JTMAE SPECIAL EDITION

January 2015

Authors:
Dr. Raymond A. Dixon
Dr. Linda Stricklin

The Journal of Technology, Management, and Applied Engineering© is an official publication of the Association of Technology, Managment, and Applied Engineering, Copyright 2015

ATMAE
275 N. YORK ST Ste 401
ELMHURST, IL 60126

www.atmae.org

JTMAE The Journal of Technology, Management, and Applied Engineering

Linking Technology Education in Rural Schools in North Central Idaho to Manufacturing

Keywords:

CADD technicians; mentoring; STEM reflective guides; workforce development council; rural manufacturing; professional development

PEER-REFEREED PAPER ▪ PEDAGOGICAL PAPERS

Dr. Raymond A. Dixon is an assistant professor of engineering and technology education in the College of Education, University of Idaho. His experience span Industry as a maintenance engineer and a training and program development specialist, and in Education as a teacher, instructor, lecturer and administrator. His research focus on STEM integration, expert performance in design, and workforce development. He was a fellow of the National Center for Engineering and Technology Education (NCETE), and ITEEA, CTETE leadership Institute.

Dr. Linda S. Stricklin Director of Workforce Training at Lewis-Clark State College in Lewiston Idaho has worked in post-secondary Workforce Training for fifteen plus years. She has been successful in securing grants in this area along with developing statewide curricula, publishing articles, book chapters and conference papers. Dr. Stricklin holds an Idaho Professional Technical Administrators Certificate and maintains a very active involvement in current and evolving issues with the Idaho State Division of Professional Technical Education.

Linking Technology Education in Rural Schools in North Central Idaho to Manufacturing

Dr. Raymond A. Dixon and Dr. Linda Stricklin

Abstract

In 2010, Clearwater Economic Development Association (CEDA), Valley Vision and Northwest Intermountain Manufacturers Association (NIMA) collaborated with Lewis-Clark State College and the University of Idaho to link technology education and students to local businesses in rural North Central Idaho. This project was funded by a National Science Foundation (NSF) Advanced Technology Education (ATE) grant #1104078. The NSF ATE initiative arose directly from consultations with manufacturers to identify entry-level employee skills urgently required in the region. The technology skill focus for this project was entry-level Computer Aided Drafting and Design (CADD) technicians due to manufacturers' indications of this as an area of great need. This article describes major accomplishments of this project which includes a job analysis; development of multiple resources for teachers; professional development of math, science, and technology education teachers; a student showcase; a mentoring program; and establishment of a workforce development council.

Background

In 2010, Clearwater Economic Development Association (CEDA), Valley Vision Economic Development and Northwest Intermountain Manufacturers Association (NIMA) collaborated with Lewis-Clark State College, University of Idaho, and six school districts in North Central Idaho on a National Science Foundation (NSF) Advance Technology Education (ATE) project. This project was designed to address the workforce needs of small to medium sized North Idaho manufacturing companies. North Central Idaho is comprised of Idaho, Lewis, Latah, Clearwater and Nez Perce counties. Rich in natural resources, the region has historically relied on agriculture, timber, and government for its economy. However, this area has endured a series of wrenching economic shifts over the last three decades as mainstay industries lost hundreds of jobs (K. Tacke, personal communication, September, 16, 2013). The region's population is older than the national average. The population of young people between 15-24 years of age within the counties containing the two higher education institutions is 16.7%. Much of this population, however, is comprised of transient students who come to study, earn their degree, then leave the area. High retirement rates combined with a growing manufacturing industry and their need for specific skills foretell the region will face significant workforce challenges (Idaho Department of Labor, 2013).

The aim of the NSF ATE project was to support a multi-agency educational initiative through which a collaborative model for regional workforce development would be developed to link rural students to manufacturing workforce needs. The primary population of focus was secondary school students and teachers in six, regional school districts. This initiative was supported through a carefully crafted team composed of members from higher education, economic development, and manufacturing. While models for collaboration and partnerships have emerged to prepare Career and Technical Education (CTE) teachers to teach STEM in urban areas with adequate resources, this project addressed unique challenges CTE professionals face in teaching STEM in rural regions where resources are scarce and population density is low.

Objectives

Key objectives associated with this initiative reflect the scope of activities necessary to build school capacity and teaching resources, and to sustain those activities after funding from NSF came to an end. Objectives were:

1. Pilot integration of solid modeling, computer-aided design into participatinghigh schools to encourage innovation and problem solving using STEM concepts coupled with career and educational ladders for students to lead into careers in manufacturing.

2. Develop, test, and revise an active manufacturing mentoring program with theschools to provide practical technical skill development in a contextual manner that can be transferred from school to the world of work.

3. Create and document the process of establishing a regional consortium that includes stakeholders from higher educational, K-12 systems, regional manufacturers, state agencies, and economic/community development groups.

Key deliverables associated with each objective stated above are hereafter described.

Pilot Integration of Solid Modeling in Participating High Schools

DACUM Research Chart

Manufacturing companies in the region were having difficulty employing workers with entry level Computer Aided Designing and Drafting (CADD) skills. It became obvious there was no competency profile describing duties and tasks of the entry level CADD technician required in the region. This information was necessary to design CADD training that was prescriptive so as reduce the gap between what is actually performed in manufacturing enterprises and what is taught in technology education classrooms. The decision was made to conduct a job analysis using the Developing A Curriculum (DACUM) process.

DACUM is a job-oriented task analysis process that seeks to understand and define skills and knowledge required to perform a particular job at a defined proficiency level. The DACUM process provides information about duties, tasks, general knowledge and attitudes for a particular job or occupation (Cooper, Aherne, & Pereira, 2012; Finch, & Crunkilton, 1999; Norton, 1997). A modified DACUM workshop was conducted. The process required a one-day workshop instead of the normal two to three days (Norton, 1997). The rationale for limiting the workshop to one day was based on recognition it would be too costly for small manufacturers to allow their expert CADD employees to participate in a two or more day workshop; most small manufacturers only employ one or two CADD workers. The DACUM research chart produced consisted of eight duty statements and 54 task statements along with general skills and attitudes for an entry level Mechanical CADD Technician; a portion of these are presented in Figure 1. In the summer of 2012, after the DACUM research chart was developed, solid modeling professional development workshops were conducted for mathematics, science and technology education teachers.

FIGURE (1): Entry Level Mechanical CADD Technician DACUM Research Chart

ENTRY LEVEL MECHANICAL CADD TECHNICIAN

Duties	Tasks			
Perform Project Research **A**	A-1 Gather reference documents & drawings	A-2 Review project scope	A-3 Review project specifications	A-4 Review relevant standards
Create Preliminary Designs **B**	B-1 Convert external files (e.g. images models)	B-2 Create 3D models	B-3 Update engineering data	B-4 Create preliminary layout
Participate in Project Review **C**	C-1 Review design with project team	C-2 Check for design issues	C-3 Specify design changes (e.g. redlines, markup)	C-4 Obtain owner approval of design
Create Final Drawings **D**	D-1 Revise drawing based on review	D-2 Rename and register project files	D-3 Check drawings for quality (e.g. appearance & legibility)	D-4 Print final drawings
Assist with Project Management **E**	E-1 Monitor project schedule/progress	E-2 Respond to vendors contractors phone calls	E-3 Determine project Issues	E-4 Resolve project issues (e.g., drawing, revisions)
Produce Project Documentation (Technical, Marketing, safety) **F**	F-1 Create as built drawings	F-2 Obtain approval of project official (e.g., stamp, signature)	F-3 Assist with project cost/time analysis	F-4 File project documents
Perform Administrative Task **G**	G-1 Perform software upgrades	G-2 Assist with CADD library maintenance	G-3 Assist with CADD standards manual maintenance	G-4 Request equipment and supplies
Participate in Professional Development **H**	H-1 Read professional literature	H-2 Participate in internal training (e.g. procedures, software, safety)	H-3 Network with professionals	H-4 Participate in external training (e.g., seminars, online, workshops)

Professional Development Workshops

The decision was made that in addition to improving CTE teachers' proficiency in solid modeling, it was also necessary to expose mathematics and science teachers to basic drafting and designing processes using the same solid modeling software. This decision was influenced by the fact that due to limited resources some rural schools use science teachers to teach technology education courses and other technical elements that underpin STEM and technology education. Manufacturers and the project team believed that greater opportunities for collaboration in STEM projects would materialize if mathematics and science teachers understood the software and tools used by CTE teachers. This decision was also strategic due to an impending inclusion of engineering content in the Next Generation of Science Standards (NGSS). Exposing mathematics and science teachers to basic drafting and design procedures was a positive step toward orienting them to engineering concepts.

In June and July 2012, two five-day professional development workshops were conducted for fourteen regional mathematics and science teachers in solid modeling and basic designing using SolidWorks®. Topics included sketching, basic part modeling, patterning, and simple analysis. The following year two additional one-day workshops were conducted with mathematics, science, and CTE teachers to discuss how they could more effectively collaborate using design projects allowing students to use concepts learned in both science and technology. During the final month of the project in 2014, a three-day SolidWorks® workshop was conducted to refresh mathematics, science, and CTE teachers' skills. In this final workshop, business and agricultural teachers also participated because they teach math or science at their schools. Additional instructional resources developed to improve students' skills in solid modeling and designing and to help students connect their drafting and designing experience to broader STEM concepts, were shared with teachers during the workshops.

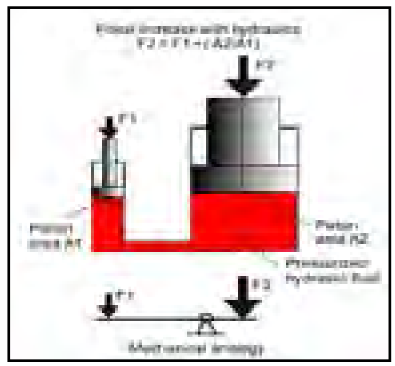
STEM Reflective Guides

One resource developed and provided to teachers were STEM Reflective Guides. The purpose of a STEM Reflective Guide was to provide resources to teachers to encourage student reflection of STEM concepts used and learned with CADD experiences. Through these reflections, it was hoped students would make connections between their CADD experiences and STEM concepts learned in other classes to be better equipped to transfer learning to solving mathematics and science problems. Linking relevant STEM concepts to design problems would also improve students' cognitive flexibility, metacognition, and reflective thinking, thus aiding in the creative and innovative solutions students could generate when faced with novel problems (Grossman, 2009; Johnson, 1997; Spiro, Coulson, Feltovich, & Anderson, 1988). The guides incorporated resources from Khan Academy, PhET (University of Colorado, Boulder), YouTube, and other web-based tools (see Figure 2).

FIGURE (2): Science Learning Experience #1

Science Learning Experience #1

There are several scientific principles associated with the function of a hydraulic or pneumatic cylinder. However, in this first activity we will focus on the hydraulic lever.

Activities	Special Instructions
The unique behavior of a fluid, including its ability to transmit an omnidirectional force, was summarized by Blaise Pascal in a theory known as Pascal's principle in 1653. Pascal's principle may generally be stated as follows: *"The pressure applied to a confined fluid is transmitted undiminished in all directions to every portion of the fluid."* This characteristic of a fluid allows it to function as a hydraulic lever. Its function therefore is similar to a mechanical lever. The break system in a car uses a hydraulic cylinder that follows the same principle of a mechanical lever. Follow the instructions in the column to your right to understand more about the principles behind a hydraulic lever.	Read this webpage. It explains how a hydraulic brake system functions as a lever. Watch the following YouTube Video: Pascal's Law and Hydraulic Brake System. Note in some places the video will pause momentarily. After a few moments it will continue. 

Online Video Resources

Six modular video series were developed for online delivery for CTE teachers to use in teaching solid modeling and designing. Module content was based on feedback from regional manufacturers. The intent of these videos was to provide students resources for independent use, at their own pace, outside of classroom time to develop CADD skills using SolidWorks®. Additional student and instructor resources were provided with permission of SolidWorks® from SolidWorks® Curricula. Two modules, which included twelve instructional videos, were developed covering information from basic through complex modeling of hydraulic and pneumatic cylinders. Three modules with twenty-three instructional videos covered content regarding designing and modeling a mold and other complex shapes. A final module with eight instructional videos with content about sheet metal and boat building was developed. These video resources supplement teaching tools CTE are using in their CADD classes. Students can view the resources at any time at home or in school to assist with learning (see http://www.lcsc.edu/nsf/teaching-resources/learning-videos).

Articulation

In 2013, articulation workshops were held at Lewis-Clark State College during which CTE teachers were provided a training CD containing curricular materials for SolidWorks®. These CD materials were provided for teachers to prepare students with CADD competencies required for articulated credit. Educational topics included *sketching, features tools for plastic parts, modeling sheet metal, simple sweeps and lofts, parts drawing, editing, building assemblies, visualization techniques*, and *assembly drawing*. Additionally, a course plan that illustrated content delivery in one semester was provided. Three articulated credits will be available to students who cover required content in the established timeline. These three credits articulate into Lewis-Clark State College's (LCSC) Automated Manufacturing Program (AMFTI 290 – Directed Study).

On-Line Option

In this rural region, some high schools are unable to offer CADD training due to limited resources, so an alternate delivery methodology was developed. A teacher in a distant school district was able to offer an on-line version of SolidWorks® training to students interested in learning CADD. This served as an alternative delivery model to help students and teachers begin learning SolidWorks®. LCSC developed an articulation agreement with the online teacher so these students are also able to register for articulated credit. A limited number of computers were purchased for some schools to build their capacity to offer CADD classes.

High School Showcase

In March 2014, three of the six secondary schools, manufacturers, and LCSC participated in a showcase at Lewis Clark State College. Students were able to display projects they, their teacher, and mentor from manufacturing worked on that semester. A criterion for the showcase was students demonstrate how STEM concepts were used in completion of their project. The goals were to spur students' interest in the manufacturing industry through "hands-on" learning experience involving manufacturing, solidify ties to STEM and engineering design, and to highlight mentoring programs.

Develop an Active Manufacturing Mentor Program

Mentoring Program

Benefits of mentoring are well documented (Eby & Lockwood, 2004; Denson 2008; Mott, 2002). One of NIMA's roles in this project was to help manufacturers contact schools close to their manufacturing facilities to initiate mentoring relationships with CTE teachers and students. The mentor program allowed manufacturers to provide technical assistance to CTE teachers and students. For example, students had access to machinery and equipment not available at their school with which to complete technology projects. Additionally, students were able to collaborate with their industry mentor to solve typical problems encountered in manufacturing. To ensure participating schools and manufacturers were aware of responsibilities as mentors and mentees, a handbook for mentoring was developed. Response from most of the manufacturers involved in the mentoring program was positive.

Establishing a Regional Consortium

Workforce Development Council

Clearwater Economic Development Association (CEDA) established a regional Workforce Development Council as a portion of the NSF grant to sustain the momentum developed through the project. The Workforce Development Council's first official meeting was held on July 17, 2012. Twenty-five individuals from the region participated— representing post-secondary and secondary education, manufacturing, the Nezperce Tribe, economic development, state government, labor, and elected officials. The Council's mission is to support and facilitate development of a business-focused, skilled workforce system that meets the needs of the region, enhances workplace productivity, and supports opportunities for employment and entrepreneurship through quarterly meetings.

Conclusion

The forgoing information outlined major accomplishments of this NSF ATE project in North Central Idaho. To date, the project has demonstrated the ability of various stakeholders from, higher education, economic development associations, manufacturing, and K-12 institutions to work together to address the unique in workforce education challenge that exist in this rural region and at the same time increase the partnership between to K-12 systems, higher education, community agencies, and manufacturing. Presently, project documents are being examined and project personnel are being interviewed so the authors can clearly articulate themes that emerge from this collaborative model with the intent that other rural areas with similar educational capacity and workforce education needs can replicate.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant No. 1104078. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Cooper, D., Aherne, M., & Pereira, J. (2012). The competencies required by professional hospice palliative care spiritual care providers. *Journal of Palliative Medicine, 13*(7), 869-875.

Denson, C. D. (2008). *Impact of mentorship programs to influence African-American male high school students' perception of engineering.* (Doctoral dissertation). Retrieved from http://ncete.org/flash/publications_dis.php.

Eby, L. T., & Lockwood, A. (2004). Protégé and mentors reactions to participating in formal mentoring programs: A qualitative investigation. *Journal of Vocational Behavior*, 67(3), 441-458.

Finch, C. R., & Crunkilton, J. R. (1999). *Curriculum development in vocational and technical education* (5th ed.). Boston, MA: Allyn Bacon.

Grossman, R. (2009). Structures for facilitating student reflection. *College Teaching*, 57(1), 15–22.

Idaho Department of Labor. (2013). *A report on the general economic conditions in North Central Idaho*. Retrieved from http://labor.idaho.gov/publications/lmi/pubs/IdahoProfile.pdf.

Johnson, S. D. (1997). Learning technological concepts and developing intellectual skills. *International Journal of Technology and Design Education*, 7, 161-180.

Mott, V. W. (2002). Emerging perspective on mentoring. In C. A. Hanson, *Critical perspective on mentoring: Trends and issues* (Information Series No. 8). Retrieved from http://files.eric.ed.gov/fulltext/ED465045.pdf

Norton, R. E. (1997). *The DACUM handbook*. Columbus, Ohio: The Ohio State University Center on Education and Training for Employement.

Spiro, R. J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. *Proceedings of the tenth annual Conferences of the cognitive science Society*, 375-383.