5-1-2024

Examining Attitudes Towards Scientific Research

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A Thesis
Submitted in partial
Fulfillment for Graduation with Honors Distinction and
the Degree of Bachelor of Science in Health Sciences

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May 2024

EXAMINING ATTITUDES TOWARDS SCIENTIFIC RESEARCH

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May 4 / 2024

Abstract

Undergraduate students are often anxious about participating in a research experience. In this study, students conducted research as part of their introductory biology course and were then surveyed using the Attitudes toward Research Scale, to understand their views on research. Students were surveyed at the beginning and end of the semester, and their scores in five attitudinal categories were compared. The attitudes examined were usefulness of research, positive attitudes towards research, relevance of research, difficulty of research and anxiety towards research. We hypothesized that participation in research as part of a course would improve students' attitude toward research. Initial analysis of the data indicates no significant change in student's attitudes toward research at the end of the semester, but there are interesting trends in attitudes of students from different backgrounds.

Acknowledgements

I would like to thank Dr. Burns for his willingness to help me complete this extensive project, and always being a kind individual to talk with in the years of stopping by his office.

I would like to thank Dr. Ginger Fisher for her continuous support, and encouragement in my pursuit for higher education. Without her prior research, this project, something I am passionate about contributing to, would not be possible.

I'd also like to thank the advisors and professors in the upper division honors program, for their guidance, patience, and belief that I can achieve at a level befitting of an honors student.

Finally, I'd like to thank my family members for their love and support as I continue my education nearly one thousand miles away from home.

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Introduction

Each year, students are introduced to the research process at various stages in their scholastic career. Research and its associated methods are a vital cornerstone of many STEM (science, technology, engineering, math) related fields of study, and in many cases are required for completion of a degree or acceptance to courses of higher education. The University of Northern Colorado has incorporated independent research projects into their introductory biology courses to expose beginning STEM majors to the rigor and methods of independent research. Understanding how students initially view the course, as well as their views after they have completed the class can provide valuable insight into possible areas of improvement within the field of biology education (Papanastasiou et al. 2008.) Anxiety towards research can be detrimental towards students interested in a STEM related field but have little experience with the subject. Understanding a student's concerns, what made them anxious, and how they view themselves within the field can provide valuable insight into students beginning their scientific degree. Insight into what helps students the most and what could use adjustment can give direct evidence into means to change curriculum and alter biology education.

Prior to this project, research has taken place involving various aspects of CURES (course based undergraduate research experience) but none have examined student attitudes towards research, and the outcomes of these attitudes towards research. Currently, research exists to support the notion that student attitudes contribute to positive learning outcomes (David, Lopatto, et al. 2022), increased engagement can lead to a greater appreciation for scientific research (Olimpo, Jeffrey T., Ginger R. Fisher, and Sue Ellen DeChenne-Peters 2016) and a nature-based research project increases measurable skills in research writing and analysis (Stanfield, Erin, et al. 2022.) However, no research currently exists to survey, measure, and

record student responses and their views towards research, after a CURE. This research has the potential to reshape how undergraduate STEM curriculum can function on an introductory level, and potentially increase overall student psychological views towards the research field at an earlier stage in their planned academic studies. This poses the question then; Do course based undergraduate research experiences lead to more positive attitudes towards research?

Background

When examining the overall question behind this project, it's important to view what other topics and subjects have already been reviewed and studied related to student attitudes, positive benefits from research, and how likely or possible it would be to establish a CURE in any academic setting. To begin, it is worth noting how to test a CURE, what characteristics a CURE incorporates, and what minimum requirements would exist to create a CURE at any undergraduate level academic institution. Looking at supporting documents, it is relatively easy to find documents and publications that discuss the use, properties, and setup of CUREs for university settings.

To begin any work into CUREs at a university level setting, it is important to establish what goals or anticipated outcomes instructors are looking for, or, if a curriculum currently exists, what does it aim to change? CUREs are a tool for education like many others, and their use has been shown to benefit students and instructors (Shortlidge et al. 2016), giving many students an important early glance into the research process. Incorporating this type of curriculum, deviating from the previously known "cookbook" lab courses has been shown to improve attitudes towards science, the ability to interpret data, and conceptualize ideas like an experienced scientist (Shortlidge et al. 2016.) If the goals are to improve on these categories,

expand on them to help improve other benefits that may be derived from increased experience and skill, or help give an early start to aspiring STEM majors, a CURE may be appropriate.

Once it is determined there is a clear goal and measurable outcome to establishing a CURE, preparation work must be done to determine if the framework can be established, what the classes will look like, and whether the CURE is valid. The length of a CURE can take the place of weeks of lab, and a hybrid CURE/undergraduate lab is also possible, with the minimum recommended length of a research experience being six weeks for a noticeable benefit (Bell, Jessica K., et al. 2022.) While a six-week course is possible, many institutions have opted to design the course over the entire semester, such as the University of Northern Colorado and their Bio 110 course. Additionally, the size of the classroom is important as well. Designing a CURE for a class is important to tailor around groups and teams working together, but not so many as to overwhelm any instructor or professor with excessive work to support this class. Because of this, course syllabus and methods from established courses show that classes as small as 12 students, and as large as 40 students are possible (Duboue, Erik R., Johanna E. Kowalko, and Alex C. Keene. 2022) without any measurable detriment to the learning outcomes. Finally, the CURE needs to be validated and tested, much like a solid hypothesis.

CURES are designed to provide increased value and experience to introductory level classes and students, but to provide this measurable benefit, they must be able to be tested for their validity and efficacy. CUREs can be nearly any subject or discipline, but any project that focuses on learning and understanding research through the scientific method is the primary background to most CUREs. In the example of University of Northern Colorado Bio 110, students are asked to study a specific species of aquatic crustaceans known as Copepods. This serves as the common theme to all research experiments, as students are instructed to formulate

their own research project based off some aspect of their copepods. From this, the full research process is explored, with the main goal of formulating a hypothesis, and testing it, being the primary item to be graded. This coincides with established research describing ways of testing a CURE to ensure it is a viable and measurable item to study. A learning outcome is established, an assessment is then aligned with the desired learning outcomes, and finally the results are interpreted based on the outline of the class (Shortlidge et al. 2016.) Once these steps are taken examinations or quizzes could be given, ensuring students have a solid understanding of experimental design. These steps were followed at University of Northern Colorado's Bio 110 CURE, and students were instructed to present their findings in a similar format to how a journal article may be presented, with introductions, abstract, references, and more. With the information and criteria posted by Shortlidge et al. it can be understood that the CURE established at UNC meets these requirements to be an adequate example of a CURE.

With the foundation of this project in place at UNC, it is then important to view similar papers and concepts that have been explored, examining the benefits of CUREs in undergraduate study. CURES have been shown to improve a number of aspects relevant to student performance, such as test scores, research competencies, and the student's science identity; how the student views themselves as a scientist and in the scientific field (Waddell et al. 2021.) This is important as STEM retention in upper division fields could be improved or increased by introducing students to the research process early, as well as allow them to develop their own independent science identity at an earlier stage in their undergraduate studies, preparing them for the rigor and format for research later. These attitudes towards research are important as well, because student's epistemic beliefs are directly related to achieving a positive learning outcome and will lead to an overall greater academic success (Davis, Lopatto, et. al. 2022.) The common

factor linking these different attributes together are CUREs in an undergraduate, university-based setting, and attitudes towards positive learning outcomes. So, based on these observations and trends, it is worth exploring if there is a correlation between student's attitudes towards research, and other positive factors that may be extrapolated from this data gathering process. To this end, if a CURE included a questionnaire, focusing on how students view themselves and attributes (factors) of research before and after their CURE was completed, quantitative data could be studied to determine if such a correlation exists, or if other trends could be observed within the data gathered, and student's background data. If it is determined that correlations do exist, and positive trends are observed, then CUREs could potentially be introduced on a wider scale, if they do indeed provide a greater positive benefit to students, compared to a traditional guided lab experience.

Methodology

This project involved several different methods for the initial data gathering, with the primary goal of surveying undergraduate Biology 110 students at the University of Northern Colorado. Students were surveyed twice, once at the start of the semester-long course, and again at the end of the course. The survey consisted of 40 questions, with the first seven questions establishing the students educational and personal background, 30 questions made up of Likert style questions, and the final three questions being short answer responses to be coded. The surveys used were based off the established Likert style model of questions, with questions asking, "to what extent you agree or disagree with the following statements?" This would allow students to reply to the question with a "not at all" response, to a "neutral" response and finally a "very much so" response, with intermediate answers allowed between the two ends of possible responses. These questions and styled responses are designed to provide an overall score, with

"not at all" likely responses being a "1" while a "very much so" response would translate to a "5." At the time of writing this project proposal, the data gathered is from BIO 110 students from Fall 2021, which includes data from the pre course, and post course survey. These data include 322 student's initial replies, each assigned a unique identifier to compare their pre and post survey scores. Once matched, a total of 233 student's provided a post survey response, and only a total of 188 final data points were able to be matched with their pre and post identifiers, providing us with a final n = 188 students. This data was then organized into Microsoft Excel documents, and organized by the Factor score, a predetermined series of categories that each question fell under (Papanastasiou, 2005). the student's background questions were gathered to help determine relationships, if any, between their responses in the 33 questions of the survey, and their personal or educational background. The final data was prepared and analyzed in IBM SPSS software, allowing the researchers to run various data comparative tests. For the data analyzed as of writing this, one way ANOVA tests, comparison of means, and T-Tests were run on data sets to examine relationships, if any, between various student backgrounds and the data collected. These data are best run through SPSS currently, due to its ability to provide in depth statistical analysis of relationships and determine if there is a low probability of error between the relationships. Prior to this analysis, Dr. Fisher would remove all student identifiers, except the student's unique survey ID, to protect student identities and comply with ethical data handling. The author of this proposal handled data with confidentiality, in compliance with CITI HSR (Human Subject Research) standards and requirements.

Results

Overall results from data obtained after matching students who completed the full course, with their pre lab scores indicated that participation in CURE (course-based undergraduate

research experience) did not indicate any statistical impact on their attitudes towards research (see Figure 1.) However, several data points could be examined and were statistically significant. Students of Hispanic, Latino(a) or Spanish origin were found to display the highest increase in positive attitudes towards research, with an increase of roughly 7% (see Figure 2.) Students who are listed as Biology, Chemistry and Sports and Exercise Sciences all indicated a positive increase in their attitudes towards research, while Nursing indicated a decrease in positive attitude (see Figure 3.) Students who had not previously participated in a CURE indicated a statistical 10% reduction in anxiety towards research (see Figure 4.)

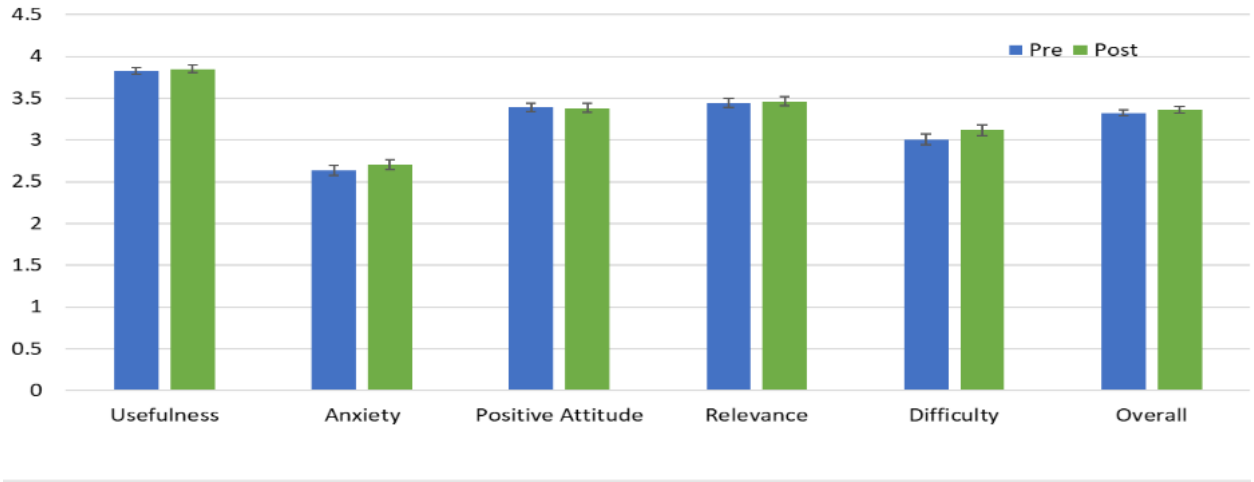

Figure 1: Averages for all factors, and overall scores comparison

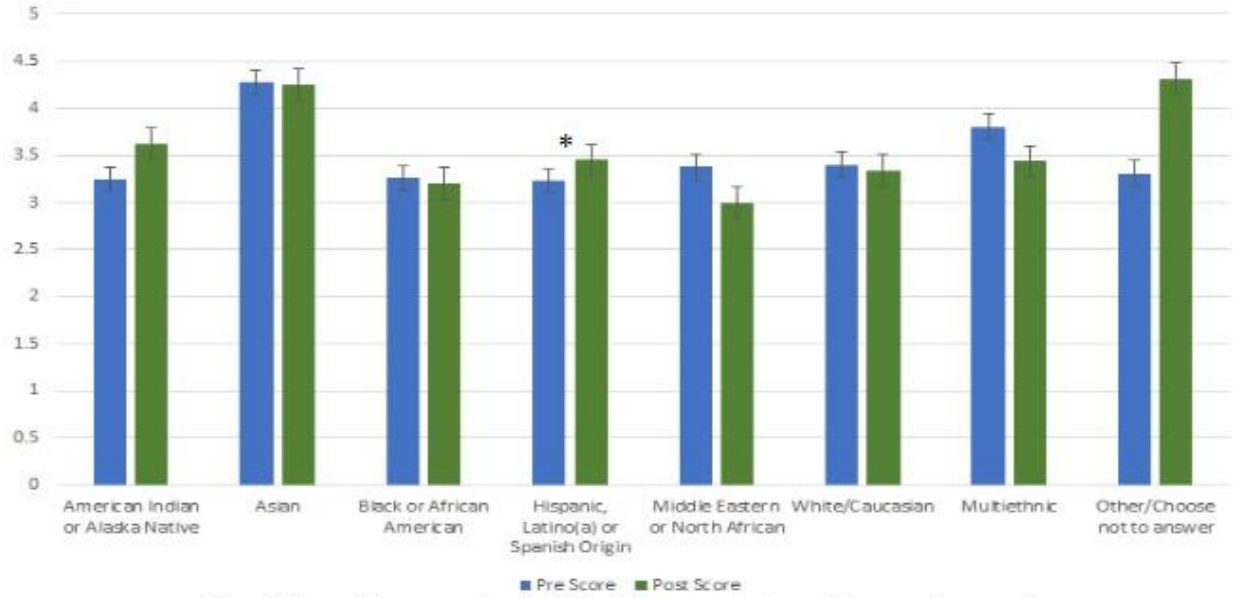

Figure 2: Pre and Post scores of student's identity compared with positivity towards research

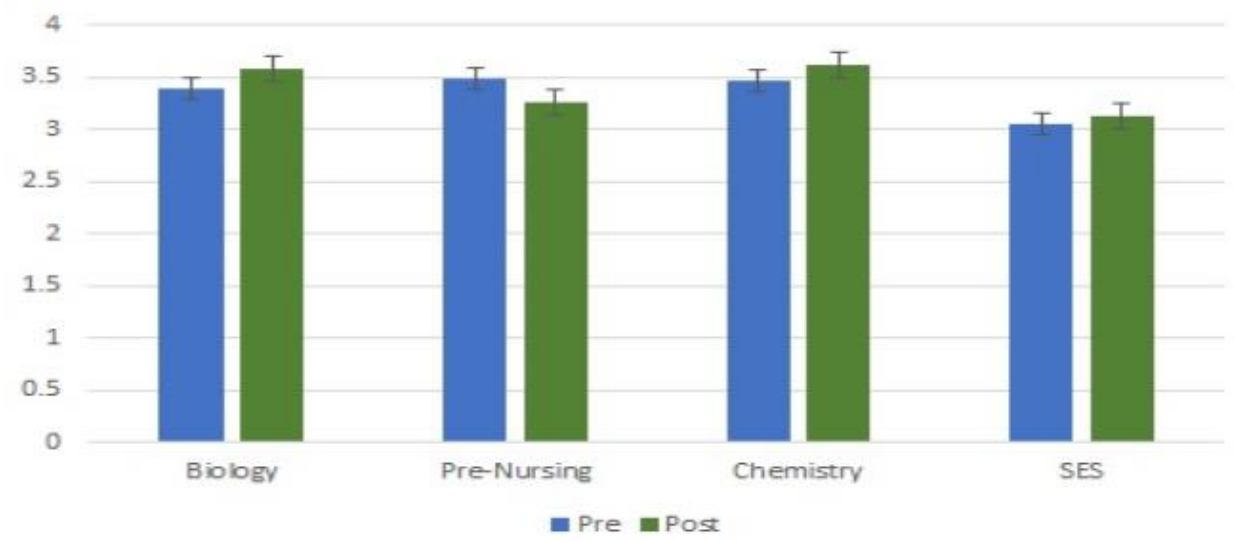

Figure 3: Averages for factor 3, positivity towards research and major

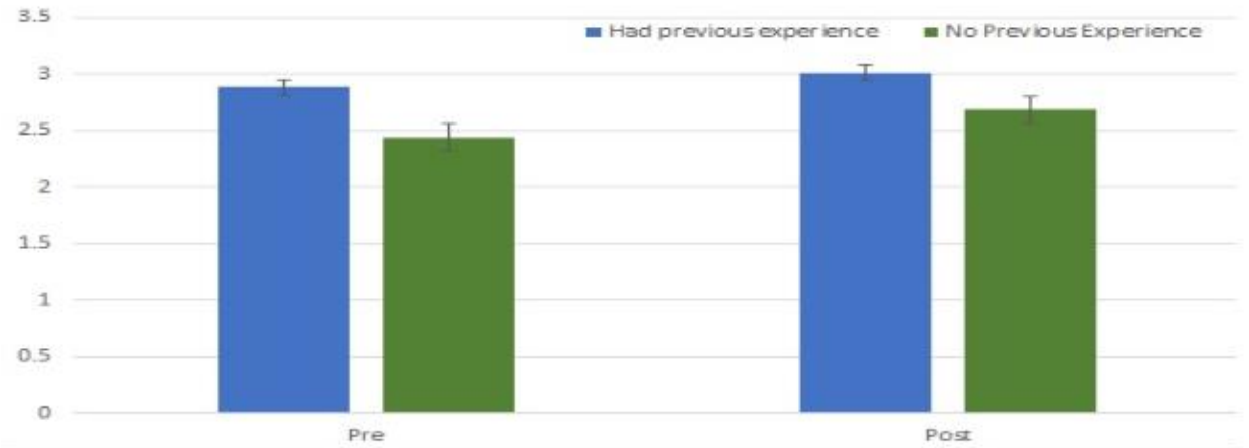

Figure 4: Anxiety towards research based on previous research experience

Discussion

Attitudes towards research have been studied previously, and similar demographic and background factors have been researched, but different methods exist to quantify and study these data. In similar research, attitude towards other STEM fields were examined to determine if the overall education received influenced an individual's science identity (Hazari et al., 2010.) This study focused on many factors, but positivity towards research and anxiety towards research were two major factors studied. Using the quantitative analysis framework based off similar studies (Papanastasiou, 2005) a survey asked questions that helped gauge anxiety towards research, positivity towards research, other attitude related questions towards research and identity. During this study, the authors found no significant differences in all five main factor scores amongst all students. However, individual groups could be studied, and data showed an increase in positivity towards research among Hispanic, Latino(a) or Spanish origin students. Additionally, students who had not completed an independent research course as part of a STEM related class showed a decrease in anxiety after their time in a CURE class. When reviewing this data, some survey questions were reviewed for clarity and changed to be more specific. The question "Have you conducted research before taking this current BIO 110 course?" was

clarified to specify “independent research conducted as part of a course” as various COVID restrictions may have caused many students to have an altered scientific lab-based experience. This altered scientific research experience may also be contributing to differing results, but further research is required. Further research into this field may involve running additional surveys, to determine what, if any, changes could be made to CURE courses to help reduce anxiety towards research, and help the student view research in a more positive light.

Conclusion

In conclusion, the results of this research have not shown a statistically significant correlation between whether a student had completed a CURE and their attitudes towards scientific research. Individual metrics and data, such as individual identifiers or demographics of the individual and their attitudes towards research could be studied, as our data indicated that some positive correlations could be found. One of the most statistically significant correlations found in this study was the relationship between students of Hispanic, Latino(a) or Spanish origin, noting a 7% increase in positivity towards research (see Figure 2.) According to recent statistics released by University of Northern Colorado, UNC has a nearly 27% Hispanic/Latino(a) or Spanish origin population, which is a significant population of the university and designating the university as a Hispanic Serving Institution (HSI,2024.) This positive correlation should be explored, as a significant portion of students could be positively impacted by a change in curriculum towards CUREs, while there appears to be no statistical negative impact towards other students. Increased positivity in research can lead to higher representation of these populations in the STEM field, leading to greater diversity in the fields.

Appendix A

Survey

Below is the survey given to students in Bio 110 courses and would normally be given through a survey software through the University. These questions are typed and reflect the substance given on the survey but may not reflect the exact format.

This survey is designed to gather your opinions about science and research. We greatly appreciate your participation and will not reveal any personal information to anyone other than the research team (Dr. Fisher and Alaina Buchanan) at any time.

1. What is your major?
    a. Biology
    b. Pre-nursing/Nursing
    c. Chemistry
    d. Sport and Exercise Science
    e. Other

2. What is your history in the BIO 110 course?
a. Currently enrolled for the first time
b. Currently enrolled for the second time
c. Took the course in a previous semester
d. Never took the course

3. What is your current overall GPA?
a. 3.0-4.0
b. 2.0-2.99
c. 1.0-1.99
d. 0-0.99

4. What year are you (based on credits)?
a. Freshman
b. Sophomore
c. Junior
d. Senior

5. What is your current gender identity?
a. Male
b. Female
c. Nonbinary

d. Transgender
e. Choose not to answer

6. How would you best describe yourself?
a. American Indian or Alaska Native
b. Asian
c. Black or African American
d. Hispanic, LatinX or Spanish origin
e. Middle Eastern or North African
f. Native Hawaiian or Other Pacific Islander
g. White
h. Multiethnic
i. Other/choose not to answer

7. Have you conducted scientific research in the past?
a. Yes, in an instructor's research laboratory
b. Yes, as part of a course
c. No

To what extent you agree or disagree with the following statements?

	Not at All		Neutral		Very Much So
8. Research makes me anxious	○	○	○	○	○
9. Research should be taught to all students	○	○	○	○	○
10. I enjoy research	○	○	○	○	○
11. Research is interesting	○	○	○	○	○
12. I like research	○	○	○	○	○
13. Research scares me	○	○	○	○	○
14. Research is useful for my career	○	○	○	○	○
15. I find it difficult to understand the concepts of research	○	○	○	○	○
16. I make many mistakes in research	○	○	○	○	○
17. I love research	○	○	○	○	○
18. I am interested in research	○	○	○	○	○
19. Research is connected to my field of study	○	○	○	○	○

20. Most students benefit from research	○	○	○	○	○
21. Research is stressful	○	○	○	○	○
22. Research is very valuable	○	○	○	○	○
23. Research makes me nervous	○	○	○	○	○
24. I use research in my daily life	○	○	○	○	○
25. The skills I have acquired in research will be helpful to me in the future	○	○	○	○	○
26. Research is useful to every professional	○	○	○	○	○
27. Knowledge from research is as useful as writing	○	○	○	○	○
28. Research is irrelevant to my life	○	○	○	○	○
29. Research should be indispensable in my professional training	○	○	○	○	○
30. Research is complicated	○	○	○	○	○
31. Research thinking does not apply to my personal life	○	○	○	○	○
32. I will employ research approaches in my profession	○	○	○	○	○
33. Research is difficult	○	○	○	○	○
34. I am inclined to study the details of research procedures carefully	○	○	○	○	○
35. Research is pleasant	○	○	○	○	○
36. Research-oriented thinking plays an important role in my daily life	○	○	○	○	○
37. Research is a complex subject	○	○	○	○	○

1. How will research experience help you in your planned career field?
2. What makes you most nervous about participating in research as an undergraduate student?
3. What makes you most excited about participating in research as an undergraduate student?

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