Stop Writing & Teaching Lab Reports! Integrating Research-based Writing into First-Year Chemistry Courses

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Spring 2019 Writing in the Field Lecture
CAS Writing Program

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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)

BU Hub: Communication learning outcomes

To thrive as citizens of the contemporary world, we all need the capacity to communicate effectively … ***writing remains the foundation***.

By graduation, all students will be able to communicate effectively … special proficiency in those forms of communication ***most relevant to their particular majors or prospective professions***.

1. Students will be able to craft responsible, considered, and well-structured written arguments…
2. Students will be able to read with understanding, engagement, appreciation, and critical judgment.
3. Students will be able to write clearly and coherently in a range of genres and styles, integrating graphic and multimedia elements as appropriate.

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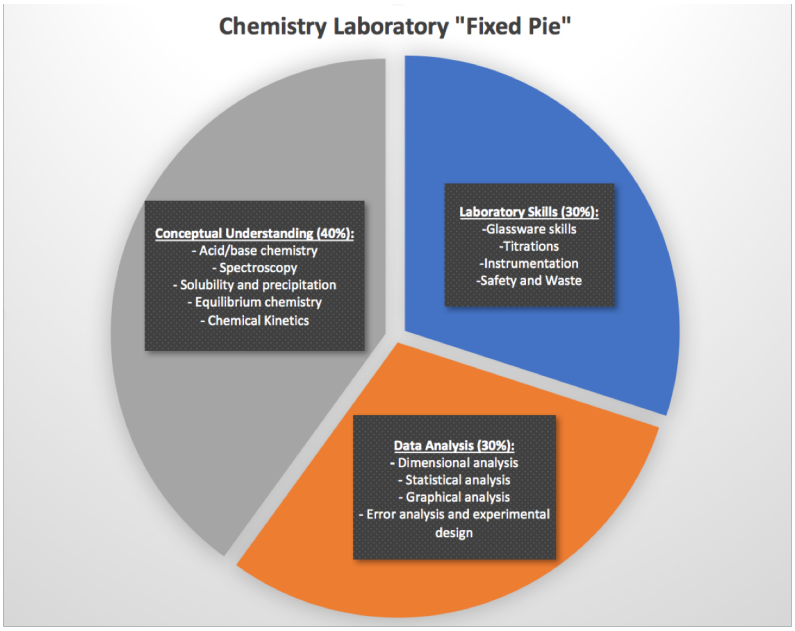
Integrating Research-based Writing into First-Year Chemistry Courses

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[2,3]
- Writing Across the Curriculum (WAC) – ***start early*** and build up[4]
- 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

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

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CH 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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CH WRITES: Development of the program

We made mistakes. A lot of mistakes …

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Integrating Research-based Writing into First-Year Chemistry Courses

Timeline of Development and Implementation

Year 0 – Baseline

- Formal lab reports for every other lab (5 per semester, including 1st)
- Students receive a five-page "Basic Guide to Writing Lab Reports"
- No explicit, in-class writing instruction
- ~**20** hours of writing, >**50** pages per student/semester

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Timeline of Development and Implementation

Year 0 – Baseline

- ~**20** hours of writing, >5**0** pages per student/semester

Year 1 – No logic / Writing instruction as an afterthought

- In-class instruction and optional writing tutoring
- No change in work, No change in outcomes
- Changes for next year: handouts and schedule for revisions

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Integrating Research-based Writing into First-Year Chemistry Courses

Timeline of Development and Implementation

Year 0 – Baseline

- ~**20** hours of writing, >**50** pages per student/semester

Year 1 – No logic / Writing instruction as an afterthought

- In-class instruction and optional writing tutoring

Year 2 – Rhetorical logic of Scientific Communication

- Writing Fellow role is cemented. Handouts are provided.
- Instruction follows the sequence of the rhetoric discourse (Intro ⟶ Conclusion).
- Significant improvement in quality of form, voice of papers
- Student anxiety increases, but writing remains juvenile
- Changes for next year: direct instruction of craft skills (figures, literature, outlines)

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Integrating Research-based Writing into First-Year Chemistry Courses

Timeline of Development and Implementation

Year 0 – Baseline

- ~**20** hours of writing, >5**0** pages per student/semester

Year 1 – No logic / Writing instruction as an afterthought

- In-class instruction and optional writing tutoring

Year 2 – Rhetorical logic of Scientific Communication

- Writing assistant role is cemented. Handouts are provided.
- Instruction follows the sequence of the rhetoric discourse.

Year 3 – Craft logic of Scientific Practice and Communication

- Craft skills taught first: exhibits (figures/tables), outlines, and literature
- Remaining instruction follows the sequence of the rhetoric discourse (Intro ⟶ Conclusion)
- Polished, shorter papers (looks polished); still juvenile (no change in critical thinking)
- Student anxiety maximum, despite decrease in page production (35 pgs)
- Changes for next year: rethink sequence of assignments, focus on "meaning"

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Integrating Research-based Writing into First-Year Chemistry Courses

Timeline of Development and Implementation

Year 0 – Baseline

- ~**20** hours of writing, >**50** pages per student/semester

Year 1 – No logic / Writing instruction as an afterthought

- In-class instruction and optional writing tutoring

Year 2 – Rhetorical logic of Scientific Communication

- Writing assistant role is cemented. Handouts are provided.
- Instruction follows the sequence of the rhetoric discourse.

Year 3 – Craft logic of Scientific Practice and Communication

- Craft skills then IMRD sequence
- Polished, shorter papers (looks polished); still juvenile (no change in critical thinking)

Year 4 – Less-is-more, Just-in-time logics added (Multiple logics)

- New sequence: craft skills, RDC papers, Methods/Introduction when relevant
- Less juvenile (no irrelevant Introductions and Methods sections)
- Lowest anxiety level since baseline (decrease in time and pages: 15 hrs, 15 pgs)

  - Overall argument in paper remains superficial and novice.
  - Then, 2013 CCCC…
  - Year 5 starts the program as it exists now

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Year 5 – Nature of science logic / 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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Assessment Rubrics for Scholarly, Research-Based Writing

	(A) Research and Info Literacy		(B) Argument and paper logic
Novice	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
Expert-like	4) A ***survey*** of the 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	1 – 2
CH109/110	1.8 ± 1.3	2.4 ± 1.2	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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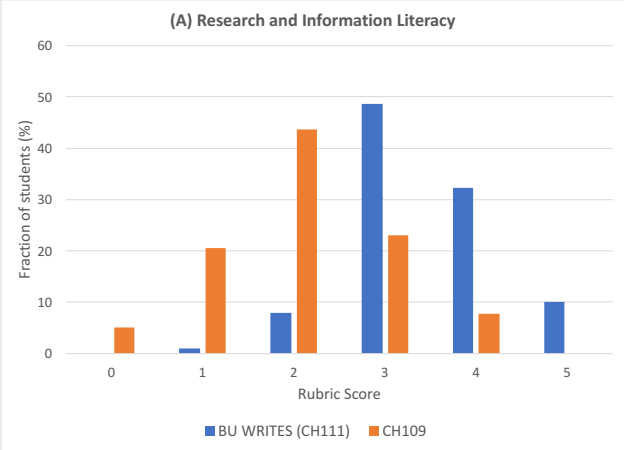
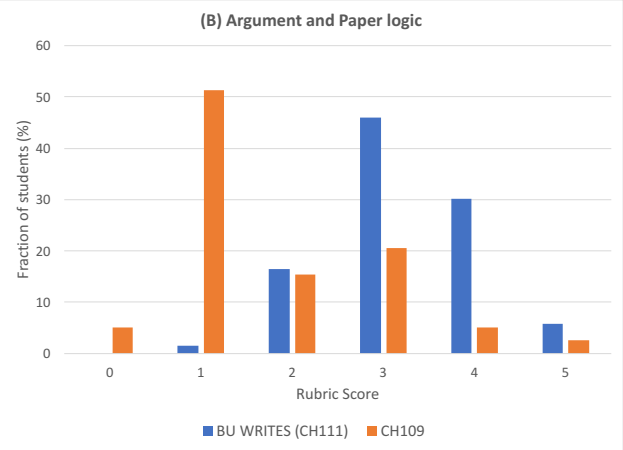
Integrating Research-based Writing into First-Year Chemistry Courses

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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Integrating Research-based Writing into First-Year Chemistry Courses

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 be 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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Horizontal expansion plans: CH109/110

- Major challenge: enrollment is 150-180 students
- Enable us to more uniformly reach our chemistry majors
- Identical course structure, some similar labs
- New division of labor for writing instruction, feedback, and assessment (i.e., no WFs)

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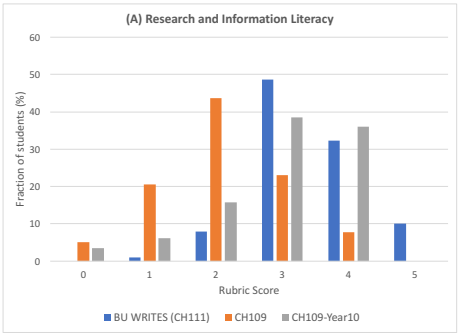
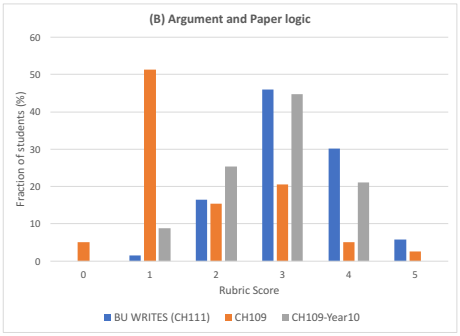
No writing fellows? No problem! (somewhat)

Cohort	(A) Research and Info. Literacy	(B) Argument and Paper Logic	(C) Voice, Organiz., and Language
CH109 – Year 5	1.8 ± 1.3	2.4 ± 1.2	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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Horizontal expansion plans: CH109/110 (Complete)

- Major challenge: enrollment is 150-180 students
- Enable us to more uniformly reach our chemistry majors
- Identical course structure, some similar labs
- New division of labor for writing instruction, feedback, and assessment (i.e., no WFs)

Vertical expansion plans: upper-division CH courses

- Reinforce lessons, skills learned in first-year courses (Writing Intensive Courses; BU Hub)
- Expand skill-sets as students progress from novices to experts
- Introduce students to additional genre-specific conventions and forms (Oral, MM)

Collaborations with other disciplines

- Searching for collaborations with other disciplines…

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Acknowledgments

- Joseph Bizup (Associate Dean, former director of 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	2.0 ± 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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Multiple Considerations and Challenges to Developing and Implementing a Writing-Intensive Chemistry Class

Pedagogical

- Need to theorize relationship among learning goals: content instruction, mastery of laboratory techniques, and writing
- What *principles* should govern pedagogy and assignment sequence?

Institutional and Curricular

- Who "owns" the course?
- What is the relationship to the first-year writing requirement (2-sem sequence of writing seminars)?
- What will CH111/112 "count" for?
- What is the relationship to other chemistry courses?

Disciplinary: pieties, provincialisms, and skepticisms

- Scientists: "Do we (you) *really* care about writing, like we say we do?"
- Humanists: "Are they (you) *really* qualified to teach writing, as we are?" "Will *it* (the class, the writing) look like what I teach?"

Practical

- Scale?
- Workload for students, teachers?
- Staffing and division of labor?
- Funding?
- Sustainability?

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