The Impact of Skill Identification Practice on Student Persistence

Proposal

Something I have noticed in my teaching is that when students look at a problem and don't immediately know how to do it, or think that it is "too hard", they disengage with it completely and make very limited attempts to solve it. The instructional approach I have chosen to implement in order to address this problem is putting a greater emphasis on learning objectives during instruction, and on skill recognition when approaching a problem. Research has shown that setting clear objectives for student learning has a positive impact on student achievement and can lead to students being better able to self-monitor their progress and self-assess their learning (Dean & Marzano, 2013). I hypothesize that if students are more self-have a better awareness of the concepts that they are expected to learn and use, they will be better able to identify these skills in the context of challenging problems and thus be able to approach the problem with more confidence in their ability to work on it. More specifically, I will implement these changes by putting emphasis on each day's learning goals, and by asking students to identify skills that they'll need to solve a problem before they begin to work on it. The types of problems I intend to focus on are high cognitive demand, complex tasks that require more than one skill to solve. These could include problems that need to be interpreted within a context, problems with a solution method that is non-algorithmic and requires abstract thinking or trial-and-error, and problems that combine multiple skills into one task.

Once this approach is implemented, students will be able to identify the skills that they are learning on any given day. For example, a student would be able to articulate during and at the end of a lesson that they were working on learning how to find the range of a rational function, or whatever topic happens to be being covered. Students will also be able to make predictions about what a problem is asking them to do, and what skills or background knowledge they need, before beginning to work. As a result, students will be able to approach challenging problems with confidence and be able to begin working on them and persist through the problem solving process. Placing clearer emphasis on daily learning objectives and having students practice identifying necessary skills will help to further my goals by helping students develop a consistent approach to challenging tasks, and that sets them up for success in solving them.

As a novice teacher, this instructional approach has the potential to benefit me in many ways. We currently exist in an educational culture that places increased value on the presence of learning goals and alignment with multiple sets of state and national standards. Standards are typically written or easily converted into “I can” statements that could be easily utilized as recognizable learning objectives. For this reason, it will be worthwhile to develop an educational practice where my lessons’ alignments to standards like the SAT Skills Suite or Common Core skills are clear and automatic. In addition to these advantages within the education system, the approaches outlined in this proposal also align with my evolving teaching philosophy that mathematics teaching should give students not only math skills, but the ability to think about challenging problems and persist in solving them in any context. Too often in my class, students are presented with a complex task and decide that they can’t do it before even beginning, or will take off in any familiar direction without thinking about what they are being asked to do. I hypothesize that this happens because they lack the ability to recognize the places in which they need to apply their learning from class. Developing the habit of looking at a task and analyzing “What do I need to do here and what skills do I need to get it done?” is a skill that will serve students inside and outside of the classroom, and one that will be supported by the practice of analyzing necessary skills before beginning a task.

Action Plan

To reiterate, I hypothesized that if students have a better awareness of mathematics concepts that they are expected to learn and use, they will be better able to identify these skills in the context of challenging problems and thus be able to approach the problem with more confidence in their ability to work on it. The instructional approach I selected in order to test this hypothesis is to have students develop a practice of identifying the skills they think they'll need to solve a problem, before beginning to work on it.

Mathematics education researchers argue that "a curriculum that supports [meaningful learning] is one that has a dual agenda consisting of content and process." An approach called the Multiple Intelligence strategy (MI) has been shown to be highly effective in teaching mathematical processes that can be used to solve problems (Douglas, Burton & Reese-Durham, 2008). MI involves putting intentional emphasis on the ways in which students with different strengths and weaknesses can all contribute to solving a rich, complex mathematical task, and can point them to potential approaches they could take to solve it (Multiple Abilities Strategy). My instructional approach of having students identify all of the skills needed to solve a problem is well-aligned with MI, as it allows students to see all of the various skills that contribute to finding a problem's solution. Students will generate these lists of skills on their own, and will be encouraged to reference recent learning objectives if they need help articulating a concept. This will allow students to notice that they likely have some of the background knowledge needed to complete a problem, and be able to identify specific areas where they need to ask a peer or access a resource for help before giving up. I hypothesize that this boost in confidence will lead to increased student engagement with challenging tasks because they will spend more time making ernest attempts at completing the problem, instead of giving up and allowing themselves to become distracted with other things. Additionally, my observations in the classroom have shown that students give up on tasks quickly when they don't know how to start. Generating a list of skills they think they'll need will provide students with several potential starting points; I believe that this will lead to increased engagement with a task since it gets students over the barrier of figuring out where to begin.

The primary way in which I will prepare students for their new role is by putting increased emphasis on daily learning goals. These are typically displayed on the board and read out loud at the beginning of class, and typically closely resemble Common Core Standards in the form of "I can" statements. By returning to learning goals not only at the beginning and end of a lesson, but also throughout the delivery of content and practice problems, students should develop an increased ability to articulate what skills they are learning on any given day.

The second aspect of preparing students for their new roles will come with modeling the process of looking at a problem and attempting to identify the skills needed to solve it. This will involve initial modeling by myself during instruction; guided practice in the form of explicit directions at the beginnings of problems; and by developing the classroom expectation that students go through the process of skill prediction (on paper or orally) before beginning any mathematical task. In the beginning, these will be scaffolded by explicit instructions for students to write out the information that is given in the problem, the goal or what they're trying to find, and any skills or processes that they think could be helpful in reaching that end. As stated above, they will be able to reference any of our previous learning objectives from their notes to aid in this process. As time progresses and students get used to this procedure, I will make it clear that I expect them to continue writing out their predicted necessary skills but will stop listing the steps as requirements on the assignment.

As mentioned above, a crucial component of preparing students for their new roles is modeling what they are expected to do. I will do this myself during instruction by pointing out each skill necessary as we walk through practice problems. For example while demonstrating how to solve quadratic functions that cannot be easily factored, I will clearly point out in class that at one point we are using simple solving and balancing equations skills, creating perfect square trinomials, factoring, and taking square roots. I will also scaffold the practice by asking students to identify which skills they are using during each step of a problem when they share out answers on the board during class. This typically happens as we work through the solution to the Bell Ringers, or after we spend time on a set of practice problems. From there, we will have direct instruction on how to look at a problem and try to identify all of the skills we might need to solve it. By thinking out loud through my own process of predicting the skills needed for example problems in class, I will model for students how to make these predictions on their own. We can then move into guided practice, such as being asked to list three possible necessary skills as part of the initial steps to solving a task. For example, before being asked to find the roots of a quadratic students could be expected to list some skills such as factoring, using the zero product property, completing the square, or using the quadratic formula.

While implementing this new instructional strategy, I will manage students in several ways. An important element to managing students through the implementation of this instructional approach is to anticipate areas in which students might resist. Some students may see the listing of skills as an additional “busy work” step added on to already-difficult problems. They may also resist if they come across a task whose list of skills contains many abilities that they feel they do not have, and few that they feel confident about. In order to engage with these forms of resistance, I need to be prepared to explain to students how identifying necessary skills can help them not only to solve the problem, but also to self-assess their strengths and weaknesses and identify specific areas where they can contribute or where they know they can still improve. Even in cases where students don’t understand the bigger concepts, identifying that each problem also requires component skills such as addition and subtraction, the ability to solve an equation, or plotting points could build confidence as students realize that there are valuable skills that they have mastered, and that those skills build into the new ones they are trying to learn.

To manage my own self while implementing this approach, I plan to utilize Pear Deck, an interactive slideshow platform, to have students submit their lists of skills electronically. This will help me monitor their work in an organized fashion, as responses to Pear Deck questions can be exported to a spreadsheet organized by student names. This will also help keep students engaged, as the integration of technology adds to student interest (Wardlow, 2016). For similar reasons, I will also make use of sticky notes and a “Chime In” board on which students can post their responses in their own box on a gridded poster (Ferdinandt, 2018). The use of the Chime In board gets students out of their seats and writing on a non-traditional piece of paper, which will increase their engagement with the task by differing from their normal routine. It will also allow me an instant, visual overview of who wrote what; this will make it easier to gage student progress at a glance.

Naturally, any change to instructional approaches also requires more attention placed on lesson preparation. I will make use of my planning periods more efficiently by minimizing distractions, and spend time at the public library after school several times a week in order to devote the additional time necessary to plan my instruction sufficiently. I will carry out this approach over a 5 week period (due to the fact that my school implements assessments every five weeks), using one of the school assessments as a pre-assessment and the next as my post-assessment. If repeating the study in my own classroom, I would expand this to ten weeks so that I would have a pre-, mid-, and post-assessment of the same style. Implementing a midpoint assessment in this experiment, I feel, would over-test my already tested-out juniors.

Evaluation Of My Efforts

In order to evaluate whether my students have successfully increased their perseverance in solving difficult tasks by identifying necessary skills before beginning work on a problem, I will collect several different types of evidence. Among those included will be video of student groups, pre- and post-assessments that will be graded on a number of criteria, timed observations of students' attempts to solve complex tasks, and some student interviews.

Video of student groups will be used to record students' problem-solving strategies in real time, as well as to monitor the amount of time students spend actively working on a difficult task before giving up. This will be collected using a laptop camera and its built-in microphone. This camera will be positioned sitting on an empty desk in a group of four students who are have been previously observed to be easily discouraged by challenging or unfamiliar problems. The camera will be able to see two of the students fully, and one of the students partially, and the microphone should pick up audio from all four of them. It does not see the rest of the class, particularly any peers that they might get up to consult or who would be a distraction. Cadets at Air Force Academy High School signed a waiver granting the school and its associated parties permission to videotape them, so the policy demands of collecting video in my context will be a non-issue. Observations made from video of students working will help reveal the initial state of perseverance in the classroom by observing how long students truly spend working on the problem, at what points they begin to express frustration, when and if they shut down, and what types of behaviors accompany their "giving up" (such as grumbling, facial expressions, posture, body language, etc. that I might miss in classroom observations). This will then be compared to the post-implementation state in order to find differences in students' approaches to difficult tasks.

Students will also be given pre- and post-assessments consisting of complex tasks. This assessment will be written in the style of SAT questions and will consist of both multiple choice and free response questions. Some of the problems will review prerequisite skills from Algebra I and Algebra II classes that are necessary to understand the current unit's content. The majority of the problems will be based on content and standards being covered in the current unit. Here, that's standards associated with quadratic functions. Finally, approximately 33% of the problems will be questions in a format that students have not seen before, but that they should possess all of the necessary content knowledge and prerequisite skills to be able to figure out. An example of this would be *"The graph of* $y = -x^2$ *is shifted 3 units up and 4 units to the right in the standard* (x, y) *coordinate plane. Which of the following is the equation of the new graph?."* Students have practiced identifying the vertex of a parabola, and writing the equation of a parabola if they are given its vertex. Being able to shift a point in the coordinate plane is a prerequisite skill from Algebra I. Thus, students have all of the necessary skills to complete the problem, they have just not seen questions like this in our in class practice. Both the pre- and post-assessments will be graded for degree of completion and correctness, the goal of the study being to show increases in both metrics. Other observations can also be made from these assessments, such as the prevalence of doodling or other "distracted" behaviors, or monitoring of students' implementations of strategies we teach in class. If problems are difficult to students for reasons other than what I expect (they're thrown off by fractions or large numbers, assessment items are worded in a confusing manner, they completely forget how to do a prerequisite skill such as solving an equation in one variable or using complex numbers, etc.) then I hope my approach could still be implemented to encourage them to persevere on the task, though in these cases it probably would not have a strong impact on the degree of correctness of their work. The simplest arithmetic has made a fool out of each of us at one point or another, and sometimes no amount of perseverance or skill identification can prevent a thoughtless calculation error.

Timed observations of students' attempts to solve complex tasks will serve as a significant piece of evidence collected during my research. At the beginning of the study, students will be given a high cognitive demand problem and I, the observer, will note the time that they begin to work on the problem and the time at which students either finish the task or stop their attempts to solve it. This procedure will be repeated with a comparable problem at the end of the study, and the results will be compared in order to determine whether implementing skill recognition practices increases the amount of time that students spend attempting to work out the problem; more time spent would serve as an indicator of a greater degree of perseverance. Stage and Kloosterman (1991) have found that students in mathematics classes develop beliefs about their ability to do mathematics based in part around their attitude toward time-consuming math problems, and self-confidence in one's ability to solve time-consuming mathematics problems is consistently low. An increase in students' willingness to continue work on time consuming problems will indicate a shift in engagement and attitude toward the mathematics being attempted.

Finally, student interviews will be used to record potential changes in students' attitudes toward solving difficult or complex math tasks. These interviews will be conducted mostly informally, with casual conversation before or after class recorded in a field notebook Questions I will ask could include inquiring how students felt while solving the problem, what was frustrating about it, when and how they decided to give up, and whether they had an idea of what skills they could practice to be better at these types of problems in the future. Based on what they share, I expect to be able to support my claim that not knowing how to approach a problem is a significant reason why students give up on complex or unfamiliar tasks.

Conclusion and Reflection

In my efforts to expand my instructional repertoire, I had hoped to increase students' perseverance in solving difficult or unfamiliar problems by placing increased emphasis on the identification of skills that would be helpful or necessary in solving the unfamiliar problem. This would increase student engagement by providing learners with more confidence in approaching unfamiliar problems, and by increasing time spent engaged in mathematical work. My plan was to accomplish this by placing increased emphasis on daily learning objectives, and by having students develop the practice of listing the skills they may need to complete a problem before they attempt to solve it.

Before beginning the implementation of new teaching practices, I assessed students' strategies in solving unfamiliar problems through the use of an SAT-style practice test, a written assignment on the purposes of various procedures, and a performance task that asked students to apply a previously-learned skill to an unfamiliar type of function. The SAT-style practice test was generated using Academic Approach test preparation software; it consisted of 5 problems that required prerequisite skills learned in Algebra II, 9 problems that were similar or identical to practice problems that had been used in classroom instruction, and 8 problems that were identified as reasonably falling within students' Zone of Proximal Development (ZPD). Development, as used in ZPD, is defined as "a differentiation due to the coming together and reorganization of already existing psychological functions," and the ZPD is a category of tasks that can be completed, with guidance, by reorganizing and expanding the skills that a learner already possesses (Schneuwly, 1994). Test items identified as being reasonably within the class's ZPD were questions that only required skills that students had been explicitly taught in class, but that were phrased in unfamiliar ways or that required application of a prerequisite skill in combination with the skills being taught in the unit. This provided the baseline data by which I would assess student growth and the accomplishment of my research objectives, which can be found in Table 1. Students spent an average of 31.25 minutes working on the pre-assessment.

Table 1: Accuracy of Student Responses on Initial SAT-Style Assessment

Type of Question	Number of Questions	Average Accuracy Rate
Review of Algebra II	5	69.4%
Instructed in Unit	9	34.9%
Zone of Proximal Development	8	17.3%

The written assessment asked students to identify the purposes for completing each of the processes that were being learned in the unit (methods for finding the roots of a quadratic equation; forms of quadratic equations; the zero product property; graphing key features of parabolas) and the information that would be gathered as a result of completing each process. Finally, students completed an exit ticket that asked them to apply information about transformations of quadratic functions, to an unfamiliar absolute value function.

I implemented several practices that I believed would support my goals. The most simple of these was presenting clear learning goals at the beginning of the class and returning to those learning goals frequently throughout the lesson. This often sounded like something along the lines of “Today we’re going to find the x intercepts of a parabola,” at the beginning of the lesson and then, later “...and once we’ve gone through this process, the result we get are the x-intercepts of the parabola we’re looking at.” This differed from my previous teaching practice of presenting the learning goal at the beginning of the lesson but not returning to it throughout the rest of the hour. I believe that this repetition helped students to remember the association between the mathematical processes they were practicing and the goals or skills associated with them; this was supported by students’ increased ability to articulate the mathematical skills that they know how to do. The other practice that was implemented was having students identify the component skills they would need in order to solve complex or multi-step tasks. This frequently looked like the introduction of a problem situation (“Given an equation for the path of a ball thrown through the air, we are going to create a visual representation of its flight”), followed by an exercise in which students identified the skills that they would need in order to complete the problem (finding the initial height of the shooter, determining the highest point the ball will reach, figuring out where it will hit the ground, etc.). Once each skill was identified, students would then set to work on completing each of the component tasks that they needed. The intention behind this practice was to make complex problems more approachable and give students tools to break down what a problem was asking them for and how to get it. This strategy was enhanced by the dedication of one 50-minute lesson to explicitly identifying the purposes of each process we had learned in the unit so far. Students were given the opportunity to practice these skills during daily bell ringers, where they were instructed to write: 1) Known information; 2) Goal of the problem; and 3) Potentially useful skills; before attempting to solve.

After new instructional practices were implemented, progress toward achieving learning goals was measured through the implementation of a similar SAT-style post-assessment, and with a performance task that asked students to apply previously learned information to an unfamiliar problem. Comparative scores from the pre- and post- SAT assessments can be found in Table 2. Students spent an average of 34 minutes working on the post-assessment, which supports my initial hypothesis that using this approach to unfamiliar problems would produce an increase in time spent working on a task. Students’ willingness to work on math tasks for longer periods of time has been shown to correlate with their beliefs about their own ability to do the mathematics (Stage & Kloosterman, 2004), which leads me to believe that students’ ability to identify mathematical skills that they know how to use contributed to their increased amount of time spent actively working on the test.

Table 2: Comparing Accuracy of Responses on Pre- and Post- SAT-Style Assessments

Type of Question	Number of Questions	Accuracy of Responses - Pre	Accuracy of Responses - Post
Review of Algebra II	5	69.4%	65%
Instructed in Unit	9	34.9%	35.2%
Zone of Proximal Development	8	17.3%	20.6%

Before beginning to implement my chosen instructional practices, the majority of students could replicate procedures but could not articulate the purpose of the procedure or the significance of their final product, or connect the information to another representation of the problem (i.e. connect their numerical answer to a graph, or a context). This was revealed by the written assignment implemented before instruction. After several weeks of implementing clear objectives and practicing skill recognition, as well as the 50-minute lesson on the purposes of procedures that had already been learned, students were better able to articulate the purpose of a procedure when asked about it in isolation. However, in the context of multi-step problems they still were largely unable to identify an appropriate procedure to reveal the information they were seeking. They were able to identify what skills might be useful to solve the task as a whole, and they could interpret the end results of each piece once they had completed the computation, but were unable to anticipate which procedure would reveal what information before completing it. A result of this that I was not anticipating was that while students spent more time working on the assigned tasks, this did not necessarily increase the quality of the work being done. Just because students were thinking through necessary skills and spent more time on the problems did not necessarily mean that they were done more accurately; students sometimes spent more time following flawed logical paths and assumptions, leading to errors that were based in fundamental conceptual misunderstandings rather than simple misapplication of or misremembering rules. They also spent more time implementing procedures that did not reveal the information that they wanted, causing them to start over and try a new procedure in hopes of getting the necessary information. This was evidenced by video taken of students working in a group on the post-assessment performance task, during which students identified the procedures they were using, but provided inaccurate justifications for why and where they were applying them. Students were also observed recognizing their mistakes (i.e., “Oh wait, these are the roots. I wanted to put it in vertex form.”) and starting over. While this did reveal more about student thinking and could inform re-teaching and review activities, it did not accomplish the goal of consistently improving student performance on novel tasks. These errors were not rooted in students’ approaches to solving the problem, but instead in misunderstandings of the concepts and their purposes, which would evidence a need for me to be more clear in my teaching in how to decide what procedure to apply in a given situation.

Despite the exacerbation of errors made on the exit slip performance task, students percent accuracy on ZPD problems in the SAT-style assessment did improve by 3.3%, indicating that overall the method was probably more helpful than harmful.

As a result of this experience so far, I can conclude that there is value in teaching students to recognize the ways in which the skills they already have can be applied to solving unfamiliar problems. This approach did lead to increased time spent on problems and an overall (if small) increase in accuracy on unfamiliar problems on SAT-style assessments. The accomplishment of this goal revealed flaws in my original objective, particularly in that increased time spent on a problem would evidence increased engagement but not increased understanding or accuracy. If I were to complete this research again, I would place more emphasis on how much of a complex problem students completed accurately, not the time spent solving it. I would also shift my focus to look less at raw accuracy and more at the types of errors that students were making, as this would be more helpful in informing future teaching. In order to accomplish these new objectives, the assessments I used would probably switch away from SAT-style multiple choice tests and toward fewer, more open-ended free response tasks. I would also eliminate the review questions from the assessment, as they were not actually relevant to the goals of the project. As a whole, in the future I would aim my efforts more toward whether skill recognition helps students to spend more time working in the right direction (i.e. minimizing logical errors, following trains of thought in circles, listing skills without anticipating their products, etc.). This study showed me that while increased time spent working on a problem does show evidence of increased engagement with it and has a positive correlation with student performance on SAT-style tests, work time alone is not sufficient to ensure that students are consistently producing work that is high-quality and accurate.

Works Cited

Douglas, O., Burton, K., & Reese-Durham, N. (2008). The Effects of the Multiple Intelligence Teaching Strategy on the Academic Achievement of Eighth Grade Math Students. Journal of Instructional Psychology, 35(2), 182-187. Retrieved from https://www.questia.com/library/p6137/journal-of-instructional-psychology/i2855623/vol-35-no-2-june.

Ferdinandt, L. (2018, January 31). Getting It Together: Management in the CPS Classroom. Lecture presented at Classroom Management Workshop in CPS Garfield Park Offices, Chicago, IL.

Multiple Abilities Strategy. (n.d.). Retrieved from http://www.sfusdmath.org/multiple-abilities-strategy.html

Schneuwly, B. (1994). Contradiction and Development: Vygotsky and Paedology. *European Journal of Psychology of Education,9*(4), 281-291. Retrieved from http://www.jstor.org.gatekeeper.chipublib.org/stable/23420124

Stage, F., & Kloosterman, P. (1991). Relationships Between Ability, Belief and Achievement in Remedial College Mathematics Classrooms. *Research and Teaching in Developmental Education, 8*(1), 27-36. Retrieved from http://www.jstor.org.gatekeeper.chipublib.org/stable/42801817

Wardlow, L. (2016, August 8). How Technology Can Boost Student Engagement. Retrieved March 27, 2018, from https://www.pearsoned.com/technology-can-boost-student-engagement/