

# Integration of an Information Technology Software Project in Engineering Graphics Instruction

Cameron Coates, Kam Fui Lau, and Lorrie Hoffman

**Abstract**— In this paper, we describe a method of integrating an information technology software project in engineering graphics instruction. We have two main goals in the study. Our first goal was to expose information technology students to a second discipline for which they will be developing software. Our second goal was to assess if integration could lead to better academic performance of engineering students. The background, objectives, architecture and justification for the application are also discussed. The authors present the application within an Engineering Graphics course and examine the effect of software use on Engineering Graphics students' academic performance as well as their perceptions and expectations of their understanding, appreciation, motivation, interest, and knowledge retention in engineering graphics transferability. The academic performance outcomes assess the impact of the software use on the student's ability to interpret solid model data, and use this data to understand how engineering graphic components are represented by numerical data files and their transferability among different CAD programs. Statistical analysis is performed on course survey data that includes academic performance outcomes and the student's perceived impact of the software on their ability to learn the material. By introducing a linear discriminant function, we demonstrate that the introduction of the software in the engineering graphics course serves to improve student learning.

**Keywords**— Computer Science Education, Engineering Education, Engineering Graphics and IGES File

## I. INTRODUCTION

Researchers have reported that many engineering graphics courses are focusing on teaching students procedural knowledge of how to use CAD software, mainly of using the appropriate commands and procedures in generating the engineering drawings [1]. While learning procedural knowledge is important for engineering graphics students, it is

substantially more important that they understand how each CAD program interprets and represents engineering design concepts, this may be defined as conceptual knowledge. For example, one important skill required of engineering graphics students is the ability to transfer various types of engineering drawing files from one CAD program to another. The engineering students need to know or be able to quickly determine how the dominant CAD programs import and export files from other commonly used CAD programs. This is the procedural knowledge. In general, engineering graphics drawings are captured in several files with different file formats. Some of them are binary which cannot be visually interpreted, but there are also ASCII numerical files that can be. The ability of an engineer to manipulate those numerical data files in order to transfer them between CAD programs serves to optimize design productivity in industry. The knowledge required in order to develop this skill set is primarily conceptual. Conceptual knowledge is defined as a connected web of knowledge; a cognitive network in which relations between nodes are as important as the discrete pieces of information constituting these nodes [2]. Rittle-Johnson et al. [3] and Mahir [4] show that understanding the concepts may enhance procedural knowledge and performance. With the advent of concurrent engineering, modern engineers also now need to communicate with a greater diversity of technical professionals. In many cases these professionals will use different graphic modeling packages from new and old clients, other engineering firms, government agencies, and legacy systems [5], [6]. The understanding of numerical representation of 3D data and their transferability among different graphic modeling packages has therefore become more important for today's engineers [7]. Engineering students should not only know the most common file formats available for file transfer, but they should also be able to understand and manipulate these formats in order to combine capabilities of the various modeling packages.

As the complexity and number of CAD packages increase, companies want engineering graduates who are able to understand, manage and troubleshoot data transferability between these packages. Branoff, Hartman, and Wiebe [8] surveyed several engineering design companies in 2001 to determine the types of skills that applicants would need to

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secure a position in constraint-based modeling. The authors concluded that companies prefer graduates who are able to identify and fix problems in 3-D geometry, use powerful knowledge-based systems to design complex assemblies, and be flexible enough to do design and development work. Cumberland [9] also performed a similar survey of twenty eight companies and concluded that data translation, file and data management, constraint-based solid modeling, web technologies, simulation, animation and a study of current trends and issues were among their essential requirements for engineering graduates. Consequently, it is imperative that Engineering Graphics students, at a minimum, understand how the more popular neutral file formats translate CAD files and what the current issues are regarding static data exchange, one-way data exchange, redundancy, and information loss. Students should therefore learn the fundamentals of the interpretation process so that the transferable mechanism is not treated as a “black box” and be able to effectively manage and troubleshoot these systems. Our work is an attempt to provide engineering students the necessary foundation of engineering graphics representations and their transferability.

The objectives of this work were (1) to develop an Information Technology (IT) Senior Capstone Project that would provide the exposure of a second discipline (i.e., Engineering Graphics) to an IT student who would need to integrate the requirements of Engineering Graphics in his project and (2) the application of this project within an Engineering Graphics course that would result in, (a), improved student performance using traditional assessment measures, and (b), improved student perceptions of personal characteristics that have been shown to enhance learning (e.g., motivation, interest).

In order to design the IGES Parser Utility, our Information Technology student needed to fully grasp the concepts of numerical data representation in engineering graphics programs in general and how the numerical data representation is stored in IGES file format in particular. The development of the IGES Parser Utility enabled our IT student to learn integration of a second discipline knowledge in an information technology project. Information Technology professionals are required to provide solutions of computing and specialized application needs of users within their organizations. Often the users are from other departments within their organizations, like marketing and sales, accounting and finance, engineering and manufacturing, and more. The user needs of specialized application solutions from other departments require the understanding of the specific requirements of those specialized applications from the information technology professionals in order to provide effective service. We call those specialized application areas second disciplines. It is apparent that information technology students should be exposed to applications within second disciplines in order to prepare them for serving different users needs when they graduate and work in organizations. Aasheim et. al. [10] and Spooner [11] reported the usefulness and importance of the concept of

integrating a second discipline in the information technology curriculum.

Since the development of software packages tailored towards CAD/CAM, various neutral data formats have also been designed in order to allow for the digital representation and exchange of product definition data. Two of the more prominent systems are the Initial Graphics Exchange Specification (IGES) format and the STandard for the Exchange of Product model data (STEP) format. The IGES format has been an American National Standards Institute (ANSI) standard since the 1980s while the STEP format has been an International Standard’s Organization (ISO) standard since 1994. Nevertheless, both file types have similar data exchange architectures and are capable of exporting wireframe, surface or solid model information.

The IT project chosen was the design of an IGES parser utility able to import IGES files, and display models of the various entities (e.g., arcs, surfaces) and their related numerical components. The Engineering Graphics curriculum is already quite full and there is not much time available within a one semester course for the exploration of file transferable mechanisms. The efficiency with which IGES file essentials are taught can be increased with the use of interpretive software. The IGES Parser Utility software that we have developed is able to interpret the various numerical elements and provide the geometric equivalencies. The use of the software can be added to a multimedia presentation, a web-based presentation or a digital tutorial system. Additionally, engineering students’ ability to utilize engineering graphic drawing packages would be greatly enhanced if they understand what information gets lost in the file transfer process and why.

The IGES was chosen over the more recently developed STEP for several reasons. While the STEP file format offers several advantages [12], [13], IGES has a longer history, and has had a wide range of applications in the last decade [14]-[17]. With the explosion of numerous CAD software packages, a growing trend has been the importation of CAD files from diverse sources in order to increase overall design efficiency. Often these sources may be international or from archives developed prior to the establishment of STEP. In many cases, older software packages are still being used by the engineering industry in less developed countries. The more popular CAD packages on the market today (SolidWorks, ProEngineer, CATIA, AutoCad) have both IGES and STEP capability. While there are commercial and shareware IGES parsers available, we chose the development of our own parser so that we could customize it for our Engineering Graphics course. Additionally, we have the architecture of the software on file which allows us to use it as a teaching tool in our IT courses. The IGES was also easier to develop for the IT students as there are more free resources online dedicated to interpreting or modifying IGES files. The IGES parser utility platform will serve as an example framework for future interdisciplinary projects with engineering and may be modified in the future to

accommodate STEP files.

In this paper, the authors describe a novel software application that provides geometric interpretation of IGES files and examine the impact of the software use by Engineering Graphics students on academic performance and perceived traits that have been shown to improve learning [18]-[20]. The IGES parser utility allows for immediate feedback to the Engineering Graphics students and serves as an efficient instructional tool in understanding the fundamentals of neutral file formats.

## II. OVERVIEW OF THE IGES PARSER UTILITY SOFTWARE

The National Bureau of Standards published its Digital Representation for Communication of Product Definition Data (The Initial Graphics Exchange Specification (IGES)) in January 1980 (USPRO, 1993 [21]). The goal of IGES is to facilitate the exchange of engineering drawing among different engineering graphics programs.

In the Armstrong Atlantic State University Engineering Studies program, we use SolidWorks CAD software in our Engineering Graphics course. SolidWorks files are stored as binary files for two conditions; one file is for the parts document (.SLDPRT) and the other for assembly information (.SLDASM) for a multi-part drawing. However, the SolidWorks preprocessor is also able to convert its files to many other formats, including the IGES file format, which is the industry standard ASCII file for engineering drawing.

As discussed, we developed the IGES Parser Utility software for enhancing our Engineering Graphics instruction. The software is a 32-bit application designed to help engineering students understand and appreciate the numerical representation of engineering graphics elements in the IGES file. The design of the software can also serve to support an introductory module on CAD/CAM systems for Information Technology and Computer Science students. For these students, such a module may strengthen their awareness and appreciation for other fields where information technology applications are prominent (such as engineering). Similarly, the software can be used to increase the awareness of the engineering students regarding the importance of information technology functions such as file reading and parsing, that they might normally take for granted.

The software was developed in order to improve the efficiency of the learning process in the study of neutral file formats. The learning objectives were (i) to develop and retain an understanding of IGES file structure and architecture (ii) to acquire and retain knowledge of IGES file functions and limitations (iii) to develop and retain an understanding of the characteristics most likely to be universal to all neutral file formats, i.e. those shared with other neutral files such as STEP, and (iv) to be able to apply the knowledge from (i)-(iii) towards the development of solutions for basic CAD file transfer problems.

### A. Software Design

The software was designed to accommodate visual, sensing, inductive, and active learning styles. Felder [22] demonstrated that the implementation of tools or strategies that support these learning styles will reduce the mismatch between student learning styles and typical engineering teaching styles. Other authors [23]-[25] have found particular support for this concept for engineering design and visualization instruction. Therefore the software was designed to satisfy specific cognitive goals that naturally evolve from the aforementioned learning objectives. These include recognizing entities, relationships, structure, differentiation, diagnosis, prescription and the application of theoretical knowledge to practical solutions.

### B. User Friendliness

The software was designed to have a familiar and comfortable visual interface, while maintaining efficiency and functionality. The functional purpose of the software application is to parse and display in a readable format of the various sections and data contained in an IGES (Initial Graphics Exchange Specification) file. Primary functionality of the software application includes:

- Tree view structure of IGES file sections and data
- Web-page style summary of IGES file sections
- Web-page style detail of IGES file section data
- 3D CAD viewer for representation of the object

This type of structure has been shown to allow efficient assimilation and dissemination of information.

The IGES Parser Utility window is shown in Fig. 1 and Fig. 2. Fig. 1 displays a 3D object in the IGES Parser Utility window. Fig. 2 displays the numerical data representation of a 3D object. The data is provided in tabular form such that the entity designation, value and description are distributed among three columns.

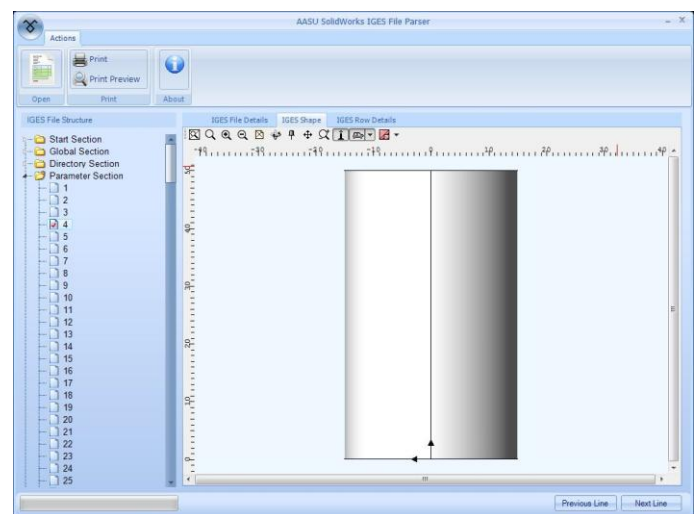


Fig. 1: The IGES Utility Parser displays a 3D Object

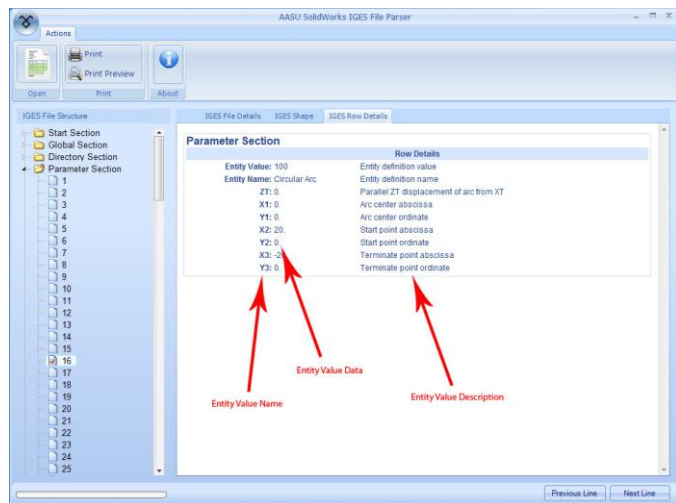


Fig. 2: IGES Parser Utility displays the parameter sections

### C. IGES File Structure

The fundamental unit of data in the file is the entity. Entities are categorized as geometrical and non-geometrical. Geometrical entities represent the definition of the physical shape and include points, curves, surfaces, solids, and relations that are collections of similarly structured entities. Non-geometrical entities typically serve to enrich the model by providing a viewing perspective in which a planar drawing may be composed and by providing annotation and dimensioning appropriate to the drawing. Non-geometrical entities further serve to provide specific attributes or characteristics for individual or groups of entities and to provide definitions and instances for groupings of entities. The definitions of these groupings may reside in another file. Typical non geometrical entities for drawing definition, annotation, and dimensioning are the view, drawing, general note, witness line, and leader. Typical non-geometrical entities for attributes and groupings are the property and associativity entities.

An IGES file consists of 5 sections: Start, Global, Directory Entry, Parameter Data, and Terminate. The file may include any number of entities of any type as required to represent the product definition. Each entity occurrence consists of a directory entry and a parameter data entry. The directory entry provides an index and includes descriptive attributes about the data. The parameter data provides the specific entity definition. The directory data are organized in fixed fields and are consistent for all entities to provide simple access to frequently used descriptive data. The parameter data are entity-specific and are variable in length and format. The directory data and parameter data for all entities in the file are organized into separate sections, with pointers providing bi directional links between the directory entry and parameter data for each entity. The specification provides for groupings whose definitions will be found in a file other than the one in which they are used.

### D. Code Architecture

Careful consideration was given to the scalability of the programming code. XML was the data format chosen to encapsulate the parsed file data due to its portability. For example, given the data is packaged in XML format it can be easily distributed or ported to a web application.

Open Cascade is an open-source library used to visualize the shape in the 3D control environment represented in the application interface. Basic functionality is used currently and consists of simple “view-only” visualization within the application interface. This gives the end user the ability to “see” what type of object the software application is representing.

The Directory section organizes and gives structure to the information in the Parameter Data section. There can be only one directory entry for each Parameter Data section entity. Directory section entries may reference other Directory section entries. This would occur when a transformation matrix is specified in order to represent structures. The supported parameter data is the data being communicated. Table 1 lists some directory entries supported by the IGES Utility Parser.

The Parameter Data section contains the data that defines the entity. For example, if the entity is a circular arc, you will find the center, start, and end points, unit normal, and whatever else is required to define it. Entity parameter details are parsed and represented in a line break format. An example of a circular arc data is provided in Table 2. As the program is used for institutional purposes only a few common entity types are fully described to the end user. More definitions may be added in the future as needed.

TABLE I  
DIRECTORY ENTRIES THAT CAN BE SUPPORTED

Entity Name	Input/Output	Entity Number
Circular Arc	I/O	100
Composite Curve	I/O	102
Copious Data (Forms 1,2,11, and 12)	I/O	106
Plane (Forms 0 and 1)	I/O	108
Line	I/O	110
Parametric Spline Curve	I/O	112
Parametric Spline Surface	I/O	114
Point	I/O	116
Ruled Surface (Form 1)	I/O	118
Tabulated Cylinder	I/O	122
Transformation Matrix	I/O	124
Rational Bspline Curve	I/O	126
Rational Bspline Surface	I/O	128
Offset Surface	I	140
Boundary Entity	I/O	141
Curve on Parametric Surface Entity	I/O	142
Bounded Surface	I/O	143
Trimmed Surface Entity	I/O	144
Manifold Solid B-Rep Object	I/O	186
Color Definition	I/O	314

TABLE 2  
CIRCULAR ARC DATA EXAMPLE

Index	Name	Type	Description
1	ZT	Real	Parallel ZT displacement of arc from XT, YT plane
2	X1	Real	Arc center abscissa
3	Y1	Real	Arc center ordinate
4	X2	Real	Start point abscissa
5	Y2	Real	Start point ordinate
6	X3	Real	Terminate point abscissa
7	Y3	Real	Terminate point ordinate

Fig. 3 shows the process flow of the IGES File Parser application. The flow is described from the standpoint of an end user running the application and selecting a valid IGES file from their local computer.

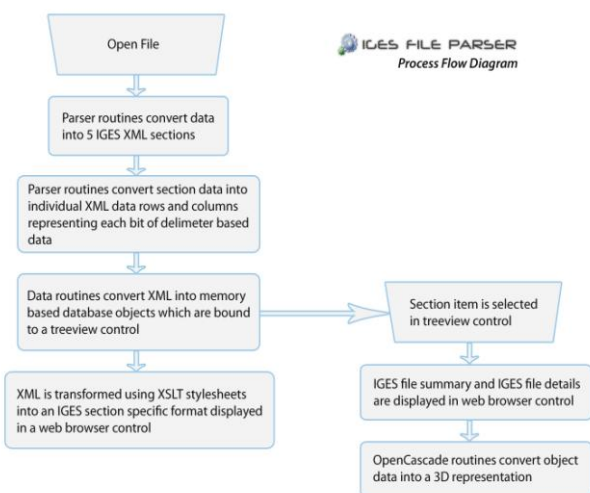


Fig. 3: Software Architecture of IGES Parser Utility

### E. Beta Testing

Three Engineering Graphics sections were given with the inclusion of IGES Parser Utility software in the course whose numbers were shown in Table 3. For two sections, the software was used in the lecture in order to demonstrate the architecture and mechanics of the IGES file. Students were able to follow directly as the software was also loaded on a computer at each student desk. Students in one of these two sections were also able to download the software on their home PC's or laptops. No software demonstration or support was provided in the lecture to the third section. All students in each section were expected and encouraged to ask questions and take notes in keeping with the traditional learning model.

At the end of each section, we gave a final examination of 30 questions in the class for assessing the students' actual performance as well as their perception of their learning of using the IGES Parser Utility software. The first 15 questions were designed to assess the students performance and the last 15 questions were survey/profile questions. A learning profile refers to the ways in which a student learns best. Our 15 survey/profile questions were designed to assess student perception of their own understanding, motivation, interest,

knowledge appreciation and their expectations of their ability to retain and apply the information learned. The 30 question set is included in the appendix. All students were therefore given fifteen subject questions and fifteen survey/profile questions during their final exam. The answer choices for the survey/profile questions were strongly disagree, disagree, agree, strongly agree and impartial. Sections are designated A, B and C such that the following criteria are satisfied:

Section A: Lecture with software demonstration in class and allowed to download and use software at home

Section B: Lecture with software demonstration in class only

Section C: Lecture only

TABLE 3  
ENROLLMENT OF ENGINEERING GRAPHICS SECTIONS WITH THE INCLUSION OF IGES PARSER UTILITY SOFTWARE SURVEYED AND TESTED

Section	Frequency	Percent
A	20	31%
B	23	36%
C	21	33%
TOTAL	64	100%

Several authors [20], [22] have demonstrated that these categories or closely related ones play a significant role in student academic success. A few questions are provided below as an example. Note that questions were slightly grammatically altered to accommodate each section's situation. For example, section C did not have access to the software so instead of "I more easily understood", the question became, "I would have more easily understood".

Q1: I (would have)\* more easily understood the mechanics and architecture of the IGES file lecture when (had)\* the instructor used demonstration software in class.\*-Section C  
Q2: Having demonstration software at home as well (would have)\* made understanding the mechanics and architecture of IGES files easier.\*-Sections B, C

Note that the remaining questions replaced "understanding" with interest, motivation, appreciation and expectation of knowledge retention.

Based on the performance and survey quiz results, we expected to ascertain the students' level of mastery of the material (assessed via the first 15 questions) and determine a difference between classes based on learning methods (assessed via the last 15 questions). We therefore examined responses to the 30 questions between each of the classes, using SPSS software [26]. Since the fact that normality of distributions and equality of variances between the classes might be questionable when viewing all 30 questions, we proceeded with caution by 1) declaring differences only when standard *t*-tests exhibited *p*-values smaller than .001 (being conservative, too, because we were conducting nearly 100 comparisons) and 2) conducting parallel nonparametric tests. For the final investigations where we use discriminant analysis for the last 15 questions we were able to establish equality of covariance matrices but still we refrain from drawing inferential conclusions because the answers are not from a continuous (and thus a non-normal distribution) so we may have a violation of assumptions, but we do present the

descriptive statistics regarding separation of the classroom responses along with an interpretation.

Our hypothesis declares a difference in understanding (performance) between the three classrooms. Using the total score on the first 15 questions as an assessment measure we noted that the class average for classroom A was 95.33% and for B it was 90.47% and for C it was 79.07%. Using either a parametric ANOVA or a nonparametric Wilcoxon approach we are able to conclude that there was no difference in the performance of classrooms A and B but both of those classrooms differed from C. Relying on a sample proportion difference's standard error of .16 or 16% spread (calculated as  $2\sqrt{(.85*.15)/20}$ ) no question differentiated classroom A from classroom B. Thus, we combined A and B and compared that group to classroom C. Here we found percent correct differences ranging from 17% to 29% (ordered in magnitude from largest to smallest) on questions 15, 10, 11, 12, 13, 4 and 3.

Further support for combining classrooms A and B is apparent when comparing the last 15 survey questions that purport to measure learning profiles by querying a student's interest, motivation, appreciation and expectations. The interval scorings of 1, 2, 3, 4, 5 have a variance equal to 2 and we can then argue that  $2\sqrt{2/20}$  or conservatively a difference of 1.0 would indicate significance. Profile question 19 was the only profile question out of the 15 that could have been used for delineation between classrooms A and B.

By combining A and B we may now look at a linear discriminant function [27] that would maximally separate these combined classrooms from classroom C using the last 15 survey questions that pertain to learning profiles. We are

interested in the eigenvector of  $\begin{pmatrix} \mathbf{n}_1 & \mathbf{n}_2 \\ \mathbf{n}_1 + \mathbf{n}_2 \end{pmatrix} \mathbf{S}^{-1} (\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_2) (\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_2)^T$

where  $\bar{\mathbf{x}}_1$  and  $\bar{\mathbf{x}}_2$  are the sample mean vectors for combined classrooms A and B and for classroom C respectively and  $\mathbf{S}$  is the estimate of their common covariance matrix and  $\mathbf{n}_1$  is 43 and  $\mathbf{n}_2$  is 21, the sample sizes of the classrooms. Our interest is that the eigenvector gives us the coefficients for our discriminant function. (see Table 4).

These coefficients are used to generate discriminant function scores. For example, in the combined classroom A and B student 1's answers to the 15 questions were: <4, 5, 4, 4, 3, 4, 5, 5, 5, 5, 4, 4, 5, 5, 3>. Multiplying each answer by its respective coefficient and adding the constant gives a discriminant score of 2.17. The learning profile questions of the highest correlation with the discriminant scores and largest coefficient value (and thus the most influential in the classification process) are questions 25 and 27. To determine to which group this student appears to belong we need to first compute the cut point. The cut point is the midpoint between the discriminant scores for  $\bar{\mathbf{x}}_1$  and  $\bar{\mathbf{x}}_2$ . Those values are .743 and -1.522, respectively. So the midpoint is -.39. This student with a computed discriminant score greater than -.39 would have a learning profile like those in combined classrooms A and B and those with scores smaller than -.39 are like the students in classroom C. These values in Table 4 for the

TABLE 4  
UNSTANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS

Survey Questions	Coefficients
Q16	.069
Q17	-.267
Q18	-.221
Q19	.019
Q20	.074
Q21	-.111
Q22	.318
Q23	-.109
Q24	.405
Q25	.747
Q26	-.569
Q27	1.113
Q28	-.306
Q29	.034
Q30	-.605
Constant	-1.619

discriminant function represent the "best" coefficients (in terms of maximal separation causing a minimization of misclassification errors, see Table 5). Using the student's self-perceived learning profile we able to correctly classify 52 of 64 or 87.5% of the students.

TABLE 5  
CLASSIFICATION RESULTS

CLASS	Class Membership via Score			Total
	A&B	C		
Original Count	A&B	38	5	43
	C	3	18	21
%	A&B	88.4	11.6	100.0
	C	14.3	85.7	100.0

### III. DISCUSSION

The statistical analysis leads to several noteworthy conclusions. First, classrooms A and B both used the software during laboratory meetings and lectures but students in classroom A had the added (assumed advantage) of home use. Despite the extra exposure both of these groups of students performed comparably and had identical learning profiles. This may be unique to our university because of the lack of time students have to devote to off-campus investigations due to high involvement in job situations. The software use did however improve learning as judged by the performance of students (from the first 15 questions on the assessment tool). This was indicated by the statistical comparison of the combined classes of A and B when compared to classroom C. Classroom C students had the most difficulty in identifying the format of an arc (question 15) and in reading the code presented (questions 10 and 11 and 12 and 13).

Secondly, as for the difference in the learning profiles between the combined classrooms A and B versus classroom C, the most discerning survey questions 25 and 27 both address motivation. A plausible interpretation would be to note that the selection of “disagree” by the classroom C students means that they do not perceive that the use of software could activate increased levels of activity needed to assimilate the material. The classroom C students might see the IGES Parser Utility software as a motivating factor if they had believed that the software could have reduced their workload, or provided shortcuts to homework solutions, or improved their grade outcomes. The other factors of understanding, appreciation, and interest were not influential in the class discrimination/separation. This fact may point to the propensity of human nature regarding selection of activities as being influenced by one’s perceived ability to follow-through on that selection [28]. In this situation students dismiss potential advantages of software use because they expect that it would only add to their workload.

#### IV. CONCLUSION

Our integration of an information technology project in an engineering graphics course has shown the benefits to both the information technology as well as the engineering graphics students. For the information technology student, he learned how to integrate a second discipline in designing an information technology project. For the engineering graphics students, their academic performance improved via using the IGES Parser Utility software created for the course.

#### APPENDIX

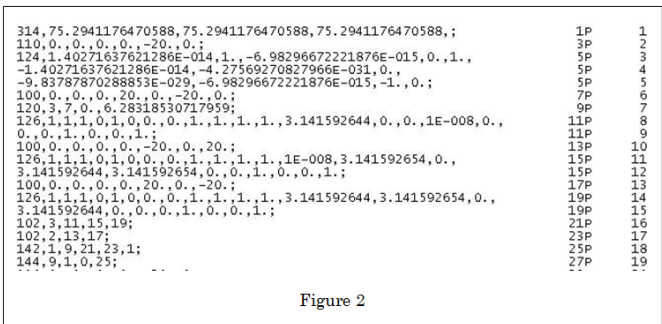
1. The IGES file format was created in order to
  - a. Allow database information in CAD files to be interpreted in Microsoft Excel
  - b. Allow the digital transfer of CAD information using a neutral data format
  - c. Allow only a select group of professional engineering societies to interpret CAD files
  - d. Allow the exchange of analogue information between CAD files
2. Currently IGES files have certain disadvantages, these include all except
  - a. Design intent may be lost
  - b. Data might be misinterpreted
  - c. Feature or constraint information may be lost
  - d. Entities are defined using an inconsistent set of rules
3. The fundamental unit of the IGES file is the
  - a. Parameter
  - b. Entity
  - c. ASCII character
  - d. Record
4. The IGES file is divided into five sections in the following order
  - a. Start, global, directory entry, parameter data, terminate
  - b. Start, global, parameter data, directory entry, terminate
  - c. Start, parameter data, global, directory entry, terminate
  - d. Terminate, global, start, directory entry, parameter data
5. Which section is set to 24 fields and contains information such as the filename, scale, units, IGES version?
  - a. Start
  - b. Directory Entry
  - c. Global
  - d. Parameter Data
6. Each 80 character line of the IGES is a record that ends with a/an
  - a. Comma
  - b. Period
  - c. Semi-colon
  - d. Backslash
7. Each record line is subdivided into fields by a/an
  - a. Comma
  - b. Period
  - c. Semi-colon
  - d. Backslash
8. Which section specifies information specific to each entity such as coordinate values, number of spline data points, etc.
  - a. Start
  - b. Directory Entry
  - c. Global
  - d. Parameter Data

```

Solidworks IGES file using analytic representation for surfaces      S      1
1H, ,1H; ,17Hsphere_D40.SLDprt,73HC:\Documents and Settings\cameron\Desktop      1
p\cameron\research\sphere_D40.IGES;15HSO11dworks: 2008;15HSO11dworks: 2008;G      2
32,308,15,308,15,17Hsphere_D40.SLDprt,1.1,2,2HMM,50,0.125,13H081029.19235G      3
3,1E-008,499990.,7Hcameron,,11,0,13H081029.192353;      G      4
  
```

**NOTE:** if only a space precedes a comma then this is NOT a field in itself {eg. in [ *field*, , ] the space between the commas is not a field}

9. Figure 1 shows the Start and Global Section of an IGES file. Identify the following information by inspecting the Global Section. The largest coordinate value (field 20) is
  - a. 1E-008
  - b. 11
  - c. 308
  - d. 499990
10. The IGES filename (field 4) in Figure 1 is
  - a. 7Hcameron
  - b. sphere\_D40.IGS
  - c. 17HSphere\_D40.SLDprt
  - d. 73HC
11. The type of units (field 15) used were
  - a. 2HMM (millimeters)
  - b. 2HIN (inches)
  - c. 2HM (meters)
  - d. 2HFT (feet)



12. Figure 2 shows the Parameter Data section of the file. The entity 126 (Rational B Spline) first occurs in which record
  - a. Second
  - b. Eighth
  - c. Sixth
  - d. Seventh
13. The entity 102 (a composite curve) appears how many times?
  - a. Once
  - b. Twice
  - c. Thrice
  - d. Never
14. The first line entity (110) ends at the co-ordinates
  - a. 0,-20,0
  - b. 0,0,0
  - c. 20,0, -20
  - d. -20, 0, 20
15. Entity 100 is a circular arc, the format is described below

Field	1	2	3	4	5	6	7
	z disp. From x-y plane	Arc center-x	Arc center-y	Start point-x	Start point-y	End Point-x	End Point-y

- The first circular arc in the file has a start point at
- a. -20,0
  - b. 0, 0
  - c. 0, 20
  - d. 20, 0
16. Having the IGES application/demonstration software at home in addition to use in lecture, (would have made/made) understanding this material easier compared to use in lecture only (*B vs A-understanding*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  17. Having the IGES application/demonstration software in lecture (would have made/made) understanding this material easier compared to no use in lecture(*B vs C-understanding*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  18. Having the IGES application/demonstration software at home in addition to use in lecture, (would have

- made/made) understanding this material easier compared no use in lecture only (*C vs A-understanding*)
- a. Strongly disagree
  - b. Disagree
  - c. Impartial
  - d. Agree
  - e. Strongly Agree
19. I (would have found/found) the lecture on IGES files more interesting (if/when) the instructor used demonstration software in class compared to no use of the software (*B vs C-interest*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  20. I (would have found/found) the lecture on IGES files more interesting (if/when) the instructor used demonstration software in class AND we had use of it at home as well compared to in class demos only (*A vs B-interest*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  21. I (would have found/found) the lecture on IGES files more interesting (if/when) the instructor used the demonstration software in class AND we had use of it at home as well compared to no use of the software(*A vs C-interest*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  22. I (would have had/had) a greater appreciation for File Transfer mechanisms (if/when) the instructor used demonstration software in class (*B vs C-appreciation*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  23. I (would have had/had) a greater appreciation for File Transfer mechanisms (if/when) the instructor used demonstration software in class AND we had access to the software at home, compared to class use only (*A vs B-appreciation*)
    - a. Strongly disagree
    - b. Disagree
    - c. Impartial
    - d. Agree
    - e. Strongly Agree
  24. I (would have had/had) a greater appreciation for File Transfer mechanisms (if/when) the instructor used demonstration software in class AND we had access to the



- software at home, compared to no software use (*A vs C- appreciation*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
25. Use of software which demonstrates IGES architecture and mechanics in lecture AND having availability at home (would have increased/increased) my motivation to learn this material compared to no software use (*A vs C – motivation*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
26. Use of software which demonstrates IGES architecture and mechanics in lecture AND having availability at home (would have increased/increased) my motivation to learn this material compared to use in lecture only (*A vs B – motivation*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
27. Use of software which demonstrates IGES architecture and mechanics in lecture (would have increased/increased) my motivation to learn this material compared to no use of the software (*B vs C – motivation*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
28. I suspect I (would/will) retain more information about file transfer mechanisms when I start my first engineering job, (if/since) I had the application software at home, in addition to use in lecture. (*B vs A, -expectation of knowledge retention*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
29. I suspect I (would have retained/will retain) more information about file transfer mechanisms when I start my first engineering job, with the software demonstration in class only vs no software use. (*C vs B- expectation of knowledge retention*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree
30. I suspect I would retain more information about file transfer mechanisms when I start my first engineering job, with the software demonstration in class AND a classroom demonstration compared to no software use whatsoever. (*C vs A- expectation of knowledge retention*)
- Strongly disagree
  - Disagree
  - Impartial
  - Agree
  - Strongly Agree

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