Developing Student Self-Awareness and Responsibility

The most powerful learners are those who are reflective, who engage in metacognition—thinking about what they know—and who take control of their own learning (White & Frederiksen, 1998). A major failing of traditional mathematics classes is that students rarely have much idea of what they are learning or where they are in the broader learning landscape. They focus on methods to remember but often do not even know what area of mathematics they are working on. I have visited math classes many times and stopped at students' desks to ask them what they are working on. Often students simply tell me the question they are working on. Many of my interactions have gone something like this:

JB:

What are you working on?

Student:

Exercise 2.

JB:

So what are you actually doing? What math are you working on?

Student:

Oh, I'm sorry—question 4.

Students are often not thinking about the area of mathematics they are learning, they do not have an idea of the mathematical goals for their learning, and they expect to be passively led through work, with teachers telling them whether they are “getting it” or not. Alice White, an assessment expert, likens this situation to workers on a ship who are given jobs to do each day but don't have any idea where the ship is travelling to.

One research study, conducted by Barbara White and John Frederiksen (White & Frederiksen, 1998), powerfully illustrated the importance of reflection. The researchers studied twelve classes of seventh-grade students learning physics. They divided the students into experimental and control groups. All groups were taught a unit on force and motion. The control groups then spent some of each lesson discussing the work, whereas the experimental group spent some of each lesson engaging in self- and peer assessment, considering criteria for the science they were learning. The results of the study were dramatic. The experimental groups outperformed the control groups on three different assessments. The previously low-achieving students made the greatest gains. After they spent time considering the science criteria and assessing themselves against them, they began to achieve at the same levels as the highest achievers. The middle school students even scored at higher levels than AP physics students on tests of high school physics. The researchers concluded that a large part of the students' previous low achievement came not from their purported lack of ability but from the fact that previously they had not known what they should really be focusing upon.

This is sadly true for many students. It is so important to communicate to students what they should be learning. This both helps the students know what success is and starts a self-reflection process that is an invaluable tool for learning.

There are many strategies for encouraging students to become more aware of the mathematics they are learning and their place in the learning process. Beginning here, I will share nine of my favorites.

1. Self-Assessment

The two main strategies for helping students become aware of the math they are learning and their broader learning pathways are self- and peer assessment. In self-assessment, students are given clear statements of the math they are learning, which they use to think about what they have learned and what they still need to work on. The statements should communicate mathematics content such as “I understand the difference between mean and median and when each should be used” as well as mathematical practices such as “I have learned to persist with problems and keep going even when they are difficult.” If students start each unit of work with clear statements about the mathematics they are going to learn, they start to focus on the bigger landscape of their learning journeys—they learn what is important, as well as what they need to work on to improve. Studies have found that when students are asked to rate their understanding of their work through self-assessment, they are incredibly accurate at assessing their own understanding, and they do not over- or underestimate it (Black et al., 2002).

Self-assessment can be developed at different degrees of granularity.

Teachers could give students the mathematics in a lesson or show them the mathematics from a longer period of time, such as a unit or even a whole term or semester. Examples of self-assessment criteria for shorter and longer time periods are provided here. In addition to receiving the criteria, students need to be given time to reflect upon their learning, which they can do during a lesson, at the end of a lesson, or even at home.

The self-assessment example in Exhibit 8.1 comes from a wonderful third-grade teacher I have worked with, Lori Mallet. Lori attended a summer professional development workshop I taught where we considered all the ways of encouraging a growth mindset. In her self-assessment example she offers three options for the students to choose from.

Self-Assessment: Polygons

	I can do this independently and explain my solution path(s) to my classmate or teacher.	I can do this independently.	I need more time. I need to see an example to help me.
Draw lines and line segments with given measurements.			
Draw parallel lines and line segments.			
Draw intersecting lines and line segments.			
Create a polygon with a given perimeter.			
Create a square or rectangle with a given area.			
Create an irregular shape whose area can be solved by cutting it into rectangles or squares.			

Source: From Lori Mallet

Exhibit 8.1

Rather than giving words for students to reflect upon, some teachers, particularly of younger children, use smiley faces such as those in Figure 8.4.

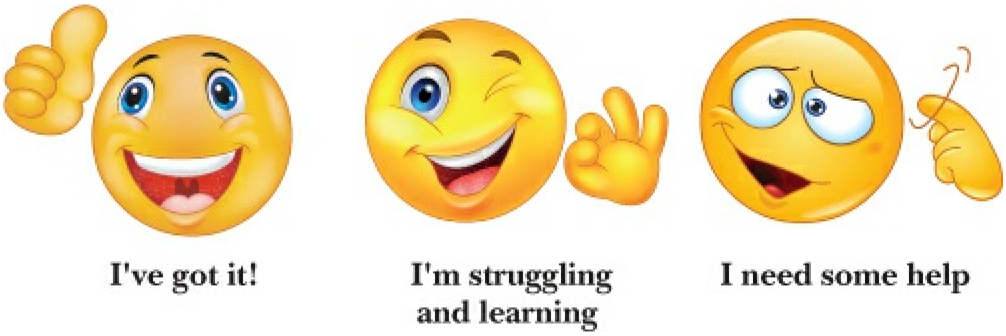

Figure 8.4 Self-reflection faces

Both options prompt students to consider what they have learned and what they need to learn.

My second example of self-assessment comes from Lisa Henry, an expert high school teacher from Brookland, Ohio. Lisa has been teaching high school mathematics for 23 years. Four years ago Lisa became dissatisfied with grading. She knew that her grades did not represent what the students knew. Lisa moved to assessing students against criteria that she shared with the students. Lisa kindly shares with others the self-assessment statements she wrote for the whole of her algebra 1 course (see Exhibit 8.2). Now that students are assessing themselves against criteria and Lisa is assessing students by deciding what they know and don't know, instead of an overall grade, she says she knows a lot more about students' knowledge and understanding.

Algebra 1 Self-Assessment

Unit 1 – Linear Equations and Inequalities

- ☐ I can solve a linear equation in one variable.
- ☐ I can solve a linear inequality in one variable.
- ☐ I can solve formulas for a specified variable.
- ☐ I can solve an absolute value equation in one variable.
- ☐ I can solve and graph a compound inequality in one variable.
- ☐ I can solve an absolute value inequality in one variable.

Unit 2 – Representing Relationships Mathematically

- ☐ I can use and interpret units when solving formulas.
- ☐ I can perform unit conversions.
- ☐ I can identify parts of an expression.
- ☐ I can write the equation or inequality in one variable that best models the problem.
- ☐ I can write the equation in two variables that best model the problem.
- ☐ I can state the appropriate values that could be substituted into an equation and defend my choice.
- ☐ I can interpret solutions in the context of the situation modeled and decide if they are reasonable.
- ☐ I can graph equations on coordinate axes with appropriate labels and scales.
- ☐ I can verify that any point on a graph will result in a true equation when their coordinates are substituted into the equation.
- ☐ I can compare properties of two functions graphically, in table form, and algebraically.

Unit 3 – Understanding Functions

- ☐ I can determine if a graph, table, or set of ordered pairs represents a function.
- ☐ I can decode function notation and explain how the output of a function is matched to its input.
- ☐ I can convert a list of numbers (a sequence) into a function by making the whole numbers the inputs and the elements of the sequence the outputs.

- ☐ I can identify key features of a graph, such as the intercepts, whether the function is increasing or decreasing, maximum and minimum values, and end behavior, using a graph, a table, or an equation.
- ☐ I can explain how the domain and range of a function is represented in its graph.

Unit 4 – Linear Functions

- ☐ I can calculate and interpret the average rate of change of a function.
- ☐ I can graph a linear function and identify its intercepts.
- ☐ I can graph a linear inequality on a coordinate plane.
- ☐ I can demonstrate that a linear function has a constant rate of change.
- ☐ I can identify situations that display equal rates of change over equal intervals and can be modeled with linear functions.
- ☐ I can construct linear functions from an arithmetic sequence, graph, table of values, or description of the relationship.
- ☐ I can explain the meaning (using appropriate units) of the slope of a line, the y-intercept, and other points on the line when the line models a real-world relationship.

Unit 5 – Systems of Linear Equations and Inequalities

- ☐ I can solve a system of linear equations by graphing.
- ☐ I can solve a system of linear equations by substitution.
- ☐ I can solve a system of linear equations by the elimination method.
- ☐ I can solve a system of linear inequalities by graphing.
- ☐ I can write and graph a set of constraints for a linear-programming problem and find the maximum and/or minimum values.

Unit 6 – Statistical Models

- ☐ I can describe the center of the data distribution (mean or median).
- ☐ I can describe the spread of the data distribution (interquartile range or standard deviation).
- ☐ I can represent data with plots on the real number line (dot plots, histograms, and box plots).

- ☐ I can compare the distribution of two or more data sets by examining their shapes, centers, and spreads when drawn on the same scale.
- ☐ I can interpret the differences in the shape, center, and spread of a data set in the context of a problem, and can account for effects of extreme data points.
- ☐ I can read and interpret the data displayed in a two-way frequency table.
- ☐ I can interpret and explain the meaning of relative frequencies in the context of a problem.
- ☐ I can construct a scatter plot, sketch a line of best fit, and write the equation of that line.
- ☐ I can use the function of best fit to make predictions.
- ☐ I can analyze the residual plot to determine whether the function is an appropriate fit.
- ☐ I can calculate, using technology, and interpret a correlation coefficient.
- ☐ I can recognize that correlation does not imply causation and that causation is not illustrated on a scatter plot.

Unit 7 – Polynomial Expressions and Functions

- ☐ I can add and subtract polynomials.
- ☐ I can multiply polynomials.
- ☐ I can rewrite an expression using factoring.
- ☐ I can solve quadratic equations by factoring.
- ☐ I can sketch a rough graph using the zeroes of a quadratic function and other easily identifiable points.

Unit 8 – Quadratic Functions

- ☐ I can use completing the square to rewrite a quadratic expression into vertex form.
- ☐ I can graph a quadratic function, identifying key features such as the intercepts, maximum and/or minimum values, symmetry, and end behavior of the graph.
- ☐ I can identify the effect of transformations on the graph of a function with and without technology.
- ☐ I can construct a scatter plot, use technology to find a quadratic function of best fit, and use that function to make predictions.

Unit 9 – Quadratic Equations

- ☐ I can explain why sums and products are either rational or irrational.
- ☐ I can solve quadratic equations by completing the square.
- ☐ I can solve quadratic equations by finding square roots.
- ☐ I can solve quadratic equations by using the quadratic formula.

Unit 10 – Relationships That Are Not Linear

- ☐ I can apply the properties of exponents to simplify algebraic expressions with rational exponents.
- ☐ I can graph a square root or cube root function, identifying key features such as the intercepts, maximum and/or minimum values, and end behavior of the graph.
- ☐ I can graph a piecewise function, including step and absolute value functions, identifying key features such as the intercepts, maximum and/or minimum values, and end behavior of the graph.

Unit 11 – Exponential Functions and Equations

- ☐ I can demonstrate that an exponential function has a constant multiplier over equal intervals.
- ☐ I can identify situations that display equal ratios of change over equal intervals and can be modeled with exponential functions.
- ☐ I can use graphs or tables to compare the rates of change of linear, quadratic, and exponential functions.
- ☐ I can rewrite exponential functions using the properties of exponents.
- ☐ I can interpret the parameters of an exponential function in real-life problems.
- ☐ I can graph exponential functions, identifying key features such as the intercepts, maximum and/or minimum values, asymptotes, and end behavior of the graph.
- ☐ I can construct a scatter plot, use technology to find an exponential function of best fit, and use that function to make predictions.

Source: By Lisa Henry

Exhibit 8.2

2. Peer Assessment

Peer assessment is a similar strategy to self-assessment, as it also involves giving students clear criteria for assessment, but they use it to assess each other's work rather than their own. When students assess each other's work they gain additional opportunities to become aware of the mathematics they are learning and need to learn. Peer assessment has been shown to be highly effective, in part because students are often much more open to hearing criticism or a suggestion for change from another student, and peers usually communicate in ways that are easily understood by each other.

One of my favorite methods of peer assessment is the identification of “two stars and a wish” (see Exhibit 8.3). Students are asked to look at their peers' work and, with or without criteria, to select two things done well and one area to improve on.

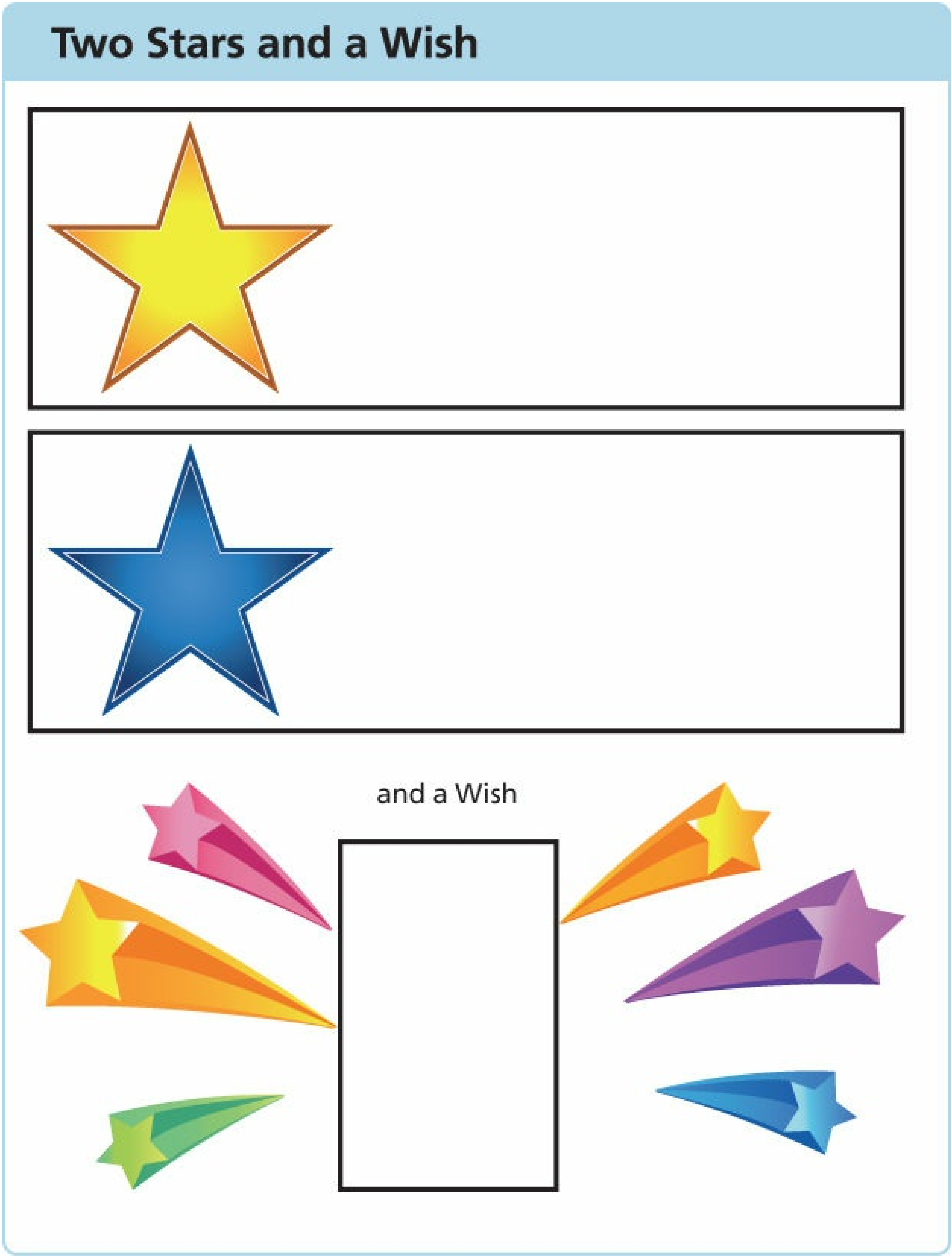

Exhibit 8.3

When students are given information that communicates clearly what they are learning, and they are asked, at frequent intervals, to reflect on their learning, they develop responsibility for their own learning. Some people refer to this as inviting students into the guild—giving students the powerful knowledge—knowledge that usually only teachers hold—which allows them to take charge of their learning and be successful.