# SHARE: A Scaffolded Approach to Teaching First-Year Engineering Students How to Read Research Articles

**Grace Hellen Ford, University of Virginia**

Grace Ford recently graduated with a degree in Biomedical Engineering from the University of Virginia and has a strong interest in undergraduate research accessibility. She has taught and helped develop the peer-led course Starting an Undergraduate Research Experience (SURE), fouced on supporting first-year students in building confidence and navigating the process of joining research labs. Her current research focuses on identifying and modeling key factors that enable students to successfully access and engage in undergraduate research.

**Dr. Brian P. Helmke, University of Virginia**

Brian Helmke is Associate Professor of Biomedical Engineering at the University of Virginia (UVA), where he teaches courses in diverse topics such as physiology, mechanobiology, biotransport, and bioelectricity. Brian also serves as Faculty Consultant to the UVA Center for Teaching Excellence, acting as facilitator for the Course Design Institute and faculty development workshops on Equity in Collaborative Learning, Universal Design for Learning (UDL), and Specifications Grading. As Director of Undergraduate Research for the UVA School of Engineering and Applied Science, Brian created Starting an Undergraduate Research Experience (SURE), a student-led program to lower barriers to entry in research experiences for 1st-year engineering students. Brian has received the UVA Alumni Association Distinguished Professor Award and the Harold S. Morton Teaching Prize for excellence in 1st- and 2nd-year teaching in engineering, and he is a Fellow of the Biomedical Engineering Society and the American Institute for Medical and Biological Engineering. Brian is co-founder and Deputy Editor in Chief of Biomedical Engineering Education. Brian's educational scholarship encompasses active learning, collaborative and inclusive pedagogies, and alternative grading. His science and engineering research interests include cardiovascular physiology, cellular mechanobiology, and nanotechnology-based biomaterials.

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## Motivation and Learning Objective

This Strategies for Hands-On Activities, Resources, and Engagement (SHARE) paper outlines a method for making primary research articles more approachable to undergraduates. Undergraduate research is a high-impact learning opportunity that helps students develop academic, personal, and professional skills [1], [2]. One skill that is necessary for student success in a research lab, especially in biomedical engineering (BME), is the ability to read and interpret scientific literature. Through scientific literature, students learn both background and emerging knowledge in their field of interest. However, not all students have been taught how to effectively read research papers, and this skill is not formally taught in our institution's first-year engineering curriculum. As a result, students who are unable to read research articles may feel as though they are inadequate and lack the background necessary to join a research lab [3]. To address this problem, within our one-credit, peer-taught introduction to research course, we created a series of scaffolded activities with the learning objective of helping students develop strategies to read and discuss primary research articles.

## Implementation

We began by introducing a framework to systematically approach a research article rather than reading an article from start to finish. We developed the acronym ACT FAST, which guides students through the steps for reading a research article: **A** (Abstract), **C** (Conclusion and Discussion), **T** (Tables and Figures), **F** (Focus on Methods), **A** (Analyze Results), **S** (Skim the article), and **T** (Takeaways). An infographic of this acronym can be found in Appendix A.

The approach was implemented over three 50-min class sessions. During the first session, the instructor demonstrated how to apply the ACT FAST method using an example article. For homework, students selected one of three research articles [4], [5], [6] to independently practice the method. The instructor selected the three research articles to ensure they were approachable in length and content. Articles were considered approachable if they were fewer than 10 pages and focused on concepts typically taught in first-year engineering courses.

In the second class session, students participated in a mock journal club using their chosen articles. A journal club is comprised of a group of individuals, professors, graduate students, and/or undergraduate students who meet to discuss and analyze research articles. This format was chosen because journal clubs are commonly used in research labs to stay up to date on scientific literature and to practice critical thinking and scientific communication. The journal club format was inclusive for students since journal clubs are often hosted in smaller groups and avoid the additional stress of public speaking in front of a class.

In our class, we created groups of 5 students, and grouping was based on which article students had analyzed for homework. The instructor prepared questions ahead of time that were based on using the ACT FAST method. There were also open-ended questions that asked students to think critically about the paper. The questions we used can be found in Appendix B. Within each group, students rotated asking the prepared questions to their peers. After the discussions ended, the instructor presented strategies for finding relevant research articles. The instructor explained that students should use the ACT FAST method to decide whether an article is worth reading. If they could not reasonably understand the abstract or conclusion, they were advised to choose a different article and not proceed with ACT FAST. The instructor explained that being able to complete the full ACT FAST method is a very good indicator that the paper was appropriate to further analyze. For homework, students were asked to find and analyze an article on their own.

In the final session of the three-class module, students worked together with 5 peers who were different than in the second class to create a concept map using the articles they analyzed for homework. Each student was given sticky notes and instructed to write ideas from the paper they read based on instructor-provided headings. The headings were given to serve as a starting point and included unknowns in the field, computational or experimental approaches, key findings, and new questions formed. Each group of students then combined their sticky notes on a shared surface and collaborated to create a concept map. The only rule was that they could not group the sticky notes by the provided headings. An example concept map is provided in Appendix C. After 25 min, the instructors debriefed the activity. The instructors pointed out that students had engaged in research by synthesizing ideas and generating new ideas by combining papers in unexpected ways. By the end of the three-class module, students had increased their confidence in their ability to read, interpret, and discuss scientific literature.

## Situational Factors

This course included 40 first-year engineering students who met once a week for 50 min. Most students were first-year engineering students, and approx. 40% intended to declare biomedical engineering majors. The choices of research articles should align with the research interests of the students to maximize their motivation (e.g., using expectancy value theory [7]). Class size will affect the size of each group. We chose groups of 5 so that the groups were big enough to have a range of perspectives and ideas, but small enough to allow each student the opportunity to participate. Ideally, groups should have between 3-6 students, and larger groups should be provided with additional time to ensure everyone has the chance to contribute. Ideally, the classroom configuration would allow students to sit facing one another in a circle to promote collaboration. Preferably, there would be enough room for students to easily move around while creating the concept map. If space is limited, ensure that groups can easily communicate, and if necessary, the concept map can be moved to a digital format such as a PowerPoint slide. Finally, student background experiences will affect the depth of discussion, since upper-level undergraduate and graduate students are typically more experienced with reading scientific literature. The discussion questions should be tailored to students' prior experience. For students with less experience with scientific literature, discussion questions can focus more closely on the text, while students with more experience can be asked questions that require them to apply the material or explain it to a different audience.

## References

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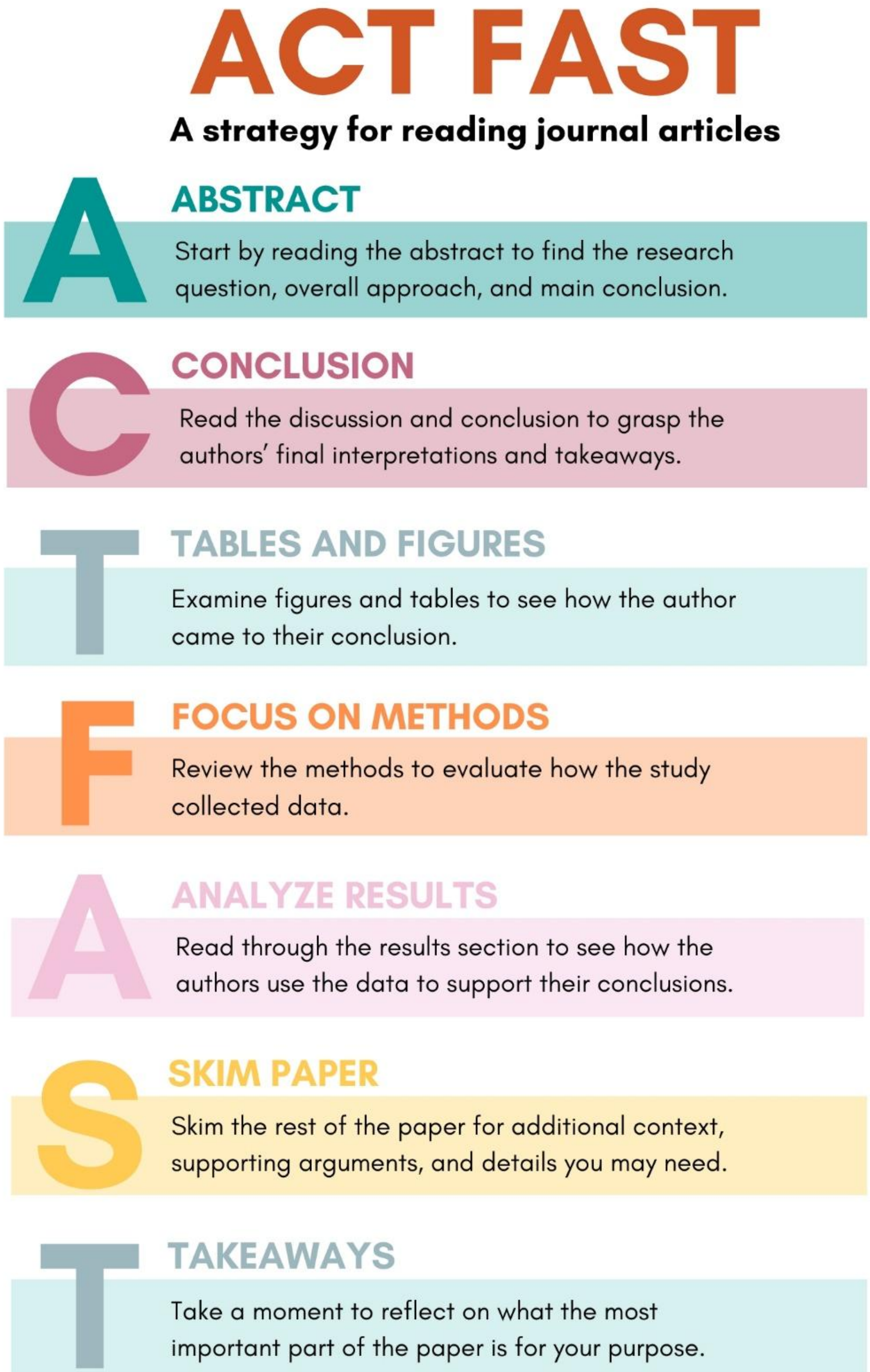
**Appendix A: ACT FAST Infographic**



## Appendix B: Additional Journal Club Questions

- What is the central question or hypothesis of the study? How does it relate to the broader scientific context?
- What is the purpose of the study? What is the hypothesis?
- What was the main conclusion?
- How did the figures and tables present the data? What conclusions could be made from the figures and tables?
- What data or figures do you find most compelling, and why? Are there any aspects of the data that seem unclear or unconvincing?
- What techniques did they use to test their hypothesis? How did they collect data? How were results analyzed?
- What are the key findings of the study, and how do they answer the research question?
- What questions remain unanswered after this study?
- Why do you think the authors chose this particular experimental design? What are its strengths and potential limitations?
- How does this research relate to research initiatives at our university, and what are the broader implications of this research?
- How might the findings of this research impact different groups of people, such as specific patient populations, healthcare providers, policymakers, or underrepresented communities? What considerations should be made to ensure the research benefits all groups equitably, and are there any risks or unintended consequences that could affect certain groups disproportionately?
- How does this research connect with your personal goals?

## Appendix C: Example Concept Map