Stop Writing/Teaching Lab Reports: Integrating Authentic Research-based Writing into Chemistry Courses

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ACS Guidelines (section 7): Development of Student Skills[1]

"In order to **prepare students to enter the workforce** … programs must provide experiences that **go beyond chemistry content knowledge** … to develop competence in other critical skills necessary for a professional chemist."

- Chemical Literature and Information Management skills (7.2)
- Communication skills (7.4)

"[…] either dedicated courses or **integration of learning opportunities** throughout the curriculum can be used to develop and assess student skills."

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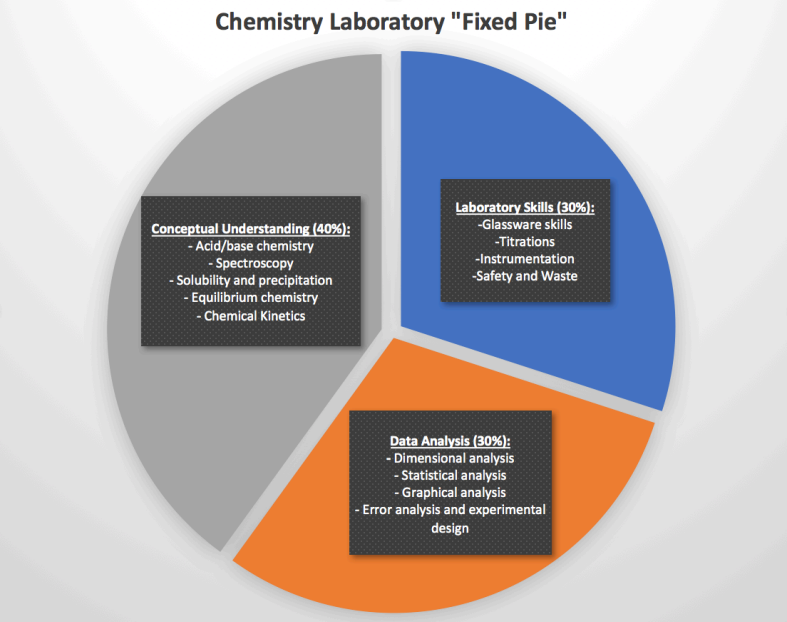
1. Undergraduate Professional Education in Chemistry: ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs. **Spring 2015 (**ACS Committee on Professional Training)

Addressing concerns about teaching writing in chemistry

- ***Fixed pie*** fallacy
- Successful ***translation***
- Qualified instructors
- International and ESL students



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What we know about teaching writing in the disciplines

- Simulations don't work – scientists need ***something meaningful*** to write[1,2]
- Writing Across the Curriculum (WAC) – ***start early*** and build up[3]
- Asking students to write without instruction leads to reinforcing problems

- Paper "***structure***" is easy (easier?) to teach
- Students developing a scientific "***voice***" is harder to achieve – takes time

1. C.Keys. "Revitalizing Instruction in Scientific Genres: Connecting Knowledge Production with Writing to Learn in Science." Science Education 83 (1999).
2. C. Moskovitz, D. Kellogg. "Inquiry-Based Writing in the Laboratory Course." Science 332 (May 2011).
3. S. McLeod. "Defining Writing Across the Curriculum." *Writing Program Administration* **1987**, *11* (1), 19

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BU WRITES: Integrated Chemistry Writing in Quant Labs

Standard, honors-level first-year chemistry course sequence

- Lecture (3 hrs), discussion (1 hr), pre-lab lecture (1 hr), and lab (4 hrs)
- Students take first-year writing concurrent with first-semester of the course

Types of assignments in lab portion of the course

- Data analysis and thought-provoking questions (50%)
- Writing and Information Literacy assignments (50%)
- Capstone project (team-based, semester-long research project in spring semester)

Division of instructional labor

- Course Instructor: content instruction, course design, assignment
- Graduate TA's: practice and skills instruction, evaluate conceptual post-lab assignments
- Undergraduate Learning Assistants: peer mentors and lab support
- Writing Fellows: mentor students writing/argumentation/literacy skills, one-on-one instruction

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Structured development of science literacy and writing

- Scientists generate ***exhibits*** – science writing starts by engaging with them: What exhibits are useful? not useful? (Figures, tables)
- Results are not just the data/exhibits. Results must engage in an ***argument*** with the field. Are their results affirming? Disputing? Refining?
- Analyzing, presenting, and communicating results requires a deep understanding of the ***theory*** and ***methods*** of the chemistry
- Refocused on the use of the ***literature*** as practitioners of science
- This is how ***expert scientists*** think about their results – our job is to get these students to start seeing their work in the same way.
- Voice, tenses, conventions, and structure are a (necessary) ***veneer*** on top of the science.

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Rubrics for Scholarly, Research-Based Writing

(A) Research and Info Literacy		(B) Argument and paper logic
1) Did not understand results 2) Used ***instructor-provided*** info, or Found ***any*** source to match	Novice	1) Argument is not sound 2) Erroneous or irrelevant claims make argument weak, unfocused, or circular
3) Found a ***reputable*** source to match		3) Logical argument, but lacks strength
4) ***Survey*** of literature for match or contrast of their work 5) True motivation, true impacts	Expert-like	4) Well-supported argument that is persuasive 5) Presentation of the argument is well-ordered, articulated, and written

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Substantial gains in literacy, argument, and writing

Cohort	(A) Research and Info. Literacy	(B) Argument and Paper Logic	(C) Voice, Organiz., and Language
Incoming students	1 – 2	1 – 2	- -
CH109 Course	2.0 ± 1.2	2.4 ± 1.1	3.8 ± 0.7
"Year 5" CH111	3.0 ± 1.0	3.8 ± 0.9	4.0 ± 0.8
"Year 10" CH111	3.8 ± 0.8	3.9 ± 0.9	3.9 ± 0.7

- ***Significant gains*** across the board
- Year 6+: added emphasis on literature, bibliographies, and ***collaboration***
- ESL students show ***no significant difference*** in (A) or (B)
- Incredible result: student effort remains **20** hours/semester
  output is focused (**10** pgs final product, **20** pgs workflow)

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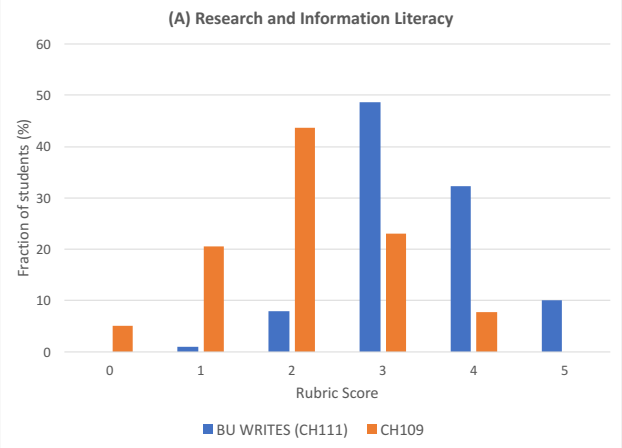
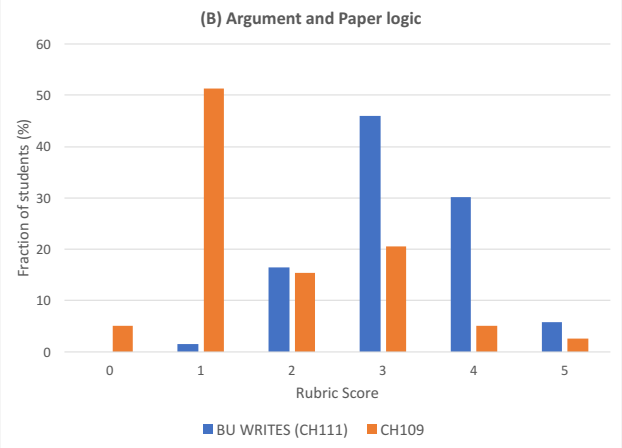
Substantial gains in literacy, argument, and writing





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Shifts in students attitude about writing in chemistry

Nature of Writing in the Sciences

Attitude	Before	After
Understand importance of writing in science	3.0 ± 1.0	4.7 ± 0.5
Scientists write in complicated/obtuse way	4.0 ± 0.8	1.9 ± 0.8
Feel prepared to write science papers	2.1 ± 0.9	4.4 ± 0.5

Student feelings about the integrated writing program

Question about program	Response
Despite being more work, do it again?	4.6 ± 0.7
Necessity of program documents	4.3 ± 0.7
Usefulness of writing assistant	4.3 ± 0.9

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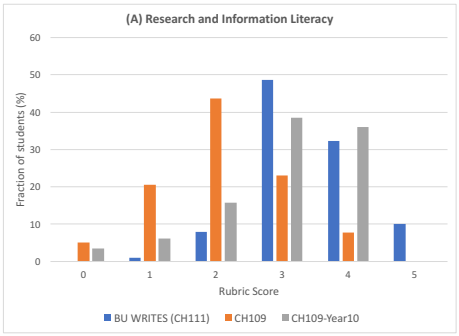
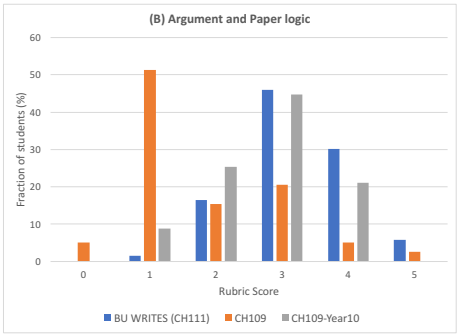
No writing fellows? No problem! (mostly)

Cohort	(A) Research and Info. Literacy	(B) Argument and Paper Logic	(C) Voice, Organiz., and Language
CH109 – Year 5	2.0 ± 1.2	2.4 ± 1.1	3.8 ± 0.7
CH109 – Year 10	3.4 ± 1.2	3.2 ± 1.0	3.1 ± 0.9

- Writing instruction for CH109 during ***in-lab workshops*** with ***GTAs*** and LAs





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Major Conclusions – What we believe

- Focus on nature of science and crafting ***strong arguments*** leads to writing with maturity
- Writing must be ***preceded*** by instruction in critical thinking
- Students must ***engage with sources*** as part of process of science
- Structure and conventions should taught ***in context*** of argument

Major Outcomes

- ***Content Knowledge Gains*** achieved without explicit goals stated
- Major ***shift in attitudes*** about the nature of science and writing
- Significant gains are achieved through ***in-class workshops*** even without writing fellows
- Increased rate of funded undergraduate research proposals
- ***ESL students thrive*** as well as native speakers in this type of instruction.
- WAC instruction has ***programmatic impact*** and improved ***graduate student education***

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Acknowledgments

- Joseph Bizup (Director, CAS Writing Program)
- Sandy Zhang (Graduate student)
- Seann Mulcahy (Post-doc, now at Providence College)
- Rebecca Kinraide (CAS WP)
- All of the writing fellows

Details about writing program and assignments:
people.bu.edu/abramsb/research/

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ESL students succeed in BU WRITES program

Cohort	(A) Research	(B) Argument	(C) Paper
CH111	3.8 ± 0.8	3.9 ± 0.9	3.9 ± 0.7
CH109	1.8 ± 1.2	2.4 ± 1.1	3.8 ± 0.7
ESL-111	4.0	4.5	3.5

- ESL students in the BU WRITES program (CH111) succeeded as well as native speakers on all measures except for language (a component of the paper grade)

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