. C. (2012). The Co-Evolution of ESD and EE. *Journal of Education for Sustainable Development*, *6*(1), 43–47. https://doi.org/10.1177/097340821100600110

Monroe, M. C., Adams, A. E., & Greenaway, A. (2019). Considering research paradigms in environmental education. *Environmental Education Research*, *25*(3), 309–313. https://doi.org/10.1080/13504622.2019.1610863

Motz, B. A., Quick, J. D., Wernert, J. A., & Miles, T. A. (2021). A pandemic of busywork: Increased online coursework following the transition to remote instruction is associated with reduced academic achievement. *Online Learning Journal*, *25*(1), 70–85. https://doi.org/10.24059/olj.v25i1.2475

Nicholson, L., Putwain, D., Connors, L., & Hornby-Atkinson, P. (2013). The key to successful achievement as an undergraduate student: Confidence and realistic expectations? *Studies in Higher Education*, *38*(2), 285–298. https://doi.org/10.1080/03075079.2011.585710

Panhwar, A. H., Ansari, S., & Shah, A. A. (2017). Post positivism research: an effective paradigm for social and educational research. *International Research Journal of Arts & Humanities (IRJAH)*, *45*, 253–260. https://sujo-old.usindh.edu.pk/index.php/IRJAH/article/view/3371

Resasco, J. (2013). Field-based and hands-on ecology lab increase undergraduate interest in the natural world. *Journal of Natural History Education and Experience*, *7*, 22–25.

Robnett, R. D., Chemers, M. M., & Zurbriggen, E. L. (2015). Longitudinal associations among undergraduates' research experience, self-efficacy, and identity. *Journal of Research in Science Teaching*, *52*(6), 847–867. https://doi.org/10.1002/tea.21221

Simmons, M. E., Wu, X. B., Knight, S. L., & Lopez, R. R. (2008). Assessing the Influence of Field- and GIS-based Inquiry on Student Attitude and Conceptual Knowledge in an Undergraduate Ecology Lab. *Life Sciences Education*, *7*(3), 45–53. https://doi.org/10.1187/cbe.07

Switzer, P. V. (1995). Campus field trips: an effective supplement to classroom instruction. *Journal of College Science Teaching*, *XXV*(January), 140–143.

van de Schoot, R., & Miočevic´, M. (2020). Small Sample Size Solution, A Guide for Applied Researchers and Practitioners. Routledge.

Wofford, A. M. (2021). Modeling the Pathways to Self-Confidence for Graduate School in Computing. *Research in Higher Education*, *62*(3). Springer Netherlands. https://doi.org/10.1007/s11162-020-09605-9

Young, A. M., Wendel, P. J., Esson, J. M., & Plank, K. M. (2018). Motivational decline and recovery in higher education STEM courses. *International Journal of Science Education*, *40*(9), 1016–1033. https://doi.org/10.1080/09500693.2018.1460773

Appendix A

Pre-semester Volunteer Questionnaire

Basic Info:

1. Name:
2. Major:
3. Year:
4. Briefly describe any previous out-of-the-classroom experience(s) you may have had in ecology, wildlife management, or research in general (feel free to use more space than provided to answer):

Section One: On a scale of 1 to 4, indicate how much you agree with the following statements by typing an "X" into the appropriate box; with 1 indicating strongly disagree, 2 indicating somewhat disagree, 3 indicating somewhat agree, and 4 indicating strongly agree.

		1	2	3	4	NA
1	I am interested in pursuing a Master's or PhD in a field related to ecology and/or wildlife management.					
2	I am interested in pursuing a Master's or PhD in any field.					
3	I am interested in pursuing a career related to ecology and/or wildlife management.					
4	I am interested in pursuing a career related to science, technology, engineering, and/or math.					
5	I am interested in pursuing a career that involves conducting research.					
6	I enjoy learning about science.					
7	Conservation is important.					
8	Natural resource management is important.					

Section Two: On a scale of 1 to 7 indicate how much you agree with the following statements by typing an "X" in the appropriate box; with 1 indicating strongly disagree, 4 indicating unsure or no opinion, and 7 indicating strongly agree.

		1	2	3	4	5	6	7	NA
1	I am confident in my ability to conduct research.								
2	I am confident in my ability to use search engines to find the scientific publications I need.								
3	I am confident in my ability to read and understand scientific publications.								
4	I am confident in my ability to synthesize scientific publications and extract key information.								
5	I am confident in my ability to communicate information.								
6	I am confident in my ability to coordinate and work in a team.								
7	I find research in the field of ecology and/or wildlife management to be enjoyable.								
8	I am ready for a career in ecology and/or wildlife management.								
9	I understand what skills are important to have in order to be an ecologist and/or wildlife manager.								
10	I can learn new skills.								
11	I am eager to learn the skills that are important for work as an ecologist and/or wildlife manager.								

Appendix A Cont.

Post-semester Volunteer Questionnaire

Basic Info:

1. Name:
2. Major:
3. Year:
4. Courses you enrolled in during the Spring 2021 semester:

5. Briefly list any other research or volunteer projects you participated in during the Spring 2021 semester:

Section One: On a scale of 1 to 4, indicate how much you agree with the following statements by typing an "X" into the appropriate box; with 1 indicating strongly disagree, 2 indicating somewhat disagree, 3 indicating somewhat agree, and 4 indicating strongly agree. Please answer regardless of whether or not you worked on the project throughout the semester.

		1	2	3	4	NA
1	I am interested in pursuing a Master's or PhD in a field related to ecology and/or wildlife management.					
2	I am interested in pursuing a Master's or PhD in any field.					
3	I am interested in pursuing a career related to ecology and/or wildlife management.					
4	I am interested in pursuing a career related to science, technology, engineering, and/or math.					
5	I am interested in pursuing a career that involves conducting research.					
6	I enjoy learning about science.					
7	Conservation is important.					
8	Natural resource management is important.					

Section Two: On a scale of 1 to 7 indicate how much you agree with the following statements by typing an "X" in the appropriate box; with 1 indicating strongly disagree, 4 indicating unsure or no opinion, and 7 indicating strongly agree. Please answer regardless of whether or not you worked on the project throughout the semester.

		1	2	3	4	5	6	7	NA
1	I am confident in my ability to conduct research.								
2	I am confident in my ability to use search engines to find the scientific publications I need.								
3	I am confident in my ability to read and understand scientific publications.								
4	I am confident in my ability to synthesize scientific publications and extract key information.								
5	I am confident in my ability to communicate information.								
6	I am confident in my ability to coordinate and work in a team.								
7	I find research in the field of ecology and/or wildlife management to be enjoyable.								
8	I am ready for a career in ecology and/or wildlife management.								
9	I understand what skills are important to have in order to be an ecologist and/or wildlife manager.								
10	I can learn new skills.								
11	I am eager to learn the skills that are important for work as an ecologist and/or wildlife manager.								

Appendix A Cont.

Section Two: On a scale of 1 to 7 indicate how much you agree with the following statements by typing an "X" in the appropriate box; with 1 indicating strongly disagree, 4 indicating unsure or no opinion, and 7 indicating strongly agree.

1. What did you learn from this experience?

2. How did this experience compare with other out-of-the classroom work/volunteer/learning experiences you have had?

3. After participating in this research project, do you feel more or less interested in pursuing a career in ecology and/or wildlife management? Why or why not?

4. After participating in this research project, do you feel more or less prepared for a career in ecology and/or wildlife management? Why or why not?

5. Do you feel that by participating in this research project you learned skills that you will use later as a student or professional? If so, what were those skills?

6. Would you recommend this sort of experience to other students? Why or why not.

7. Please feel free to let me know any other comments you might have about the experience, such as your overall impression and/or ways it could be improved. Leave blank if you don't have any other comments.

Appendix B

Section One: Motivation

Student ID	1	2	3	4	5	6	7	8	9
species_sheets_completed	36	6	15	16	6	15	0	3	0

Pre-semester survey responses									
1.1_pre	3	3	3	3	4	4	3	4	3
1.2_pre	4	4	3	3	3	3	NA	2	2
1.3_pre	4	4	4	4	4	4	4	4	4
1.4_pre	3	2	4	4	3	4	NA	3	2
1.5_pre	3	3	3	3	4	3	4	4	3
1.6_pre	4	4	4	4	4	4	4	4	4
1.7_pre	4	4	4	4	4	4	4	4	4
1.8_pre	4	4	4	4	4	4	4	4	4
total1_pre	29	28	29	29	30	30	23	29	26

Post-semester survey responses									
1.1_post	4	3	3	2	NA	4	4	4	3
1.2_post	3	4	3	2	NA	4	NA	2	3
1.3_post	4	4	4	4	NA	4	4	4	4
1.4_post	3	2	4	4	NA	4	NA	4	2
1.5_post	3	3	4	3	NA	3	4	4	2
1.6_post	4	4	4	4	NA	4	4	4	3
1.7_post	4	4	4	4	NA	4	4	4	4
1.8_post	4	4	4	4	NA	4	4	4	4
total1_post	29	28	30	27	NA	31	24	30	25
total1_pre	29	28	29	29	NA	30	23	29	26
detla_pre_post	0	0	1	-2	NA	1	1	1	-1

Appendix B Cont.

Section Two: Confidence

StudentID	1	2	3	4	5	6	7	8	9
species_sheets_completed	36	6	15	16	6	15	0	3	0

Pre-semester survey responses									
2.1_pre	5	6	5	5	5	3	6	1	6
2.2_pre	5	7	6	6	4	6	5	4	6
2.3_pre	5	4	5	7	5	6	6	4	6
2.4_pre	4	4	4	6	6	6	6	4	5
2.5_pre	4	3	5	6	5	5	7	6	7
2.6_pre	6	6	5	7	7	7	7	7	7
2.7_pre	6	7	5	7	7	7	7	7	6
2.8_pre	3	3	3	4	7	6	5	3	7
2.9_pre	5	4	3	6	6	7	6	4	5
2.10_pre	6	7	7	7	6	7	7	7	7
2.11_pre	7	NA	7	7	7	7	7	7	7
total2_pre	56	51	55	68	65	67	69	54	69

Post-survey survey responses									
2.1_post	**5**	**5**	**6**	**6**	**NA**	**7**	**6**	**3**	**5**
2.2_post	6	5	7	6	NA	7	5	7	4
2.3_post	6	5	6	6	NA	7	5	6	5
2.4_post	6	5	7	6	NA	7	5	6	4
2.5_post	5	6	7	6	NA	6	6	5	6
2.6_post	6	6	7	6	NA	7	7	7	5
2.7_post	7	7	7	7	NA	7	7	7	7
2.8_post	5	6	5	4	NA	7	5	3	7
2.9_post	6	5	5	7	NA	7	5	4	7
2.10_post	6	7	7	7	NA	7	7	7	7
2.11_post	7	NA	7	7	NA	7	7	7	7
total2_post	65	57	71	68	NA	76	65	62	64
total2_pre	56	51	55	68	NA	67	69	54	69
delta_pre_post	9	6	16	0	NA	9	-4	8	-5

Appendix B Cont.

Total response values grouped by question rather than by student

Question*	Sum_pre**	Sum_post
1.1	26	27
1.2	21	22
1.3	34	32
1.4	22	23
1.5	26	26
1.6	32	31
1.7	32	32
1.8	32	32
2.1	37	43
2.2	45	47
2.3	43	46
2.4	39	46
2.5	43	47
2.6	52	51
2.7	52	56
2.8	34	42
2.9	40	46
2.1	55	55
2.11	49	56

*Refer to Appendix A for question wording
**Sum_pre totals do not include student 5 who responded to the first pre-semester survey, but did not reply to the post-semester survey