General Education Competency Assessment Report for Blue Ridge Community College 2020-2021: Quantitative Literacy and Scientific Literacy

This assessment report is to fulfill the State Council for Higher Education in Virginia's Policy on Student Learning Assessment and Quality in Undergraduate Education.

General Education Philosophy at BRCC

Blue Ridge Community College's general education offerings intentionally strive to develop a liberal arts perspective. The program exposes students to a broad body of knowledge of the major social, cultural, historical, and scientific forces that have shaped human identity and the world. General education enables students to integrate knowledge to address fundamental questions about the nature of the world and its inhabitants. Blue Ridge Community College believes general education is an important component for all students whether they are going immediately into the workforce or continuing their education.

The implementation of general education differs depending upon the type of associate degree that students are interested in pursuing. In the associate of applied science degree programs, faculty employ general education courses to introduce students to the concept of a liberal education while simultaneously striving to help students integrate knowledge and apply broad academic concepts in a practical manner in the world of work. In comprehensive transfer degree programs (AA&S and AS degrees) faculty not only introduce the liberal arts perspective but also strive to provide a depth to general knowledge that prepares students for upper-level educational experiences at the bachelor's degree level and beyond. In transfer programs, faculty strive to help students integrate the interdisciplinary nature of theoretical concepts and reveal how historical, philosophical, cultural, and other academic concepts influence human interactions.

As a part of the VCCS, Blue Ridge Community College adheres to the VCCS General Education Policy in selecting and defining general education competencies. The General Education Policy states that "upon completion of the associate degree, Virginia Community College System graduates will have achieved competency in 1) civic engagement, 2) communication, 3) critical thinking, 4) professional readiness, 5) quantitative literacy, and 6) scientific literacy" (p. 1). The competencies are defined as follows:

Civic Engagement is the ability to contribute to the civic life and well-being of local, national, and global communities as both a social responsibility and a life-long learning process. Degree graduates will demonstrate the knowledge and civic values necessary to become informed and contributing participants in a democratic society.

Critical Thinking is the ability to use information, ideas, and arguments from relevant perspectives to make sense of complex issues and solve problems. Degree graduates will locate, evaluate, interpret, and combine information to reach well-reasoned conclusions or solutions.

Professional Readiness is the ability to work well with others and display situationally and culturally appropriate demeanor and behavior. Degree graduates will demonstrate skills important for successful transition into the workplace and pursuit of further education.

Quantitative Literacy is the ability to perform accurate calculations, interpret quantitative information, apply and analyze relevant numerical data, and use results to support conclusions. Degree graduates will calculate, interpret, and use numerical and quantitative information in a variety of settings.

Scientific Literacy is the ability to apply the scientific method and related concepts and principles to make informed decisions and engage with issues related to the natural, physical, and social world. Degree graduates will recognize and know how to use the scientific method, and to evaluate empirical information.

Written Communication is the ability to develop, convey, and exchange ideas in writing, as appropriate to a given context and audience. Degree graduates will express themselves effectively in a variety of written forms.

Furthermore, BRCC complies with the VCCS General Education Policy by assessing each of the six competency areas outlined above in accordance with SACSCOC accreditation standards and SCHEV policy.

General Education Assessment Schedule

BRCC will assess the general education competencies on a three-year cycle. Within the first three-year period, each competency will be assessed either directly or indirectly. The following three-year period, or cycle 2, each competency will be assessed on the level they were not previously assessed. The chart below demonstrates how alternating assessments will occur for each competency.

Table 1: General Education Assessment Cycle

		Cycle 1			Cycle 2	
Competency	**2019-2020**	**2020-2021**	**2021-2022**	**2022-2023**	**2023-2024**	**2024-2025**
Written Communication	Direct			Indirect (VPT)		
Civic Engagement	Indirect (PSRI)			Direct		
Quantitative Literacy		Direct			Indirect (QR)	
Scientific Literacy		Indirect (SR)			Direct	
Professional Readiness			Direct			Indirect (PSRI)
Critical Thinking			Indirect (TER)			Direct

Specifics for indirect and direct assessments including the measurement tool for each competency are outlined under each competency separately.

Direct assessment of general education competencies is performed on student work drawn from course assignments. We have two different procedures at work:

1) For our Occupational/Technical (AAS) programs, we ask each year that as part of the program's overall General Education assessment strategy, they perform a course-embedded assessment of the highlighted competency for that year. For this report, all AAS program heads were asked to identify a program course for 2020-21 in which they would assess the Quantitative Literacy competency using student work in that course.
2) For our Transfer (AA&S and AS) programs, it is more difficult to pin down specific courses that are representative of "the program," as students seeking to transfer may be in any of several hundred courses fulfilling either General Education or transfer elective requirements. We have instead developed a system to promote General Education assessment within General Education coursework based on the distribution requirements within the AA&S and AS degrees. As part of this system, we assess across all the competencies every year; for the purposes of reporting, we will document activities supporting the themed competency since the last report. This report will include assessment data from 2017-18 (pilot year) through 2020-21.

Both processes will be described in detail below. As the BRCC assessment team developed a strategy for General Education assessment, we focused first on building a process that directly engaged faculty, tied General Education assessment to classroom delivery and assignment design, and presented assessment results in a way that offered a framework for improvement.

Competency: Quantitative Literacy

Quantitative Literacy is the ability to perform accurate calculations, interpret quantitative information, apply and analyze relevant numerical data, and use results to support conclusions. Students will calculate, interpret, and use numerical and quantitative information in a variety of settings.

For direct assessment of student work, BRCC has designated four measurable outcomes under Quantitative Literacy:

QL1: Perform accurate calculations and symbolic manipulation.
QL2: Interpret mathematical models such as functions, graphs, tables, and schematics and draw inferences from them.
QL3: Represent mathematical information numerically, symbolically, and visually.
QL4: Apply mathematical reasoning and techniques in discipline specific ways.

The assessment rubrics for each outcome are included in Appendix A. Outcomes and rubrics were chosen, developed, and approved by faculty across all disciplines as part of a year-long process, and continue to be revised and updated. Multiple sources were considered and adapted, including the existing set of VCCS Communication outcomes prior to the revision. Rubric statements are modeled after the AAC&U Written Communication VALUE Rubric and borrow heavily from that source but have been significantly modified to better align with our assessment structure.

General Education assessment within General Education coursework: the role of the General Education Clusters

For part of its process, BRCC has adopted a general education assessment approach based on cluster areas aligned with the distribution requirements for General Education within the VCCS. The cluster areas for assessment purposes are as follows:

- English composition and literature
- Fine arts and humanities
- Mathematics
- Science
- History and social sciences

Each cluster area is assigned a leader. This leader is a faculty member responsible for coordinating the assessment of general education competencies in courses in their cluster. The General Education Assessment Coordinator is a faculty member responsible for overall direction of assessment activities and supports the work of each cluster leader. Cluster leaders, the General Education Assessment Coordinator, and representatives from the Office of Institutional Research and Effectiveness meet weekly throughout the academic year. The group functions collectively as the assessment team and performs the scoring of artifacts across all clusters.

The procedure for assessing the competencies in general education courses is well established. First, the group selects courses for initial assessment at the beginning of the academic year. Each cluster lead reaches out to the faculty teaching that course and works with them to determine an appropriate artifact for assessment that demonstrates at least some of the outcomes associated with that cluster. Faculty may also ask to have outcomes assessed that are not usually under that cluster if the information will be helpful. AAC&U style rubrics for each outcome exist (the group maintains a “rubric cookbook” which is updated every year) and are written broadly enough to be applicable to various works. The cluster lead works with the teaching faculty to determine criteria as to how the general rubric applies to the specifics of the assignment.

For smaller courses with only one or two sections, the team will score all the work from that course. For larger multi-section courses, the coordinator generates random samples of at least 60 students. All sections are incorporated into the assessment process, including those taught as Dual Enrollment sections in our local high schools. The cluster leads work with the course faculty to collect the artifacts. The leader invites faculty to attend a meeting to describe the assignment and content necessary for the group to accurately assess the student work; if the course faculty are not available in person, they will have filled out a cover sheet and spoken with their lead to communicate the information.

Immediately following the presentation on the assignment, the assessment team norms by assessing four sample student artifacts and discussing. Each leader is assigned a selection of student work to rubric on their own, and each work will have at least three team members scoring it. After scoring is completed, the group discusses observations and notes strengths and weaknesses and possibilities for improving student performance. The cluster leaders share the initial assessment report with the course faculty and ask them to pick one thing to work on for the following year and produce an action plan.

Action plans have included revising existing assignments, creating new assignments to better align with outcomes, and creating new course activities to better support assignments.

In the following year, the courses go through a second round of assessment to see if changes in student performance have occurred after the action plan has been implemented. A comparable selection of student work is taken for scoring, and at the end of the process, the course faculty receive a detailed report of the whole two-year process from start to finish. After the initial year, we have had two sets of courses in play each year – one set entering the initial assessment phase and another in the follow-up phase.

At least one competency will be assessed each year, but there is no set schedule for when assessment of each competency at the general education course level will take place. We assess multiple competencies each year in various general education courses.

Assessment results for Quantitative Literacy within the General Education Clusters (AY 2017-18 through AY 2020-21)

Our approach for this piece of General Education assessment does not fit the "this year we do this competency" model; we aggregate results over the multi-year period leading up to the report. This also gives a larger institutional view of the average across of many courses in many disciplines taught at various levels.

Aggregating the results also addresses another concern. To obtain a high level of faculty participation and to generate honest and open discussion with faculty about their assignment and course strategies, we have promised a level of anonymity in public-facing reporting. While course faculty are provided with precise scores and detailed feedback, we will not separate scores for individual courses. The following is a combined score report for all courses that chose at least one Quantitative Literacy outcome for assessment on student work products over the reporting period.

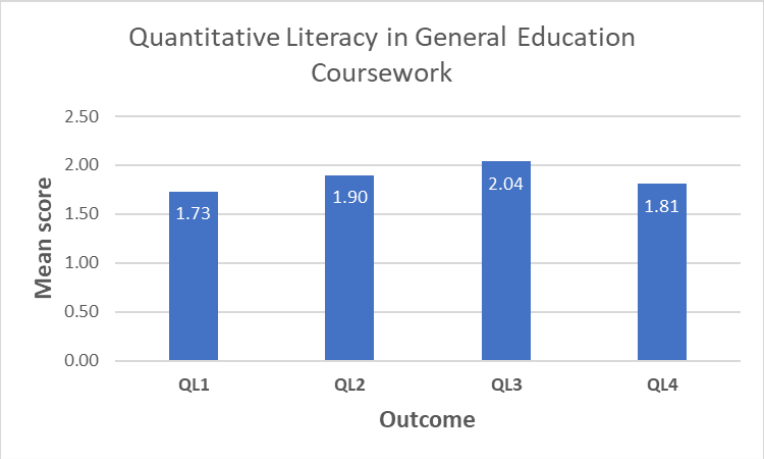
Table 2: Disciplines Contributing Student Work

Discipline	***Count of Student Work (% Contribution)***
Biology	*n* = 43 (11.3%)
Economics	*n* = 51 (13.4%)
Geology	*n* = 42 (11.0%)
Mathematics	*n* = 245 (54.3%)
Total	***n* = 381**

Table 3: Quantitative Literacy Outcome Summary

	n	mean	SD	% Scoring 1 or higher
QL1	164	1.73	1.05	68.9%
QL2	190	1.90	0.89	85.8%
QL3	162	2.04	0.87	86.4%
QL4	125	1.81	0.90	86.4%

Figure 1: Quantitative Literacy Mean Scores



QL1: Perform accurate calculations and symbolic manipulation.
QL2: Interpret mathematical models such as functions, graphs, tables, and schematics and draw inferences from them.
QL3: Represent mathematical information numerically, symbolically, and visually.
QL4: Apply mathematical reasoning and techniques in discipline specific ways.

In all categories, scores average on the border of "emerging (1)" and "developing (2)" with *QL1: Perform accurate calculations and symbolic manipulation* appearing to be the weakest area. We found that students would attempt the problems, and could perform computations partially correctly, but had difficulty getting questions completely correct. Students were a bit better at interpretation and could score higher on those outcomes if they drew conclusions which were at least consistent with their (sometimes faulty) calculations.

We then asked participating faculty for their permission to include their work as highlights to offer a better sense of what the assessment process provides for them.

Highlight: Quantitative Literacy in Calculus I

MTH 263 (Calculus I) is a course where faculty perception is that the students come in with weak background skills in algebra/trigonometry/precalculus, and that deficiencies in these areas contribute

more to the difficulties with Calculus than the Calculus concepts do. The assessment process gave course faculty the means to test this perception and to examine a specific area of concern.

Our new General Education embedded assessment process coincided with the VCCS Math Pathways course redesign. As part of that work, the number of credit/contact hours in MTH 263 (former MTH 173) was reduced from 5 to 4. Course faculty were concerned about the impact and believed the extra hour to be essential in helping refresh and remediate weak algebra skills.

The initial assessment of final exam questions in 5 credit MTH 173 looked at multiple outcomes and confirmed faculty perception that QR1 was an area of weakness ($\bar{x} = 1.70$, $s = 0.95$, $n = 22$) with only 23% of the students performing all calculations correctly, and 19% failing to achieve even a "1". Course faculty met to discuss strategies to improve student background skills in algebra and precalculus, despite the coming reduction in class time.

Faculty began construction of a review materials website ("The Worst Part of Calculus is Algebra") and mapped background algebra skills to Calculus I outcomes, with topic shell pages set up to house supplementary material. A link to the site was made available to course faculty at the beginning of the semester and shared with the students. Faculty would not spend class time lecturing on background skills but would direct students back to the review materials and practice problems as needed preparation for course assignments.

For the follow-up assessment the next year at the conclusion of 4 credit MTH 263, comparable final exam questions were used. Analysis of student work for on campus students ($\bar{x} = 2.27$, $s = 0.95$, $n = 26$) showed not only that their algebra skills held but appeared to have improved. The key takeaway was that they had not felt the impact of the credit reduction in the way they had feared. Other than doing a few less examples, it had not changed much about how they conducted the class and providing the supplemental materials for review outside of class seemed to more than compensate for the missed time.

We also brought the dual enrollment sections into the assessment process, and all faculty agreed to administer common test questions on the final exam. Here we learned that these sections performed comparably ($\bar{x} = 2.12$, $n = 21$). Dual enrollment faculty expressed positive reactions to the process, appreciating how it fostered communication with their BRCC colleagues and reassured them that everybody was on the same page with expectations.

Highlight: Quantitative Literacy in Principles of Macroeconomics

ECO 201 (Principles of Macroeconomics) draws heavily on quantitative skills that students are assumed to have acquired prior to the class. However, the course has no mathematics prerequisite courses, and faculty perception is that students come in with varied backgrounds, with many lacking the preparation needed to understand the material.

The student artifact chosen for assessment was a discussion board question in which students were asked to incorporate discussion of distributions (normal vs. power law) as part of understanding an economic argument. In the initial assessment stage, outcomes from Critical Thinking and Quantitative Literacy were considered; QL2: *Interpret mathematical models such as functions, graphs, tables, and*

schematics and draw inferences from them was the weakest ($\bar{x} = 1.08$, $s = 0.54$, $n = 29$) and was chosen for follow-up. Students had difficulty with correctly describing the graphs in relation to the argument, and some dodged the question entirely.

Course faculty proposed they administer the same prompt/assignment and build in some additional instruction on the quantitative interpretation piece. Students would get more direct instruction about the mathematical models involved in the prompt and how to interpret them.

ECO 201 faculty indicated that they "made very clear exactly what the question was asking students to think about […] [dialing] up direct instruction about quantitative aspect." Student performance improved on follow-up in FA19 ($\bar{x} = 1.46$, $s = .60$, $n = 22$). There was a noticeable shift in student work reaching at least a score of 1 (Emerging): in FA 18, 68% achieved a score of 1 or better, while in FA 19, the percentage increased to 91%.

The Social Sciences Cluster Lead and Economics faculty also agreed to investigate empirically whether a math prerequisite might be helpful. BRCC's Office of Institutional Research complied data comparing performance among students who have and have not completed math courses, including business math and developmental math, prior to taking ECO 201. The data showed no correlation between ECO 201 grade and prior math performance.

The ECO lead faculty was pleased with the follow-up and indicated that "The exercise of walking through an assignment and comparing my content grades with my assessment of gen ed outcomes is useful, and I find myself constructing new assignments a bit differently. In particular, I'll use quizzes these days (which are really cooperative problems to work through) deliberately to hit gen ed as well as [Economics learning outcomes]." Faculty will not pursue a course prerequisite, as the data do not support, and agree no further analysis is needed.

Quantitative Literacy within Career and Technical Programs

For the course embedded assessment of Quantitative Literacy within the Career (Occupational) and Technical education program, we asked faculty in all programs to identify a course and assignment to assess

> QL4: Apply mathematical reasoning and techniques in discipline specific ways.

Then, if any of

> QL1: Perform accurate calculations and symbolic manipulation.
> QL2: Interpret mathematical models such as functions, graphs, tables, and schematics and draw inferences from them.
> QL3: Represent mathematical information numerically, symbolically, and visually.

were applicable to the assignment, we asked that they also score and submit additional outcomes as well.

For Fall 2020, BRCC designated an additional cluster lead to guide the Career and Technical program heads through the assessment process each year. We assumed existing familiarity with the new process

as most of the program heads had participated in the Written Communication assessment the following year. Due to COVID-19 restrictions, the training with the program heads was completed virtually through recorded video. The cluster lead for the Career and Technical programs reviewed the rubrics for QL1-4 and explained that QL4 would be the focus for the year. Program heads were asked to identify a course and assignment in which the rubric could be applied to student work. The lead also explained that the rubric should be used in addition to the existing grading scale faculty were using. Faculty were asked to record their course and assignment selections on a shared document. At the end of the academic year, faculty were reminded to enter their results. Results for each outcome were recorded individually using a shared document. Again, due to the varied nature of the programs, the level of the course chosen, and the complexity of the assignment within the course, there is no value in using the data to compare programs to each other. The intent is that, looking across many students across many programs, we get a picture not only of student competency, but also the extent to which program faculty view their students as sufficiently prepared to function in a professional setting.

Assessment results for Quantitative Literacy within Career/Technical Education Programs (AY 2020-21)

The breakdown of programs that scored designated student works within program courses is shown below.

Table 4: Disciplines Contributing Student Work

Program	Works scored (% contribution)
Accounting	79 (31.6%)
Admin of Justice	14 (5.6%)
Adv Manufacturing	9 (3.6%)
Aviation	15 (6.0%)
Business Management	29 (11.6%)
Computer and Elec Tech	57 (22.8%)
Emergency Med Serv	7 (2.8%)
Info Sys Tech	7 (2.8%)
Engineering Technology	7 (2.8%)
Vet Tech	26 (2.8%)
Total	***n* = 250**

Not all artifacts were scored for all outcomes. Although we asked all instructors to focus on QL4, we did have some omissions there. Additional outcomes were optional, and no programs selected QL3 to assess. Average scores (on a scale of 0-4) are shown.

Table 5: Mean Score Summary by Outcome

Outcome	Works scored	Mean score
QL4	219	2.61
QL1	147	2.42
QL2	15	3.20

Score distributions for each outcome are shown in the figures below.

Figure 2: Career/Technical Program Score Distribution (QL1)

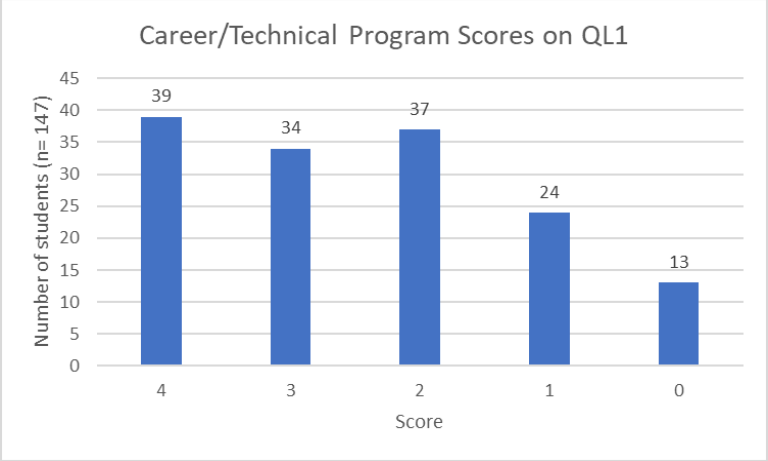


Figure 3: Career/Technical Program Score Distribution (QL2)

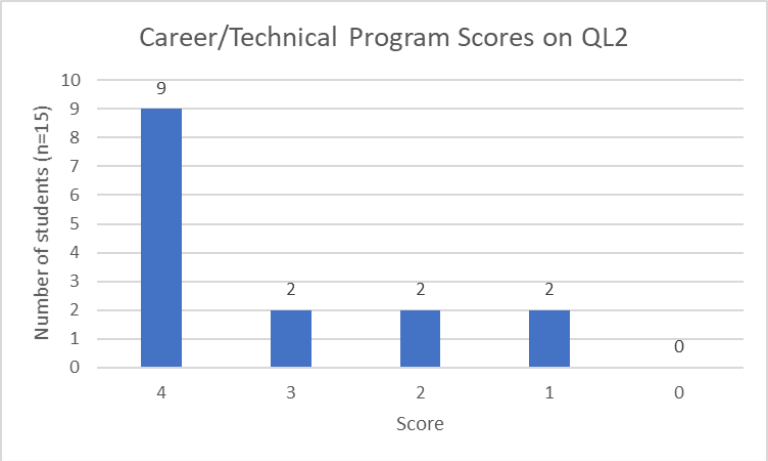
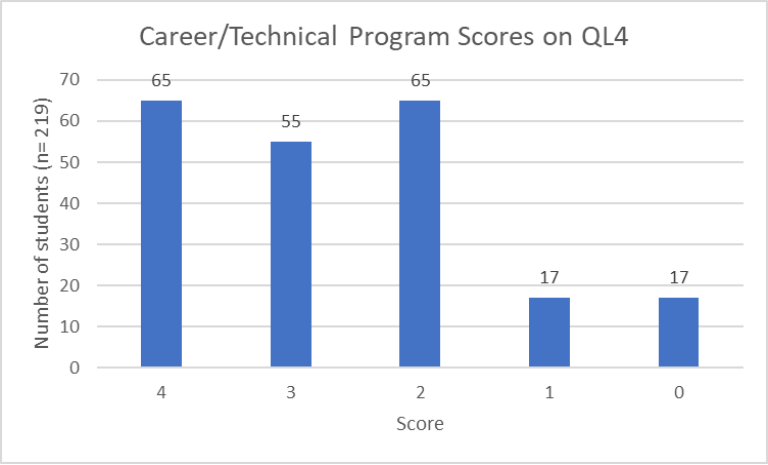


Figure 4: Career/Technical Program Score Distribution (QL4)



Highlight: Quantitative Literacy in Accounting

Accounting students were asked to evaluate the profitability and solvency of a publicly traded company through the calculation of eighteen financial analytical measures/ratios and then disseminate the ratio outcomes to accurately describe the financial position of the company. A target mean score of 2 was set to demonstrate proficiency in conceptualizing accounting tasks and disseminating accounting data on outcome QL4: Apply mathematical reasoning and techniques in discipline specific ways.

The target was partially met. The mean score among all students completing the assignment was 1.74. 7.5% of students performed at a 4; 18.8% of students performed at a 3; 37.5% of students performed at a 2; 12.5% of students performed at a 1 and 23.8% of students did not complete the analysis. The findings of this assessment demonstrated an actual proficiency in the analysis piece of the financial statement analysis by those who completed that part of the assignment. If you remove the students who did not attempt this piece of the assignment the mean score is 2.8.

Highlight: Quantitative Literacy in Administration of Justice

Administration of Justice students will use were assessed on their ability to use quantitative data t from the FBI Crime Data Explorer to support or refute assertions in a news article. The requirements included identifying and explaining the number of crimes, crime rate, and crime trends. The assessment involved students answering questions on the final exam which required the use of these materials and data to select and present the correct answers. The target mean score of 2 was set to demonstrate proficiency in QL4: Apply mathematical reasoning and techniques in discipline specific ways. The target was met. 14 student works were assessed. The mean score was 2.07. The breakdown in scores was: 4: [0], 3:[2], 2:[11], 1:[1], 0[0].

Action steps

At this stage, we are making progress toward the goal of establishing an assessment process that has program heads reporting out on General Education competencies using authentic work within their program courses. We are seeing a wide range of assessments in use that call on the students to use higher order integrative skills, and this speaks to the strength of our programs. However, we are working with faculty to move this process along past reporting the findings to providing more reflection on where they observe strengths and weaknesses in student performance and using the results of assessment to propose changes to instruction.

Our roll-out of this embedded assessment process was significantly disrupted by COVID closures. We introduced the front end of the process – choosing assignments and generating the data – in a Fall 2019 workshop that was well-attended, and this piece is working smoothly. The back end of the process – using the results for reflection and proposing curricular based actions – had a planned complementary workshop scheduled for Spring 2020; this was cancelled as faculty needed all their attention focused on moving courses online. Our plan for this year is to return to this topic and focus in the Spring on the reporting piece for the current and future assessments.

Competency: Scientific Literacy

Scientific Literacy is the ability to apply the scientific method and related concepts and principles to make informed decisions and engage with issues related to the natural, physical, and social world. Degree graduates will recognize and know how to use the scientific method, and to evaluate empirical information.

Instrument: Scientific Reasoning (Madison Assessment LLC)

Our timetable for assessing Scientific Literacy at BRCC was identified for both the indirect and direct (i.e. course-embedded) assessment methods in our assessment plan. We chose to continue our use of the Scientific Reasoning (SR-9) assessment from Madison Assessment as a graduation assessment for Scientific Literacy. This 49-question multiple-choice test was developed by the Center for Assessment and Research Studies at James Madison University to measure the scientific reasoning skills that come14 from completion of a general education curriculum. We have administered this instrument in both the SR-only form and as a component of the NW-9 ("Natural World" combined SR and QR from Madison Assessment) under the previous VCCS General Education assessment policy and procedure for many years.

The SR/NAW-9 had previously (July 2008) been mapped to the former VCCS outcomes for Scientific Reasoning. As these outcomes are no longer in use, our first question to consider was whether it still was a valid measure for our priorities in Scientific Literacy. Madison Assessment furnishes a test blueprint showing the outcomes it uses internally and which test items were associated with each outcome. There are six outcomes:

SRO1: Describe the methods of inquiry that lead to mathematical truth and scientific knowledge and be able to distinguish science from pseudo-science.
SRO2: Use theories and models as unifying principles that help us understand natural phenomena and make predictions.
SRO3: Recognize the interdependence of applied research, basic research, and technology, and how they affect society.
SRO4: Illustrate the interdependence between developments in science and social and ethical issues.
SRO5: Formulate hypotheses, identify relevant variables, and design experiments to test hypotheses.
SRO6: Evaluate the credibility, use, and misuse of scientific and mathematical information in scientific developments and public-policy issues.

For each outcome, they designate three levels:

Comprehend: classify, describe, identify, locate, recognize, select
Apply: choose, demonstrate, employ, interpret, use, write
Analyze: appraise, compare, contrast, differentiate, discriminate, distinguish, examine, question

Table 6: Madison Assessment Test Blueprint for SR-9

Test Blueprint for SR-9

Objective	Comprehension	Apply	Analyze
	classify, describe, identify, locate, recognize, select	choose, demonstrate, employ, interpret, use, write	appraise, compare, contrast, differentiate, discriminate, distinguish, examine, question
Describe the methods of inquiry that lead to mathematical truth and scientific knowledge and be able to distinguish science from pseudo-science.	2, 10, 14, 23, 39, 40, 41	3, 5, 25, 26, 27, 28	
Use theories and models as unifying principles that help us understand natural phenomena and make predictions.	13, 16	22, 48	17, 47, 49
Recognize the interdependence of applied research, basic research, and technology, and how they affect society.	1	11, 12, 30, 31, 32, 33	
Illustrate the interdependence between developments in science and social and ethical issues.	2, 24, 39, 40, 41	15	19, 20, 21
Formulate hypotheses, identify relevant variables, and design experiments to test hypotheses.	14, 18, 23, 35, 36	3, 4, 5, 28, 29, 37, 38	6, 7, 8, 9, 34, 42, 43, 45, 46
Evaluate the credibility, use, and misuse of scientific and mathematical information in scientific developments and public-policy issues.	2, 10, 24	25, 26, 27	19, 20, 21, 43, 44, 45, 46
Total[a]	23	25	22

[a] Some items correspond to more than one objective; therefore, the number of items assessing each objective sums to a value greater than the total number of items assessing SR.

We see that the instrument incorporates the outcomes course faculty have developed for use in the course-embedded part of our assessment process and includes additional components as well.

Table 7: Scientific Literacy Outcomes Map

Current (2020-21) BRCC Scientific Literacy Outcomes	Madison Assessment SR Test Blueprint	# of Items
SL1: Distinguish scientific information from non-scientific information.	**SRO1:** Describe the methods of inquiry that lead to mathematical truth and scientific knowledge and be able to distinguish science from pseudo-science.	**13**
SL2: Apply scientific methodology to analyze data and draw conclusions supported by the data.	**SRO2:** Use theories and models as unifying principles that help us understand natural phenomena and make predictions.	**7**
	SRO3: Recognize the interdependence of applied research, basic research, and technology, and how they affect society.	**7**
	SRO4: Illustrate the interdependence between developments in science and social and ethical issues.	**9**
SL2: Apply scientific methodology to analyze data and draw conclusions supported by the data **SL3:** Propose one or more solutions that demonstrate comprehension of a problem	**SRO5:** Formulate hypotheses, identify relevant variables, and design experiments to test hypotheses.	**21**

	SRO6: Evaluate the credibility, use, and misuse of scientific and mathematical information in scientific developments and public-policy issues.	**13**

Methodology and Limitations

The Scientific Reasoning Test (SR) from Madison Assessment was administered to all graduating students during the academic year 2020-2021. BRCC graduates have been assessed at the time of graduation for over 15 years and participation is required of all associate degree graduates. Students were notified at the time they applied for graduation that they are required to take the graduation assessment. All students completed the SR test online at home. Testing was open for one month and students were allowed to choose when they completed the test. This was not a proctored assessment.

The limitations of the assessment were that there were not consistent testing conditions in which students completed the SR. Additionally, the assessment might be considered low stakes because there was no impact on students' grades or GPA, although some students expressed concern regarding the fact that not completing the assessment would affect their graduation status. Student graduation is not impacted, but we do place a hold on diplomas and transcripts. Of additional concern is the number of test takers when examining results by program. There were 10 programs which had an n of less than 10.

Our goal was for students' average scores to be higher than previous administrations of the Scientific Reasoning (SR) test and to meet or exceed the average score for comparable community colleges. The SR has been administered to students previously (AY 2017-2018) and results will serve as a baseline.

Test-taker Demographics

In 2020 – 2021, the assessment was administered to a total of 294 students, of which 276 were identified as graduating with an associate degree level award in that year. The following tables describe the demographics of the 276 graduates:

Table 8: Test-taker Demographics (Age, Gender, Ethnicity)

Age Group	Count	Gender	Count	Ethnicity	Count
18-22 yrs	134	Female	186	Unidentified	2
23-28 yrs	87	Male	90	AMIND	1
29-35 yrs	29	**Total**	**276**	ASIAN	7
36-45 yrs	16			BLACK	6
Over 45 yrs	10			HISPA	19
Total	**276**			NSPEC	1
				OTHR	4
				PACIF	2
				WHITE	234
				Total	**276**

Results by Program

The breakdown of test-takers by award type and program is shown below. Specializations within a program are counted under the major and do not appear as separate items.

AA&S: Associate of Arts and Sciences
AS: Associate of Science
AAS: Associate of Applied Science

Table 9: Test-takers by Award Type and Program

Award	Program	Frequency*
AA&S	College/University Transfer	153
AS	Science	16
AAS	(All AAS combined)	108
AAS	Accounting	5
AAS	Administration of Justice	3
AAS	Advanced Manufacturing Technology	7
AAS	Automotive Analysis and Repair	4
AAS	Aviation Maintenance Technology	2
AAS	Business Management	15
AAS	Computer and Electronics Technology	1
AAS	Emergency Medical Services	4
AAS	Engineering Technology / Mechanical Design	2
AAS	Human Services	9
AAS	Information Systems Technology	3
AAS	Nursing	28
AAS	Veterinary Technology	25

* One student graduated with associate awards in both Science and College/University Transfer and is counted in both groups

For comparison and analysis we have the results from the large-scale administration of the instrument that took place at the VCCS level in 2010 – 2011 and a more recent prior administration at BRCC in 2017 – 2018.

The VCCS did not disaggregate by program but did provide a combined score for all graduate assessments submitted: of a count of 956 students, the mean score in terms of percentage correct (of 49 questions) was found to be 64.3, with a standard deviation of 12.72. The report further indicates a demographic breakdown of test takers as 51% college transfer (AA&S/AS/AA) and 49% career/technical education (AAS/AAA) but does not provide sub-scores for these groups.

The mean score for all BRCC graduates for the 2020 – 2021 assessment was 65.0 ($n = 276$, $s = 13.8$), which is in line with the system-wide average, and a modest improvement over the 2017 – 2018 average of 62.4 ($n = 398$, $s = 16.1$).

A cut score for minimum proficiency of 51% (25 out of 49 questions) correct was also determined at the time by a panel of science faculty from the VCCS. In 2010 – 2011, 88.1% (842/956) of VCCS graduates scored above the cut-score for minimally proficient. In comparison, 84.4% (233/276) of BRCC graduates scored above the cut-score in 2020 – 2021; while the BRCC percentage is slightly below the VCCS benchmark, it is not concerning.

We also have a recent prior administration at BRCC in 2017 – 2018. Here, we may break down the results by award type and to some extent by program; however as noted, a limitation of this type of assessment is that most of our programs have only a handful of graduates. BRCC provides disaggregated data for programs with $n \geq 10$.

The following table compares the results, using a two-tailed two-sample (Welch's) t-test to examine the difference in mean scores; the last two columns record *p*-value and standardized effect size *d* when $p < .05$.

Table 10: Comparison of Mean Scores

	BRCC: 2020 – 2021			BRCC: 2017 – 2018					
	n_1	$\bar{x}_1$	s_1	n_2	$\bar{x}_2$	s_2	$\bar{x}_1 - \bar{x}_2$	p	d
All Graduates	276	65.0	13.8	398	62.4	16.1	2.6	0.025	0.17
AA&S: College Transfer	153	64.9	13.3	197	61.8	15.9	3.1	0.048	0.21
AS: Science	16	70.0	16.0	30	71.9	16.1	-1.9	0.704	
AAS: All Majors	108	63.7	14.4	173	61.4	15.9	2.3	0.212	
AAS: Business Management	15	58.9	13.6	12	62.8	15.2	-3.9	0.494	
AAS: Nursing	28	67.4	13.2	45	58.6	16.3	8.8	0.014	0.58
AAS: Veterinary Technology	25	69.6	14.7	57	63.3	16.0	6.3	0.088	

We are seeing what we have come to expect from these graduation competency assessments: broken out by program, the mean scores cluster around an average that is close to the VCCS benchmark. Graduates with transfer-oriented associates (AA&S, AS) perform slightly higher than applied associates graduates (AAS) on average. However, our two largest AAS programs, Nursing and Veterinary Technology, were high performers this year. In most cases, there is little change between administrations of the assessment. Differences in mean scores between administrations are for the most part not significant at the .05 level, and when they are, the effect size is small. This reflects the broad nature of the instrument, and what we are examining are areas where a mean score is out of line with expectations. This could reflect a major change to a program, and we do see a correlation with Nursing.

Highlight: The Nursing Curricular Redesign

Nursing scores on the SR-9 jumped 8.8 percentage points from a mean score of 58.6 in 2017 – 2018 to a score of 67.4 in 2020 – 2021. This also was a change in relative positioning as Nursing went from one of the lower performing AAS groups to one of the higher. We reported out the data to our Nursing Program head and requested feedback regarding curricular changes that have occurred in this period.

> This is great news! I believe that the biggest factor playing into this would be the curriculum change to concept-based nursing. Concept-based nursing requires a higher level of critical thinking and clinical judgement across the curriculum. This curriculum change occurred Fall of 2018. Since then, we have improved our instructional delivery to ensure that students apply critical thinking and clinical judgement at a higher level of expectation than previous.
>
> Speaking for the 2021 year alone, numerous strategies to incorporate participatory teaching methods instead of passive teaching methods, have been delivered in the classroom setting.

Mainly, case study activities. With doing this, we have seen a significant shift in students being able to apply knowledge and anticipate outcomes much faster than before.

I am glad that changes we are making seem to be working!

Item Analysis

Based on the test blueprint furnished by Madison Assessment, we were able to calculate mean scores for the question groups associated with the outcomes and levels for 2020 – 2021. We did not have level data for 2017 – 2018 but did have mean scores by outcome for comparison.

Table 11: Breakdown by Outcome and Level

	2020-2021				2017-2018
	Comprehend	**Apply**	**Analyze**	**All levels**	**All levels**
SRO1	74.1	65.1	N/A	**69.9**	**68.5**
SRO2	75.9	55.6	55.9	**61.5**	**59.8**
SRO3	68.7	56.9	N/A	**58.6**	**55.1**
SRO4	73.6	52.7	70.1	**70.1**	**66.5**
SRO5	77.8	71.1	58.6	**67.4**	**64.9**
SRO6	70.9	56.1	52.9	**57.8**	**55.7**
All outcomes	**73.5**	**59.6**	**59.4**		

We are trying to find new ways to examine these graduation assessments in ways that tie them back to the curriculum – a known challenge with assessments of this type. One observation is not surprising: student performance is stronger on "comprehend" level questions, much more so than questions that ask them to apply or analyze information.

We are seeing a very loose connection between performance and how the outcomes map onto our own internally developed outcomes. Two of the three lowest scoring outcomes (SRO3 and SRO6) do not map onto any of the outcomes we have developed through our faculty input process. Two of the three highest scoring outcomes (SRO1 and SRO5) map onto outcomes (SL1 and SL2) that were chosen by the faculty as areas of focus. We put this information in front of our assessment group to see if suggested any areas for exploration.

Action steps

Externally developed instruments only partially align with the outcomes we have identified as priorities. The assessment group determined that this could be a productive avenue for further conversation; if we see outcome results such as SRO3 and SRO6, which are not institutional priorities, we can put the question to the faculty as to whether they should be. For outcomes

SRO3: Recognize the interdependence of applied research, basic research, and technology, and how they affect society.

SRO6: Evaluate the credibility, use, and misuse of scientific and mathematical information in scientific developments and public-policy issues.

We are planning a survey of faculty to ask two questions:

(1) To what extent do they currently address these outcomes within their course content?

(2) Should they become institutional priorities?

From the responses, we can determine if these are areas we want to devote resources to developing and assessing or if we are satisfied with our current identified priorities and would prefer to continue to strengthen those areas.

Conclusions

Our multiple-level, multiple-measure assessment plan is continuing to take shape. We are still recovering from setbacks and challenges in the 2019 – 2020 and 2020 – 2021 years. Our process for course-embedded assessment within the General Education Clusters has been in place for several years now and is working smoothly, and we are accumulating evidence that shows multiple small successes in improving curricular outcomes through reflection on pedagogy and assignment design. We are working bringing a similar approach to General Education outcomes embedded in Career/Technical Program courses. Having a more robust underlying system of course-embedded assessment threaded throughout the curriculum takes the pressure off attempting to extract actionable information from graduation assessments that are not designed for that purpose and allows them to function in their appropriate role as general indicators of overall program health.

Appendix A: Quantitative Literacy Rubrics

Rubrics are styled after and adapted from the AAC&U Quantitative Literacy VALUE Rubric, under the Creative Commons license CC BY-NC-SA 4.0. Rubrics are significantly modified from original source and there is no implied endorsement by AAC&U.

QL1: Perform accurate calculations and symbolic manipulation

	4 (Exemplary)	3 (Proficient)	2 (Developing)	1 (Emerging)	0 (Insufficient)
QL1: Perform accurate calculations and symbolic manipulation	Calculations and/or algebraic operations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely, etc.)	Calculations and/or algebraic operations attempted are essentially all successful and sufficiently comprehensive to solve the problem.	Calculations and/or algebraic operations attempted are mostly successful but represent only a portion of the calculations required to comprehensively solve the problem.	Calculations and/or algebraic operations are attempted but are partially unsuccessful and/or insufficient to solve the problem.	Calculations and/or algebraic operations are completely unsuccessful or not attempted.

QL2: Interpret mathematical models such as functions, graphs, tables, and schematics and draw inferences from them

	4 (Exemplary)	3 (Proficient)	2 (Developing)	1 (Emerging)	0 (Insufficient)
QL2: Interpret mathematical models such as functions, graphs, tables, and schematics and draw inferences from them	Provides accurate explanations of information presented in mathematical forms in the context of a larger work. Makes appropriate inferences based on that information in connection to the work as a whole.	Provides accurate explanation of information presented in mathematical forms, and makes appropriate inferences based on that information within the context of the problem.	Provides somewhat accurate explanation and interpretation of information presented in mathematical forms, but makes minor errors related to computations or units and/or provides minimal interpretation.	Provides somewhat accurate explanation and interpretation of information presented in mathematical forms, but makes major errors related to computations or units and/or provides incomplete interpretation.	Attempts to explain information presented in mathematical forms but draws incorrect conclusions about what the information means.

QL3: Represent mathematical information numerically, symbolically, and visually

	4 (Exemplary)	3 (Proficient)	2 (Developing)	1 (Emerging)	0 (Insufficient)
QL3: Represent mathematical information numerically, symbolically, and visually	Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding.	Competently converts relevant information into an appropriate and desired mathematical portrayal.	Completes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate.	Completes conversion of information but resulting mathematical portrayal is inappropriate or inaccurate.	Fails to convert information into any mathematical portrayal.

QL4: Apply mathematical reasoning and techniques in discipline specific ways

	4 (Exemplary)	3 (Proficient)	2 (Developing)	1 (Emerging)	0 (Insufficient)
QL4: Apply mathematical reasoning and techniques in discipline specific ways *(including, but not limited to, quantitative analysis of data)*	Uses mathematical analysis within a discipline as the basis for deep and thoughtful evaluations, drawing insightful conclusions from this work.	Uses mathematical analysis within a discipline as the basis for competent evaluations, drawing reasonable conclusions from this work.	Uses mathematical analysis within a discipline as the basis for elementary evaluations, drawing simple conclusions from this work.	Uses mathematical analysis within a discipline as the basis for tentative, basic evaluations, although it is hesitant or uncertain about drawing conclusions from this work.	Fails to use mathematical analysis within a discipline as a basis for drawing conclusions.

References

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