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A Modified Case Study: Teaching Modular Fixturing Concepts by Integrating Multimedia Courseware

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Abstract

Modular fixturing is an important concept in advanced manufacturing and tool design courses in the Industrial Technology (IT) curriculum. The wide variety of tooling and fixtures are difficult to cover within a single semester (or quarter) through traditional methods, especially if consideration of related topics on cutting tools or geometric dimensioning and tolerancing are included. Therefore self-learning multimedia software entitled ToolTRAIN© for modular fixturing applications was developed to address this need.

The original concept to develop the ToolTRAIN© courseware evolved from an interest in courseware applications available in manufacturing technology curriculum. The lack of multimedia based tutorials in this area was the impetus for developing this courseware. Although multimedia tutorials and courseware tools can greatly enhance learning in ways that traditional instruction can not, research has shown that poor design of the tutorial and user interface (e.g., tutorial fails to run from the CD, or is incompatible across multiple operating system platforms) can limit its use by students. ToolTRAIN© Plus addresses these issues and was developed and tested on multiple platforms, and the user interface developed using feedback from manufacturing students at the University of Northern Iowa, Western Washington University, South Dakota State University and Millersville University.

This paper will disseminate the outcomes of a research project investigating student learning outcomes through the integration of multimedia courseware in modular fixturing concepts, where traditional lecture on this topic was replaced by the ToolTRAIN© Plus multimedia courseware. The methodology will be implemented to determine whether or not students gain knowledge about modular fixturing concepts by using ToolTRAIN© Plus. This will be assessed by examining the difference in student performance on a pre-test before application of the ToolTRAIN© Plus courseware and a post-test after using the software.

ToolTRAIN© Plus will be tested on advanced manufacturing students in the Department of Industry & Technology at Millersville University to determine the effectiveness of the ToolTRAIN© Plus multimedia courseware and the results of this modified case study will be presented.

Introduction

Multimedia technology has added an entirely new dimension to the classroom environment. The ability to utilize sight, sound, video and/or animation to describe complex constructs has been proven to greatly enhance student learning outcomes. Research into the use of multimedia curriculum tools (tutorials) has shown that, while widely used in education they have seen limited application and success in the manufacturing/engineering curriculums. [1][2] Furthermore, the research shows that if done poorly (e.g., tutorial is difficult to navigate, tutorial fails to run from the CD, or is incompatible across multiple operating system platforms) the tutorial can be seen as a distraction, limiting its use by students and thus limiting its effectiveness. ToolTRAIN© Plus was developed taking these problems into consideration and the tutorial and its user interface was tested by students at four separate universities (i.e., University of Northern Iowa, Western Washington University, South Dakota State University and Millersville University) to determine its appeal. [3] ToolTRAIN© Plus, the first of its kind, focuses on the teaching of modular fixturing techniques. The software tutorial takes students step by step through the theory and practice of modular fixturing and includes sample projects that demonstrate the proper use of modular fixturing elements. While the previous research focused on the user interface and students thoughts about the software in general, this research focuses primarily on student learning outcomes. The methodology was implemented to determine whether students had gained knowledge about modular fixturing concepts by using the ToolTRAIN© Plus multimedia courseware. Student learning outcomes were assessed by examining the difference in student performance on a pre-test before application of the ToolTRAIN© Plus courseware and a post-test after using the software using advanced manufacturing students in the Department of Industry & Technology at Millersville University to determine the effectiveness of the tutorial. Although pre-test/post-test research designs do not provide enough experimental control and are considered less desirable than other research designs; it is the most straightforward and due to the limited sample size this methodology was chosen for this pilot study, and the statistical data derived will be used to help determine the direction of future research. This paper will therefore introduce the ToolTRAIN© Plus curriculum and user interface and then disseminate the results of the recently completed research into student learning outcomes.

The ToolTRAIN© Plus Courseware

The ToolTRAIN© Plus courseware system contains four main units of instruction: (1) Modular Fixturing; (2) Components; (3) Implementation; and (4) Quiz. Figure 1 shows a flowchart diagram of the tutorial's hierarchy. [3] The lessons are delivered in a step-by-step format that allows students to repeatedly review the modular tooling concepts in each unit until they have mastered the subject matter. The sublevels of the courseware are intuitive and navigation is user friendly and straightforward. [4]

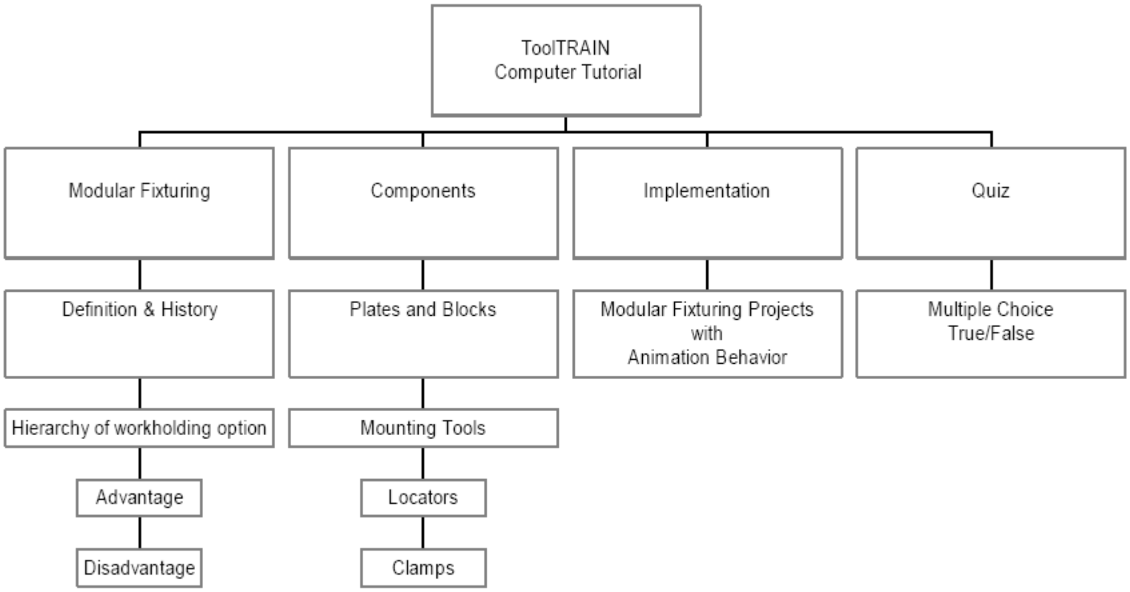

Figure 1: Diagram of tutorial hierarchy

The Modular Fixturing Unit

The modular fixturing unit provides definitions, history, applications, hierarchy of related workholders and components, and covers the advantages and disadvantages of utilizing modular fixturing systems. The unit incorporates graphics, written definitions in a sample application that gives students insight into appropriate drawing layouts, and a video clip of a manufacturing professor providing a working definition of modular fixturing systems. Figure 2 shows a sample screen of the modular fixturing unit on history. [3]

The Components Unit

The components unit deals with the fundamentals of modular fixturing components. Within this unit four of the main components of modular fixturing are presented: (1) tooling plates and blocks; (2) mounting tools; (3) locators; and (4) clamps. The components unit is especially valuable for students with limited knowledge of tooling classifications and technology as the subtle differences between styles and correct applications are critical to well-designed production fixturing. Figure 3 shows a sample screen of the components unit – a rectangular tooling plate. [3]

The Implementation Unit

The Computer-Aided Fixture Design (CAFD) process has three main steps: setup planning, fixture planning, and fixture configuration design. [5] The objective of fixture configuration design is to select proper fixture elements and place them into a final configuration in order to locate and clamp the workpiece. The intent of the implementation unit is to introduce the practical application of modular fixturing components in sample fixture configurations.

Figure 2: Modular fixturing unit on history

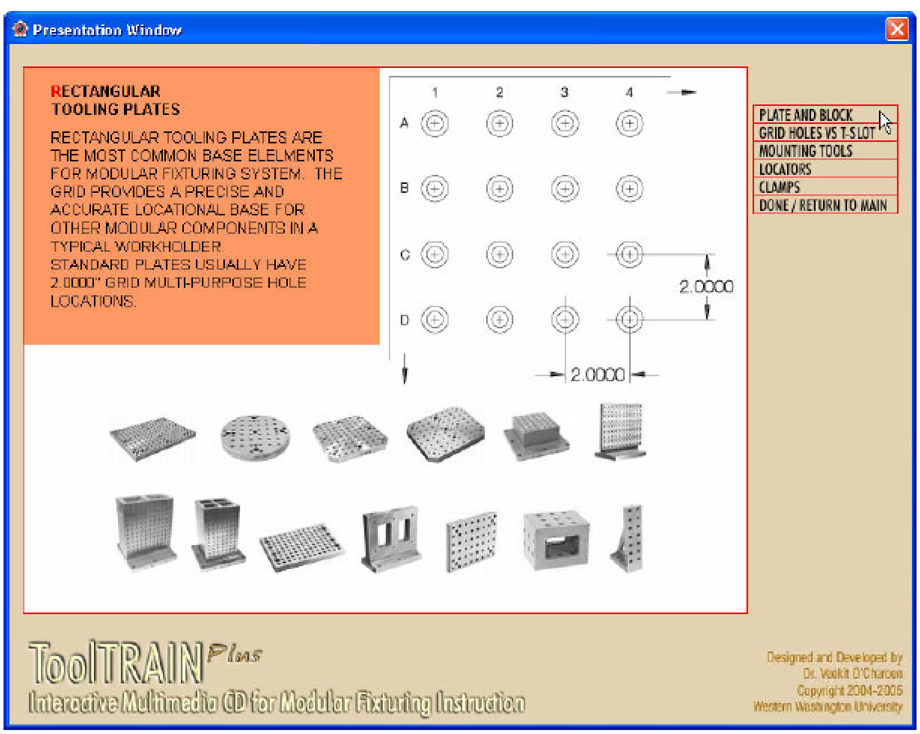

Figure 3: Modular fixturing unit on components

Figure 4 shows a sample screen of the implementation unit. The implementation unit of ToolTRAIN© Plus contains five projects based on a variety of possible part geometries (see Figure 5). Here animation is used as students see how modular fixturing components are used to properly build a fixture. The part and fixture components are brought in one by one, from the tooling plate, locators, supports, clamps and even fasteners; and positioned on the tooling plate. [3] The fixturing components used in the sample projects each have active links to information on that specific component showing the component's name, pictorial description and how it is used.

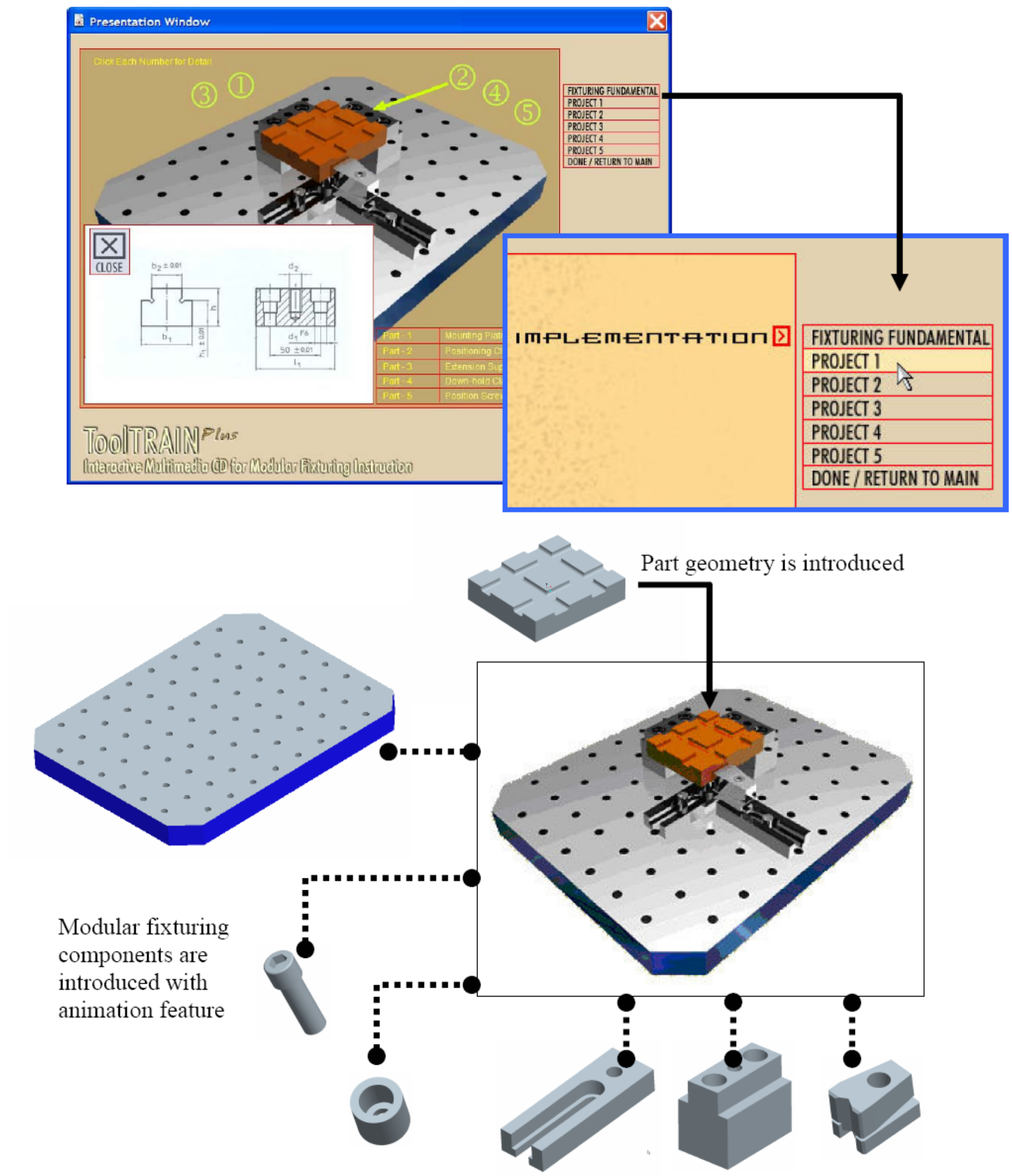

Figure 4: Modular fixturing unit on implementation

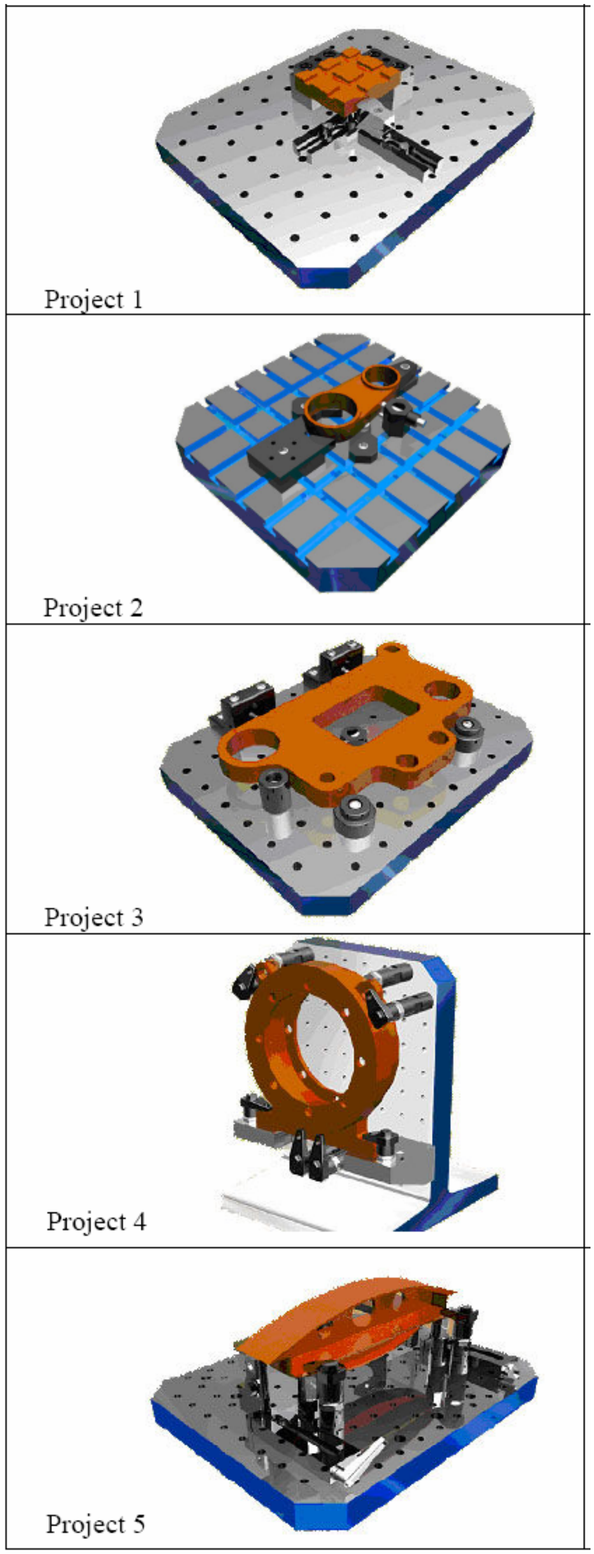

Figure 5: Implementation unit sample projects

The Quiz Unit

Assessing student knowledge and linking it to the stated objectives of the course is an integral part of courseware development. [6] Therefore, the last teaching unit in ToolTRAIN© Plus is the quiz unit where students have the opportunity to test their knowledge through multiple choice and true/false questions based upon the material covered in the previous units (i.e., fixturing definitions, components, and implementation). [3]

Case Study Results

In this research the focus was on determining the effectiveness of the ToolTRAIN© Plus courseware tutorial to increase student's knowledge of the subject matter, in this case, modular fixturing. Previous research has already determined that students considered the ToolTRAIN© Plus courseware to be useful and that they were happy with the layout of the material and the user interface. [3] Therefore, this research focused on developing quantifiable (statistical) evidence of the increase in student knowledge of modular fixturing by using the ToolTRAIN© Plus courseware system. To accomplish this, a small sample (n=12) of advanced manufacturing students in the Department of Industry & Technology at Millersville University were chosen to take part in the study. It should be noted that this research focused on a smaller sample population at a single university as a preliminary pilot study – the results of which will be used to help determine the direction of future research replicating the findings on a larger scale and across a number of university settings, including a control group to guard against error. In this study the sample group was given a 25 question pre-test to gage any knowledge students had in the area of modular fixturing. During the course of the semester, the traditional lecture on the subject of modular fixturing was replaced with the ToolTRAIN© Plus software tutorial. After all of the students had a chance to complete the tutorial (at their own pace) the students were brought together again and given a post-test consisting of the same 25 questions given in the pre-test earlier in the semester, although the post-test questions were in varying order in comparison to the pre-test. It should also be noted that the authors recognize that pre-test/post-test designs are less desirable because they do not provide enough experimental control, but because of the small sample group and the fact that this design is the most straightforward, it provides the foundation on which to build future research. Descriptive statistics are provided to make inferences about the means of the two dependent samples using both dependent and independent sample t-tests.

The data shows that all of the students improved their scores on the post-test after learning modular fixturing via the ToolTRAIN© Plus courseware system. Table 1 shows both the pre and post-test raw scores by students during the course of this research. Figures 6 and 7 graphically illustrate each student's pre and post-test scores.

Table 1: Pre-test and post-test raw scores

Test	A	B	C	D	E	F	G	H	I	J	K	L	*Mean*	*SD*
Pre	44	72	80	48	36	44	68	68	68	64	52	72	***59.66***	***14.11***
Post	64	92	88	84	80	84	88	92	84	80	88	84	***84.00***	***7.43***

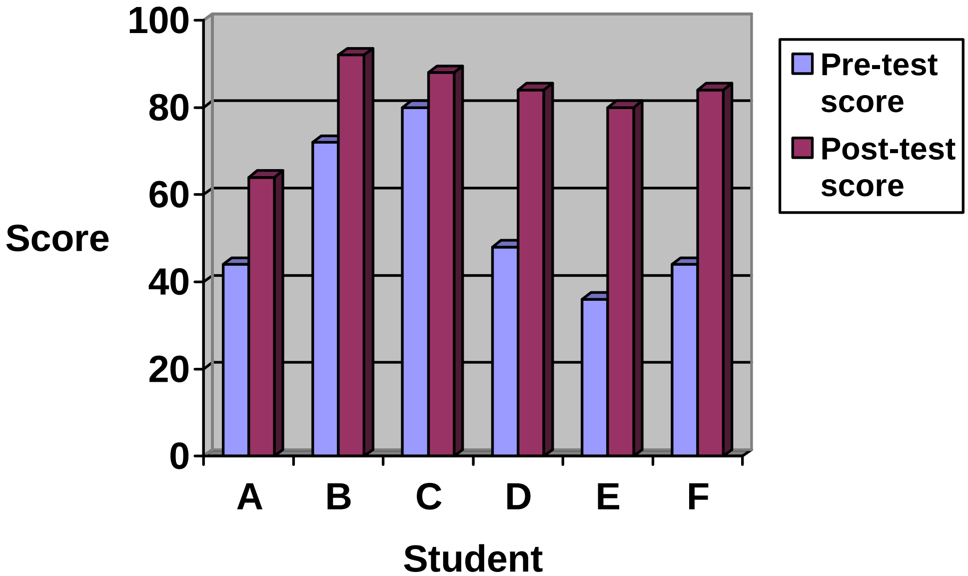

Figure 6: Graphical comparison of student's pre-test and post-test scores (A-F)

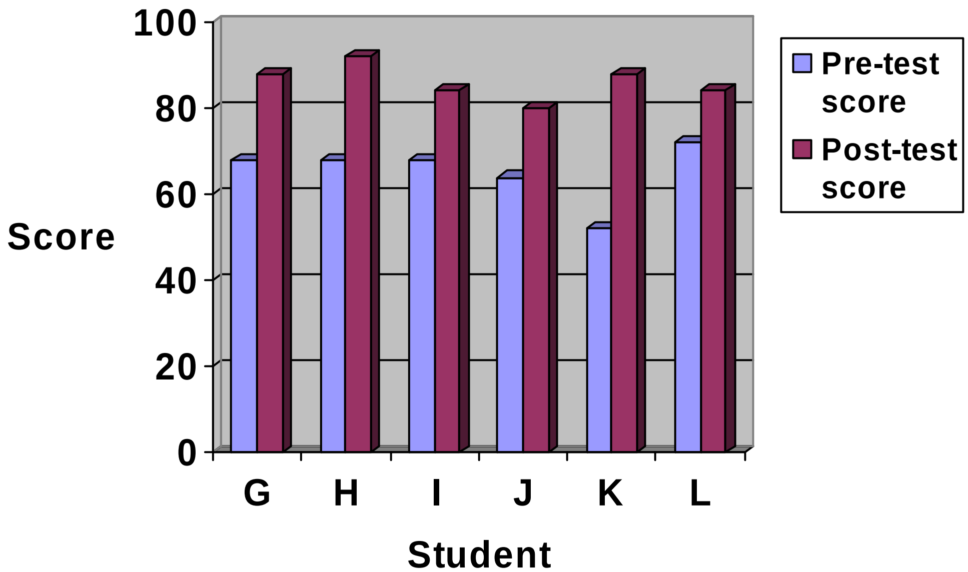

Figure 7: Graphical comparison of student's pre-test and post-test scores (G-L)

The mean score by students on the pre-test was 59.66 points with a standard deviation of 14.11. The mean score for the post-test was 84 points with a standard deviation of 7.43 showing a mean Δ change (increase) from pre-test to post-test of +24.33 points with a standard deviation of 11.15. Further statistical tests show that the dependent sample t-test (evaluating difference scores) shows a $t_{cv} = 1.796$ (critical value) assuming α=.05 level of significance, single tailed t-test with 11 degrees of freedom and a $t_{obs} = 7.17$ (observed value) showing a significant increase in post-test scores. To add an additional level of analysis, the independent sample t-test was performed (pooling the variances, computing the standard error of the difference between two means) the data showing a $t_{cv} = 1.717$ assuming a α=.05 level of significance, single tailed t-test with 22 degrees of freedom and a $t_{obs} = 1.6$ showing a lack of significance. However, the t_{obs} value of 1.6 is not dramatically lower than the t_{cv} of 1.717 providing reasonable cause on which to investigate these outcomes with further research.

Conclusion

Computer based instructional tutorials have been widely used in education to enhance traditional curriculum. However, the literature shows that they have been scarcely used in the manufacturing curriculum, thus creating a great need for computer based teaching tools in engineering and industrial technology programs. The development of targeted software programs that teach content like modular fixturing for manufacturing tooling applications would be a valuable curriculum tool for the engineering technology and industrial technology educator. The complex components used in tooling applications and the subtle differences in their application make computer graphics based instruction an attractive teaching tool. [3] The ToolTRAIN© Plus courseware system was developed specifically to address this need.

This limited case study involved advanced manufacturing students in industrial technology at Millersville University and has shown that students had achieved an increase in their knowledge of modular fixturing concepts when the traditional lecture on the subject was replaced with the ToolTRAIN© Plus courseware system. Further statistical tests show that the dependent sample t-test shows significance between pre and post-test while the independent sample t-test failed to show significance. The data is a bit ambiguous, but the independent t-test (observed) statistic is not drastically lower than that of the t-test (critical value) warranting further research. Despite the ambiguity, this pilot study does provide the foundation on which to base future research using a larger sample group and control group to prove the value of this courseware.

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Biographies

HAIG VAHRADIAN, is an Assistant Professor in the Department of Industry & Technology at Millersville University. He received his D.I.T. (Doctor of Industrial Technology) from the University of Northern Iowa. His research interests include advances in CAD/CAM, CNC, CIM and tooling technology.

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