Annotated Bibliography – Writing in Earth and Planetary Sciences

This annotated bibliography of writing activities in the geosciences is compiled from a search of the ERIC ProQuest database for peer-reviewed articles published in English. Seventeen articles were included and were chosen based on the presentation of short writing activities that maximize the benefits of writing in undergraduate geology courses and minimize the time commitment to grading demanded of the course instructor. The articles in this annotated bibliography were selected and summarized by Anna Hayden, a graduate student and former undergraduate student in the Department of Earth and Planetary Sciences. Guided by Anna's experience in the Department's B.Sc and M.Sc programs, each entry in the annotated bibliography includes notes and examples of how the different writing activities could be integrated into EPSC courses.

Copies of all articles are available from the Office of Science Education (OSE). This compilation represents a work in progress that we intend adding to in the future. If you know of interesting examples, please contact the OSE Director, Marcy Slapcoff: marcy.slapcoff@mcgill.ca.

Search terms used in the ERIC database: (writ* OR communicat*) AND (geol* OR geosci*)

(Balgopal, Wallace, & Dahlberg, 2012; Bank, 2006; Beiersdorfer & Haynes, 1991; Caplan-Auerbach, 2009; Carlson, 2007; Conrad & Macdonald, 1991; Cooper, 1993; Davis & et al., 1991; Halsor & et al., 1991; Koffman, Kreutz, & Trenbath, 2017; Leydens & Santi, 2006; Macdonald, 1991; Mango, 2000; Markley, 2010; Snow, 1991; Stanesco, 1991; Yates, Williams, & Dujardin, 2005)

Balgopal, M. M., Wallace, A. M., & Dahlberg, S. (2012). Writing to learn ecology: a study of three populations of college students. *Environmental Education Research, 18*(1), 67-90. doi:10.1080/13504622.2011.576316

This article focuses on writing to learn in an undergraduate ecology class, with the students coming from different educational and cultural backgrounds. The study uses short writing activities to examine what students know about a topic (in this case, the ecological issue of hypoxia), how students integrate personal experience in writing, and how students might use this knowledge to inform decision makers. The authors introduce a model that addresses the three domains of learning: conceptual, affective (i.e. reflection), and behavioural (i.e. decision making), and use this model to design their assignments. The authors emphasize that reflective writing improves conceptual understanding in addition to highlighting the concepts that were unclear. The students in the class are asked to read short, Science News articles, and write three short essays (less than a page) with different audiences and purposes. The first essay is written from the perspective of a community member who sends an educational piece to a local newspaper informing the community of an environmental issue (hypoxia). The second piece, still written from the perspective of the community member, is a blog post that expresses the community member's feelings towards hypoxia. The last writing assignment is a conversation between the community member and a you (i.e. the student) that focuses on decision making, with an emphasis on what needs to be done and can the issue be resolved. In EPS, this type of

activity could be used as a way to pitch their research to different audiences (e.g., in ESYS 500, students could write a column to the Montreal Gazette raising awareness about their research topic, then a blog post, and then a conversation with a city official).
https://doi.org/10.1080/13504622.2011.576316

Bank, C.-G. (2006). Reading and Writing Taught in a Sophomore Course on Plate Tectonics. *Journal of Geoscience Education, 54*(1), 25-30. doi:10.5408/1089-9995-54.1.25

Bank outlines an approach for reading and writing scientific articles. The author emphasizes that improving student writing requires, as a first step, effective reading of scientific journals, and provides a flow-chart that can be used to guide reading. Bank first ntroduces and explains the "Four Cs" of scientific writing, which can be used to structure student writing: Content, Clarity, Coherence, and Craft. After introducing the framework, the author goes through a paragraph with the students to show how to apply the four Cs. Assignments are one-paragraph summaries of scientific articles. First, the author provides feedback on the student writing, but indicates that peer-review is also valuable in engaging students in writing exercises. The course also includes a longer, essay-style assignment, which is reviewed by the author and the students' peers. The author provides the sheet of peer-review questions. The frameworks and assignments mentioned in this paper could be used in seminar-style classes in EPSC, where paper discussions and term papers are often the primary form of assessment.
https://search.proquest.com/docview/202779779/fulltext/29B31196095148E2PQ/1?accountid=12339

Beiersdorfer, R. E., & Haynes, J. (1991). An Integrated Approach to Geologic Writing for Non-Science Majors Based on Study of California River. *Journal of Geological Education, 39*(3), 196-198.

Beiersdorfer and Haynes teach a geomorphology class to non-geology majors that incorporates a technical report writing assigment. To prepare for the final technical report, the students are given a series of intermediate assignments. For example, in the first assignment, the student is asked to select a topic, write about what they already know about that topic and what they need to find out, and indicate where they would find the information needed to complete their report. This assignment has a length limit of one page. In subsequent assignments, the students must provide a list of references a first draft of the technical report, and a final report. The instructors emphasize that the audience is not the instructors themselves, but rather a supervisor at a technical firm that has a geology background but it not an expert. To ensure that the teaching assistants marking the assignments give constructive and helpful writing feedback, a session with the university's writing center is organized. This type of technical report writing assignment could be adapted to EPSC courses that include field work.
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Caplan-Auerbach, J. (2009). Every Equation Tells a Story: Using Equation Dictionaries in Introductory Geophysics. *Journal of Geoscience Education, 57*(5), 348-355.

In an introductory geophysics course, the author introduces the equation dictionary activity, as a way to address the fear of math that many geology students have. Each student creates their own equation dictionary based on equations presented in class. Each entry includes the equation, definitions of the variables and their units, the definition of the processes behind the equation, and any extra comments that the student feels is necessary for their understanding of the equation (e.g., what the relationship means). The author provides several examples of how the equation dictionary could be structured. The author allowed students to use the equation dictionary in exams. The author assigns the equation dictionary as homework and is graded based on the students' ability to write about the processes defining the mathematical equation, and can be used to highlight to the professor what student misconceptions about course content are. Grading of the equation dictionary was based on completeness, organization, and how well the student explained the meaning behind the equation. The dictionary was worth 5% of the course grade. In EPSC, this type of exercise would be useful in EPSC 220 (Geochemistry), EPSC 320 (Elementary Earth Physics), and EPSC 510 (Geodynamics).
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Carlson, C. A. (2007). A Simple Approach to Improving Student Writing. *Journal of College Science Teaching, 36*(6), 48-53.

The author of this paper presents a simple framework for using the standard "W questions" (what, where, how, when, who, why) in introductory-level scientific writing. The author suggests that this straightforward approach is appealing to students since it links familiar writing concepts present in other genres to writing in science. The author notes that the order in which the W-questions are presented (see above) is important for the logical flow of scientific reasoning. This framework can be used throughout the whole report, not just in the introduction. The author states that this method can also be applied to writing figure and table captions. In EPS, this writing framework could be presented in introductory 100- and 200- level classes, in which the students often have varying levels of experience with scientific writing.
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Conrad, S. H., & Macdonald, R. H. (1991). Balancing Teaching and Learning Geology on the Writing Fulcrum. *Journal of Geological Education, 39*(3), 230-231.

Conrad and Macdonald provide several examples of writing assignments designed for undergraduate geology classes. The first writing activity asks the student to write and answer two exam questions. The questions and answers are compiled into a study guide that the students can use as a study guide for the exam. The questions must be thought provoking and link two or more course topics together in order to receive full credit. Answers should be several paragraphs. The second writing activity that the authors assign is a "reaction paper", in which the students are asked to write a one-page response following a departmental seminar or guest lecture. In the paper, the students may write about: interesting points raised by the speaker and/or thought-provoking questions asked by the audience, in addition to the student's reaction to the topic and style of presentation. Conrad and Macdonald also introduce the concept of "short papers", one page papers that cover a broad range of topics, such as an interpretation of an outcrop sketch or a

rock description. The fourth writing activity is a 2-3 page paper in which the student must take a position on a controversial topic in environmental geology. The authors suggest that this paper is written in two drafts, and provide questions and objectives for the students to think about when they are writing the paper. The exam question exercise and the reaction paper could be adopted in a broad range of EPSC courses. both at the undergraduate and graduate levels.
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Cooper, M. M. (1993). Writing: An approach for large-enrollment chemistry courses. *Journal of Chemical Education, 70*(6), 476. doi:10.1021/ed070p476

Cooper outlines a series of informal writing assignments created for large enrolment classes. Each assignment is 100-200 words in length. The first assignment that Cooper suggests asks the student to describe, in 150 words or less, a course concept that is unclear. In this activity, the student is asked state specifically which concepts are unclear, avoid blanket statements, and ensure that the question is answerable by another person. In the follow-up assignment, the students exchange their questions and a second student attempts to answer the problem posed by the first student. The response should be 100-200 words. This exercise is graded for completion. Cooper notes that this activity is helpful for instructors in identifying problem areas that require further explanation, and states that this activity would be beneficial before a formal assessment. A third writing activity asks the student to reflect on why a certain concept is being studied in the class. Cooper's final writing activity asks students to describe how they will improve their performance on tests, and indicates that students were grateful that the instructor expressed a vested interest in their success. In EPS, these writing activities could be used in introductory and upper level classes in order to develop the students' ability to succinctly describe ideas and concepts, and to facilitate group discussions. As faculty in the EPS department are already highly invested in the success of their students, the action-plan writing activity would further strengthen this mentor-mentee relationship.
https://doi.org/10.1021/ed070p476

Davis, L. E., & et al. (1991). Student Abstract Writing as a Tool for Writing across the Curriculum in Large Introductory-Geology Courses. *Journal of Geological Education, 39*(3), 178-180.

Davis et al. advocate for abstract writing in large introductory-level undergraduate classes as a way to promote clear and concise writing, minimize the amount of time required for grading, and to help identify knowledge gaps. The abstract is intended for a lay person without a scientific background in geology. Davis et al. provide directions and a rubric for how the abstract should be written. In EPS, abstract writing could be integrated in 100- and 200- level classes, but also in upper level classes which often require final papers in the form of scientific reports. With an increasing number of journals requiring plain language summaries of manuscript findings, learning to write this this form of abstract would prepare graduate students to write for non-specialists within and outside academia.
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Halsor, S. P., & et al. (1991). Enhanced Student Learning through Writing in a Physical-Geology Class. *Journal of Geological Education, 39*(3), 181-184.

Halsor et al. present formal and informal writing activities in a geology class. The formal writing activity is a two-page summary of a scientific article. Halsor et al. assign four summary paper assignments throughout the term. The second form of writing evaluation is the informal "laboratory journal", in which students write a one-page reflection on laboratory exercises. In the laboratory journal, the students are encourages to think critically about the laboratory exercises, such as what might the data show, what hypotheses can be drawn, and what is the appropriateness of the techniques used. As undergraduate students are required to take several laboratory-based courses in EPS, the laboratory journal would complement the curriculum in these courses.
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Koffman, B. G., Kreutz, K. J., & Trenbath, K. (2017). Integrating Scientific Argumentation to Improve Undergraduate Writing and Learning in a Global Environmental Change Course. *Journal of Geoscience Education, 65*(3), 231-239. doi:http://dx.doi.org/10.5408/16-232.1

Koffman et al. present writing exercises that assess data literacy, develop argumentation, and promote reflection in an introductory earth system science class. Each week, the students are given problem sets that focus on a component of the earth system (e.g., CO2 and global mean temperature: past, present, and future) The problem sets involve data generation, modelling, interpretation of results, and usage of primary literature. As a complement to the problem sets, the students are evaluated on a longer written assignment. The assignment is an argumentation essay (max. 1200 words) that addresses a concept covered by the couse, incorporates references to primary literature, and written in the style of a Science Perspectives article. The rubric for the assignment is developed with the students. The students are asked what constitutes a good scientific argument. Since the criteria outlined by the students aligned with the authors' expectations, the authors incorporate the students' suggestions in the rubric. The authors provide feedback on first and second drafts of the assignment. During the course. the authors offer 20-30 minute writing workshops to help guide the students through the writing. These workshops focus on basic concepts of scientific writing such as proper usage of references and paragraph-level writing. Two examples of focused writing activities were provided in the article: 1 - show a paragraph with citations removed, and ask students to point out where citations should be. 2 - show a paragraph with topic sentence removed and ask students to write a topic sentence for the paragraph, in addition to asking students what they think should be included in a topic sentence. For these activities, the authors use their own writitng to demonstrate that writing develops over time and to show that they were open to critique (as the students should be with their own writing). The activities presented by Koffman et al. would be well-suited for seminar style classes in EPS (e.g. EPSC 5XX).
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https://www.tandfonline.com/doi/pdf/10.5408/16-232.1?needAccess=true

Leydens, J. A., & Santi, P. (2006). Optimizing Faculty Use of Writing as a Learning Tool in Geoscience Education. *Journal of Geoscience Education, 54*(4), 491-502.

In this article, Leydens and Santi focus on a writing approach they termed “”less is more”, aimed at maximizing the benefits of academic writing with minimal time committment for grading. The authors list four strategies for implementing the less is more framework. The first strategy, assignment integration, involves designing purposeful writing assignments that address one or many course objectives, apply conceptual knowledge, and promote critical thinking. The second strategy, effective assignment design, involves clearly communicating through the assignment and to the students, how the assignment addresses the course objective. Writing-to-learn is the third strategy, and can be utilized in classes to probe what the students already know, in addition to identifying knowledge gaps. The authors provide sample three-minute writing-to-learn pyramid exercises to illustrate this concept, and emphasized that writing to learn activities do not always need to be graded, The authors’ fourth strategy focuses on instructor feedback, and suggests that instructors should give brief, but constructive feedback that focuses on the broader writing issues rather than the small details. All EPSC courses would benefit from considering the less-is-more approach to writing.
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Macdonald, R. H. (1991). Writing Assignments Challenge Students in a Physical-Geology Course. *Journal of Geological Education, 39*(3), 199-201.

In this article, Macdonald presents writing assignments intended to be read by a broad range of audiences. In the first assignment, Macdonald asks the students to write a description of a rock that is intended 1) for a geologist and 2) for a lay person with no geology background. The students are asked to be detailed and use the appropriate language. This assignment has a length limit of two pages. In the second assignment, the students are asked to write a two page paper on a topic selected from a list provided by the instructor. The students are asked to write either: 1) a letter to a governmental official on an environmental geology issue, 2) submit a editorial piece on an environmental geology issue to a local newspaper, or 3) write an essay based on an interview with a geologist to be used in a brochure for the geology program. Each piece of writing undergoes peer-review by students in the classrom, guided by a set of questions provided in the article. The assignments presented in this article could be helpful in teaching EPSC students the concept of writing for different audiences.
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Mango, H. (2000). A Reading and Writing Approach to Teaching Environmental Geology. *Journal of Geoscience Education.*

Mango assigns weekly readings from scientific literature accessible to students coming from diverse educational backgrounds and asks students to write their own abstracts for the material. The students are required to stay up-to-date with current environmental geology issues and discuss a recent article and write a summary the main findings in the article. Each week, the instructor gives feedback on the abstracts. Mango notes that this type of course is time-intensive

for grading, and is best suited for classes of no more than 20-25 students. As such, this type of course would be best suited for seminar-style courses in EPSC.
https://www.tandfonline.com/doi/pdf/10.5408/1089-9995-48.5.662?needAccess=true

Markley, M. J. (2010). The [Geo]Scientific Method; Hypothesis Testing and Geoscience Proposal Writing for Students. *Journal of Geoscience Education, 58*(4), 198-202.

Markley first presents different views on hypothesis testing and the concept of mulltiple working hypotheses. Markley suggests that proposal writing can be used as a way to introduce students to hypothesis testing. The student is asked to choose two scientific journal articles (e.g. from Science or Nature) and present them to the class. The student must then write a proposal that would advance the research presented in the paper. A guide for undergraduate proposal writing is provided at the end of the paper. This type of writing activity could be integrated into a seminar-style course in EPSC. This activity would also be beneficial to Master's students in preparation for the required outline of proposed research.
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Snow, R. S. (1991). Early Writing in the Research Mode via Digital Modeling of Rivers. *Journal of Geological Education, 39*(3), 227-229.

Snow, motivated by the poor quality of final reports in research-oriented undergraduate classes, presents a paper writing activity to accompany a modelling-based course. The students are asked to select a topic within a larger theme (in Snow's class, the theme is river geomorphology). After selecting a topic, the students are asked to write a one-page proposal outlining the project. The students must describe the data, methods, and any hypotheses they have in their proposal. The final paper structure is representative of a scientific journal article, and consists of an introduction, overview of model runs, results, conclusions, and an appendix. The research-based class and writing activity discussed in Snow's paper is most similar to ESYS 500, suggesting that this form of writing activity is appropriate for undergraduate modelling courses.
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Stanesco, J. D. (1991). The Personal Journal as a Learning and Evaluation Tool in Geology Field-Trip Courses. *Journal of Geological Education, 39*(3), 204-205.

Stanesco presents a organizational structure for journals used in a field geology course. The journal (or "Learning Log" in this paper) is intended to assess learning and comprehension in a class with students from different educational backgrounds. The journal is divided into five sections: Noting, relating, creating, telling, and listening. In the noting section, students are asked to record lecture notes, definitions, terminology, and any other relevant course material. The relating section is intended to integrate course knowledge from the field course with material from other courses, such that the student is able to make connections between material presented in traditional, lecture-based courses, and experimental field work. The students are encouraged to think critically in the relating section. In the creating section, the students are given the liberty to

express their findings or ideas creatively, through sketches, photographs, and creative writing. Stanesco argues that the creating section emables students to gain a greater appreciation of field work by adopting a different perspective. The telling section is where students are asked to summarize what they have learned, answer exam questions, and write other assignments. In the last section, listening, the students receive peer feedback on what they have written in their journals. Any or all of the journal sections presented in this article could be adopted in EPSC field work courses.
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Yates, S. J., Williams, N., & Dujardin, A.-F. (2005). Writing geology: Key communication competencies for geoscience. *Planet, 15*(1), 36-41. doi:10.11120/plan.2005.00150036

Yates et al. investigated the weaknesses in student writing in a geology class and suggested strategies for addressing these weaknesses. The authors noted issues in correct and consistent register, appropriate use of citations, and differentiating observations and interpretations. The authors held writing improvement seminars to address these weaknesses and found that most students responded that they know how to write already. Attendance was primarily students who scored poorly on the writing assignments. Yates et al. elaborated on the specific challenges that arose during the writing seminars and presented activites aimed at addressing the weaknesses in student writing. The first activity, intended for teaching tone and register (i.e. level of formality of writing), involved reading two articles on the same topic but intended for different audiences 1) the general public and 2) a scientific audience. The students were asked to compare and contrast the articles, including the formality of the language used, past and present tense, and purpose. The second activity addressed argumentation. In this activity, the students were given sentences and asked to categorize them as either observations, processes, environment, or interpretation, and explain why they categorize the phrases the way they did. A follow-up activity required students to place the phrases in what they thought was the correct order. Students were then asked to list and describe the necessary sections of a geology report and to put the sections in the correct order. The activities outlined in this article would be helpful in teaching students how to write for a scientific audience in addition to improving paragraph-level writing.
https://doi.org/10.11120/plan.2005.00150036