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Using Astrobites in the Classroom

Sample Lesson Plans
Updated 2022

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This packet includes four different types of sample lesson plans that integrate content and principles from Astrobites. Each lesson plan includes step-by-step instructions, suggestions for adapting the lesson to different class levels across the undergraduate and graduate spectrum, sample student handouts, and a grading rubric. These four lesson plans are: periodic reading assignments, student research projects, student writing assignments, and student presentations.

This is an updated version of our lesson plans developed in 2018, originally based on discussions with educators and published in the American Journal of Physics, plus a new lesson focusing on diversity and inclusion in astronomy through student presentations. These revised lesson plans are now in the process of research validation with a new cohort of participating educators and their classes.

This document has been revised by the following members of the Astrobites collaboration:

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This document is available in electronic form here: bit.ly/3QBIW0C
Based on our original set of lesson plans (bit.ly/3QDimUW) from an American Journal of Physics article available here: goo.gl/cAYjqH
Visit http://astrobites.org/ for more information about Astrobites.
If you have questions about Astrobites' education efforts, please reach out to education@astrobites.org.

Lesson Plan Type 1:
Periodic Astrobites Reading Assignments

Activity Outline

Students are asked to read an assigned Astrobites article and respond to guided questions that test reading comprehension and conceptual understanding. Students are graded on their responses to the questions, which can be gathered electronically through an online form. The questions are discussed in class to promote greater understanding.

This assignment can be adapted to any course level, including introductory level classes, and is reproducible. It could be done, for example, once per week or once per class period. These readings could be used as pre-lab assignments to connect lab activities to current research, as University of Maryland instructors have done.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading and to identify connections to course curriculum or previous readings. Students will also gain the ability to parse technical terminology used in scientific literature.

- **Conceptual understanding:** Students will strengthen their understanding of course curriculum by integrating information from new readings.

- **Literature familiarity:** Over several assignments, students will develop familiarity with astronomical literature. They will form an understanding of active disciplines of research and gain the ability to draw connections to the course curriculum or their own research interests.

- **Self-efficacy:** Students will gain confidence in their ability to understand and keep pace with current astronomy research.

B. Instructions

1. **Instructor selects an Astrobites article and formulates 2–4 guided questions.**

   Guided questions are intended to encourage mindful student reading of the assigned article and check student understanding of major concepts. We suggest questions that can be answered by straightforward application of concepts learned in previous lessons to newly-encountered subject matter from the reading, for example applying an understanding of the Doppler effect to describe the observational effect of the orbit of

Alpha Centauri on its radial velocity. These questions should not involve much computation; typically, questions would be either purely qualitative or would focus only on symbolic manipulation or scaling relations, depending on the level of the class. A set of example questions can be found in the sample Google Form linked below (see the "Materials" section of this lesson plan).

2. **Instructor distributes Astrobites article to students along with guided questions in the form of a fillable Google Form.**

   As the students read the selected Astrobites article, they construct a glossary of new astronomy terminology (i.e., jargon) encountered in the article; students may use whichever resources they prefer to help define these new terms. Suggested resources include the Unified Astronomy Thesaurus and the SAO Encyclopedia of Astronomy. Students submit their glossary alongside their responses to guided questions via Google Form. Below, we provide a sample Google Form that can be used to gather student responses to questions electronically.

3. **(Optional or extra credit) Students leave a comment on the assigned Astrobite with a question or thought about the article.**

   Astrobites authors track article comments, so students will usually receive a timely response to their comment. All Astrobites authors are practicing scientists (graduate students or recent grads) and can provide additional subject matter or insight, or they can answer questions about the practice of science in their reply.

4. **(Optional or extra credit) Students write a short paragraph contrasting the original journal paper to the Astrobite about the same paper.**

   Students are asked to compare and contrast the scientific findings emphasized in the original paper versus the Astrobites article they read, identify the scientific concepts that were explained for non-technical audiences in the Astrobites article, and comment on how the language, tone, and audience seem different between the two forms of writing. This option provides an opening for instructors to talk about different genres of science writing and how science is communicated to different audiences.

5. **Instructor evaluates responses and scores according to the rubric below.**

6. **Instructor reviews guided questions during the next class period.**

   One or more students are asked to provide their answers to each question. Instructor guides student discussion towards accurate understanding, as appropriate.

7. **(Optional or extra credit) Students read another Astrobites or popular science article on a topic closely related to the original article.**

   To apply the knowledge gained in reading the originally selected Astrobites article, students read a second, closely related article; instructors may choose this second article themselves or allow the students to choose an article independently. Students write a paragraph comparing the scientific content of the two articles, demonstrating their newly acquired familiarity with the relevant jargon and overarching key concepts.

8. **(Optional) Post-lesson reflection**

   Students write a short paragraph identifying how the content of the assigned Astrobites article complements or supplements material previously learned in class. Students list 2-3 new things that they learned from reading the article and 2-3 things that they would still like to learn about the broader topic. Instructors may collect feedback from students by asking them to respond to specific questions in their post-lesson reflection (e.g., "What concepts from the article(s) did you not have enough information to understand?"); student responses can be reviewed before the next lesson and used to inform instruction.

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
  Instructors should:
  - Carefully select articles that are closely related to the current subject matter at hand and that do not introduce new concepts that have not yet been covered in the course.
  - Assign readings less frequently and with several days before the due date to promote careful reading.
  - Preferentially pose questions that test understanding of course content and relevant vocabulary more so than full reading comprehension.
  - Focus on questions with straightforward interpretations and use open-ended questions less frequently.

- **Upper level undergraduate:**
  Instructors should:
  - Give assignments more frequently to encourage students to develop strong familiarity with the literature.
  - Try collecting feedback from students with questions like "What subjects from the article(s) would you like to learn more about in class?" to inform future lessons or areas of exploration.

- Reinforce conceptual understanding of physical formulae from the course by using questions that ask students to develop order-of-magnitude arguments that demonstrate consistency with calculations from the paper.
- Ask students to “update” a relevant section of their textbook by adding information from the current research article, using a short written response or a brief in-class discussion. Instructors may collect written responses using the same Google Form as the guided questions.
- Ask students to annotate a figure from the paper or a related diagram with a caption and/or axes labels using their own words to demonstrate comprehension. This can be done as an in-class activity.

- **Graduate level:**
  Instructors should:
  - Preferentially assign recent articles covering new results to challenge students to draw connections to current topics without being pulled off course by less relevant content.
  - Preferentially pose questions that invite students to extend beyond the subject matter of the article at hand or apply their understanding to personal research experience.
  - Build student understanding of physical formulae from the course curriculum by posing questions that call on students to reproduce calculations from the paper.
  - Use open-ended question formats to explore student perspectives.
  - Occasionally ask students to go beyond the Astrobites summary by asking questions that direct them towards the source paper.
  - Use this assignment as a launching point to a Lesson Plan Type 2 or 3 assignment in the same topic area.

D. Materials

Grading Rubric

Guided questions (score assigned per question):

Score	Completeness	Content
0	Questions not answered or partially answered.	Student does not address all questions or demonstrates partial or no understanding of underlying concepts.
1	Question completely or mostly answered.	Student demonstrates some understanding of concepts underlying guided questions but may have major factual inaccuracies or logical

		inconsistency.
2	Question completely answered, with 1–3 sentences.	Student demonstrates strong overall understanding of concepts underlying guided questions, though may yet have some factual inaccuracies or logical inconsistency.

Glossary:

Score	Completeness	Content
0	Glossary terms are partially defined or not defined at all.	Student's glossary definitions are inaccurate.
1	Glossary terms have been defined, but definitions could be fleshed out.	Student's glossary definitions are accurate, but don't demonstrate how the vocab is used in context.
2	Glossary terms are clearly and completely defined.	Student's glossary definitions are accurate and illustrate how the vocab is used in context.

Student Handout

Sample Google Form with example questions for distribution to students (same as above): https://forms.gle/QABv7mdvBjDqEWty8

Lesson Plan Type 2:
Student Research Project

Activity Outline

Students are asked to select a research topic and then identify and read several Astrobites articles related to that topic. Students then prepare a written paper or class presentation based on this independent research. In advanced courses, students can be asked to read the source material (original paper), so that the Astrobites article serves as scaffolding to introduce them to that material. A set of optional research tasks asks students to construct an annotated bibliography of their reading and/or a concept graph that links topics from the course curriculum to the modern research. While we suggest modifications to make use of this method at introductory undergraduate through graduate levels, this method is perhaps best suited to the upper-level undergraduate course.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading and to identify connections to course curriculum or previous readings. Students will also gain the ability to parse technical terminology used in scientific literature.

- **Synthesis:** Students will gain the ability to synthesize concepts and information from a variety of sources into an original work in a presentation or paper format.

- **Interpreting data:** Students will gain the ability to extract information from data visualizations and statistical graphics.

- **Self-efficacy:** Students will gain confidence in their ability to understand and discuss scientific papers.

B. Instructions

1. **Students select a research topic.**

   The students can select their topic from an instructor-provided list of topics specific to the course curriculum, from the most popular tagged topics within our daily paper summaries category, or from elsewhere.

2. **Students identify what they already know about the topic.**

Students write a brief paragraph describing what they already know, or think they know, about the topic they have selected. This paragraph can be revisited as they work through the assignment and used as a starting point for their paper or presentation. It can also be used as a metric for how much they have learned while working through the assignment.

3. **Students identify 2–4 Astrobites articles related to the topic.**

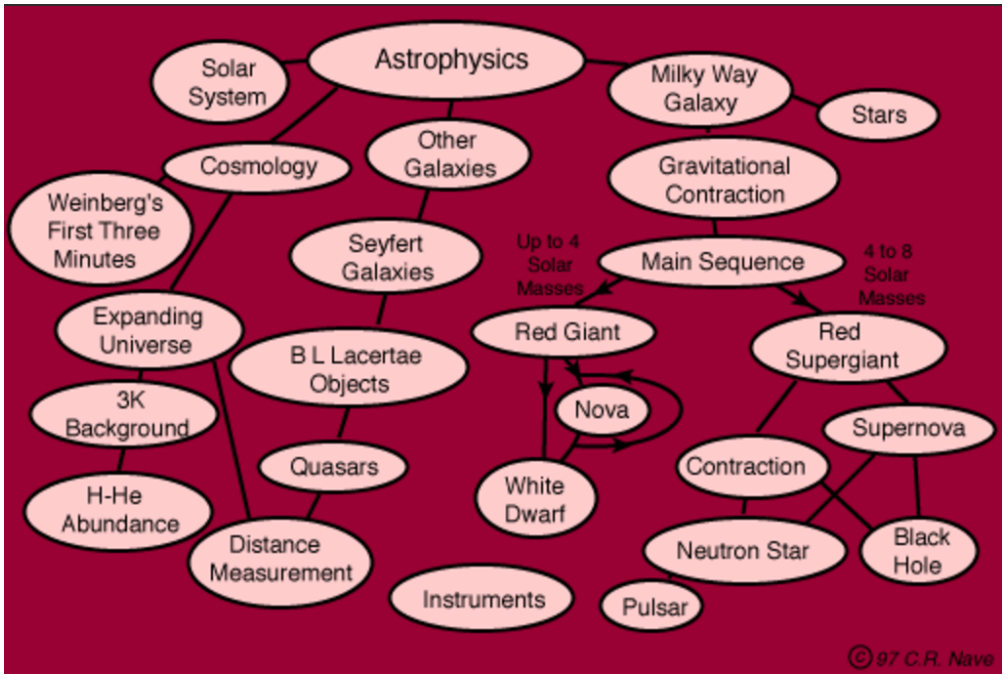
   (Optional) Utilize the student research to construct an annotated bibliography for the course. Instructors can use a Google Form like the example below to collect a response from each student to document their research on each Astrobite. After the initial research assignment (Step 2), instructors can then make the filled responses available to all students as a resource to help with the remainder of the project (Steps 3+).

   Example Google Form: https://forms.gle/1UB1YpFNn6s44puW8

   Example filled responses: https://goo.gl/oTj9cc

4. **Ask students to construct a concept graph.**

   Students write down a list of significant concepts from the curriculums that are prerequisite to understanding the present topic. The list of concepts could be culled, for example, from the table of concepts of their course text. The student then constructs a dependency graph showing how the topics link together. Examples of similar concept graphs are provided by HyperPhysics:



5. **Ask students to construct a glossary of technical terminology.**

   As the students conduct their research, they construct a glossary of new astronomy terminology (i.e., jargon) encountered in their reading; students may use whichever resources they prefer to help define these new terms. Suggested resources include the Unified Astronomy Thesaurus and the SAO Encyclopedia of Astronomy.

   The glossary is submitted to the instructor, but should only be graded based on completion as a participation/scaffolding step.

6. **(Optional or extra credit) Ask students to construct a research timeline.**

   Students consult the introductions of the source papers associated with their Astrobites selections. They cross-reference the citations in the sources to reconstruct a sequence of major milestones in research related to their topic.

   The Astrophysical Data System (ADS) Bumblebee Author Network tool can also help students. Students can search for a subject, sort in descending order by citation, and then view the author network to get a view of major collaborations and how their contributions impacted the field over time, as in this example: https://goo.gl/8cZSY9

7. **Students complete their project assignment.**

a. **Student presentation path:** Students are asked to prepare a brief (5–10 min) group or individual presentation about the topic they selected, to deliver in class. Presentations should be a short summary of what they learned on the topic.

   Instructors encourage students to build skills in interpreting data visualizations by asking them to include and explain one or more figures from the Astrobites source papers in their presentation.

b. **Student paper path:** Students are asked to prepare a short (3-5 pages) written paper related to the topic they selected.

   The instructor should give guidance as to how the paper should compare to a typical Astrobite or to the published source papers in terms of accessibility/audience (how easy it should be for, for example, someone who has not taken your course to understand) and level of detail.

   (Optional) Scaffold the paper assignment such that students turn in a rough draft, complete a round of peer review, and then revise to turn in a final draft, emphasizing that writing is a process, and possibly drawing connections to peer review in scientific research.

8. **Students revise their pre-lesson paragraph.**

   Before turning in their assignments, students return to their pre-lesson paragraph (from Step 2), correct any misconceptions, and add a new paragraph about what they learned or found most interesting during their research.

9. **Instructor reviews responses and scores according to the rubric below.**

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
  - Since Astrobites articles generally link to several past articles to establish foundational concepts, instructors should encourage students to make use of those links if they have trouble constructing a bibliography through their own searches.
  - For students who may major in or have experience in other disciplines, instructors should ask them to compare the process of astronomical research to those other fields. What aspects of the research process in astronomy are familiar, or seem surprising?
  - Instructors may also refer students to Astrobites “Guides” posts, which offer introductory knowledge on various topics.

- **Upper level undergraduate:**
    - Challenge students to dive into the original source articles for each Astrobite. Instructors can use the “annotated bibliography” form to ask students to provide additional information extracted from the source article.

- **Graduate level:**
    - Use the “annotated bibliography” form to invite students to augment the reading from Astrobites with their own knowledge. Instructors can append a question to the form that prompts students to provide additional context that they feel would add understanding to what was presented in the Astrobite.
    - Ask students to criticize the body of research they have investigated. Are there lines of evidence that are more or less rigorous? Are there alternative theories that deserve more or less credence? What are the caveats to the observational, statistical, or theoretical approaches used in the field?

D. Materials

Grading Rubric

(total points: 30)

Score	Scope	Accuracy	Communication
0–3	Total number of sources consulted or project length significantly less than assigned.	Significant factual or conceptual errors presented. An expert in the selected topic would not have agreed with fundamental points made.	Paper / presentation incomplete, not comprehensible, and/or not aligned to course standards. A non-expert would not have learned from it.
4–7	Student integrated fewer sources than expected or did not cover as many aspects of the selected topic as expected.	An expert in the topic may have pointed out a few, minor factual or conceptual errors presented. Student presentation would not have significantly enhanced their peers’ understanding of the selected topic.	Paper / presentation was largely informative for peers in the course, but had some flaws in explanation or depth that inhibited understanding. A non-expert would have learned about some elements of the selected topic.
8–10	Student consulted and integrated at least the expected number of Astrobites articles and other sources. Student comprehensively discussed aspects of the selected topic at the level expected for the course.	No factual or conceptual errors presented. Student presentation aided their peers’ understanding of the selected topic.	Paper / presentation was strongly coherent, informative, and clearly understood by peers in the course. A non-expert would have learned substantially from it.

Student Handout

Example Google Form for collaborative bibliography (same as above):
https://forms.gle/1UB1YpFNn6s44puW8

Lesson Plan Type 3:
Student Writing Assignment

Activity Outline

In this project, designed with upper-level undergraduate or graduate classes in mind, students write their own Astrobites-like article to synthesize and summarize the content of one or more research papers. As the outcome is a set of brief written summaries based on substantial amounts of student research, this assignment helps to build literature understanding and communication skills without subjecting instructors to a high burden of reading long pieces of student work. A sample handout provides guidance as to the form, content, and style of the written pieces.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading and to identify connections to course curriculum or previous readings. Students will also gain the ability to parse technical terminology used in scientific literature.

- **Composition:** Students will gain the ability to synthesize concepts and information from a variety of sources into an original written work.

- **Communication:** Students will gain the ability to convey key ideas and to translate technical information from scientific literature to an audience that may be different in age, training, perspective, or experience than the student.

- **Interpreting data:** Students will gain the ability to extract information from data visualizations and statistical graphics.

- **Self-efficacy:** Students will gain confidence in their ability to parse scientific literature and to communicate scientific concepts to their peers.

B. Instructions

1. **Introductory reading assignment.**

   Students read an introductory source article and its associated Astrobite, following, e.g., the approach of Lesson Plan 1. Instructors should select an article with a topic

appropriate for the course. This serves to introduce students to the Astrobites style of summaries and the level of background and outside context they should use in their own article.

2. **Students select a source article.**

   The instructor can provide a list of research papers tailored to the course curriculum, or students can be asked to identify their own. Especially for lower-level courses, articles that have previously been the subject of Astrobites posts can be a good fit (see 'Adapting' below).

   Students should be given constraints on the source material, such as articles appearing in a certain journal or on the arXiv preprint server. Students should submit their selection to the instructor to verify that it is appropriate before they begin drafting their piece.

3. **Students create a glossary of key terms and map out the key ideas of their source article.**

   As the students read their source article, they construct a glossary of technical astronomy terminology (i.e., jargon) used in the article; students may use whichever resources they prefer to help define these new terms. Suggested resources include the Unified Astronomy Thesaurus and the SAO Encyclopedia of Astronomy.

   Additionally, students create a bulleted list of key ideas from the source article. Students organize the key ideas according to the prompts given in the example "article template" below, thereby creating a summary outline in terms of the motivation, hypothesis, observations, analysis, results, and implications of the source article.

   The glossary and summary outline are submitted to the instructor, but should only be graded based on completion as a participation/scaffolding step.

4. **Students write a first draft of their article.**

   See "project description" handout below for a set of writing guidelines covering the length and scope of the piece, target audience, and formatting style.

   The most important choice for the instructor is what audience to direct students to write for. A clear focus on audience should set strong expectations for the content level of the piece. Astrobites articles are written for an undergraduate level audience of physics or astronomy majors. Instructors might ask students to target an audience of their peers or perhaps at one or two levels below their current status.

   As in this example, we recommend setting a fairly narrow word count range and directing

students to adhere to it, as this project is meant to help students build experience writing in a concise and clear format. We also recommend asking students to include 1–2 figures from the source paper in their article with captions written in their own words. This will strengthen their ability to understand and convey the most significant aspects of technical graphics and data visualizations presented in scientific literature.

5. **Students exchange drafts for peer editing.**

   All Astrobites articles are proofread for content and style by another graduate student in the collaboration; similarly, in this lesson, students will provide peer feedback on their classmates' writing. Instructors can provide the peer editing rubric linked below to guide student feedback.

   If possible, instructors are encouraged to hold peer review sessions in class, so instructors can provide oversight and help ensure uniformly thoughtful and constructive feedback. The feedback rubric provided asks peers to force rank areas for improvement and answer guiding questions to encourage constructive critical feedback.

6. **Students revise based on peer feedback and submit final drafts of their article.**

   (Optional) For the purposes of self-evaluation, students are encouraged to revisit their initial drafts and to compare and contrast the versions before and after the final set of edits.

7. **Instructor reviews articles and scores according to the rubric below.**

8. **(Optional) Submit the article as a guest post to Astrobites.**

   If the target audience for the piece is set by the instructor at or near Astrobites' undergraduate level target, then interested students are welcome to submit their articles to Astrobites for possible publication as a guest post. Students are asked to follow the instructions on our website to submit and clearly label the submission as one associated with a class, mentioning the university, instructor, and course.

   Submissions on recent articles are preferred. Submissions in html or a word processing format (Google Doc, MS Word, OpenDocument) are preferred.

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
  - In place of writing an article, consider having students read and summarize in their own words articles that already have previously written summaries. Valuable

resources include past Astrobites subject articles or the historical articles from Marcia Bartusiak's Archives of the Universe.
    - Alternatively, add some structure to the assignment by asking students to focus on a very specific aspect of the article that ties into the course curriculum (e.g., a particular physical law or discovery), or by increasing the supportive scaffolding leading students to a full draft (e.g., additional pre-writing steps or multiple iterations of feedback).

- **Upper level undergraduate:**
    - Consider asking students to submit their articles in a particular digital format of your choice such as a LaTeXed PDF or html to build technology skills relevant to communication and publication.

- **Graduate level:**
    - For a sense of the commitment involved, consider that the time Astrobites' own graduate students typically spend reading and summarizing an article can vary from 3 to 8 hours.
    - Ask students to incorporate salient, related research such as the presentation of a recent colloquium speaker at their institution or the students' or advisors' own work. Optionally or for extra credit, the student can be invited to interview the researcher to add additional context to their writing.

D. Materials

Grading Rubric

(total points: 30)

Score	Scope	Content	Communication
0–3	Article incomplete or significantly different in length than the requirement (shorter or longer). Does not cite other articles or resources beyond the subject.	Article has significant factual inaccuracies.	Key ideas are described in a vague or overly complicated manner. Article is difficult to understand due to typographical or grammatical issues, or because it is written at a level incongruous with the target audience.
4–7	Article deviates somewhat from length requirement (shorter or longer). Occasionally cites other articles or resources beyond the subject.	Article may have minor factual inaccuracies. Article provides little additional context beyond what was explicitly mentioned in the subject.	Key ideas are described accurately, but could be made more concise. The article would be understandable by a member of the target audience, but its value would be impaired by moderate typographical,

			grammatical, or content level inconsistencies.
8–10	Article in line with word count requirement. Frequently cites other articles or resources beyond the subject.	Article has no factual inaccuracies and provides significant additional context beyond that explicitly mentioned in the subject.	Article is well edited and written clearly. Key ideas would be readily understandable by a member of the target audience.

Student Handouts

- Project description: https://goo.gl/qY3qt5
- Article template: https://goo.gl/uuHYOg
- Peer editing rubric: https://goo.gl/KOSIym

Some recent sample Astrobites:

- JWST direct imaging: https://astrobites.org/2022/09/01/jwsts-first-directly-imaged-exoplanet/
- Dust devils on Mars: https://astrobites.org/2022/09/07/another-one-bites-the-dust-what-dust-devils-tell-us-about-mars/
- Exoplanets and machine learning: https://astrobites.org/2022/07/30/finding-young-exoplanets-with-machine-learning/
- Planet formation: https://astrobites.org/2022/01/20/iron-abundance-and-the-formation-of-terrestrial-exoplanets/
- High-z stars: https://astrobites.org/2022/04/07/highest-redshift-star-ever-observed/
- Galaxy clusters: https://astrobites.org/2022/02/19/an-intracluster-investigation-via-radio-rotation/
- Gravitational waves: https://astrobites.org/2022/01/04/gw-cosmo/
- Formation of supermassive black holes: https://astrobites.org/2022/08/25/behind-the-black-hole-curtain/
- Cosmic rays and astrochemistry: https://astrobites.org/2021/07/14/template-post-2-2-2-2-3/
- How different instructors have implemented our lesson plans: https://astrobites.org/2022/06/03/writing-astrobites-in-your-courses/

Lesson Plan Type 4:
Student Presentation

Activity Outline

In this project, undergraduate and graduate students select an Astrobites interview post and a paper by the interviewee to give an in-class presentation, featuring a profile of that astronomer with a summary of their research. This touches on a more recent development in Astrobites' focus: the interview series, which features voices of underrepresented minorities in astronomy. This type of assignment will help students build literature understanding and communication skills while also introducing them to the variety of ways that one can become an astronomer. Because this assignment will be delivered as an in-class presentation, it will highlight the wide variety of career trajectories taken by astronomers; students will not only learn about their own astronomer of interest, but will also learn about the astronomers researched by their classmates. If class time permits, following the presentations students may discuss their scientist's work in the context of a few other students' presentations.

A. Learning Objectives

- **Reading comprehension:** Students will gain the ability to extract information from new reading and to identify connections to course curriculum or previous readings.

- **Communication:** Students will gain the ability to convey ideas and knowledge to a group of peers who share the same experience and knowledge of the field.

- **Sense of belonging:** Students will be able to see themselves as part of the astronomy community.

- **Self-efficacy:** Students will gain confidence in their ability to succeed in astronomy.

- **Career preparation:** Students will be able to identify and compare different paths to success in modern astronomy research

B. Instructions

1. **Students select a subject.**

Students select an interview post from the Astrobites interviews page and select a paper by the interviewee that interests them; students may search for this paper on the interviewee's website, NASA ADS, or elsewhere.

Students are encouraged to select an interviewee with whom they share an identity or with whom they share a research interest. Students submit their selected paper to their instructor for approval; instructors should vet papers as a preliminary progress check and to ensure that the selected paper is not too long or inaccessible for the scope of the assignment. Alternatively, instructors can offer a list of subjects from which students can choose from.

2. **Students identify and read related Astrobites.**
   Because students will be independently reading a research paper by their astronomer of choice, they will select and read Astrobites on related topics to familiarize themselves with the field and the jargon. At the same time, students will read the Beyond post interview and take notes on important career milestones/advice/other related information that would be interesting and valuable to share with the class.

3. **(Optional or extra credit) Students contact their selected interviewee via email.**
   If students are interested in hearing more about specific aspects of their selected interviewee's career, research, or anything else touched on in the interview, they are encouraged to reach out to the interviewee directly. This will be a good networking opportunity for students who are especially motivated by the interviewee they have chosen.

4. **Students read their selected paper.**
   Students read the academic paper that they have chosen and produce an outline for their article. They summarize key points and figures from each section of the paper and make notes of things that may be unclear. Students may reach out to the instructor for clarification on areas of confusion. This outline can be submitted to the instructor as a progress report/extra scaffolding step, but will not be graded.

5. **Presentation: Students present their assigned/chosen scientist.**
   Students prepare a brief (~10 minute) presentation about their astronomer of choice, to be delivered in class. A sample presentation structure is as follows: students provide a profile of their chosen astronomer (with a focus on career trajectory and career advice), introduce the astronomer's area of research to motivate and position the selected paper, and finally summarize the salient points of the paper, if possible connecting methods and ideas used in the paper to content presented in class.

6. **(Optional) Post-presentation assignment: Comparison of career paths.**
   Students will compare the path taken and research pursued by their chosen scientist to those of two or three other scientists highlighted in the presentations of classmates.

Students will submit a one-paragraph writeup comparing and contrasting their subject to those discussed by their classmates; students should also highlight their biggest takeaways from this activity.

C. Adaptation to Different Course Levels

- **Entry level undergraduate:**
    - Students may not yet be comfortable diving into a full paper on their own, so instructors should encourage them to focus their presentation on the career profile of their chosen scientist and a brief summary of the paper of choice
    - Instead of breaking down methods from their paper in detail, in their presentation students can summarize the related Astrobites they read and describe the main takeaways from their chosen paper (i.e., they can focus on the introduction/context and conclusions of the paper rather than the methods)
- **Upper level undergraduate:**
    - Students should be encouraged to tackle the full paper directly and to break down the context, methods, and results in their presentation.
    - Students should also attempt to draw connections between material from this course and other courses they have taken to ideas presented in the paper.
    - Add metacognitive steps to help students begin to reflect on their own career goals, in relation to the career paths they're learning about.
- **Graduate level:**
    - Students should be encouraged to read several papers by their chosen scientist and provide a research profile that summarizes various aspects of that scientist's work
    - Encourage students to search beyond the Astrobites profile to learn more about their assigned scientist. Beyond their research, what service have they done for the field? Outreach? Teaching?
    - Students should be encouraged to think critically and ask questions of the papers they are reading. If students are especially interested, they should be encouraged to reach out to the authors directly and present their questions in an email.
    - Add metacognitive steps to help students begin to reflect on their own career goals, in relation to the career paths they're learning about.

D. Materials

Grading Rubric

(each category evaluated out of 10 possible points)

Score	0-5	5-9	10
Presentation: Scientist Profile	Student's profile of their selected scientist was incomplete or was missing one or more significant stages of the scientist's career path.	Student's profile of their selected scientist touched on the major stages of the scientist's career path, but did not highlight how this path was unique or how it could inform the career paths of other students.	Student's profile of their selected scientist clearly and holistically outlined the scientist's career path. The student distilled their scientist's experience into relevant career advice for other students.
Presentation: Scientific Paper	Student's explanation of the paper was unclear and/or the fundamental points in the paper were incorrectly identified.	Student's explanation of the paper contained some errors that could be identified by one familiar with the topic. The student's explanation was accessible and clear.	Student's explanation of the paper was informative and engaging and could be easily understood by peers. Student identified connections between paper and class topics.
Post-presentation Assignment (Optional)	Student did not/minimally discussed other presentations and did not/minimally identified connections.	Student discussed other presentations but engagement was surface level/cursory.	Student demonstrated engagement with other presentations and drew meaningful connections between various scientist profiles.
Timeliness	Work was turned in very late or not at all.	Work was turned in with a slight delay.	Work was turned in on time.

Sample: Astrobites Guided Questions for 'Settling the Proxima Centauri Question'

Read the Astrobite here: https://astrobites.org/2016/11/16/settling-the-proxima-centauri-question/

Provide 1–3 sentence responses to each of the following questions.

* Required

Name / Student ID *

Used to assign grades

Your answer

Question 1: Proxima Centauri is currently the closest known star to our solar system. According to the information in the paper, was this true 300,000 years ago? *

This is a sample question for an entry level astronomy course.

Your answer

Alternate Question 1: How would the authors' conclusions have changed if they had measured the kinetic energy of the stars to be greater than their gravitational potential energy? *

This is a sample question for an entry level astronomy course.

Your answer

Question 2: What would the authors have found if the orbital plane of Alpha and Proxima Centauri were parallel to our line of sight? *

This is a sample question for an upper level undergraduate astronomy course.

Your answer

Alternate Question 2: Suppose we want to apply these same techniques to a system 100x farther away. What factors would make this system harder to study? *

This is a sample question for an upper level undergraduate astronomy course.

Your answer

Question 3: In what ways might Alpha Centauri's orbit have affected the formation and evolution of the planet recently detected around Proxima Centauri? *

This is a sample question for a graduate astronomy course.

Your answer

Alternate Question 3: Look at the paper by Kervella and Thévenin (https://arxiv.org/pdf/1611.03495v1.pdf) and provide a caption in your own words for Figure 1b (bottom panel). *

This is a sample question for a graduate astronomy course.

Your answer

Please submit your completed glossary here *

Your answer

Submit

Clear form

Sample: Astrobites Collaborative Bibliography

Students: Identify a set of Astrobites articles related to your research topic. For each article, read the piece and then submit a response to this form.

* Required

Name / Student ID *

Your answer

Student Research Topic Category *

Choose

Astrobites Article Title *

Your answer

Astrobites Article Link *

Your answer

Why was this article valuable to your research?

1-2 sentences

Your answer

Course concepts related to this article

List one per line, 2-4 total

Your answer

Submit

Clear form

Never submit passwords through Google Forms.

Timestamp	Name / Student ID	Student Research Topic C	Astrobites Article Title	Astrobites Article Link	Why was this article valua	Course concepts related to this article
12/19/2016 8:39:24	John Doe	Dark energy	Dark Energy in the Early U	https://astrobites.org/2011	it helped me understand h	LCDM Model Cosmological constant Cosmic microwave background
12/19/2016 8:42:59	Jane Doe	Supernovae	A Blast from the Past: For	https://astrobites.org/2016	It provided an example of	Gravitational lensing General relativity Galaxy clusters

Astrobites Writing Assignment

Sample Project Description

You will select a research paper to synthesize and summarize in a brief and accessible format, like the articles on Astrobites (http://astrobites.org). By supplying overall context not mentioned in the source article, and by improvement through peer editing and revision, your piece will help a reader from our target audience to better understand the subject matter of the paper.

Guidelines

Target Audience

All pieces will be targeted at a lower-level undergraduate audience. For example, consider a physics student who has just completed their introductory mechanics course. Assume familiarity with basic physical and mathematical concepts, but very limited specialized and very low awareness of astronomical research results and methods.

Format & Style

- Follow the provided article template.
- Total length should be 800–1000 words.
- Although scientists usually write in the passive voice (e.g. “The data were collected”), use the active voice whenever possible (e.g. “Dr. Evil collected the data”).
- Avoid the “be” verbs whenever possible: am, is, are, was, were, be, being, been. Use active verbs instead: measured, hypothesized, contested, observed, validated, etc.
- Be concise. If there are two ways to say the same thing, use the shorter way.
- Consider using headings to break your post into small, digestible chunks.

Content Requirements

- Your piece must address the key findings and methods of the source article.
- Include 2 figures from the source paper and caption in your own words.
- When using terms or concepts that will be challenging for the target audience, use hyperlinks to cite helpful materials such as online textbooks or encyclopedia articles.

Procedure

1. Select a source article (Due: *October 1*)
2. Write first draft (Due: *October 14*)
3. Peer editing (in class: *October 15*)
4. Final draft due (Due: *October 21*)

Your Title: Astrobites Article Template

Author: [Your name here]

Source article
Title: A Disk-based Dynamical Mass Estimate for the Young Binary V4046 Sgr

Authors: Katherine Rosenfeld et al.

First Author's Institution: Harvard-Smithsonian Center for Astrophysics

Status: Published in the Astrophysical Journal

This is the first paragraph of your article. It uses engaging language to introduce the most important concept of the paper.

Sub-heading 1

The body of your piece uses information from the source article, your outside knowledge, and your research to provide readers with a better understanding of the authors' methods and results. It cites other educational sources frequently to explain concepts and jargon like blackbody radiation or Markov Chain Monte Carlo.

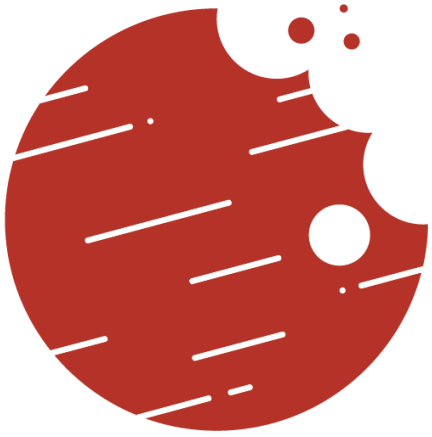


Figure 1: Figure captions should be concise — usually only a couple of sentences long — and indicate the figure source at the end. Make sure they are referred to in the text! (Figure 2 in the paper).

Depending on your article content and course goals, the ideal structure of your paper may vary. For example, you may choose headings like the following:

Introduction/Motivation

Observations/Setup

Analysis

Results

Implications

Astrobites Writing Assignment

Sample Peer Editing Rubric

Steps for Peer Editing

Gather into pairs and repeat the sequence below for each partners' article.

1. 5 min: Read the article together silently, making any typographical edits or content notes.
2. 3 min: Author describes their major goals in writing their piece, including a brief description of the source paper and what information in the piece came from that source, and what they want the reader to take away.
3. 5 min: The editor should reflect on what they've read and heard, making notes on bigger picture recommendations based on the rubric below.
4. 7 min: Discuss the major recommendations, perhaps using the discussion questions below, exploring the implications of the editors' suggestions.

Use the outcome of the peer editing session to revise your piece for final submission.

Editing Rubric

Questions for discussion

These questions are NOT the required changes that you need to include in your revisions, but they should help you discover possible improvements.

1. What familiar topic or concept could you reference to help connect the source material to the audience's prior knowledge?

2. What sentence will be hardest for the target audience to understand?

3. What is the most exciting part of the source article? Where is this explained in the piece?

4. Before you had taken this class, what part of the source article would have been most difficult for you to understand? How do you present that topic in your article?

Focus for revision

Force rank the following key elements to help focus revisions. Check one row each for ‘focus’, ‘moderate’, and ‘minor.’

	Focus for revision	Moderate revision	Minor revision
Outside context How much information does the article supply beyond what was in the source paper?			
Accessibility How easy would it be for a member of the target audience to understand the piece?			
Content How completely does the article cover the key concepts from the source paper?			