



ENHANCING STUDENT LEARNING WITH SELF-DIRECTED TUTORIALS IN A FRESHMAN LEVEL ENGINEERING TECHNOLOGY COURSE

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Abstract:

Educators are often constrained by time and resources in their efforts to have breadth and depth in their teachings. One way to get around time and resource limitations of in class education is to provide additional materials. These materials can expand on the information provided by lecture notes, course book and in-class examples. This becomes especially important if the class is designed to teach students a new skill set, i.e. a computer software, drafting, simulation, use of a certain tool or equipment. When designing a course to introduce new skills with new materials, cognitive learning by students should be considered. That is, during the learning process, students' cognitive learning must be maximized. This paper will provide a detailed look into adoption of Bloom's Revised Taxonomy in designing and developing tutorial modules, and will provide the development of continuum from first tutorial module to last tutorial module how knowledge dimension evolved from factual knowledge to metacognitive knowledge. In addition to the design of the modules, the implementation process will be discussed in detail.

Introduction:

This study describes design and development of a set of tutorials for a freshman level Computer Programming and Applications course in the Mechanical Engineering Technology department at a State College. The Computer Programming and Applications course teaches students how to use excel and specifically how to program in excel in the context of engineering requirements. During lectures and lab sessions, the instructor covers theory and practical applications, and students are responsible to review the material that was covered in the class and submit their homework assignments. The excel applications covered generally involve multiple complex functions applied in a certain sequence. Even after the examples covered during classes, students can still struggle to remember the steps, the functions, and the order of their applications. In an effort to provide students additional study materials, a set of tutorials designed and developed. The tutorials are designed to follow Bloom's Revised Taxonomy where the six stages of cognitive process dimension (Remember, Understand, Apply, Analyze, Evaluate, and Create) are set as a step in each tutorial whereas, the knowledge dimensions are set as Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge. The original taxonomy was developed by Bloom in 1956 and the revision of the taxonomy was developed in 2001^[1].

Many educators aimed to create learning models to support and supplement their students learning experience. Especially for the courses that require some programming as part of their

material, ability to support the learning process became very important. Some educators developed online practice tools^[2], whereas some developed tutorials that are completed in small groups^[3]. In an effort to make tutorials more interesting and engaging to the students, some educators took the action of “gamifying” their tutorials^[4] to make them more interesting and appealing to the students; showing that a tutorial must be engaging, informative and supportive to the student’s learning process. In an effort to promote learning and focus on students’ cognitive learning process more in depth; many educators implemented Bloom’s Taxonomy into their classroom materials. Bloom’s Taxonomy is used to connect cognitive domain as students learn theory, procedure and practice^[5]. Bloom’s Revised Taxonomy is also used in teaching business plan development, especially in measuring the learning outcomes of business plan development^[6]. Bloom’s Revised Taxonomy of educational objectives is also used in educational business games^[7]. Bloom’s Taxonomy measures the cognitive process dimension and how cognitive process dimensions are met throughout a learning process through a cognitive process dimension as shown in Table 1.

Table 1. The Cognitive Process Dimension^[1]

| The Knowledge Dimension | 1. Remember | 2. Understand | 3. Apply | 4. Analyze | 5. Evaluate | 6. Create |
|-----------------------------------|--------------------|----------------------|-----------------|-------------------|--------------------|------------------|
| A. Factual Knowledge | | | | | | |
| B. Conceptual Knowledge | | | | | | |
| C. Procedural Knowledge | | | | | | |
| D. Metacognitive Knowledge | | | | | | |

In this study Bloom’s Revised taxonomy will be used as a guideline in developing tutorials to be implemented in the Computer Programming and Applications course. With the implementation of Bloom’s Revised Taxonomy as a framework it is hoped to develop tutorials that are continuous not only within each tutorial but also throughout the semester.

Overview of Implementation Process

Tutorials are developed to be implemented in the MET 109 – Computer Programming and Applications course in a Mechanical Engineering Technology Department in a State College. This 2 credit freshman level course meets once a week for 50 minutes for lecture, and 1 hour 40 minutes for the lab portion. In the lecture portion of the course students are introduced to the excel program fundamentals such as; how to build excel tables, graphs, how to write, modify and edit excel functions, if and nested if functions, integrals and creating macros. During the lab portion of the class, students are provided with in-class examples where they can practice the material they learnt during the lecture portion of the course. Even though a good amount of examples are covered during the lecture and lab, in an effort to provide students with additional practice materials, a set of tutorials are developed to be implemented in the Spring 2014 semester.

Every week a new tutorial will be made available to the students. Tutorials are designed to accompany homework assignments, where it is recommended that students complete the tutorial prior to their homework assignments. This way, in addition to their class notes, textbook and in-class examples, they will receive a step-by-step overview of the material. The tutorials will help students gain more practice, answer any questions they might have related to the material, and more importantly serve as a roadmap on how-to complete certain programming tasks in excel.

Tutorials will follow Revised Bloom's Taxonomy framework, and provide students with 6 steps of learning: Remember, Understand, Apply, Analyze, Evaluate and Create^[1]. As students follow the tutorial and complete these six steps they will refresh their memories on the material covered in the class and by completing the exercises provided within each tutorial, they will strengthen their knowledge and understanding of the material. All the tutorials are developed following the same six steps provided in the Revised Bloom's Taxonomy format^[1]. In an effort to demonstrate the tutorial development process, AND/OR Statement Tutorial steps are explained in this paper.

Development of Tutorials

A set of tutorials are developed to supplement the learning in the Computer Programming and Applications course. A list of tutorials is shown in Table 2 below:

Table 2. Developed tutorials

| Number | Tutorial Name | Number | Tutorial Name |
|--------|---------------------------------|--------|----------------------------|
| 1 | Introduction to Excel Functions | 6 | Sorting Data |
| 2 | Editing in Excel | 7 | Unit Conversion in Excel |
| 3 | And/Or Statements | 8 | Solving Equations in Excel |
| 4 | IF Statements | 9 | Fitting Equations |
| 5 | Creating Histograms | 10 | Creating Macros |

In an effort to provide an overview of how each tutorial is developed an example tutorial is examined and explained in this paper. Tutorial three – AND/OR Statements are selected to be examined. All other tutorials follow the same framework of Revised Bloom’s Taxonomy.

Step 1: Remember: In this step of the tutorial students are provided with a template that aims to refresh their memory on AND/OR statements. This first step is more conceptual and provides an overview on the outcomes of combinations of AND/OR statements. Step 1 is more focused on students remembering the AND/OR statements and outcomes of AND/OR logic independent from the Excel component. This step aims to strengthen students factual knowledge. Figure 1 shows examples of AND/OR statements and outcomes of AND/OR statements provided in this tutorial.

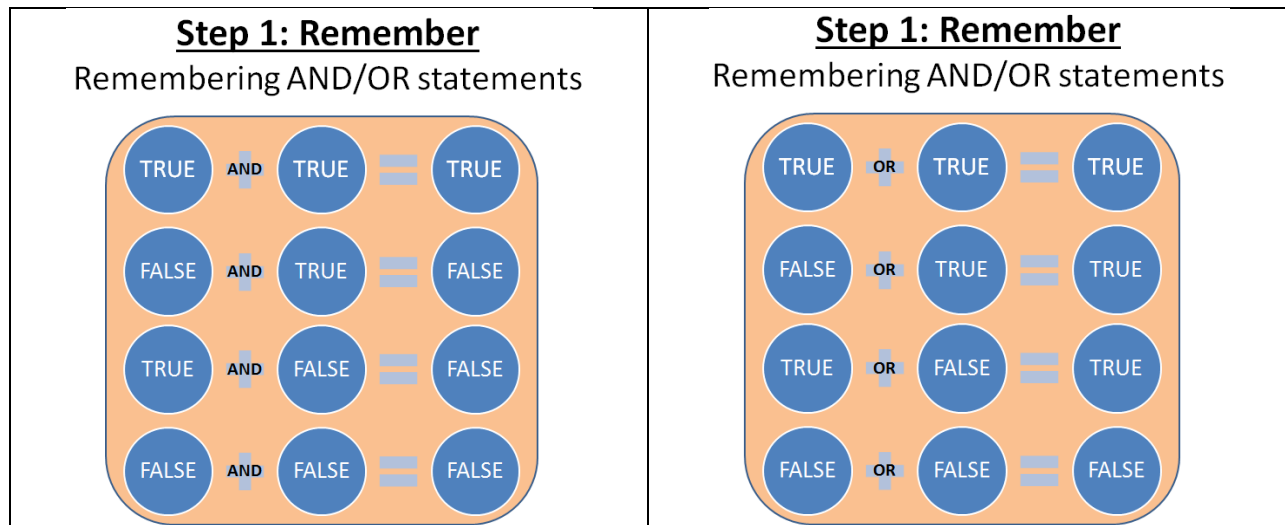


Figure 1. Step 1 – Remember: An Overview of AND/OR statements

Step 2: Understand: In the second step students are provided with an exercise that will help them understand the concept of AND/OR statements more in depth. This step will provide a fill-in-the-blanks style exercise to help students practice and strengthen their understanding of the concept. This step aims to strengthen students' conceptual knowledge. Figure 2 shows an overview of these exercises for this tutorial.

Step 2: Understand

Fill in the blanks for AND/OR statements

| | | | | |
|-------|-----|-------|---|-------|
| TRUE | AND | TRUE | = | ● |
| FALSE | OR | ● | = | FALSE |
| TRUE | AND | ● | = | FALSE |
| TRUE | OR | FALSE | = | ● |

Step 2: Understand

Fill in the blanks for AND/OR statements

| | | | | |
|-------|-----|-------|---|-------|
| TRUE | OR | TRUE | = | ● |
| FALSE | AND | ● | = | FALSE |
| TRUE | OR | ● | = | FALSE |
| TRUE | AND | FALSE | = | ● |

Figure 2. Step 2 – Understand: AND/OR Statement Exercises

Step 3: Apply: In this step of the tutorial, students are provided with AND/OR statement functions in excel, and given an overview of how to write the functions in excel, followed by examples on AND/OR statements in excel. At this stage students combine their knowledge of AND/OR statements and apply them in Excel program. This step serves as a transition step between the knowledge of the material to application of the material using the software, and aims to strengthen students' procedural knowledge. Figure 3 provides an overview of the examples.

Step 3: Apply

AND/OR Statements in Excel

Step 3: Apply

AND/OR Statement in Excel

Scores for a test is given below. Identify the names of the applicants that meet **either one** of the conditions.

- Condition 1: Took the exam in NY
- Condition 2: Scored 80 or higher

OR

| 1 | A | B | C | D | E |
|---|------|-------|-------|----------------------|---|
| | NAME | STATE | SCORE | OUTCOME | |
| 2 | A | NJ | 75 | =OR(B2="NY", C2>=80) | |
| 3 | B | NJ | 80 | | |
| 4 | C | NY | 65 | | |
| 5 | D | NY | 85 | | |
| 6 | E | NY | 90 | | |

Step 3: Apply

AND/OR Statement in Excel

Scores for a test is given below. Identify the names of the applicants that meet **both** of the conditions.

- Condition 1: Took the exam in NY
- Condition 2: Scored 80 or higher

AND

| 1 | A | B | C | D | E |
|---|------|-------|-------|-----------------------|---|
| | NAME | STATE | SCORE | OUTCOME | |
| 2 | A | NJ | 75 | =AND(B2="NY", C2>=80) | |
| 3 | B | NJ | 80 | | |
| 4 | C | NY | 65 | | |
| 5 | D | NY | 85 | | |
| 6 | E | NY | 90 | | |

Figure 3. Step 3 – Apply: AND/OR Statement Examples

Step 4: Analyze: In this step students are provided with questions to analyze the outcomes of the exercise they completed in the previous step. The analysis step helps students understand the outcomes of the exercise more in depth and aims to strengthen their metacognitive knowledge. Figure 4.a provides an example of the analysis component from the tutorial.

| Step 4: Analyze | | | | | | |
|--|------|-------|-------|---------|---|---------------------|
| Compare the outcomes of AND/OR Statement Example | | | | | | |
| 1 | A | B | C | D | | |
| 2 | NAME | STATE | SCORE | OUTCOME | | |
| 3 | A | NJ | 75 | FALSE | | |
| 4 | B | NJ | 80 | TRUE | → | OR Statement |
| 5 | C | NY | 65 | TRUE | | |
| 6 | D | NY | 85 | TRUE | | |
| 7 | E | NY | 90 | TRUE | | |

| Step 5: Evaluate | | | | |
|--|--|--|--|--|
| Comment on the Outcomes of the AND/OR Statements | | | | |
| <ul style="list-style-type: none"> • Evaluate the outcomes of the AND/OR statements • What are the differences between AND/OR Statement results? | | | | |

Figure 4. Step 4a – Analyze: Comparison of AND/OR Statement results, Step4b – Evaluate: Comment on Outcomes of the AND/OR Statements

Step 5: Evaluate: In this step of the tutorial students are asked to evaluate the outcomes of the AND/OR statements through a series of questions. This step is more open ended and requires a higher understanding of the concept and practice, therefore aims to strengthen students metacognitive knowledge. Figure 4b shows an example of the evaluation questions in the tutorial.

Step 6: Create: In the final step of the tutorials, students are asked to create their own exercise based on the tutorial exercise they completed. This component of the tutorial helps students to strengthen the theory and application of the concept thus, increasing their metacognitive knowledge.

The implementation of revised taxonomy in Computer Programming and Applications course is shown as in Table 3 below.

Table 3. Tutorial-based learning and the Knowledge Dimension Relationship

| The Knowledge Dimension | 1. Remember | 2. Understand | 3. Apply | 4. Analyze | 5. Evaluate | 6. Create |
|----------------------------|-------------|---------------|----------|------------|-------------|-----------|
| A. Factual Knowledge | ✕ | ✕ | | | | |
| B. Conceptual Knowledge | | ✕ | ✕ | | | |
| C. Procedural Knowledge | | | ✕ | ✕ | | |
| D. Metacognitive Knowledge | | | | ✕ | ✕ | ✕ |

The cognitive process dimensions are met as each step of the tutorial completed. The factual knowledge dimension is highlighted in the first two steps of the tutorial which are Remember and Understand. In these steps students will recall and confirm their factual knowledge on the information related to the concept they are learning. The conceptual knowledge dimension is met in the second and third steps of the tutorial. In the second and third steps of the tutorial students will apply the concept they learnt, therefore meeting the conceptual knowledge goals. The procedural knowledge dimension is highlighted at the apply and analyze steps where students will gain more confidence in the procedural development of the application procedure and the concept they are learning. Finally, the metacognitive knowledge dimension is highlighted at the analyze, evaluate and create steps, where students will have knowledge and experience in the concept and procedure to create their own examples and to evaluate the outcomes of previous examples.

Conclusion and Future Work

This paper provided an overview of how the tutorials are created based on Revised Bloom's Taxonomy. The tutorials are developed to guide students, strengthen their knowledge on the materials covered in the class as well as to provide them a roadmap on excel functions. Revised Bloom's Taxonomy provided a great framework to develop the components of the tutorial in relation to the knowledge students are expected to gain at each step of the tutorial. The next step of this project will involve the implementation of these tutorials during Spring 2014 semester in the Computer Programming and Applications course and to collect student response and feedback on the implementation process and on the tutorials. In an effort to effectively measure

students' learning outcomes a pre experience and a post experience survey will be provided to the students. The collected outcomes will be used to improve the content of the tutorials as well as the implementation process of the tutorials for the future semesters.

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