Self-regulated learning in engineering labs

Presentacion Rivera
University of Nebraska-Lincoln, privera@unl.edu

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Abstract for DBER Group Discussion on 2017-02-09

Authors and Affiliations:
Presentacion Rivera
Postdoctoral Researcher
Department of Electrical and Computer Engineering
University of Nebraska-Lincoln

Title
Self-regulated learning in engineering labs

Abstract
Students’ task interpretation is a critical first step in the process of self-regulated learning and a key determinant in students setting their learning goals and selecting strategies to approach assigned work. Laboratory activities improve students’ conceptual understanding because of the cognitive demand when students integrate laboratory activities and theory. The purpose of this study is to investigate how students’ interpretation of the task assigned during laboratory work may change during the task process, and how it is related to their conceptual understanding. One-hundred and forty-three students enrolled in the course of Electronics participated in this study. Instruments used to measure task interpretation and conceptual understanding were created, piloted, and applied before and after selected laboratory activities during the semester. Findings suggest students’ task interpretation change during the task process, increasing after the completion of laboratory activity but still showing low levels of task interpretation. Findings confirm previous research stating that students generally have an incomplete understanding of the assigned tasks, and students struggle to establish a connection between laboratory activities and theory. Lastly, this study reports a significant relationship between students’ task interpretation and conceptual understanding in laboratory work.
Students’ Task Interpretation and Conceptual Understanding in Electronics Laboratory Work

by

Presentacion Rivera-Reyes

DBER Group, February 9, 2017
Outline

- Purpose of the Study
- Framework
- Research questions
- Methodology: Course Selection, Participants, Instrumentation, Data Collection
- Findings
- Conclusions
- Implications/Recommendations
Purpose of the Study

The purpose of this study was to investigate how students’ task interpretation of laboratory work may change during the task process, and how it may influence students’ conceptual understanding. This study was focused on the explicit and implicit aspects of task interpretation based on the model of Hadwin (2006). The aspects of task interpretation and conceptual understanding were analyzed before and after the laboratory activity.
Framework: Self-Regulated Learning (SRL)

• An iterative and dynamic process with goal-directed activities that involves interpreting tasks, setting goals, selecting and adapting effective strategies for achieving those goals, monitoring progress, and adjusting approaches as needed\(^1,2,3\).

• SRL was also defined by Pintrich (2000) as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment” (p. 453).

• Self-regulated learners are generally characterized as active, efficient managers of their own learning through the use of monitoring and strategy\(^4,5,6,7\).

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Framework: Task Interpretation

- Task interpretation or task understanding refers to students’ construction of an internal representation of the externally assigned task\(^1,2\).
- The key determinant of the students’ goals\(^1,2\).
- Critical first feature and the heart of the SRL model\(^1,2,3,4\).
- Successful task interpretation engages students in their assigned tasks to academic success\(^1,2\).
- However, there is evidence that students struggle to understand their assigned tasks\(^1,4\).
**Framework: Task Interpretation**

Explicit features include information that is overtly presented in task description and discussions such as task criteria, steps to be followed, form and style of presentation.

Implicit features include information student might be expected to extrapolate beyond the assignment description, such as the purpose of the task, connection to learning concepts, and resources for completing the task.

Socio-contextual features include beliefs about knowledge, expertise, expectations, and beliefs about ability.

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Model of Task Interpretation by Hadwin (2006)

- **Explicit aspects**
  - Awareness of:
    - Criteria, terminology, instructions, standards, grading scheme

- **Implicit aspects**
  - Awareness of:
    - Task purpose, type of thinking to use, relevant course concepts and connections

- **Socio-contextual aspects**
  - Awareness of:
    - Beliefs about knowledge, ability, and disciplinary expertise
Framework: Laboratory Activities

- Laboratory activities improve students’ understanding of conceptual knowledge and help students to move from abstract ideas to concrete representations of understanding\(^1,2,3,4\).

- During laboratory activities students spend lab time working on tasks assigned by instructors\(^5\). Some studies have concluded that the fundamental concern of many lab students is simply completion of the task because it is critical to their academic success\(^5,6,7\).

- Laboratory activities as well improve students’ conceptual understanding to academic success\(^7\).

- Nevertheless, students do not involve enough mental engagement during laboratory activities.

Research Questions

1. Does students’ task interpretation change during task completion process?

2. How is student task interpretation related to conceptual understanding?
Methodology: Course Selection and Participants

- Course selected for this study: Fundamental of Electronics for Engineering (Electronics), a sophomore level course.
- The purpose of the course is the study and application of circuit fundamentals, theorems, and laws for the analysis of circuits.
- The course includes lab sessions: construction, analysis of circuits, and the use of measuring instruments, power supplies, and signal generators.
- A total of 143 students of Biological, Civil, and Mechanical engineering majors participated in this study.
- Students were informed in detail of the purpose of the study during the first lab session, and they signed the IRB-approved informed consent.
- Incentive of 8 extra credit in exams and 8 extra credit points of lab.
Methodology: Instruments -TAQ-

- A specific instruments for every lab activity to measure task interpretation: Task Analyzer Questionnaire (TAQ).
- Instruments were developed based on lab guides and the textbook of the course of Electronics (Boylestard, Kousourou, 11 Ed, 2007).
- Three lab activities of three lab sessions were selected for the study (#3, #4, and #6).
- Open-ended items: 8 items, 5 to measure explicit TI, 3 to measure implicit TI.
- Validate grading, 3 steps: learning, grading, and conciliate.
- Percentage agreement= 80.35%; Kendall’s Coefficient, \( W = .88 \) (all the labs).
- TAQ’s were tested in a pilot study by students and lab instructors (face and content validity, internal reliability).
## Methodology: Instruments -TAQ-

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cronbach’s Alpha (α) *</th>
<th>Number of Items</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ #3.1 Version A</td>
<td>.812</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>TAQ #3.1 Version B</td>
<td>.663</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>TAQ #4.1 Version A</td>
<td>.855</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>TAQ #4.1 Version B</td>
<td>.712</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>TAQ #6.1 Version A</td>
<td>.799</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>TAQ #6.1 Version B</td>
<td>.832</td>
<td>8</td>
<td>37</td>
</tr>
</tbody>
</table>

**Notes:**

*Version A, applied before lab activity.*

*Version B, applied after lab activity.*

*(*)= The SPSS® software was used to find Cronbach’s scores with responses of participants.

 α > .6, acceptable (George & Mallery, 2003; Kline, 1999).
Methodology: Instruments -TAQ-

1. What are the learning objectives of this lab activity?
2. What formulas are involved in this lab activity?
3. What materials and instruments are needed for this lab activity?
4. Describe the process in this lab activity to measure the voltage and resistance of Thevenin between terminals $a$ and $b$ for the circuit shown below.

![Circuit Diagram]

5. Describe the process in this lab activity to determine the load resistance $R_L$ for the circuit shown below.

![Circuit Diagram]

6. What is the main purpose of this lab activity?
7. List the main concepts discussed in class that will be used in this lab activity.
8. List learning resources (e.g., readings/audios/video) that you consider relevant to help you to complete this lab activity.
Methodology: Instruments -CS-

- A specific instruments for every lab activity to measure conceptual understanding: Conceptual Survey (CS).

- Instruments were developed based on lab guides and the textbook of the course of Electronics (Boylestard, Kousourou, 11 Ed, 2007).

- Three lab activities of three lab sessions were selected for the study (#3, #4, and #6).

- True-false items: 7 items (except lab activity#4, 8 items).

- The responses of the CS instruments were scored based on the following criteria:
  - ✓ Answers correct, 1 point
  - ✓ Answer incorrect or participant left blank the question, 0 point

- CS’s were tested in a pilot study (face and content validity, internal reliability).

- Internal reliability in pilot study: .134, .804, .415 (poor, good and poor consistency respectively).
Methodology: Instruments -CS-

<table>
<thead>
<tr>
<th>Instrument</th>
<th>KR-20 coefficient*</th>
<th>Number of Items</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS #3.1</td>
<td>.460**</td>
<td>14</td>
<td>143</td>
</tr>
<tr>
<td>CS #4.1</td>
<td>.517**</td>
<td>16</td>
<td>143</td>
</tr>
<tr>
<td>CS #6.1</td>
<td>.615**</td>
<td>14</td>
<td>143</td>
</tr>
</tbody>
</table>

(*)= Kuder and Richardson-20 for dichotomous variables. True/False test “low” reliability (Burton, 2010).
(**)= $\alpha > .6$, acceptable (George & Mallery, 2003; Kline, 1999).

- Add more true-false items: **14 items** (except lab activity#4, **16 items**).

- The responses of the CS instruments were scored based on the following criteria:
  - Both answers correct, 1 point
  - Only one answer correct, 0 point
  - Both answers incorrect, 0 point
  - If participant left blank the question, answer is incorrect, 0 point
Methodology: Instruments -CS-

1. Thevenin’s theorem permits the reduction of complex networks to a simpler form for analysis. (True/False)

2. The network \( N \) shown in Figure 3a below consists of a DC voltage source and resistors. It can be reduced to a two-terminal circuit having a single voltage source \( E_{TH} \) and a series resistor \( R_{TH} \) as shown in Figure 3b below. (True/False)

   ![Figure 3a](image1)
   ![Figure 3b](image2)

3. In Figure 14 below, the 10V source must be replaced by an open circuit in order to determine the Thevenin resistance \( R_{TH} \) between terminals \( p \) and \( q \) of the network. (True/False)

   ![Figure 14](image3)

4. The network \( N \) shown in Figure 12 consists of a DC voltage source and resistors. The value of the Thevenin Resistance is \( R_{TH} \). Power \( P_{RL} \) increases because of larger value of the load resistance \( R_{L} \) (\( R_{L}>>R_{TH} \)). (True/False)

   ![Figure 12](image4)
Methodology: Data Collection

The order of how instruments were applied to participants:

- **CS Version A**
- **TAQ Version A**
- **Lab activity**
- **TAQ Version B**
- **CS Version B**
- **CLQ**

**Time frame:**
- **CS Version A**
  - 4-6 min
- **TAQ Version A**
  - 4-6 min
- **Lab activity**
  - 10-12 min
  - 4-6 min
  - 30-40 min
- **TAQ Version B**
  - 10-12 min
- **CS Version B**
  - 4-6 min
  - 2-3 min
- **CLQ**
  - 16-21 min

**Total time:** 18-24 min
Findings: Preliminary

Preliminary, to examine the composition of data to determine the use of parametric analysis:

- **TAQ**: measure scale is discrete, average is continuous. *Shapiro-Wilk test*, normal distributed for \( p > .05 \), \( n = 143 \):
  - TAQ version A, \( p = .189 \), normal distribution
  - TAQ version B, \( p = .072 \), normal distribution

- **CS**: measure scale is dichotomous, average is continuous. *Shapiro-Wilk test*, normal distributed for \( p > .05 \), \( n = 143 \):
  - CS before, \( p = .048 \), non-normal distribution
  - CS after, \( p = .000 \), non-normal distribution
  - Based on visual inspection (histograms, normal Q-Q plots, box plots) and a non-parametric approach of Wilcoxon/Spearman, researcher considered the CS data as normal distribution.

**Conclusion**, Researcher conducted *parametric analysis* to answer the research questions.
Findings: Research Question #1

Does students’ task interpretation change during task completion process?

1. Descriptive statistics:

<table>
<thead>
<tr>
<th>Item</th>
<th>TAQ Explicit</th>
<th></th>
<th>TAQ Implicit</th>
<th></th>
<th>TAQ total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td><em>SD</em></td>
<td>1.79</td>
<td>1.73</td>
<td>1.24</td>
<td>1.10</td>
<td>2.66</td>
<td>2.49</td>
</tr>
</tbody>
</table>

Max score for TAQ Explicit is 15 points
Max score for TAQ Implicit is 9 points
Max score for TAQ total is 24 points.

*N = 143.*
Findings: Research Question #1

Does students’ task interpretation change during task completion process?

2. A paired sample $t$ test:

<table>
<thead>
<tr>
<th>Instruments</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ Before-TAQ After</td>
<td>142</td>
<td>-18.91</td>
<td>.000*</td>
</tr>
<tr>
<td>TAQ Explicit Before-TAQ Explicit After</td>
<td>142</td>
<td>-20.08</td>
<td>.000*</td>
</tr>
<tr>
<td>TAQ Implicit Before-TAQ Implicit After</td>
<td>142</td>
<td>-7.93</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*Note: *p< .05

3. Scores of students’ task interpretation based on 100%:

<table>
<thead>
<tr>
<th>Item</th>
<th>TAQ Explicit Pre</th>
<th>Post</th>
<th>TAQ Implicit Pre</th>
<th>Post</th>
<th>TAQ total Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>42.3</td>
<td>60.9</td>
<td>44.9</td>
<td>52.9</td>
<td>43.2</td>
<td>57.9</td>
</tr>
<tr>
<td>Improve</td>
<td>18.6</td>
<td></td>
<td>8.0</td>
<td></td>
<td>14.7</td>
<td></td>
</tr>
</tbody>
</table>
Findings: Research Question #2

*How is students’ task interpretation related to conceptual understanding?*

1. A Pearson correlation between students’ task interpretation and conceptual understanding:

<table>
<thead>
<tr>
<th>TAQ/CS Instruments</th>
<th>N</th>
<th>Pearson Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ Version A - CS Version A</td>
<td>143</td>
<td>.370**</td>
</tr>
<tr>
<td>TAQ Version B – CS Version B</td>
<td>143</td>
<td>.298**</td>
</tr>
<tr>
<td>TAQ Explicit Version A – CS Version A</td>
<td>143</td>
<td>.390**</td>
</tr>
<tr>
<td>TAQ Implicit Version A – CS Version A</td>
<td>143</td>
<td>.229**</td>
</tr>
<tr>
<td>TAQ Explicit Version B – CS Version B</td>
<td>143</td>
<td>.295**</td>
</tr>
<tr>
<td>TAQ Implicit Version B – CS Version B</td>
<td>143</td>
<td>.210*</td>
</tr>
</tbody>
</table>

* = Significant at 0.05 level, ** = Significant at 0.01 level.
Findings: Research Question #2

How is students’ task interpretation related to conceptual understanding?

2. A Pearson correlation between students’ task interpretation and conceptual understanding by topic:

<table>
<thead>
<tr>
<th>TAQ</th>
<th>Pearson Correlation - CS Before</th>
<th>Pearson Correlation - CS After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>.087</td>
<td>.002</td>
</tr>
<tr>
<td>Formulas</td>
<td>.290**</td>
<td>.183*</td>
</tr>
<tr>
<td>Materials</td>
<td>.262**</td>
<td>.286**</td>
</tr>
<tr>
<td>Steps</td>
<td>.388**</td>
<td>.281**</td>
</tr>
<tr>
<td>Main purpose</td>
<td>.264**</td>
<td>.209*</td>
</tr>
<tr>
<td>Concepts</td>
<td>.221**</td>
<td>.237**</td>
</tr>
<tr>
<td>Resources</td>
<td>.015</td>
<td>.016</td>
</tr>
</tbody>
</table>

* = Significant at 0.05 level, ** = Significant at 0.01 level.

3. Scores of students’ conceptual understanding based on 100%:

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Average</td>
<td>51%</td>
</tr>
</tbody>
</table>
Conclusion: Research Question #1

- The students’ interpretation of the task assigned during lab work changed after the completion of the activity. That is, students had a better understanding of the requirements once they completed the assigned task.

- The researcher found that students’ task interpretation improved during the activities, but still showed a low level of understanding of the assigned tasks. This could be interpreted as evidence of students’ inaccurate or incomplete understanding of the assigned tasks during lab work.

- The lowest level of improvement of the implicit aspects confirms the findings of a previous study by Oshige (2009) and Helm (2011) indicating that students listed the implicit task as challenging because they experienced difficulty trying to extrapolate the assigned tasks.
Conclusion: Research Question #2

- A direct relationship was found between high scores on students’ task interpretation and high scores on conceptual understanding. Similarly, low scores on students’ task interpretation were associated with low scores on conceptual understanding. That is, when students had a better understanding of what they were to do in the laboratory, they showed an improved comprehension of concepts, purpose, and relationships involved in the laboratory activities.

- No relevant differences were found in the strength of the correlation of conceptual understanding considering the explicit and implicit aspects of the students’ task interpretation.

- One reason for the weak correlation was the inclusion of the topics that were not correlated with conceptual understanding. A second reason might be related to another factors involved in the development of the lab activity, such as the involvement of procedural knowledge and the ability to complete the laboratory activity.
Conclusion: Research Question #2

An additional analysis identified that students improved in the conceptual quiz by an average score of 18.4%. Although the improvement is statistically significant, the average final score of the students was 69.4%. In their study, Davidowitz & Rollnick (2003) stated that students are aware of the importance to link theory and practice during a laboratory activity, but its comprehension did not necessarily indicate adoption. Perhaps this is the reason why students did not go beyond 90 or 100% of average in the conceptual survey and confirmed previous research which found that students struggle to establish a connection between laboratory activities and the material covered in the classroom (Davidowitz & Rollnick, 2003; Domin, 1999; White, 1996).
Implications and Recommendations

Implications for research:

- Because the context of the studies of task interpretation described in the review of literature was in engineering design, the findings of this study revealed that the model of Hadwin can be translated in the context of a laboratory where students conduct hands-on activities. Therefore, the results can serve as preliminary information for future studies relating aspects of the SRL process in the context of laboratory activities.

- This study contributes to research by directly investigating the relationship between task interpretation and conceptual understanding in the context of laboratory work. This study attempted to begin a line of research with these two constructs in laboratory work.
Implications and Recommendations

Implications for Facilitators:

- Students evidenced an inaccurate or incomplete understanding of the assigned tasks during laboratory work. Students’ task interpretation should be aligned with the instructors’ perception of the tasks described in the procedures of lab experiments. Therefore, facilitators need periodically to review the experiments of laboratory to identify if students are correctly interpreting the task described in the lab guides.

- Implicit aspect of task interpretation is challenging for students because the difficulty trying to extrapolate the assigned tasks. Facilitators must encourage students to put forth more effort in interpreting the implicit aspects of the task by identifying key concepts, formulas, purpose of the laboratory activity, and understanding of the procedures regardless of the student’s ability to perform the assigned task.
Implications and Recommendations

Implications for Facilitators:

- Because low level of conceptual understanding after the lab activity, facilitators have to revise the experiments of the lab to avoid misleading and routine in students. Students shouldn’t work in lab just following directions without thinking of how the experiment relates to other information they have learned.

- The implicit aspect of task interpretation is a strong predictor of academic success. Further investigation is required to examine the influence of the implicit aspect of task interpretation in order to understand its role during laboratory activities.
Thank You !