Applying the Tower of Hanoi to Pre-assess Planning and Goal Setting Skills in High School Students

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Abstract: This teaching technique applies the Tower of Hanoi as a tool to pre-assess students on the skills of planning and goal setting. Objectives: By the end of the lesson, the students will be able to determine their personal strengths and weaknesses of planning and goal setting skills and develop a plan that uses eight elements of planning and goal setting for a health concern. Primary Audience: High school students.

Key words: health education, teaching strategies, planning, goal setting, Tower of Hanoi, Tower of London, high school lesson, pre-assessment

1. Introduction

The Tower of Hanoi is a game that was originally designed by a French Mathematician, Edouard Lucas in 1883. This problem solving game consists of eight disks (with a hole in the middle) stacked (largest to smallest) on one of three large pegs. The object of the game is to move all of the disks to another peg following a specific set of rules (Hofstadter, 1985). The Tower of Hanoi can be applied as a pre-assessment tool for planning and goal setting skills to reduce a few challenges. The challenges that teachers face in assessing planning and goal setting skills include students reporting outcomes with honesty, the length of time it takes to set a goal and complete a plan, and assessing whether students are effectively applying planning skills on their own. Assessing planning skills are difficult in the classroom as students will often follow the directions of the activity and inherently practice the skill of planning and goal setting appropriately. A common practice assessment for planning and goal setting skills may include a project-based assignment that includes the elements of planning and goal setting. By using project-based assessments that necessitate the implementation of each element of the skill in order to complete the assignment, it is difficult to determine if students were completing the appropriate elements of planning and goal setting because they were aware that the assignment included each element as a requirement. It is also difficult to determine if the student transfers these skills to their own life experiences. However, if the students were given a problem to solve (such as the Tower of Hanoi) that required planning and goal-setting, and they were unaware that the teacher was using it as a tool to assess whether or not the students would apply the necessary elements, then the teacher (and student) would better understand their strengths and weakness of
applying the skills. Following a pre-assessment of the skill, the students should be encouraged to practice the elements of the skills with attention to areas of weakness.

A number of researchers have already looked into the effects of preplanning through individuals’ performance on the Tower of London (TOL) task. The TOL task that resembles the Tower of Hanoi, requires participants to perform a number of strategic moves in order to arrange a set of disks and reach a desired outcome (Kaller, Rahm, Köstering, & Unterrainer, 2011). The findings of this research support the idea that the Tower of Hanoi can also be used to assess an individual’s planning behavior.

Research has supported the idea that planning improves performance and the likelihood of goal attainment in ordinary tasks such as running an errand. Normally a small task, such as picking up bread on your way home from work, could easily be forgotten. However, individuals who make an exact plan as to when and how to complete the task are more likely to do so (Aarts, Dijksterhuis, & Midden, 1999).

Studies completed with the TOL are consistent with the research of Aarts et al. (1999) as well. Luciana, Collins, Olson, and Schissel (2009) tracked planning time and average moves made to complete the TOL among participants 9–20 years old. They found that participants that spent more time planning before attempting the TOL were able to do it in fewer moves, regardless of age. They also noted that as participant age increased through adolescence, the amount of time spent planning increased; implying that planning skills mature with age.

While the current research does make a positive correlation between time spent planning and accuracy completing the TOL, there are noteworthy limitations. For example, increased planning time could be a result of student confusion, and decreased planning time may be a sign of higher processing speed (Luciana et al., 2009). Since processing speed and possible confusion have not been accounted for in most studies, it might seem that the TOL is an unreliable tool to judge a student’s planning skills. However, if teachers observe each student closely during the planning stages of the TOL or Tower of Hanoi task, they would be able to record the steps that each student took and identify areas of strength or weakness in the skill of planning. This information allows teachers to pre-assess the skill of planning and goal setting (technique, motivation, application, etc.) in order to prepare an appropriate lesson that meets the needs of each student.

If setting a goal and planning out the steps to achieve the goal make it more likely to obtain a desired outcome, there is no question that the ability to set a goal and make a plan to achieve the goal are valuable skills. With students 11–17 years old showing varying abilities in the skill of planning, middle to high school students are ideal ages to focus on refining the skill. By asking students to think critically about tasks that require planning to be successful; such as the Tower of Hanoi or Tower of London, teachers are able to determine the strengths and weaknesses of the students (Luciana et al., 2009).

### 2. Teaching Method

#### 2.1 Objectives

As a result of this pre-assessment, students will be able to:

- Determine strengths and weaknesses of their own planning and goal setting skills (based on a pre-assessment).
- Develop a plan using 8 elements of planning and goal setting for a health concern with attention to areas of weakness (based on the pre-assessment).
2.2 National Health Education Standards: Performance Indicators

(1) Health Education Standard 6: Students will demonstrate the ability to use goal-setting skills to enhance health.

Rationale: Goal-setting skills are essential to help students identify, adopt, and maintain healthy behaviors. This standard includes the critical steps that are needed to achieve both short-term and long-term health goals. These skills make it possible for individuals to have aspirations and plan for the future.

(2) Performance Indicator: 6.12.1 – Assess personal health practices and overall health status.

(Joint Committee on National Health Education Standards, American Cancer Society, p. 34).

2.3 Materials and Resources

- A desk, chair, writing utensil, and a sheet of paper for each student
- Each desk has dividers or anything that provides private individual working spaces
- Worksheet (Figure 1)
- Homework (Figure 2)

2.4 Primary Audience

This teaching technique is designed for middle school or high school students.

3. Teaching Procedure

Pre-Activity Preparation: The teacher will arrange the desks for a testing environment (students are unable to see each other’s work). Copies of Figure 1 and 2 will be made for each student in the class. Also, a copy of figure one and a quarter, nickel, penny, and a dime will be sitting on the teacher’s desk.

3.1 Step One

Once the students find their seats, the teacher will read the following rules:

- You will be given a set of instructions for a task that must be completed on your own.
- Follow the directions carefully.
- You have 40 minutes to complete this task.
- Once you have read the directions and are confident that you can complete the task successfully, raise your hand and the teacher will call you up to the front desk and evaluate your attempt at the task. At that time, you will have only one opportunity to demonstrate your answer to the teacher (without starting over).
- Do not raise your hand to complete the task, until you believe that you are ready.
- Once you are finished, you may begin to work on your homework assignment.
- If you have a question, raise your hand and wait until the teacher approaches you before asking the question.

3.2 Step Two

The teacher will pass out the worksheet (Figure 1) and tell the students to begin. The task describes the Tower of Hanoi game; modified (using coins and circles instead of disks and pegs) for convenience. The students have one opportunity to demonstrate to the teacher that they are able to move all four coins to a different circle by only moving one coin at a time and never placing a larger coin on top of a smaller coin. The students are told that they must try to complete the task in the least number of moves. They are also told that 15 moves are the least number of moves possible for this activity. Some of the students will individually ask if they may use coins in
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their pocket or tear up paper to represent the coins to practice the activity. The teacher should allow the student to use ideas that they come up with to practice the activity. It is important that the students receive the response from the teacher individually (the question should not be answered out loud to all of the students). Assessing whether or not students identify resources to help them create a plan is determined by this action.

3.3 Step Three

It is also important that the assessment of planning and goal setting skills are not announced to the students. If the skills are announced, then the teacher will be less likely to receive a true assessment of whether or not the student would attempt to apply the skills on their own. The teacher will notice that some students will raise their hand to complete the task in the first 5 minutes and attempt the task with no planning. Other students may attempt to practice the activity at their desk by tearing off paper or writing something down before they complete the task. The most successful students will set a goal of 15 moves on their paper. They will also create a symbol or number for each move that they plan to make during the final task. These students will not raise their hands to complete the task until they have identified the exact plan of action.

3.4 Step Four

After each student who attempts the task, the teacher will count the number of times a coin is moved and record it. The student will pick up a homework sheet (Figure 2) and begin to work on it at their desk while they wait for other students to finish the task.

4. Discussion

Once every student has completed the task and completed the homework assignment (this may be the next day of class), the teacher will go over the intentions of the task and use the homework assignment to begin the following discussion:

• What did you do to plan for the task?

The teacher will list the following 8 elements (steps/stages) of planning and goal setting as they are mentioned. After the discussion, the teacher will list the remaining elements: For the students that developed a plan, the teacher will also list their examples.

(1) Determine the goal: Move all of the coins (following the rules) in only 15 moves
(2) Develop a template to guide the plan toward the goal: Numbered the paper 1–15
(3) Identify all the necessary components: Created a symbol to represent each coin, or tear up paper to represent the coins.
(4) Brainstorm ideas to identify possibilities/options: Played around with the moves to identify the most effective approach.
(5) Plan a schedule: Created a list of moves for each number of attempts
(6) Make adjustments until all necessary components are included in the schedule: If the schedule did not fit the goal (15 moves) then the schedule was altered until it met the goal.
(7) Assign responsibilities: Every move (15) was accounted for, and a list of exact moves was identified.
(8) Recognize when the plan is complete: The students did not stop planning until they were confident that the plan was going to meet the goal.

• What was the first thing that you decided to do once you became aware of the task?
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The students, who did not create a plan, will wonder why you did not tell them to create a plan, or will say that they did not know that they were supposed to make a plan. It is important to discuss the purpose of the task. The students should be able to relate this activity to other areas of their lives. Additional questions to ask these students:

- What other areas of your life do you think that you do not plan because you did not think to plan?
- What are areas of your health that you might not realize that you have no plan or goal?
- How did you feel at the beginning (once you received the rules to the task)?

Some students will identify stressful emotions and other students might have been excited that the task was not based on knowledge or information. Additional discussion items:

- The level of stress will decrease if you have direction and a plan of action.
- Once you start to feel stress, recognize that it is a sign that you may need to develop a plan.
- How much time did you spend deciding what you should do?
  Compare the students who took the time to plan with the students who did not.
- What was your goal (and why)?

Some students did not have a goal. It is important for these students to recognize that they may not be creating enough goals in other areas of their life.

Some students may have had a goal to finish the activity as soon as possible. They may have also felt excited because they believed that they accomplished their goal by not forming a plan and attempting the task with the teacher very early. It is important for these students to realize that patience and organization is a part of planning. An area for improvement for these students would include learning how to invest time in preparation and work on being thorough with attention to details. They should also try to examine other areas in their lives where they take a competitive approach rather than the most effective approach. **Weakness**: They didn’t think to create a goal or plan.

Some students may have had a goal to complete the task in 15 moves and raised their hand once they were able to practice it on their own. However, once they completed the task with the teacher, they were unable to repeat the results effectively.

It is important for these students to recognize that having an effective plan includes being able to predict the end result with the highest possible level of certainty. These students should examine areas in their lives where they plan part of their goal and hope for the best in the end. **Weakness**: They stopped the plan after the fourth element. They need to work on completing the remaining elements.

For the students who wrote down every move before attempting the task, they already knew that the end result would reach their goal. These students should recognize their strengths in planning and goal setting skills. They should also be encouraged to identify areas where they can apply these skills to improve their health.

- What barriers did you notice?

Some students may be confused with the question because they don’t understand what is meant by “barrier”. Describe a barrier as elements that made the task difficult or possibly made the student want to quit or give up at some point.

- Examples of barriers for this task:
  - Not being able to ask anyone for help
  - Time limits (end of class)
  - Not having the coins to practice the moves

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- What did you do to overcome the barriers?
  Describe the importance of recognizing barriers and trying to strategically plan to overcome the barriers rather than letting them lead to frustration or giving up. Some students created coins by tearing up paper or wrote down a list of moves they plan to make during the task with the teacher.
  - Discuss the types of questions students individually asked and what students used to help them.
  - Discuss the importance of being resourceful and thinking about options.
- How did you feel once you found out how many moves you made?
  - For students who planned effectively, they would have felt confident before the moves were made at the teacher’s desk.
  - For students who were disappointed, they would recognize that they don’t need to be disappointed, surprised, or hoping if they take the time to plan thoroughly.
- How can you relate your actions during this activity to your life to improve your ability to plan and goal set?
  It is important for students to examine their approach to this task and identify areas in their life where they do effectively plan and areas where they could do more to plan. The teacher will request the following information to be submitted in the students journal:
    (a) List 3 goals that would enhance your overall health status if you started a plan.
    (b) Using the 8 elements listed above, plan for one of the goals (identified above) to enhance a health area in your life.

5. Assessment Procedures and Evaluation Rubric

The Tower of Hanoi would be used as a tool to allow the teacher to pre-assess the student’s strengths and weaknesses of planning and goal setting skills. While the students were completing the Tower of Hanoi, the teacher would record the following information for each student:
  - Did the student create a goal and a plan?
  - How much time did the student spend planning before they attempted the task?
  - Was the student resourceful (did they ask to use coins or tear up paper for coins)?
  - Did the student identify every move before they decided to complete the task?
  - Record the number of coin moves the student completed during the evaluated task.

The teacher will also use the responses to the homework assignment (Figure 2) to guide the students through the discussion and help them identify their personal strengths and weaknesses. The 8 elements of planning and goal setting will be identified during the discussion and students should be able to identify the specific elements that they need to work on; based on the steps that they did not take during the pre-assessment.
  - The teacher is encouraged to examine and address any differences in the information that was recorded by the teacher during class to the information that the student wrote down in response to the homework assignment.

The teacher will read the journal entries of each student to determine the students’ interpretations of their strengths/weakness and measure their ability to apply the elements of planning and goal-setting to increase a health practice.

References
Aarts H., Dijksterhuis A. and Midden C. (1999). “To plan or not to plan? Goal achievement or interrupting the performance of
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Appendix

Figure 1  Worksheet

Name:_____________________________________    Date:______________

Directions:
At the teacher’s desk you will see a stack of four coins and three circles. The coins will be stacked in a specific order according to size (Quarter on the bottom, nickel, penny, and a dime on top). When you are ready to complete your task, raise your hand and the teacher will call you up to the desk. You will be evaluated on your ability to move the coins from the original circle to another circle following the set of rules below. You will only have one opportunity to complete the task; therefore do not complete the task with the teacher until you think you are ready to begin. Once you complete the task, you will be handed a homework assignment that you may begin in class if you finish before other students.

Objective of the task:
To have all four coins in the same order (quarter (bottom), nickel, penny, and dime (on top)) in a different circle. Each coin will be moved one at a time and the number of moves will be recorded by the teacher. It is your job to complete the task in the least number of moves. The least number of moves possible is 15.

Rules for the task:
1. Only move one coin at a time (the coin on top of any stack or the only coin in a circle).
2. Coins can be moved into any circle (including the starting circle).
3. When moving the coins, they must be stacked (for example: you cannot have two or more coins side by side in a circle).
4. Never place a larger coin on top of a smaller coin (note the size; disregard the value).

Hint: To begin, the only possible move is to transfer the dime into one of the other circles.
Figure 2  Homework

Name: ___________________________ Date: ___________________________

1. Have you ever done this task before this class?

2. What questions did you have after reading the directions for the task?

3. What was the first thing that you decided to do once you understood the task?

4. Rate your level of stress:  (1 = no stress – 10 extremely stressed)

5. How much time did you spend deciding what you should do?

6. What was your goal (and why)?

7. Was it important for you to achieve the highest score on this task (15 moves)?

8. Were you concerned with the amount of time you were spending on the task?

9. Did you feel frustrated at any time during the task (describe)?

10. What barriers did you notice?

11. What did you do to overcome the barriers?

12. How did you feel once you found out how many moves you made during the final attempt?

13. What would you have done differently if you could do it all over?

14. How can you relate your actions during this activity to your life to improve your ability to plan and goal set?