Assessments and Transfer of Knowledge in Case-Based Instruction — Promising Results!

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Abstract

The current paper outlines the results of an assessment study made over a two-year period of an introductory course entitled "Introduction to Electricity and Electronics." The students in this course were introduced to real-life case-based instruction using an industry-based case study model entitled "I Want My Pizza Hot." The assessment tools were developed in cooperation with the Learning Technology Center at Vanderbilt University. The case model was reviewed independently for pedagogical and technical contents and Transfer Task tools were developed to assess student learning. Several instruments have been implemented to assess the effectiveness of the case method as compared with traditional instruction. A summary of the study and its results are presented here.

I. Introduction

Transfer is defined as the application of old or gained information in new settings. For example, asking the students to estimate the area of a circle or a triangle after the students has practiced and mastered the task of estimating the area of a rectangle.

According to De Corte, 1999: *"The field of industrial and corporate training is strongly interested in the transfer of learning. This is not at all surprising when one takes into account that business and industry must invest enormous amounts of money in in-service training and retraining of personnel. From that prospective, acquiring of transferable knowledge and skills by workers, employers, and managers is seen as an important component of a "Learning Economy" resulting in a reduction of spending."*

In today's fast changing world, companies spend large amounts of money on staff training and development. To reduce costs and training time, employers are increasingly interested in improving the way employees apply their acquired knowledge and skills to new settings or situations. The current paper describes an assessment method that can be used to measure this transfer of knowledge. This research is a part of a three-year NSF-funded grant entitled "The South-East Advanced Technological Education Consortium, SEATEC." The consortium is a collaborative effort of five institutions across Tennessee, the main goal of which is to develop a practical approach to curriculum development, delivery, and assessment for engineering and technological education. This approach brings real-world problems to the classroom and is hoped to enhance learning and retention in these programs. Five case models that address five different areas of engineering and technology were developed and are being field-tested. The SEATEC goals are:

1. To provide national leadership for the development and implementation of case-based instruction in technology and engineering education.
2. To provide opportunities for continuous and appropriate professional development of participating faculty.
3. To assess the effectiveness of the case study approach in teaching technology-related curriculum.
4. To nationally disseminate information related to SEATEC activities, materials, and results, including outcomes of the use of case studies in field-test setting.

The present paper focuses on the third goal.

II. Assessments of the Case-Based Instruction Approach

Assessment tools for the case method have been developed in cooperation with the Learning Technology Center at Vanderbilt University http://peabody.vanderbilt.edu/ctrs/ltc/. The five case models that were developed during SEATEC were reviewed independently for pedagogical and technical contents and transfer tools are being developed to measure student learning. Each team identified courses where field-testing was performed and assessments were conducted. Surveys of faculty and students were conducted before, during, and after testing. Videotaping and outside monitoring were also used. Transfer task tools to assess student learning were developed and used. Technical and pedagogical content reviews by professionals in the field were also conducted.

Several instruments have been implemented to assess the effectiveness of the case method. These can be summarized as follows:

a. Pre and post student surveys: The pre-survey is done after the student briefly read the case and without looking at the case write-up. The post-survey is done after the student finished solving the case without looking at the case write-up as well.
b. Pre and post faculty surveys: Those are done before and after teaching the case.
c. Interviews with both faculty and students.
d. Transfer Task questions: These questions were designed to measure the student's retained knowledge and the ability to apply that knowledge in a different problem/situation.

The first fully assessed case was written by the author and is entitled "I Want My Pizza Hot." It is centered on a non-conventional pizza warmer. The warmer is made of a sheet of conducting material with slits and embedded copper busses. The students throughout the case were involved in making business decisions, calculating the resistance of various conducting shapes, analyzing electrical circuits, discussing basic thermodynamics concepts, and in designing their own proposed products. Additionally, the students were asked at the end of each semester to calculate the resistance of other conducting shapes. Each time, the results are compared with those of a "control" section of the same course but without exposure to the case method. Early findings indicate very positive and encouraging results.

III. Case Components

The key components that have been identified by the participating faculty and the team of experts are:

- A "set" — a brief story line intended to get the reader's attention and generate interest in the case itself.
- A background narrative — to provide a historical context and situate the problem in a real-world workplace context.
- A problem, appropriate for the reader's situation, and can be small and very specific or larger and more general — this is the issue that the reader must analyze to identify problems and develop solutions.
- Questions — to promote additional critical thinking and also to guide the analysis that the readers and student groups must conduct.
- An instructor's guide — to provide comprehensive support for the teacher through instructional strategies, possible solutions, alternative problems to solve, and tailored support material based upon the content areas and the intended student level of the problem and material contained in the case.

The teams agreed to adopt an additional checklist required for the case models being developed in order to increase quality, consistency, and appropriateness for technology education. These include: student objectives, assessment tools and techniques, "Real-world" business applications, a mathematics component, a science component, a technical focus, technical writing and oral presentation components, identification of target audience, instructor's guide, suggestions for extending the case, and supporting materials. These case models are also being further enhanced by the use of multi-media delivery systems.

IV. "I Want My Pizza Hot!" — A Sample Case

This case model is written by the author and is based on the pizza warmer that the Electrical Product Division of Heatcraft in Murfreesboro, TN has developed. The material being used for the heating element is a revolutionary sheet of plastic impregnated with carbon-composition materials and is named Polytherm™. These sheets come in various thickness and widths. In the circuit analysis track of this case, the student is asked to model the pizza warmer's electrical circuit and solve for the resistance, current, power, and energy consumption. The case can also take various other tracks such as circuit design, thermodynamics/heat transfer, and/or business applications.

The student objectives of the case are:

- Model an electrical circuit based on a real electrical load.
- Use critical thinking and apply basic algebra in problem solving.
- Convert between systems of units. C
- Calculate the resistance of a material from its physical parameters.
- Apply Ohm's law in DC circuit analysis.
- Calculate power and energy.
- Conceptualize duty cycle and basic heat transfer.
- Consider electrical safety measures.

- Use spreadsheets, interpret data, and apply charting skills.
- Use software to simulate electrical circuits.
- Use oral and written communications skills to present data and conclusions.

The student is asked to work collaboratively in teams and is led through the case to a series of events describing the design process of the pizza warmer. The students are presented then with questions that provoke critical thinking and logic reasoning and are asked to answer these questions in cooperation with their teammates. Amongst these questions, the students are asked to find the resistance of the heating element of the warmer, shown in Figure 1 below.

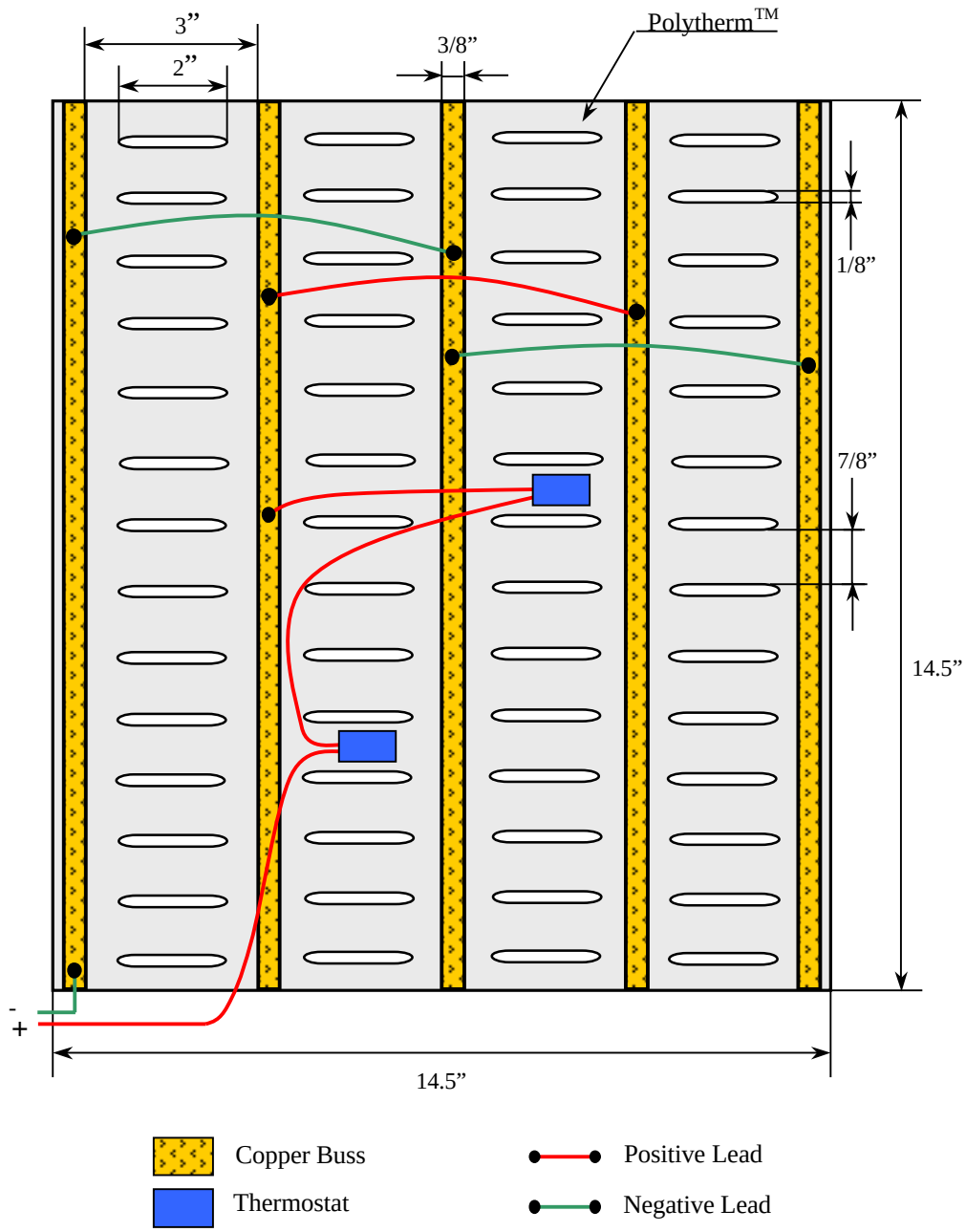


Figure 1. Polytherm Pizza Warmer Element

V. Assessments Study

The following is a description of the research setup that was conducted during the Spring 2001 Semester. Similar studies were also made during three other semesters with similar setups and results.

- The study of that particular semester involved three sections of the "Introduction to Electricity and Electronics" course that were taught by the same instructor (the author in this case). The course is offered for students not majoring in engineering technology (non-majors). These include but not limited to: Recording Industry, Aerospace, Industrial Technology, computer science, and Concrete Industry Management students.
- The three sections had the following number of students: Section 1 had 23 students, Section 2 had 19 students, and Section 3 had 23 students.
- Students in Section 1 and 2 were exposed extensively to case-based learning using two cases including the pizza case.
- Section 3 was used as a control section, i.e., students in this section were not exposed to case-based learning. One short case was used in this section as a class example (not related to resistance calculation) and it was not related the pizza case.
- The pizza case was conducted during the forth week of the semester while the transfer questions were given at the end of semester, about ten weeks later.
- The pizza case was conducted during the extra laboratory time. Students in all sections had the same material coverage and by the same instructor. During the time while the case was conducted in sections 1 and 2, students from section 3 were engaged in additional resistance calculation and a project that deals with resistance applications. Each student worked on a different project that dealt with "novel" resistance applications. The student from section 3 had to present his/her project both orally (using PowerPoint) and in written format. Students from sections 1 and 2 had also to present their case solutions orally and in written format but as team presentations.
- For all sections, topics related to calculating the resistance of an object were not required in preparation for the final exam. Furthermore, students were not told to study problems related to resistance calculation nor the pizza case.
- There were six transfer questions in all, centered on calculating the resistance of various 3-D objects. These questions were divided into two parts:

    - The first three questions were open-ended and distributed throughout Part I of the test. Students were asked to solve Part I and hand-in their test sheets before they were allowed to take Part II.
    - Part II of the test was composed of the remaining three transfer questions and was open-ended as well.
    - The transfer questions in Part I were written problems without the aid of 3-D figures, while the remaining transfer questions in Part II were accompanied by 3-D figures. The purpose of this was to see if the student could better visualize current flow in an object with the help of its 3-D figure.
    - There were total of 35 questions in the written portion of the final exam all of equal weight.

- Test results from each case section were compared with those of the control section. The six transfer questions were all open-ended and more challenging than those in the previous semesters, but basically addressed similar problems. The basic focus of those questions was on calculating the resistance of various shape of conducting materials.

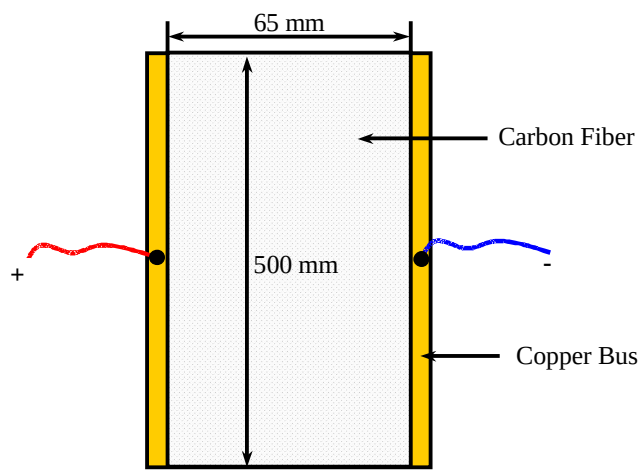
VI. Transfer Task Questions

The followings are the six transfer questions divided into two groups: Part I, word problems and Part II, word problems with companion 3-D figures.

Part I

1. Find the total resistance of a two-conductor aluminum transmission line that connects a source to a load 1000 meters away. The two conductors are identical, each having a radius of 0.01 m. The resistivity of aluminum at room temperature is 2.63×10^{-8} Ω.m.
2. Find the resistance of a conducting carbon-fiber sheet (Figure 2) that has a thickness of 0.3 mm and dimensions as shown. The resistivity of carbon fiber at room temperature is 0.002 Ω.m.

Fig. 2



3. Find the resistance of an N-type silicon rectangular prism (bar), the resistivity of which is 2.3 Ω.m at room temperature. The electric current flows along the bar, which has the following dimensions 60 X 10X 3 mm.

Part II

4. Find the resistance of the cylindrical copper conductor shown in Fig. 3. The resistivity of copper at room temperature is 1.72×10^{-8} Ω.m.
5. Find the resistance of a heavily doped P-type silicon block (Fig. 4), the resistivity of which is 0.004 Ω.m at room temperature.
6. Find the resistance of a Polytherm™ sheet (Fig. 5) that has a thickness of 0.25 mm. The resistivity of Polytherm™ at room temperature is 0.035 Ω.m.

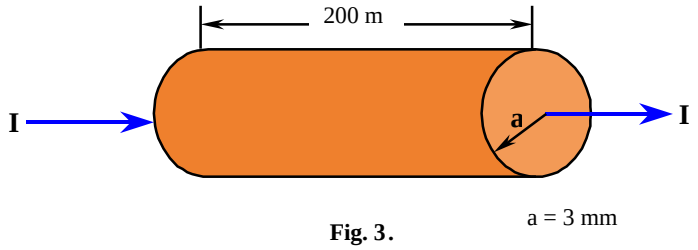


Fig. 3.

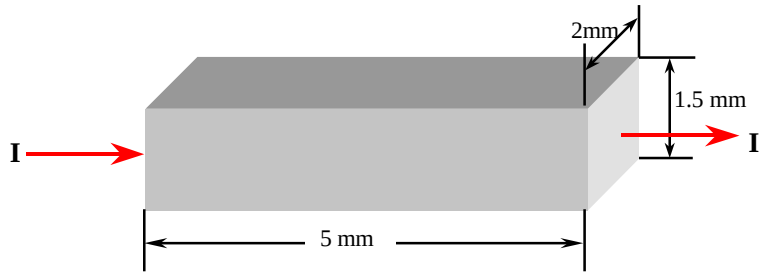


Fig. 4.

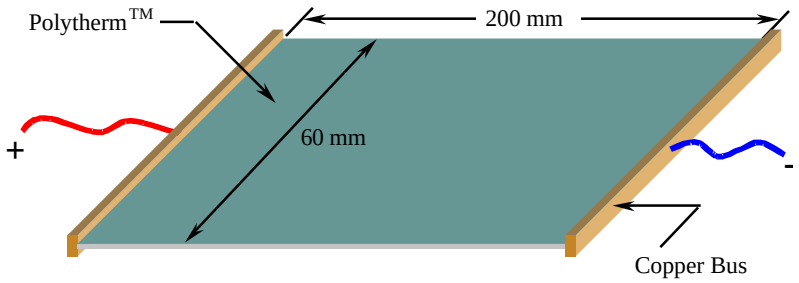


Fig. 5.

VII. Results

- The results from this study were plotted using 3-D charts and presented at the end of this paper. Two types of charts are presented:

  - The first type represents the total number of correctly answered questions as a percentage of the total number of students in each section. The caption of this type (0 R, 1 R, 2 R… 6 R) indicates the number of questions answered "right." For example, "0 R" indicates

that none of the transfer questions was correctly answered while “6 R” indicates that all transfer questions were correctly answered.

- The second type of charts represents the percent of students correctly answered each individual transfer question. The caption of this type indicates the number and type of question. For example, Q1, Q2, … and Q6 indicate question number 1, 2, … and so on. While C indicates a cylindrical object, S a sheet object, and B a block object.

- In comparing the results from each case sections with those of the control section, one can conclude the followings:

  1. Students in the case sections outperformed those in the control section in every aspect.
  2. Students in all sections performed better when a cylindrical object was used. This is due to the fact that students in all sections have practiced on this “typical” application.
  3. The case sections in particular outperformed the control section when a non-traditional object was used such as a block or sheet. This can be attributed to the fact that in solving the pizza case, students have worked collaboratively on finding the resistance of a non-traditional conducting object. It seams that the effects of the case experience have lasted longer than traditional teaching.
  4. Students in all sections found the 3-D figures in Part II very helpful and that was reflected in the results.
  5. For result consistency, only completely correct solutions were considered. No partial credits were given if there was any calculation errors or any other problems in configuring the cross section area or length. That partially explains the low overall performance of students in all sections.
  6. It was also noted that many students have problems in finding the cross section area as oppose to volume. This is especially true in the cases of a conducting block or sheet. In theses case, some students calculated the volume instead of the cross section area.

- In comparing the results between the two case sections it is noted that both sections performed equally well with close similarity in almost all categories.

- In general, it is found that students who were exposed to case-based learning outperformed those in the control section in every aspect.

VII. Acknowledgements

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Dr. Saleh M. Sbenaty is currently an Associate Professor of Engineering Technology at Middle Tennessee State University. He received the BS degree in EE from Damascus University, Syria and the MS and Ph.D. degrees in EE from Tennessee Technological University. He is the current team leader of the Nashville Tech. team and actively engaged in curriculum development for technology education. He has written and co-authored several case studies. He is also conducting research in the area of mass spectrometry, power electronics, lasers, and instrumentation.