HPU Undergraduate Quantitative Analysis and Symbolic Reasoning Assessment

Overview of the Assessment Project

During academic year 2020-2021, HPU assessed Quantitative Analysis and Symbolic Reasoning (QASR) in general education and undergraduate capstone courses that have QASR learning objectives or a focus on QASR in the discipline. This assessment project is the fifth in a series of annual assessments of institutional learning outcomes (ILOs): written communication, critical thinking, oral communication, information literacy, and QASR. Note that as defined in our University assessment plan, QASR is not assessed at the graduate level. Instead, Scholarly Mastery was assessed at the graduate level during the 2020-2021 academic year and will be reported separately.

Method

While researching methods of assessing QASR, HPU was invited to use a QASR quiz designed by faculty at Bowdoin and Wellesley Colleges. The quiz was originally written as part of a 2012 NSF-funded project to assess QASR in University and community college students. The QASR quiz authors' results have since been published in the journal Numeracy http://dx.doi.org/10.5038/1936-4660.7.2.4. In spring 2020, members of the HPU Academic Assessment and Program Review Shared Governance Committee (APRC) slightly amended the quiz by reducing the number of questions from 20 to 15 and matching the 15 remaining questions across the five HPU QASR rubric categories: interpretation; representation; calculation; analysis; communication (Appendix A). Based on content, three questions were assigned to each of the five rubric categories and categorized as "easy," "medium," or "hard." The quiz was reviewed by the APRC in Blackboard LMS in late summer 2020 and presented to Program, Department, and University leaders in Fall 2020 at our Annual Assessment Day.

QASR quiz administration:

- Data collection was conducted throughout Spring 2021 from 13 Common Core and Natural World general education courses (57 sections) and 30 capstone or senior-level courses (45 sections). Two additional capstone sections participated in Summer 2021.
- The APRC emailed the faculty of the selected courses to explain what was requested for their participation in this assessment project (Appendix B).
- Students registered in those selected sections were bulk-enrolled in either the General Education or the Capstone-level Blackboard course to participate in the QASR quiz.
- Once enrolled, students were notified about the quiz via announcement in Blackboard. Faculty were again notified via email when their students had indeed been enrolled and the Registrar and Advising offices were informed of this project in the event students contacted them with concerns about this additional Blackboard "course" enrollment.
- Updates on student participation were emailed to faculty four times during the spring semester with reminders to ask their students to take the assessment quiz. These reports provided faculty with the list of students in their CRN who had taken the quiz so that extra credit could be assigned where applicable.

- In Fall 2021, the APRC presented its assessment findings at the University assessment day. The purpose of this presentation was to engage deans, department chairs, and program chairs in a thoughtful discussion of the implications of these results and to discuss actionable changes necessary for continuous, quality improvements to the curriculum.

Assessment Findings

General Education

Target: 85% of students enrolled in general education courses will achieve an initial, emerging, developed, or highly developed score for each of the 5 rubric criteria.

In Spring 2021, 614 students in 57 general education sections were enrolled in the QASR Blackboard course and **284 students (46%) completed the quiz**. Of the 330 students who did not take the quiz:
- 25 students answered 1 or 2 questions (these answers were not included in the analysis)
- 240 students opened the quiz but did not answer any questions
- 65 students did not open the quiz

Comparison of the results of those general education students who completed the quiz against the established target reveals that students exceeded the target in two categories as more than 85% were able to:
- Identify and explain information given in mathematical forms (Interpretation) and
- Carry out necessary calculations to solve problems and arrive at the correct answer (Calculation)

However, the general education students in the sample fell short of the established target in their ability to:

- Convert relevant information between mathematical forms (Representation)
- Make judgements and draw appropriate conclusions based on quantitative analysis (Analysis)
- Express quantitative information in support of an argument or purpose of the work (Communication)

Table 1. AY 2020-2021 General Education QASR Results by Criterion (n=284)

Quantitative Analysis Rubric Criteria (% ≥ initial)	% of General Education Students Scoring in Each Category				
	0	1	2	3	4
	Not Present	Initial	Emerging	Developed	Highly Developed
Interpretation (87%)	13	6	57	4	21
Representation (77%)	23	12	16	28	22
Calculation (88%)	12	8	15	21	44
Analysis (56%)	44	13	29	5	10
Communication (70%)	30	16	30	13	12

Figure 1. AY 2020-2021 General Education QASR Results by Criterion

General Education QASR results
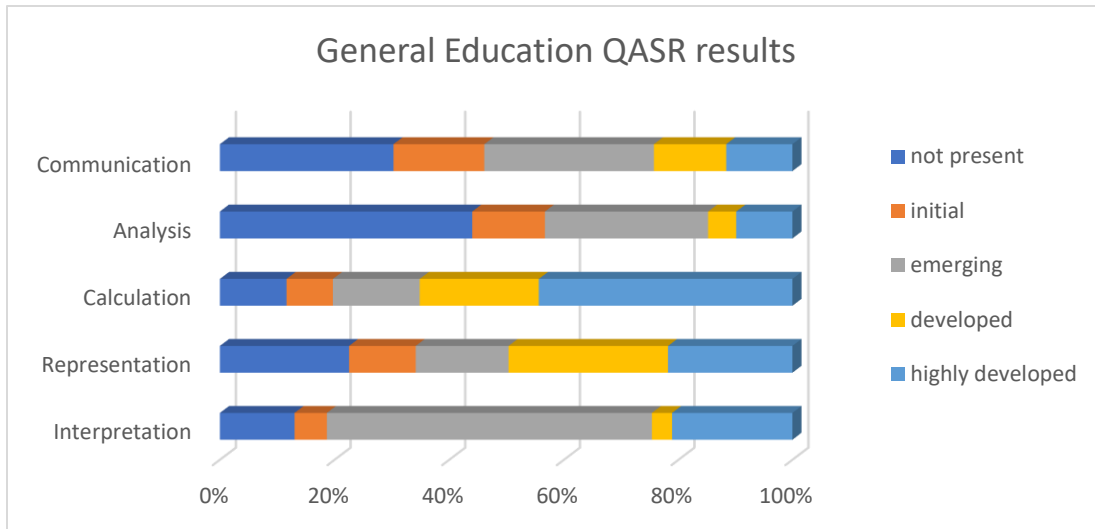
Capstone-level

Target: 85% of students enrolled in capstone-level courses will achieve an emerging, developed, or highly developed score for each of the five rubric criteria.

In Spring 2021, 430 students in 45 capstone-level sections were enrolled in the QASR Blackboard course and **235 (55%) completed the quiz**. Of the 195 students who did not complete the quiz:

- o 4 students answered 1 or 2 questions (these answers were not included in the analysis)
- o 138 students opened the quiz but did not answer any questions
- o 53 students did not open the quiz.

HPU capstone-level students that participated in this assessment project, did not meet the established target for any of the rubric categories. However, their scores were close to meeting the established target for Interpretation and Calculation, 84 and 83% respectively.

Table 2. AY 2020-2021 Capstone-level QASR results by criterion (n=235)

Quantitative Analysis Rubric Criteria (% ≥ initial)	% of Capstone-level Students Scoring in Each Category				
	0	1	2	3	4
	Not Present	Initial	Emerging	Developed	Highly Developed
Interpretation (84%)	11	5	43	3	38
Representation (68%)	22	10	17	25	36
Calculation (83%)	9	8	14	15	54
Analysis (60%)	31	9	28	9	23
Communication (62%)	23	15	28	16	18

Figure 2. AY 2020-2021 Capstone-level QASR Results by Criterion
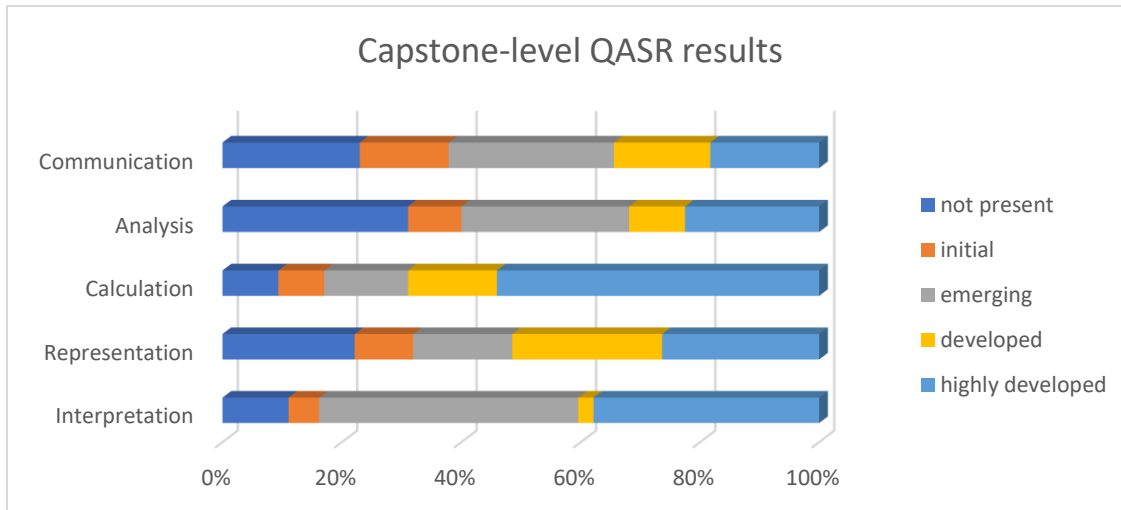
Discussion

- *How accurately do we think these findings reflect the actual level of competence of our students?*
  - We cannot comment on the "accuracy" of these results because the inferential statistics needed for such a determination were not applied to these data for the rubric category-specific analyses above. However, the APRC agreed that this analysis does provide a snapshot of the level of QASR competence of our students during the 2020-2021 academic year.
  - We did apply inferential statistics to explore any significant differences in overall mean score as a function of student demographics or course modality (Table 3). It is important to note that these are preliminary statistical analyses and that further analysis of the effects of combinations of student demographic and/or course modality may be warranted. In short:
    - For the General Education respondents, mean overall scores of male students, 31.1 ± 14.1, (mean ± stdev, *n*=92) were significantly higher than the overall mean scores of female students, 27.4 ± 14.9, (mean ± stdev, *n*=187). There was no significant difference by gender at the Capstone-level.
    - For the General Education respondents, mean overall scores of students that were not eligible for Pell grants, 30.9 ± 15.1, (mean ± stdev, *n*=168) were significantly higher than the overall mean scores of the students who were eligible for Pell grants, 25.1 ± 13.4, (mean ± stdev, *n*=116). There was no significant difference by Pell eligibility at the Capstone-level.
    - The overall mean scores of non-first-generation students were significantly higher than those of first-generation college students at both the General Education and Capstone levels.
    - There was a significant difference in overall mean scores at both the General Education and Capstone Levels as a function of course modality; face-to-face,

hybrid, online, or virtual. Note: no student scores from virtual General Education sections were represented in this analysis.

- The significance of this relationship was tested with a one-way ANOVA, $p < 0.05$ but post hoc analysis was not been completed.
- Of note; this was a "COVID-19" semester. As a result, instructors like many nation-wide were required to teach either hybrid or online due to COVID-19 with little or no professional development. We feel this, along with other COVID-19 associated issues, may have impacted our student results negatively.

  o The APRC had predicted that capstone-level students would score higher than General Education students for all categories. However, it is important to note that only 52% of the majors at HPU require a quantitative course beyond MATH1123, Introductory Statistics. The other majors (48%) would only have QASR instruction at the General Education level. While we realize that QASR skills are not only developed in math courses, these skills may not be practiced beyond the general education level for many of our students. The latter may have impacted the results in such a way that our capstone-level students did not meet the established target.

  o It is important to note that Spring 2021 was a semester during which all students were required to take courses either in a fully online or hybrid modality due to COVID-19. Therefore, students were required to be online much more than during a typical HPU semester. The resultant screen-time and/or online malaise may well have impacted both our participation rate and, possibly, our results if students were unable to properly focus on the assessment given that this assessment instrument was delivered via an online quiz. We anticipate that in AY 2025-26 when we next assess QASR at the University-level, the pandemic situation will be vastly different and that this issue will not impact our results.

- *Were there certain questions that were not appropriate for the kind of assessment conducted?*
  o The questions were written for both University and Community College students and vetted previously for assessment with both populations (see note in Methods). In fact, Blackboard analytics indicated that the quiz questions were relatively good at differentiating between those who knew the material and those who did not. There were little to no comments when faculty were provided the quiz except that at least two MATH faculty teaching at the General Education level stated they thought the questions were "fair and reasonable."

  o While there were possible issues with fitting a given quiz question to a rubric category (e.g. the adequacy of an online, multiple choice quiz to assess "communication"), the "fit" of a given question to a rubric category would have in no way impacted a student's ability to answer the question correctly.

  o The results of the Analysis category stand out, as 44% of the General Education and 31% of the Capstone-level students assessed did not even meet the "initial" score. Each of these quiz questions involved analysis of data presented in either a table, a bar graph, or a pie chart. Our students likely need additional practice in applying their analytical skills to this form of data presentation.

- o The APRC has agreed that if this quiz is used in future QASR projects, we will specifically seek "buy-in" from the Instructors of HPU courses with a QASR ILO to review the quiz questions and ensure those questions are reasonable for our student's abilities.
- *Were there other problems with the process?*
  - o Ideally, the participation rate would be higher. COVID-19 may have had an impact on participation but we can't easily assess the magnitude of that impact. Faculty whose students did not participate will be polled to determine if there was anything the APRC could have done to facilitate a higher participation rate.

Closing the Loop

- *How shall we use these findings?*
  - o The data and findings were presented and discussed with faculty and University administrators at Assessment Day in Fall 2021.
  - o The major-specific data have been reported to the respective Program Chairs to be used for their 5-year self-studies.
  - o We have posted the University-wide results on our Student Success website to make them available to the University community and general public.
  - o A new Director of Online Programs & Academic Partnerships has been hired and an inaugural Symposium for online teaching was conducted January 2022 to provide faculty with the opportunity for professional development in the area of online teaching.
  - o Finally, HPU's Director of Online Programs & Academic Partnerships will further consider the significant difference found between course modalities to determine if any changes to the delivery of quantitative skills must be made based on these results. The requirement for online learning due to COVID-19 likely impacted our results but further investigation of this result is warranted.
- *Are we satisfied with the results? If not, what are we going to do about it?*
  - o In our continuing efforts to "close the loop," we have met with the Chair of the General Education Assessment and Learning Committee as well as a number of General Education faculty to discuss the results, identify weaknesses in our students' quantitative skills, and seek their guidance as to how we can boost participation and accuracy in our next QASR project.
    - The GE Faculty indicated that the materials on the quiz seemed reasonable and were topics already covered in their courses. We identified areas where students may need additional work, e.g. interpretation of graphics, and discussed making the assessment quiz be a small part of the course grade. A graded assignment, despite being a trivial part of the course grade as a whole, may ensure that students answer the quiz questions to the best of their ability.
    - We have also reached out to the Center for Academic Success and will identify weaknesses in our students' QASR skills so that tutors are able to better help our students succeed.
  - o In AY 2025-26 we will assess QASR competence in both fall and spring semesters. We will ask faculty to make this ILO assessment a small part of the student's course grade to increase the "stakes" and ensure students participate with intent.

- In the final analysis, though our results indicate students are likely not learning QASR skills to the level we had predicted, we are satisfied that we reached the target for at least some rubric categories in such a tumultuous, pandemic year. We have new initiatives in place to support student learning and will implement improvements to QASR assessment for future projects.

Table 3. Overall mean QASR scores (mean ± standard deviation) as a function of student demographics

		GENERAL EDUCATION		CAPSTONE LEVEL	
		mean ± stdev	n	mean ± stdev	n
Gender	Female	27.4 ± 14.9*	187	34.3 ± 18.2	160
	Male	31.1 ± 14.1	92	36.1 ± 16.9	75
IPEDS race/ethnicity	Black or African American	30.3 ± 10.0	12	31.7 ± 19.9	8
	American Indian/Alaskan native	26.0	1	22.0	1
	Asian	28.8 ± 16.9	60	34.1 ± 16.3	47
	Caucasian/White	28.8 ± 13.7	81	33.9 ± 17.4	67
	Hispanic	24.4 ± 13.8	42	36.8 ± 20.1	37
	Native Hawaiian or other Pacific Islander	23.4 ± 10.7	7	30.5 ± 18.6	4
	Two or more races	29.8 ± 14.9	57	33.0 ± 17.3	45
	Race and Ethnicity unknown	26.8 ± 14.2	5	28.5 ± 16.4	4
	Nonresident alien	33.3 ± 16.6	19	44.8 ± 17.1	22
First generation college student	YES	25.1 ± 12.8*	87	31.0 ± 18.4*	65
	NO	30.0 ± 15.2	197	36.3 ± 17.4	170
STEM major	YES	29.0 ± 13.9	75	39.3 ± 16.9*	56
	NO	28.4 ± 15.0	209	33.5 ± 17.9	179
Campus Residency	Downtown	28.3 ± 15.1	245	34.8 ± 17.9	218
	Satellite	29.8 ± 11.8	39	35.4 ± 16.6	17
Semester term	8-week	30.2 ± 13.0	70	33.0 ± 15.5	20
	16-week	28.0 ± 15.2	214	35.0 ± 18.0	215
Course modality	Face-to-face	32.5 ± 15.7**	43	41.2 ± 17.7**	55
	Hybrid	25.5 ± 15.2	100	30.0 ± 18.4	43
	Online	29.4 ± 13.7	141	35.9 ± 17.9	44
	Virtual	na		32.9 ± 16.7	93
Pell eligible	YES	25.1 ± 13.4*	116	32.6 ± 16.9	95
	NO	30.9 ± 15.1	168	36.4 ± 18.3	140

* significant as determined by t-test, unequal variance, $p < 0.05$
** significant difference as determined by one-way ANOVA, $p < 0.05$