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Developing Essential Learning and Study Skills Among Students in STEM Courses at Higher Education Institutions

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INTRODUCTION

Have you ever gotten frustrated by your students lack of organization in their work?

Have you tried to work with your students on solving “word problems” but became especially frustrated with, or even bewildered over, their lack of progress?

Have you noticed that students sometimes, or often, misinterpret statements basic concepts whose meanings seem obvious to you?

Have you wondered why it seems that even good students’ critical thinking skills sometimes go lacking?

If your answer to one or more of the above questions is yes, then this session is for you. This paper outlines background information and the contents of the session.

BACKGROUND

Over many years, in the process of working to assist minority and/or adult students succeed in the study of mathematics, a myriad of challenges has continued to emerge that present barriers to the effort. Initially it was observed that many students from all backgrounds were often neglecting to employ even the basic skills necessary for success in the classroom, such as taking notes strategically, reviewing often, preparing for exams in a comprehensive manner, and being mindful of not allowing themselves to get stuck
on certain problems on exams, thus allowing time to expire before demonstrating as much of their knowledge as possible on it. Therefore, any effort that was to succeed in developing these students’ academic skills would necessarily have to consider all these challenges and others.

As the effort to promote students’ academic development programmatically continued to progress there was a need to probe further into students’ deficiencies to bring them to a level of performance which would allow them to compete successfully in the higher levels of the study of mathematics and science. Attention to concerns such as a lack of sufficient attention to detail and preciseness in their work, failure to recognize crucial concepts, communication skills deficiencies, struggles with the language of mathematics and science, lack of development with critical thinking skills, and inadequate problem-solving skills became crucial. Therefore, these crucial factors were attended to programmatically as well. They were considered and partially addressed in all classroom activities and out-of-classroom efforts. However, it was determined that a more intrusive and direct strategy was needed to ensure that students’ skills and abilities were brought to a level that was in line with academic success in the mathematics and/or science classroom, especially as they proceeded to higher levels of study in the respective disciplines.

**THE PROCESS**

After many years of systematic, yet informal, attention to the above challenges and concerns, there was a desire to aggressively address them through the implementation of a specifically designed strategy to meet the challenge. As a result, the following in-class student engagement strategy was developed and implemented in certain foundational math classes, with the eventual implementation in selected sections of Penfield College’s “orientation course” or first-year experience course. Attention is now being directed at possibly implementing it in certain other entry level courses. The bottom line is that the process is highly suitable for courses at any level and practically any discipline. The key question is “how do you get the best bang for your buck”?

There were four specific goals, or anticipated student learning outcomes, that guided the development of the strategy that emerged:

- Students will grow substantially in their ability to correctly apply critical thinking and problem-solving techniques to problem situations and typical mathematics homework exercises/problems.
• Students will develop in their ability to communicate effectively as they engage in problem solving explorations, whether in groups or alone. This is to include the communication that’s necessary to sort out the elements of problems, as well as that which is needed to explain their solutions.

• Students will gain a more in-depth understanding of, and appreciation for, the strategies that should be employed, and habits that they should develop, to successfully learn mathematics and perform up to the level of their capabilities in their math courses.

• Students will become more mature mathematics students and more mature students generally. In the process they will become better able to direct their own learning and adjust to circumstances at hand as they move from course to course in their studies.

**IN-CLASS PROCEDURE**

The specific strategy that was eventually developed, with the above anticipated student learning outcomes in mind, is explained below. During this conference session the process will be demonstrated among those in attendance, and the dynamics involved will be explored.

1. Students in the class are placed in groups of three to have them work cooperatively to arrive at solutions to novel problems.

2. All students are given the same problem to solve, and the groups are instructed to indicate that they have arrived at an agreed upon solution as soon as they have accomplished that feat. Furthermore, they were instructed to evaluate their solutions for accuracy, and to make sure that they arrive at a consensus, even if one or more of them might not initially be in complete agreement.

3. The first group to indicate that it has arrived at a “tentative solution” presents the method(s) used to arrive at it, and others are to listen carefully to detect any flaws/inaccuracies in the presentation and/or solution.
4. After a sometimes-extensive discussion about the solution to a problem, and once it was agreed upon by the entire class, each group further refines it if necessary, and a preliminary write-up of it.

5. All students are then instructed to write up their individual solutions and submit them within a few days of the class meeting. The solutions are then graded and returned to students with feedback, including suggestions for future efforts.

   In more than a few instances extensive discussions followed the presentation of solutions, as students sometimes disagreed among themselves about specific content and/or solution strategies involved. Therefore, it is necessary to be prepared to engage students in an examination of the specifics of the problems and concepts involved. There is always a concern for how to guide the discussions without discouraging students while simultaneously maintaining academic honesty.

   Among the considerations to be made, as conference session participants look to the possibility of implementing this strategy in their departments/other units is the need for adequate professional development among potential instructors. For example, many mathematics instructors are not accustomed to closely tuning in to students’ communication skills levels, nor the technique of critiquing students’ work in a questioning and thought-provoking manner. Therefore, inducing a disposition toward considering these aspects of the process involved must be carefully considered in any professional development effort.

**PROBLEM EXAMPLES & DISCUSSION**

1. **Kinney Goes to Work**

   *When Kinney travels to work he either rides his bike or walks. If he rides to work and then walks back (or vice versa) the round trip takes one hour. If he were to ride both ways the trip takes 30 minutes. How long would the round trip take if he walks both ways?*

   Several aspects of this problem are academically enhancing. *First, the solution is dependent on students sorting out the information, reflecting on it, and then constructing a solution based on logical conclusions.*
Secondly, it is necessary to focus on the overall essence of the problem, and implications from the statements in the problem, to arrive at a solution rather than only focusing on getting the final answer itself. For example, the fact that it takes Kinney 30 minutes to ride both ways implies that it takes him 15 minutes to ride one way, but it is easy for students to overlook this fact, though it’s crucial to arriving at a solution to the problem. (Note: Obviously the potential for different driving conditions going to and from work in this problem, such as the difference in topographical features, is ignored in solving this problem.)

Thirdly, to provide a solution to the problem one must explain in words how the solution was obtained rather than just write out a series of mathematical statements or solve an equation. This in turn demands serious thought about the problem and a concerted effort to organize those thoughts in a coherent and clear manner, something that’s applicable to the study and learning process within any discipline, not just those in the STEM areas of study.

2. A Day at the Amusement Park

Seventy-five children went to an amusement park where they could ride on a merry-go-round, a roller coaster, or a Ferris Wheel. Fifty-five of the children took at least two of the three rides, and 20 of these took all three rides. Each ride cost 50c and the total amount spent on the rides was $70.00. Determine the number of children who did not try any of the rides.

The first thing that stands out about solving this problem is that the those who are to solve it would necessarily need to determine that “at least two” (of 55) in reality means that either two rides were take or three rides were taken. Once that observation is made, the fact that 20 of these took all three rides implies that the other 35 must have taken two rides. From that point doing the needed calculations is fairly routine. However, experience has shown that getting to that point is a definite challenge for many students, but experiencing the challenge of doing so is certainly worthwhile, and provides one more piece in the foundation for further critical thinking/problem-solving engagements. Note that this situation is just as much a matter of communication (or grammatical recognition) as it is of mathematical recognition, perhaps even more so.