winter 2012

volume 76 number 1

THE ENGINEERING DESIGN GRAPHICS

# Journal

*Engineering Design Graphics Journal (EDGJ)*
Winter 2012, Vol. 76, No. 1
http://www.edgj.org

ISSN: 1949-9167

## Table of Contents

ISSN: 1949-9167

## Editorial Board, Advisory Board, and Review Board



**Online Distribution**
The online EDGJ is a reality as a result of support provided by East Carolina University; Biwu Yang, Research & Development, ECU Academic Outreach; Blake Smith, ECU Academic Outreach; and Cody Skidmore, Duke University Help Desk Specialist and the Journal's Web Production Manager.

ISSN: 1949-9167

## Message from the Chair

Aaron C. Clark
North Carolina State University

I would like to begin this Chair's message to the membership by thanking all the officers and members that have worked diligently over the past year to make our division the success that it is. Recently, I was working with a graduate student reviewing past proceedings and journal articles from our field and have noticed a remarkable difference in the amount research, cutting-edge technology, and overall quality of the type of data and information we are presenting to the public. With this success comes obligation, and I would like to challenge all members of the division to become active in attending our meetings regularly, as well as consider leadership roles within the profession. One area that I feel that we can improve as a division is to increase the current membership and outreach to communities. We can do this by continuing to recruit new members from within our profession, as well as from other disciplines and engineering. But a deficit that I see is graduate students attending our meetings and sessions as well as majoring with a concentration within our field. So as we begin a new year, let's take time and talk to our undergraduate and graduate students and help mentor those that we feel would make great leaders and instructors for our discipline and establish a long lasting future. Let us also reach out to public school programs and work with these instructors so that we can help provide good foundational practices for students wanting to study and develop visual literacy. It is my belief, that in this new age of technology and advanced communications that our discipline is more important than ever for the success of all students, not just those wishing to major in engineering. What we have to offer students is truly a great 21st century skill. Thank you for your time and dedication to this most important field of study, engineering design graphics.

Professionally yours,

Aaron C. Clark, DTE
Chair of the EDGD

*Engineering Design Graphics Journal (EDGJ)*
Winter 2012, Vol. 76, No. 1
http://www.edgj.org

ISSN: 1949-9167

**Message from the Editor**

Robert A. Chin
East Carolina University

Electronic Preprints: In an attempt to improve the effectiveness of disseminating research findings and the results of other creative endeavors among members of the engineering design graphics community, a message was sent to EDGD listserve subscribers in late March. The message asked the following: "Does anyone have experience with publishing preprints per the following http://cogprints.org/3019/1/eprints.htm Are preprints considered legit publications, and if so, where does it fall in the hierarchy of publications for tenure, promotion, merit, etc?"

While not mentioned in the message, an attempt is being made to revisit the relationship between manuscripts published in Mid-Year proceedings and those published in the EDGJ. Presently the EDGJ does not accept papers published in the Mid-Year proceedings unless they are significantly different from what was published in the proceedings, which is in contrast to past practices.

It can be argued however that if what is published in the proceedings are preprints, then manuscripts published in the proceedings can be submitted for consideration for publication in the EDGJ. This matter will be revisited by the EDGD's executive committee during its annual meeting in San Antonio.

Manuscript Submission: The EDGJ continues to seek high quality manuscripts for publication in the EDGJ. If you and your colleagues have research findings and the results of other creative endeavors in draft, polish them up and submit them for consideration, and encourage your colleagues to do the same. Reviews can be turned around in three to six months.

The EDGJ Review Board: The composition of the EDGJ's review board will be examined during the Division's annual meeting in San Antonio. The purpose of the review is to ensure it is comprised of and is representative of what we today and in the future consider to be full spectrum engineering design graphics. The likelihood that we will be seeking additional review board members is pretty high. During my tour as Editor, we've only added one new board member. Moreover and to the best of my knowledge, a formal review of the board's composition has never been conducted.

Please respond to any and all of the aforementioned at your earliest convenience—send me a message at chinr@ecu.edu. I'd like to synthesize all the inputs and share them with the executive committee in June. Hope to see you in San Antonio.

ISSN: 1949-9167

**The Cengage Grant**

The 2011-2012 Cengage Grant recipient is Embry-Riddle Aeronautical University's Lulu Sun.

The Cengage Grant is intended to encourage potential and new graphics instructors to participate in the activities of the Engineering Design Graphics Division of ASEE. It is also anticipated that the grant recipients will make the EDGD one of their professional affiliations and activities on an ongoing basis throughout their professional career.

Photo by Theodore Branoff

Lulu is an Assistant Professor in the Department of Freshman Engineering at Embry-Riddle Aeronautical University, where she has taught since 2006. She received her B.S. degree in Mechanical Engineering from Harbin Engineering University (China) in 1999, and her Ph.D. degree in Mechanical Engineering from University of California, Riverside in 2006. Before joining Embry-Riddle, she worked as a fire engineer in the Los Angeles office of the consulting firm Arup.

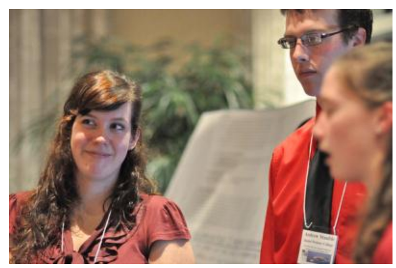
The award description can be found at http://edgd.asee.org/awards/cengage/index.html

A complete list of awardees list can be found at http://edgd.asee.org/awards/cengage/awardees.html

ISSN: 1949-9167

## The Media Showcase Award

The recipients of the 2011-2012 Media Showcase Award are M. Kelly, M. Campbell, A. Stauble, J. O'Donnell, and Nicholas Bertozzi of Daniel Webster College; Ted J. Branoff of North Carolina State University; A. Varricchio of Pratt and Whitney; and Timothy Sexton of Ohio University for their presentation entitled *Development of an Inverted Classroom Module for Multiview Drawing*—see Figure 1.



Photos by Theodore Branoff

The Media Showcase Award was established to encourage the highest level of professionalism in media presentations at the Engineering Design Graphics Division Mid-Year Conference and includes a framed citation and cash award. The Division's Chair announces the award recipient at the conclusion of the Division's Mid-Year Conference during the Awards Banquet.

The award description can be found at http://edgd.asee.org/awards/media/index.html

A complete list of awardees list can be found at http://edgd.asee.org/awards/media/awardees.html

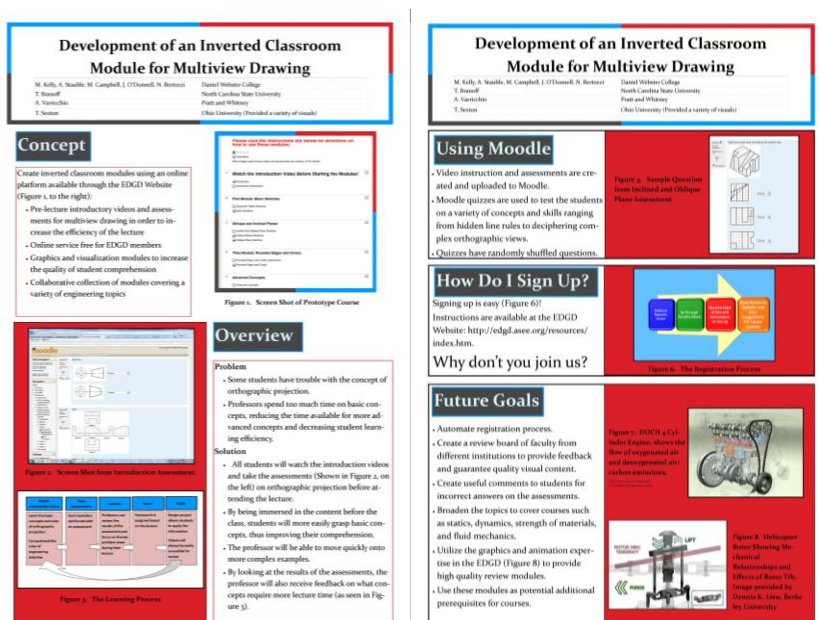



Figure 1. 2011-2012 Media Showcase Award Boards.

ISSN: 1949-9167

## The Payne Award

The Payne Award was established in recognition of Rodger Payne who, during his association with the Engineering Design Graphics Division, epitomized the best in industrial and educational cooperation, was a strong supporter of graphics education, and became a true friend to each member who knew him. The Award (1) is conferred upon an individual, who over a period of time demonstrates support and encouragement to our Division as was demonstrated by Rodger Payne of Autodesk, Inc., (2) is non-competitive, and (3) is not given regularly; rather it is reserved to recognize an extraordinary level of industrial support. During the 2011-2012 Mid-Year Conference, SolidWorks' Director World Education Markets, Marie Planchard, was recognized by the Division for her continued support of the Division and its members.

Photo by Theodore Branoff

Before joining SolidWorks, Marie spent over 10 years as an engineering professor at Mass Bay College in Wellesley Hills, MA. She has 14 plus years of industry software experience and held a variety of management and engineering positions.

Marie holds a BSME, MSME and a Certified SolidWorks Professional Certification. She is an active member of the American Society of Mechanical Engineers and the American Society for Engineering Education.

In her SolidWorks blog, she says she works “directly with educational institutions including middle schools, high schools, technical and vocational schools as well as colleges and universities. My job is to talk to all students, teachers and mentors to understand what is needed to further or enhance design and engineering education. It has been really amazing to see how far SolidWorks has gone to improve education and how this sector is continuing to grow.”

The awardee is recognized with a framed citation or plaque, which is presented by the Division Chair or their delegate at the Annual Conference Awards Banquet. Following the presentation, the recipient may address those assembled.

The award description can be found at http://edgd.asee.org/awards/payne/index.htm

A complete list of awardees list can be found at
http://edgd.asee.org/awards/payne/awardees.htm

ISSN: 1949-9167

## The Schroff Participation Grant Recipients

The 2011-2012 Schroff Participation Grant recipients are the University of Idaho's Raymond Dixon and Northeastern University's Euridice Oware.

Dr. Oware is an Executive Professor and Academic Specialist in Engineering Technology for the College of Professional Studies. Prior to coming to Northeastern, Euridice was a GK-12 Program Coordinator at Boston University. She has also done extensive engineering research for Purdue University. Euridice earned her Doctor of Philosophy in Engineering Education from Purdue University.

Dr. Dixon is an Assistant Professor in Curriculum and Instruction, College of Education. After completing his master's degree in Technology at Illinois State University, he taught for three years at the School of Technical and Vocational Education, University of Technology, Jamaica. Before joining the University of Idaho, Raymond worked as a research coordinator at the Center for Mathematics Science and Technology, Illinois State University.

The Schroff Participation Grant is intended as a developmental program to encourage potential and new graphics instructors to participate in the activities of the Engineering Design Graphics Division of ASEE. It is also anticipated that the grant recipients will make the EDGD one of their professional affiliations and activities on an ongoing basis throughout their professional career.

The award description can be found at http://edgd.asee.org/awards/schroff/index.htm

A complete list of awardees list can be found at http://edgd.asee.org/awards/schroff/awardees.htm

Photos by Theodore Branoff

ISSN: 1949-9167

## The Oppenheimer Award

The 2011-2012 Oppenheimer Award recipient is Kevin L. Devine of Illinois State University for his presentation of Dimensional Tolerances: Back to the Basics. Dr. Devine's paper appears on the following pages.

The Oppenheimer Award was established by Frank Oppenheimer to encourage the highest level of professionalism in oral presentations at the Engineering Design Graphics Division Midyear Meeting. The award includes a framed citation and cash award. At the conclusion of the Midyear Conference, the Chair announces the recipient during the Awards Banquet. The Oppenheimer Award is funded by a yearly cash award by the Oppenheimer Endowment Fund.

The award description can be found at http://edgd.asee.org/awards/oppenheimer/index.htm

A complete list of awardees list can be found at http://edgd.asee.org/awards/oppenheimer/awardees.htm

*Engineering Design Graphics Journal (EDGJ)*
Winter 2012, Vol. 76, No. 1
http://www.edgj.org

ISSN: 1949-9167

# Dimensional Tolerances: Back to the Basics

K. L. Devine
Department of Technology
Illinois State University

## Abstract

Students often have difficulty grasping the principles of dimensional tolerances and frequently fail to recognize that dimensioning practice has a significant impact on the tolerance of part features. This observation may be attributed to several factors, not the least of which are changes in prior student education and life experiences and increasing pressure in academia to add course content to cover new technologies, sometimes at the expense of fundamental concepts. This paper presents some back-to-basics instructional methods designed to help students improve their understanding of tolerances, including a description of some hands-on instructional activities that were implemented in the Engineering Technology program at Illinois State University.

## Introduction

The focus of the Engineering Technology program at Illinois State University (ISU) is to prepare technically-oriented management professionals for work in a variety of manufacturing-related careers. Few of our graduates are expected to make decisions regarding the appropriate tolerances for a given product, although many are expected to interpret part prints that include tolerance specifications. Accordingly, our focus is to provide instruction to help students develop the ability to interpret dimensional tolerances and help students develop an understanding of the relationship between dimensioning and tolerancing practices and the cost to manufacture a product.

In years past, many students came to the Engineering Technology program at ISU with prior hands-on shop experience obtained by working on the farm or in K-12 technology education classes. Today, however, seemingly few students come to ISU with experience physically making things with their hands, resulting in a student population that often has difficulty finding meaning in textbook discussions of tolerances. For example, a textbook discussion of full indicator movement (FIM) has little meaning to engineering graphics students who have never seen a dial indicator. Similarly, some students have difficulty appreciating the meaning of a tolerance callout of +/- .005” because they have never used a measuring instrument capable of measuring at that precision. Topics such as tolerance stacks and datum reference frames are abstract concepts to many students who often simply learn these concepts by rote rather than develop an understanding and appreciation for the tolerance-related messages expressed on part prints.

ISSN: 1949-9167

This paper describes several hands-on group activities that have been added to an intermediate engineering graphics course at Illinois State University. The group activities require students to interpret a variety of dimensioned part prints and physically measure the parts they describe. Although all groups measure the same physical parts, different dimensioning practices were used on the part prints, frequently resulting in the parts being "good" for some groups but "bad" for other groups. Each group created inspection reports for their parts and was required to explain and defend their report to the other groups in the class. In some cases, the part prints were intentionally over-dimensioned to help students discover that this practice leads to conflicting tolerances and multiple interpretations.

## Background

The ISU Engineering Technology Industry Advisory Board is comprised of 12 professionals working in a variety of manufacturing-related industries throughout the Midwest. One consistent theme discussed by ISU advisory board members is the importance of print reading and tolerance interpretation skills in the manufacturing workplace. Similarly, the literature is replete with work indicating that engineering and engineering technology students should receive instruction in the area of tolerancing concepts. For example, Meznarich, Shava, and Lightner (2009) presented the results of a study that indicated print reading and tolerance interpretation were seen as important topics by both industry professionals and educators. Lamb and Kurtanich (2007) describe the rationale and structure of a new course they developed at Youngstown State University to help improve instruction in various areas of print reading including tolerance interpretation. Evans (2004) describes an innovative approach to use standard CAD tools to "virtually" inspect products based on geometric dimensioning and tolerancing (GD&T) callouts. Sriraman & DeLeon (1999) describe their use of a coordinate measuring machine (CMM) to help improve instruction in the area of GD&T. In summary, based on input from our program constituents, as well as support from the literature, the engineering graphics curriculum at ISU was modified in 2010, allowing new instructional activities to be added in the area of dimensional tolerancing.

## ISU Curriculum Changes

ISU Engineering Technology students are required to take two courses specifically dealing with engineering graphics and technical drawing. Until recently, the TEC116 course, Introduction to Technical Drawing, introduced students to the fundamental principles of technical drawing using primarily hand-sketching and 2D AutoCAD™. This former TEC116 course was designed to accommodate students from primarily two technical areas: engineering technology and construction management, and therefore had broad course content. Engineering Technology students then took a second required course, TEC216 Computer Aided Design and Drafting, in which they were introduced to the principles of constraint-based solid modeling, and a variety of manufacturing-related technical drawing topics including ASME dimensioning and tolerancing principles. The former TEC216 course schedule included two days of

ISSN: 1949-9167

discussion dealing with traditional tolerancing topics and two additional days of introduction to GD&T.

Based on recommendations from our industry advisory board and program alums, several curriculum changes were implemented in 2010. A new introduction to construction graphics course was implemented to serve the specific needs of construction management students, and the TEC116 course, which is still required for engineering technology students, was significantly modified. The most notable change in TEC116 was the deletion of content dealing with 2D AutoCAD™ and the addition of 3D solid modeling content using Autodesk Inventor™. TEC116 students now receive a comprehensive introduction to constraint-based solid modeling during their first engineering graphics course. This change has had a dramatic effect in the TEC216 course because much of the time spent in previous years introducing students to the principles of solid modeling may now be spent covering other topics. The TEC216 course now includes expanded coverage of dimensional tolerancing principles. The remainder of this paper presents some of the instructional activities that have been added to the revised TEC216 course.

## Activities to Support Basic Tolerance Concepts

Dimensional tolerance instruction in the TEC216 course begins with a discussion of tolerancing terms and concepts such as tolerancing formats, limits of size, and fits. The main focus of instruction at this point is on the fundamental concepts of traditional (+/-) tolerancing. After several calculation sheets and sample part prints had been worked through together in class, students were divided into small groups and given a simple machined part, partially dimensioned print (Figure 1) and a dial caliper. Students were then asked to use the dial caliper to measure several part features, complete an inspection report (Figure 2), and make definitive statements about whether the part features were in tolerance. Finally, groups were randomly selected to present their inspection results to the class. When opinions from the groups differed, the students were required to defend their findings.

To make things a bit more interesting, several features on the part prints were dimensioned differently and given to the groups. For example, the slot feature size and location (dimensions D, E and F in Figure 1) were intentionally dimensioned using different methods, resulting in students using different inspection methods to measure the slot. In some cases, several groups concluded the slot feature met specifications while other groups did not. Using different dimensions on the part prints resulted in several discussions regarding dimensioning practice and the designer's true intentions.

After physically measuring two parts in small groups, students were required to complete several tolerance calculation exercises using only part prints. Although these exercises have been completed in the TEC216 in previous semesters, a noticeable improvement in student performance was observed, and in-class discussions on these exercises involved more students this semester. This semester, a simple part print that

ISSN: 1949-9167

was intentionally over-dimensioned was given to the students (Figure 3). This problem created quite a bit of discussion as students discovered there was more than one way to calculate the limits of size for this part. While students had previously been told that over-dimensioning is poor practice, several students commented that the exercise helped them understand why this practice is not acceptable, especially when they were pressed to complete the simple tolerance table that accompanied the print.

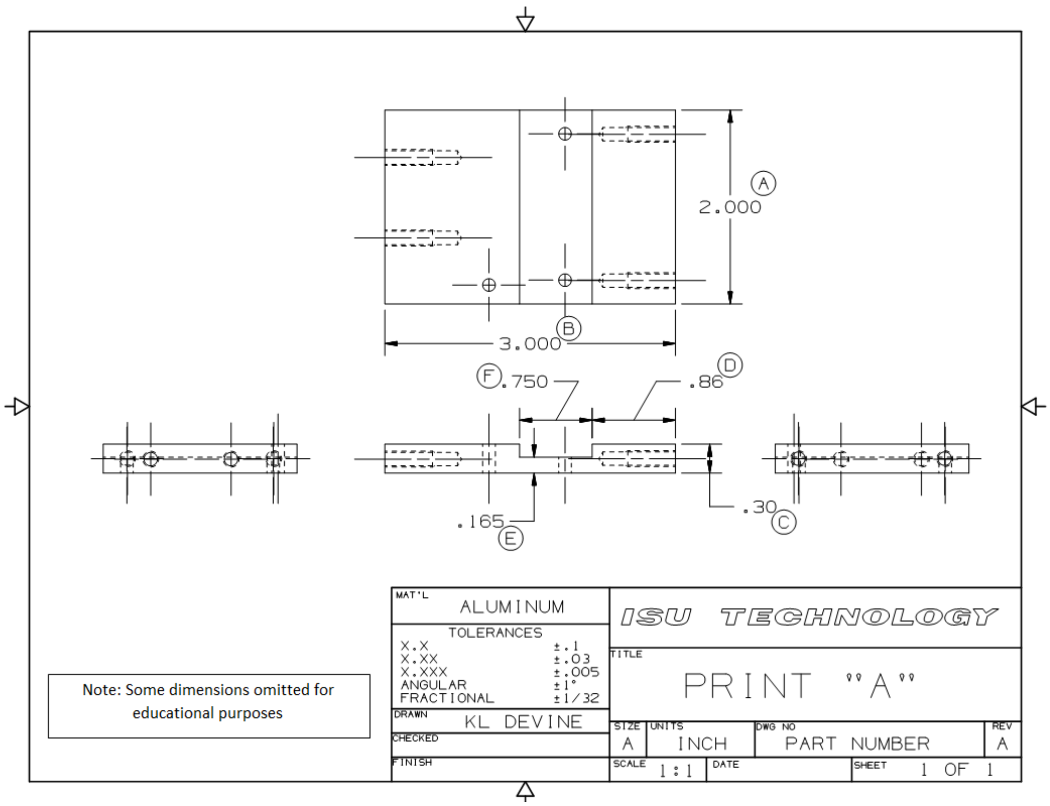



Figure 1. Sample part print.

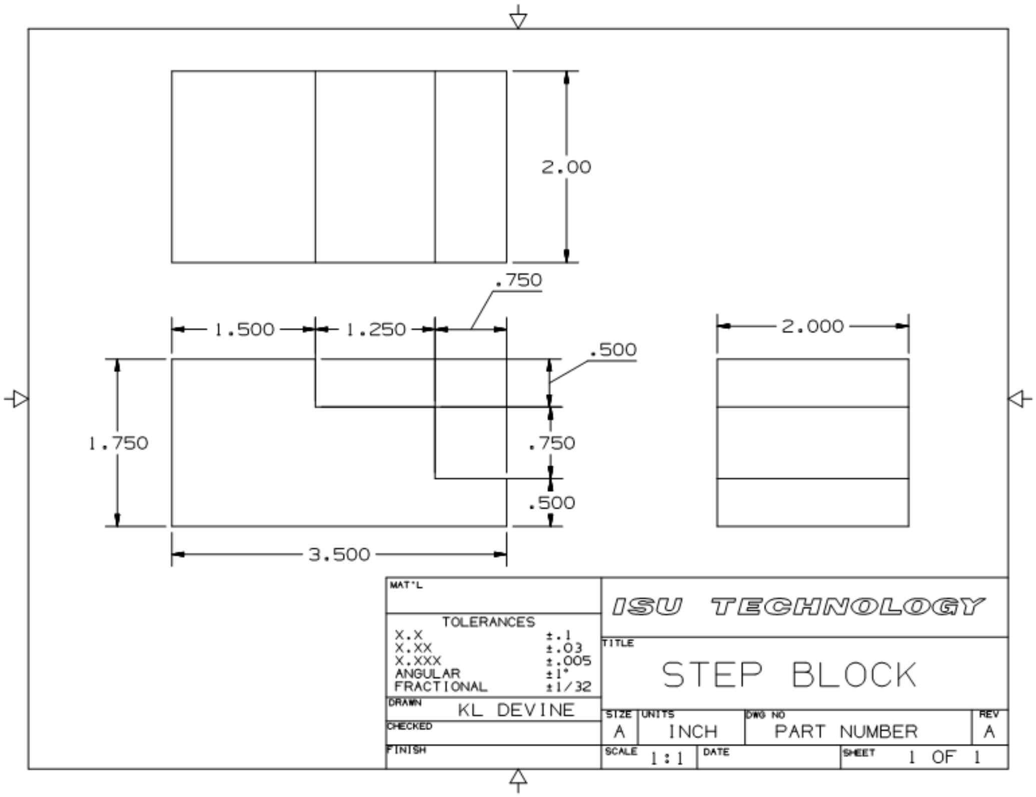
| Feature | Nominal | Actual | Deviation | Tolerance | Upper Limit | Lower Limit | Out Of Tolerance Amount | In tolerance? |
|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | Yes / No |
| B | | | | | | | | Yes / No |
| C | | | | | | | | Yes / No |
| D | | | | | | | | Yes / No |
| E | | | | | | | | Yes / No |
| F | | | | | | | | Yes / No |

Figure 2. Sample inspection report.

After spending two class periods measuring parts using dial calipers and completing print reading exercises and calculations sheets, students were required to measure two parts using a coordinate measuring machine (CMM). Working in small groups, the students were guided through the process of measuring various part features to create

Copyright 2012
ISSN: 1949-9167

a computer-generated inspection report identical in format to the report illustrated in Figure 2. These CMM measuring activities helped students better understand concepts of measurement accuracy and helped set the stage for some future GD&T measurement activities.




Based on the print above, complete the following table:

| Feature | Nominal size | Tolerance | Maximum Limit of Size | Minimum Limit of Size |
|---|---|---|---|---|
| Overall length | | | | |
| Overall height | | | | |
| Overall width | | | | |

Figure 3. Sample over-dimensioned print.

## Hands-on Activities to Support GD&T Concepts

Instruction in GD&T principles took place after students had completed the activities described above. By this point in time, students had been exposed to basic concepts such as maximum material condition (MMC), least material condition (LMC), fits, and the like. The students had also experienced print reading and simple part inspection using a dial caliper and a CMM.

  ISSN: 1949-9167

GD&T instruction started with an introduction to feature control frames and symbols, tolerance zones, and the datum reference frame. Several textbook exercises and in-class feature control frame exercises were conducted to help students learn about the basic language of GD&T. Several hands-on activities and demonstrations were added using hand-measuring instruments to augment the textbook-based instruction. For example, students were shown how to use a dial indicator, height gage, and surface plate to measure a part surface. By using these tools, students gained a better understanding of the tolerance zones being described by various feature control frames. Other instruments demonstrated included gage blocks, sine bars, and vee-blocks.

Students were then given simple machined parts and prints containing GD&T callouts. The students were first required to interpret the datum reference frame and feature control frame callouts (limited to true position). Tolerance zones specified by the feature control frames were hand-drawn on the print and a CMM inspection plan was created to measure the required physical part features. Next, a sample part was loaded on the CMM and students were instructed how to use the CMM software functions to implement their inspection plan. The graphics capabilities of the CMM software allowed a CAD solid model of the part to be opened and displayed. This feature proved to be very helpful when establishing the datum reference frame because the software displayed the frame using the same coordinate system triad (XYZ axes) used by most CAD systems. Figure 4 illustrates a simple part that was measured by the students.

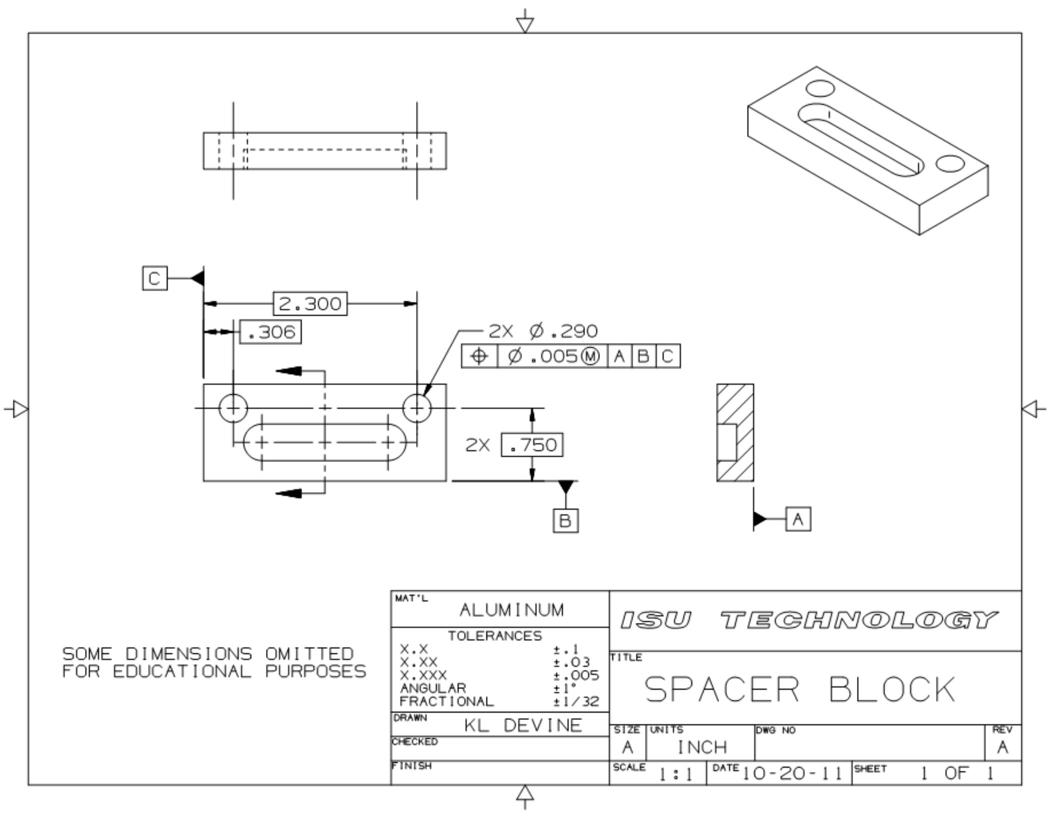



Figure 4. Sample GD&T print.

## Conclusions

Although the changes to the engineering graphics courses describe above were implemented at ISU during the Fall 2010 semester, the impact of the changes were not seen in the TEC216 course until the Fall 2011 semester. As expected, the curriculum change freed up some time in the TEC216 course to allow for additional instruction in several areas including dimensional tolerancing.

Engineering Technology students seem to learn best by putting theory into practice. Therefore a priority was placed on adding hands-on activities in the TEC216 course in the area of dimensional tolerances. The hands-on measuring activities added in TEC216 seemed to help ground the abstract tolerance concepts into knowledge that students can better understand and use. The activities were not difficult to design and implement and although the activities described in this paper included the use of a CMM, other activities utilizing less expensive measuring instruments could be developed in their place. While the activities themselves seem somewhat simple in nature, they proved to be very beneficial to student learning. Anecdotal comments from students as well as overall performance in the class suggest the activities were well received by the students and helped improve student understanding of dimensional tolerances. In a time when educators are often pushed to add new technology to their courses, sometimes a back to the basics, hands-on approach should be considered.

## References

Evans, E. R. (2004). Solid Models, Virtual Inspection and the Position Tolerance. Proceedings from the 59th Annual Midyear Meeting of the American Society for Engineering Education/Engineering Design Graphics Division (ASEE/EDGD), Williamsburg, VA.

Lamb, C. M, Kurtanich, D. G (2007). Drafting the Basics. Engineering Design Graphics Journal, 71(3), 35-44.

Meznazrich, R. A., Shave, R. C., & Lightner, S. L. (2009). A Curriculum Model: Engineering Design Graphics Course Updates Based on Industrial and Academic Institution Requirements. Engineering Design Graphics Journal, 73(2), 31-41.

Sriraman, V., DeLeon, J. (1999). Teaching Geometric Dimensioning and Tolerancing in a Manufacturing Program. Journal of Industrial Technology, (15(3). 2-6.