Quantitative Literacy Assessment Summary

Executive Summary

During the Spring 2018 semester, the Drake Curriculum Analysis Committee (DCAC) reviewed the Quantitative Literacy (QL) Area of Inquiry (AOI) by analyzing student self-perceptions of academic engagement and perceived learning gains, and by initiating a faculty review of student work in the AOI. The QL AOI consists of the following three outcomes: (1) procedure (formal representation & reasoning), (2) strategy (strategic competence & analysis), and (3) synthesis (interpretation & evaluation).

Drake students' engagement in quantitative literacy concepts largely mirror their self-perceptions of their skill level, and is consistent with responses from peer institutions. Students' perceptions of their abilities did not significantly change for quantitative understanding, with students initially scoring themselves relatively high on the pretest taken before their Drake experiences.

Faculty review of student work revealed basic competence of learning outcomes. Raters noted that students either understood the basics (i.e., calculations), or did not. Faculty largely found that students could often get the right answer, but could not explain why or were unclear or vague when explaining why (lack of complexity). During the AOI workshop, faculty discussed:

- Working through student fears of math
    - Get students to practice the concepts
    - Encourage students to take risks
    - Help students understand the purpose and value to their major and their lives
- Changing the mindset of faculty teaching in this AOI
    - QL is more about critically thinking using quantitative concepts than calculations
    - In QL, we ultimately give the most points for calculations and mechanics, and don't reward students as much for applying concepts and representational thinking.
    - Encourage more low stakes, formative assessment to allow students to practice, take risks, and understand the "why" of the material more than the mechanics

To address these concerns, DCAC has developed the following recommendations.

For the Administration and Faculty Senate:

1. Develop or obtain additional tools & strategies (pedagogy, assignment design, practice) that empower faculty to help students with higher-order, complex learning
2. Create places and spaces for faculty to discuss teaching in this AOI

For individual faculty:

3. Encourage more low-stakes, formative assessment of student learning,
4. Have intentional conversations amongst AOI faculty about:
    a. Higher-order learning in the Quantitative Literacy AOI that helps students understand not just how to perform calculations (mechanics), but also why they perform calculations.
    b. How to communicate to students why QL is important for their major
    c. Formative assessment of student learning that is low-stakes and gives students the ability to practice and take risks
    d. Best practices in assignment design

For the University Curriculum Committee (UCC):

5. Review the AOI outcomes to focus on quantitative critical thinking over mechanics, and ensure the outcomes match the description of the AOI.

Through assessment of several AOI, DCAC has noticed the following as recurring themes:

1. Across Areas of Inquiry, a common challenge for students is the ability to demonstrate higher order or more complex thinking (e.g., integrative learning, analysis and application, consideration of alternatives or different perspectives). The assessment process and recommendations acknowledge that:
    a. These are difficult competencies to teach,
    b. Assignments may not explicitly invite students to demonstrate these competencies,
    c. Additional resources/strategies/tools to help promote higher order and complex thinking.
2. Faculty need a “home base” for the AOIs they teach. They need places and spaces to discuss teaching in the AOI with people outside of their department, where they can share best practices, and challenges and opportunities.

Overview

The Drake Curriculum promises to provide students with a meaningful liberal arts education through three components: a First-Year Seminar, a set of Areas of Inquiry (AOI) requirements, and a Senior Capstone. Our institution maintains a commitment to inquire into the consequences of our work with students, something Lee Shulman described as a "pedagogical imperative."[1]

To provide evidence of student learning in the Drake Curriculum, the Drake Curriculum Analysis Committee (DCAC) regularly performs on-going inquiry of the Drake Curriculum. During the Spring 2018 semester, DCAC analyzed the Quantitative Literacy (QL) AOI. Drake students will "reason with the [principles,] symbols and components of mathematical languages"[2] through (1) procedure (formal representation & reasoning), (2) strategy (strategic competence & analysis), and (3) synthesis (interpretation & evaluation). DCAC provides evidence of student learning in this AOI through direct and indirect data.

Student Self-perceptions of Skills

Student self-reported data from several sources provide valuable context to understand challenges in particular skill areas. Student self-reported data is pulled from the 2016 National Survey of Student Engagement (NSSE), the 2018 Drake Student Survey (DSS), and the 2013-2016 Foundations of Learning Assessment (FLA). On the 2016 NSSE, 70% of Drake seniors reported that their Drake experience contributed "Quite a bit" or "Very much" to their knowledge, skills, and personal development in quantitative literacy. Drake seniors reported perceived learning gains in quantitative literacy that are consistent with student responses from peer institutions (64% for peers). Similarly, Drake first-year students reported that their Drake experience contributed "Quite a bit" or "Very much" to their knowledge, skills, and personal development in quantitative literacy at consistent percentages with peer institutions (56% Drake first-year, 53% peer first-year).

Drake students' engagement in quantitative literacy concepts largely mirror their self-perceptions of their skill level. On the 2016 NSSE, 42% of Drake first-year students and 55% of Drake seniors reported that they "Often" or "Very often" engaged in quantitative reasoning concepts. Drake students reported percentages consistent with student responses from peer institutions (45% first-year, 53% senior). See Appendix A for full results.

Drake students' perception of their skills in quantitative literacy do not significantly change throughout their time at Drake. Results of the 2013-17 Longitudinal Panel study show the lack of significant growth ($p>0.05$) in students' reported skills over their Drake experience.

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[1] Shulman, L. S. (2003). No drive-by teachers. Carnegie Perspectives. Retrieved from http://www.carnegiefoundation.org/perspectives/no-drive-teachers

[2] The Drake Curriculum: Quantitative Literacy. (n.d.). Retrieved May 15, 2018, from http://www.drake.edu/dc/areasofinquiry/quantitativeliteracy/

The 2013-17 Longitudinal Panel Study compares students' self-reported skill on institutional learning outcomes from the 2013 to 2016 Foundations of Learning Assessment (FLA), taken by incoming first-year students, to the 2017 Drake Student Survey (DSS), taken by all students. This lack of growth may be because Drake entering first-year students may have initially scored their skill level in quantitative literacy relatively high (3.84 out of 5.00). Of the 18 skills measured by the 2013-17 Longitudinal Panel Study, quantitative literacy ("Execute appropriate mathematical operations for a given question.") is the skill where students did not report significant growth over their Drake experience. See Appendix B for full results.

Faculty Review of Student Work

In Spring 2018, Drake University faculty teaching in the QL AOI reviewed samples of student work and explored student skills in quantitative literacy. DCAC aggregated results to focus on Drake's overall effectiveness in supporting student learning.

DCAC worked with a small group of QL AOI faculty to develop criteria and levels of performance per criteria based upon on the existing QL AOI outcomes. This small group of faculty also determined that because of varying specialties in quantitative literacy the previous method of faculty ratings of each sample might not provide the data that would produce conversations and results that would be most beneficial to AOI faculty. Thus, AOI faculty were asked to determine if they saw evidence of student learning for each criteria (Procedure, Strategy, and Synthesis), to reflect on the strengths and weaknesses of student samples in regards to the criteria, and to determine how the assignment design helps the student show the AOI learning outcomes.

DCAC solicited samples of student work from AOI faculty and selected 24 representative samples from 9 different courses or sections that covered Spirit of Math, Math Education, Calculus, Statistics, and Discrete Mathematics. The primary gap in student work was in Symbolic Logic. In Spring 2018, faculty used the criteria and levels of performance described above to evaluate student work. The QL criteria included the following:

- Procedure
    - *Formal representation & reasoning*: Does the student communicate relevant information in quantitative forms using appropriate symbols, components, and principles?
- Strategy
    - *Strategic Competence & Analysis*: Does the student identify and execute appropriate quantitative operations for a given question?
- Synthesis
    - *Interpretation*: Does the student draw appropriate conclusions based upon the quantitative analysis of data?
    - *Evaluation*: Does the student evaluate claims based upon quantitative arguments?

All AOI faculty who teach in this AOI were invited to participate and five AOI faculty agreed to participate. Faculty raters saw evidence of the three QL AOI learning outcomes in the student work submitted. However, evidence of "Synthesis" was only noted in approximately 80% of the faculty ratings provided.

Faculty reviewers identified the following consistent characteristic of student work per criteria. Included below are also exemplar quotes from faculty.

- *Procedure*: Students competently convert information into quantitative forms and mostly show good attention to detail in using appropriate symbolic or mathematical representations, although clarity in representation could be improved. Errors often reflect a basic misunderstanding of quantitative principles or the question at hand.
    - "The questions enable a fairly clear assessment of procedure and strategy—particularly procedure, since the main challenge seems to be representing information correctly. Asking students to explain their method for generating those representations provides an especially effective way to assess that aspect of quantitative literacy."
    - "The student seems to have a correct understanding of how to construct the area representation, but it isn't as clean/clear as it should be."
- *Strategy*: Students competently reason through given material and identify the most appropriate strategies for a given question. Students who struggle could improve in clarity (ability to show why instead of just the answer, and execution errors due to basic misunderstanding of procedure or careless errors) and scope (not always being comprehensive enough or thinking through all possibilities).
    - "The student's reply reflects an understanding of the challenge and points out Jack's mistake. Moreover, the answer does give a suggestion about how to represent the problem. However, the suggestion lacks specifics, e.g., it doesn't give Jack a formula for generating the correct representation of the problem."
    - "the student seemed to know most of the procedures, but clearly did not execute the procedure correclty for the calculation of the normal plane."
- *Synthesis*: Students show a basic grasp of how to interpret and explain results, but they often lack clarity when they communicate, even when their quantitative work shows clarity in procedure and strategy. They overly rely on describing their work instead of interpreting their work and can be vague or inarticulate. Most assignments did not appear to ask students to evaluate and synthesize further, but students who did made connections between distinct quantitative bodies of knowledge.
    - "the student's explanation of why the lines are not paralell is imprecise. S/he has demonstrated that the direction vectors are not proportional, but doesn't say that. Rather s/he says "the equations are not equal" but they're not equations, they're just numbers. That is, they don't demonstrate that they understand how to interpret the work that they've done. The student also does not demonstrate that they know what to do with the normal vector once

they've computed it in part c, or how it can be used to show that the lines lie in parallel planes."

  - **"**the student does not demonstrate that they can correctly interpret the results of their work. For example, similar to student 2, they don't explain why the two normal vectors not being scalar multiples implies that they're not parallel. For part b, there is no explanation of why the inequality implies that the lines do not intersect. The student states that lines lie in parallel planes, but doesn't explain how the work that they've done shows that."

Faculty Discussion of Teaching in the Quantitative Literacy AOI

On April 12, 2018, DCAC held an AOI Workshop on the Quantitative Literacy AOI to engage AOI faculty around the results of the faculty review of student work for QL. Faculty presented discussed the following main points:

- AOI courses should encourage students to practice quantitative literacy concepts because the repetition is important to learning in this AOI.
- The Quantitative Literacy AOI is about critical thinking using quantitative methods and we should emphasize this versus the pure technical mechanics.
- Students need to take more risks with their learning in this AOI because of their general fear of "math."
- Students need to better understand and the university needs to better communicate the value and purpose of Quantitative Literacy to all majors and to students' lives.
- Faculty should encourage student learning with more low stakes, formative assessment and less high-stakes assessment.
- Faculty need to give credit for different kinds of student learning. Faculty tend to only give credit for symbolic thinking (the abstract, quantitative symbols), but the Application/Reasoning ("Concrete") and Verbal ("Representational") are equally as important to a students' understanding of quantitative concepts.

Conclusions & Recommendations

Both student perceptions of own skills and engagement, and faculty review of student work indicated a basic grasp of quantitative concepts, in particular the technical mechanics, but greater difficulty with higher-order thinking with quantitative reasoning (application, evaluation, and synthesis). Faculty also discussed the difficulty of getting past student fear of math to get students to focus on the reasoning aspect of the AOI, to get students to practice, and to get students to take risks. To address these concerns, DCAC has developed the following recommendations.

For the Provost's Office:

1. Develop or obtain additional tools & strategies (pedagogy, assignment design, practice) that empowers faculty to help students with higher-order, complex learning
2. Create places and spaces for faculty to discuss teaching in this AOI

3. Encourage more low-stakes, formative assessment of student learning,231

For Faculty:

4. Have intentional conversations amongst AOI faculty about:
    e. Higher-order learning in the Quantitative Literacy AOI
    f. How to communicate to students why QL is important for their major
    g. Formative assessment of student learning that is low-stakes and gives students the ability to practice and take risks
    h. Best practices in assignment design

For the University Curriculum Committee (UCC):

5. Review the AOI outcomes to focus on quantitative critical thinking over mechanics, and ensure the outcomes match the description of the AOI.

After the committee's review of five AOIs, DCAC has noticed several recurring themes continued to show up. These included:

1. Across Areas of Inquiry, a common challenge for students is the ability to demonstrate higher order or more complex thinking (e.g., integrative learning, analysis and application, consideration of alternatives or different perspectives). The assessment process and recommendations acknowledge that:
    a. These are difficult competencies to teach,
    b. Assignments may not explicitly invite students to demonstrate these competencies,
    c. Additional resources/strategies/tools to help promote higher order and complex thinking.
2. Faculty need a "home base" for the AOIs they teach. They need places and spaces to discuss teaching in the AOI with people outside of their department, where they can share best practices, and challenges and opportunities.

As DCAC continues to assess AOIs, we imagine that these themes will appear in other AOIs. It is DCAC's recommendation that specific recommendations within each AOI related to these concerns be expanded to other AOIs.

Appendix A
Data for Student Self-Perception of Skills

Table 1: Percent of Drake students who have “Strong” or “Very Strong” skills in the educational goals of Drake, compared to previous years. (Source: 2018 Drake Student Survey)

Item	2018	2017
Execute appropriate mathematical operations for a given question.	63%	63%

Table 2: Percent of Drake students who engage in Higher-Order Learning “Quite a bit” or “Very much” compared to Peers. (Source: 2016 NSSE Main Survey)

Item	First-Year		Senior	
	Drake	Peers	Drake	Peers
Applying facts, theories, or methods to practical problems or new situations.	83%	80%	84%	83%
Evaluating a point of view, decision, or information source	71%	76%	80%	77%
Forming a new idea or understanding from various pieces of information.	69%	73%	83%	76%

Table 3: Percent of Drake students who engage in Quantitative Reasoning “Often” or “Very often” compared to Peers. (Source: 2016 NSSE Main Survey)

Item	First-Year		Senior	
	Drake	Peers	Drake	Peers
Used numerical information to examine a real-world problem or issue (unemployment, climate change, public health, etc.)	36%	39%	53%	49%
Evaluated what others have concluded from numerical information	40%	41%	53%	51%
Reached conclusions based on your own analysis of numerical information (numbers, graphs, statistics, etc.)	50%	55%	58%	58%

Table 4: Select Mean Scores from 2013-17 Longitudinal Panel Study (“How have you or your abilities changed in each of the following areas since coming to Drake?” 1=Much Worse, 5=Much Better). *Significance*: *=<.05, **=<.01, *Effect Size*: 0.30-0.50=Moderate

	Pretest Mean (FLA)	Posttest Mean (DSS)	2017		2014	
			Sig.	Effect Size	Sig.	Effect Size
Execute appropriate mathematical operations for a given question.	3.84	3.87		.03		.01

Appendix B

Longitudinal Panel Study (2013-17)

		Pretest Mean (FLA)	Posttest Mean (DSS)	95% Confidence Interval of the Difference		Repeated Measures Mean Comparison				2014 Comparison	
				Lower	Upper	t	df	Sig. (2-tailed)	Effect Size	Sig. (2-tailed)	Effect Size
Pair 14	Knowledge of how to participate effectively in the democratic process.	3.48	3.95	.542	.388	11.844	668	.000	0.46	0.008	0.11
Pair 5	Evaluate the quality or reliability of information	3.86	4.26	.474	.338	11.701	669	.000	0.45	0.000	0.32
Pair 11	Read and understand scientific writings written for an informed lay audience	3.36	3.85	.569	.401	11.300	667	.000	0.44	0.000	0.34
Pair 13	Ability to use educational experiences to analyze civic and global issues.	3.58	3.96	.448	.306	10.393	668	.000	0.40	0.000	0.23
Pair 2	Employ evidence effectively in writing	3.88	4.18	.358	.234	9.417	668	.000	0.36	0.000	0.33
Pair 6	Understand the ethical issues related to use and misuse of information	3.92	4.27	.432	.283	9.391	670	.000	0.36	0.000	0.26
Pair 15	Communicate effectively with people from other cultures and backgrounds.	3.79	4.13	.412	.265	9.059	666	.000	0.35	0.005	0.12
Pair 3	Construct reasoned arguments	3.96	4.24	.342	.217	8.822	671	.000	0.34	0.000	0.20
Pair 17	Apply understanding of ethical issues when developing solutions	3.84	4.15	.377	.236	8.534	668	.000	0.33	0.000	0.25
Pair 4	Evaluate reasoned arguments	3.97	4.23	.325	.196	7.980	667	.000	0.31	0.000	0.25
Pair 18	Ability to integrate skills and knowledge from different sources and experiences	4.03	4.28	.316	.184	7.439	666	.000	0.29	0.000	0.19
Pair 10	Understand the perspectives and experiences of people who are different than you	4.05	4.23	.265	.115	4.984	663	.000	0.19	0.854	0.01
Pair 1	Ability to read carefully	4.18	4.29	.163	.045	3.468	671	.001	0.13	0.604	0.02
Pair 9	Analyze differences between industrialized and developing areas of the world	3.59	3.73	.221	.055	3.276	666	.001	0.13	0.320	0.04
Pair 16	Articulate a vision of my own values, ethics, or core beliefs	4.15	4.24	.166	.019	2.476	667	.014	0.10	0.039	0.09
Pair 8	Understand the historical, political, and social connections of past events	3.60	3.68	.163	.010	2.218	668	.027	0.09	0.091	0.07
Pair 7	Create or interpret art (ex. Sculpture, painting, music, theatre)	3.02	3.12	.189	.008	2.134	668	.033	0.08	0.687	0.02
Pair 12	Execute appropriate mathematical operations for a given question	3.84	3.87	.102	-.048	0.712	663	.476	0.03	0.821	0.01