INTERSTATE PASSPORT®

Passport Learning Outcomes and Proficiency Criteria
Quantitative Literacy

PASSPORT LEARNING OUTCOMES

Faculty representatives from participating Passport institutions, along with the Passport State Facilitators and project staff, develop Passport Learning Outcomes (PLOs) for each lower-division general education knowledge and skill area. The Passport Interstate Faculty Team – comprised of faculty members with expertise in the designated area – review, compare, and contrast the sets of learning outcomes submitted by each state and then negotiate to arrive at an agreed-upon set of learning outcomes – the *Passport Learning Outcomes*. Team members vet the draft learning outcomes with faculty and other stakeholders in their states, and through a series of team conference calls, the learning outcomes are refined and finalized for the knowledge or skill area. Institutions that sign the Passport Agreement acknowledge that their lower-division general education learning outcomes map to and are congruent with the Passport Learning Outcomes.

PROFICIENCY CRITERIA

The proficiency criteria describe the EVIDENCE of proficiency with the Passport Learning Outcomes at the transfer level that one might see in a student's behavior, performance or work. These are observable behaviors rather than subjective descriptors such as "appropriate" or "excellent." Specific examples, provided in the Transfer-Level Proficiency Criteria column of the matrix below, are not intended to mandate curriculum or assessment methods, nor do they constitute a comprehensive list of concepts that each student must master. Rather, they serve as guidelines for determining whether a student has reached the desired level of proficiency for the specific learning outcome through a variety of possible methods. The inclusion of many diverse concrete examples is intentional as different courses may address a given feature in distinct ways; for example, a statistics course will address learning outcomes differently than a quantitative reasoning course. Also, a given concrete example may possibly address more than one Passport Learning Outcome. No single course, or Passport student, is expected to demonstrate all of these criteria of transfer-level proficiency.

QUANTITATIVE LITERACY FRAMING LANGUAGE

Quantitative literacy requires comfort and capability with fundamental quantitative methods and incorporation of quantitative concepts into the student's worldview so the student does not hesitate to apply quantitative skills in any appropriate context. Specific quantitative skills that must be addressed are mathematical process, computational skills, formulation of quantitative arguments, analysis of quantitative arguments, communication of quantitative arguments, and quantitative models. Relationship to institution's Passport Block: a course in mathematics, a course that intensively uses quantitative methods, or equivalent demonstration of quantitative literacy is required.

QUANTITATIVE LITERACY		
Passport Learning Outcome Features	**Passport Learning Outcomes** (What the student has learned)	**Transfer-Level Proficiency Criteria** (Evidence of proficiency of the learning outcome appropriate at the transfer level) **No single student is expected to demonstrate ALL of these proficiency criteria nor is this intended to be a list of all possible proficiency criteria.**
Computational Skills	demonstrate proficiency with arithmetic and algebraic computational skills, and extend them, for example, to geometric and statistical computations.	Correctly solves problems or equations at the appropriate level. Uses logarithms to correctly solve a compound interest problem for the desired time. Solves linear and quadratic algebraic equations accurately and reliably without the aid of a calculator. Correctly computes the mean, median, mode, and standard deviation for a given numerical data set. Rearranges the margin of error formula to find the desired sample size for a given confidence level and margin of error. Finds the area or volume of general geometric objects by decomposing them into more basic components (circles, triangles, rectangles, cubes, etc.). Uses the ideal gas law to compute how one variable is affected as another is changed. In problems where units are provided, gives answer in correct units. Also, uses units as a check when solving algebraic problems where units are given. Uses a spreadsheet or simple computer programs to automate multiple instances of arithmetic calculation. Calculates present and future values of money by evaluating appropriate formulas. Determines proportional relationships between the areas/volumes of figures given side (or other) measurements.
Communication of Quantitative Arguments	express quantitative information symbolically, graphically, and in written or oral language.	Correctly uses mathematical notation in all aspects of the solution of a typical problem at the appropriate level. Accurately converts between proper mathematical notation/expressions and written / oral narrative. Expresses answer and intermediate steps with correct units. Uses appropriate language to link between different steps of stating or solving problems. Avoids using “=” to mean anything other than equality. Uses function notation and parentheses correctly in solving problems. States the conclusion to a significance test and writes an explanation of the rationale for the conclusion. Makes appropriate use of graphical objects (such as geometrical figures, graphs of equations in two or three variables, histograms, scatterplots of bivariate data, etc.) to supplement a solution to a typical problem at the appropriate level. Includes an appropriate graph to support or emphasize trends or findings. Draws two consecutive iterations of the Koch Snowflake to demonstrate that perimeter increases at each step.

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Communication of Quantitative Arguments (cont.)		Uses graphs or plots (box-and-whisker, bar graph, etc.) to illustrate a comparison between two related data sets. Illustrates important values (such as median, mean, or extrema) on a graph or histogram of the data under analysis. Uses a graph to correctly present the data collected in a scientific experiment.
Analysis of Quantitative Arguments	select and use appropriate numeric, symbolic, graphical and statistical reasoning to interpret, analyze and critique information or line of reasoning presented by others.	Determines whether a given sequence of steps constitutes a valid line of reasoning (such as a proposed proof of a mathematical theorem or solution to a quantitative problem). If not a valid method, is able to explain why not. Reads passages which use basic statistics (such as from a newspaper story) and correctly articulates how those statistics could have been calculated and gives a correct analysis of their potential meaning. For example, distinguishes between results that show statistical correlation and causation. When presented with an estimate based on sample data, asks if that sample was randomly chosen, and if not, considers whether that is relevant. Uses present-value and future-value formulas to evaluate claims made about investment opportunities. Critiques the quantitative results obtained from a scientific experiment.
Formulation of Quantitative Arguments	recognize, evaluate, and use quantitative information, quantitative reasoning and technology to support a position or line of reasoning.	Correctly formulates, organizes, and articulates solutions to theoretical and application problems at the appropriate level. Gives a correct argument why the Koch snowflake has finite area but infinite perimeter. Analyzes quantitative data collected in an experiment. Uses optimization techniques to maximize profit for a business. Correctly proves that an irrational number is irrational (for example, $\sqrt{2}$ or 1.010010001…). Uses graphs, diagrams, and charts to compare data sets and draw conclusions. Given the results for a hypothesis test or confidence interval, draws an accurate conclusion. Describes a scenario in which poll voting (plurality method) gives a different result from ranked preference voting. Uses a graph and/or appropriate formulas to find the maximum or minimum value of a quadratic polynomial, and distinguishes between the value at which the maximum occurs and the maximum value itself.

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		When using linear programming, shows an appropriate graph and the details of how the optimum value is obtained. Employs proportional reasoning to explain why a subpopulation is over or under represented in a sample. Utilizes a graph to determine the number of real zeros of a quadratic or cubic equation.
Mathematical Process	design and follow a multi-step mathematical process through to a logical conclusion and critically evaluate the reasonableness of the result.	Correctly solves a variety of different problem types (at the appropriate level) that involve a multi-step solution. Selects an algorithm (such as Cheapest Link Algorithm) for working with a graph theory problem (Travelling Salesman) and correctly applies it to the exercise. Based on given data, correctly computes a confidence interval or hypothesis test. Uses synthetic division, factoring, graphing, and other related techniques to find all the (real) zeros of a suitable cubic/quartic polynomial. Writes a computer program to do a multi-step calculation that involves multiple cases. For example, identify whether the input is a prime number, factor the input, or sort a list of numbers. Does appropriate error checking on the resulting computer program. Calculates multiple monthly loan payments for a given principal and different interest rates/times. Then uses the figures to compare the total cost of the loans. Given three linear relationships for three unknowns, correctly solves for the desired quantities. For a given velocity and rate of deceleration, calculates the distance required to stop. Correctly solves an optimization problem, justifying why their solution is in fact an optimal one (for example, using linear programming or differential calculus). Considers the validity of a result from a multi-step problem. Rarely submits solutions that involve an answer of the wrong order of magnitude or involving the wrong type of information (such as a graphical solution when a numeric one is called for). Where possible, checks solutions with the original problem. Looks for signs of model breakdown when using an exponential growth function in a real-world setting. Evaluates the validity of experimental data. Recognizes, quantifies (where possible), and articulates the possibility of error (type I or II, as appropriate) in a significance test. Recognizes nonrandom sample data as nonrandom and considers the possible impact to conclusions.

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Quantitative Models	create, analyze and apply appropriate quantitative models to solve quantitative theoretical and real-world problems.	Correctly solves problems at the appropriate level which require the student to choose an appropriate technique or formula. Given a floor plan, the cost of the carpet per yard from a roll of given width, and the cost of making a cut, devises a scheme to carpet a floor plan and calculates the cost. Selects the correct model (linear, exponential, logistic, etc.) for a population growth problem and then uses it to solve for the population size at a given time. Given sample data, calculates confidence intervals for population means and correctly interprets results. Constructs applicable linear demand and quadratic revenue functions from given data, then uses the model to determine the price and quantity that maximizes revenue. Given an estimated growth rate per year and a desired investment value after a certain number of years, calculates the initial investment required to reach that value. Solves problems that involve adding rates. (For example if person A requires 4 hours to do a job, and person B requires 3 hours, how long is required for A and B to do this job together?) Selects the correct function type to model a set of real-world bivariate data, determines appropriate values for the constants in the model, and uses the model to answer questions. Utilizes vectors to solve problems involving direction and magnitude.