

## Assessment Measures and Outcomes for Computer Graphics Programs

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### Abstract

*Computer graphics is a fast growing field of study, which has many variable course offerings to accommodate the ever-changing technology. The differences and ambiguities in course names and degree offerings can best be explained and quantified through assessment measures. The assessment measures identify the scope of each assignment and course and identify program and department learning objectives and outcomes, and show how they are related to each other. Assessment measures also set the stage for future accreditation of a computer graphics program. This paper will discuss how to begin the assessment process for the program as a whole, and how to facilitate and use course embedded assessments within a computer graphics program and within supporting courses in other disciplines. By having a plan and a template of assessment measurement for faculty, beginning course-embedded assessments becomes an easier task for the busy faculty and will greatly improve the continuity of course offerings within the ever changing computer graphics field.*

### Background

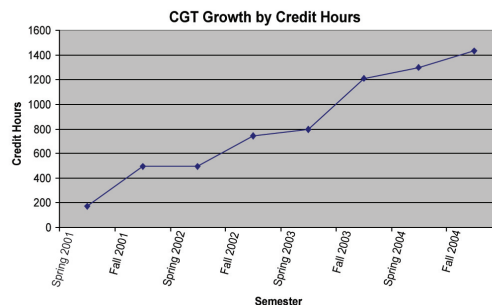
Purdue University Calumet (PUC) is a regional campus of Purdue University located in north-west Indiana. It is primarily a commuter campus, and serves just over 9,000 students. PUC started a program in Computer Graphics Technology (CGT) in the Fall 2000 semester. The course curriculum development was influenced by existing successful course offerings within the Purdue system, by nationally known universities, and by regional job demands, as well as international considerations. Figures 1 and 2 show the growth in credit hours and the increase in students in the CGT program between 2001 and 2004. In the space of a few years, laboratories were built, faculty hired, and many new courses developed to meet this demand. In the face of all this growth, and the number of changes that were occurring, faculty knew that an effective assessment and evaluation system would be required to insure that changes were in fact improving the program.

The Engineering Technology and Organizational Leadership and Supervision programs have had some measurable success with the implementation of course embedded assessment both in the class room and online (Colwell, et. al., 2004). Both of those programs provide supporting courses for CGT. The assessment model offered in this paper is adapted from those programs and

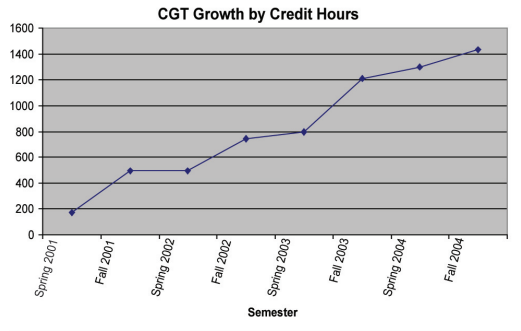
applied to the expanding and ever-changing field of Computer Graphics and CGT. The assessment measures identify the scope of each assignment, course, program and department learning objective and outcome, and show how they are related to each other. The remainder of this paper describes the process used to create these assessment measures and provides suggestions for implementation.

### Starting an Assessment Program

According to Brown, et. al., (2004) computer technology related programs in the field of industrial technology represent a rapidly emerging area of study. Furthermore, rapidly emerging programs must be continuously assessed and monitored to make certain that they are academically appropri-



**Figure 1.** Credit Hour Growth.



**Figure 2.** Number of Students.

ate, differentiated from other computer-related programs, and are meeting the needs and expectations of key stakeholders. Authors Brown, et. al., (2004) comments were made regarding industrial technology, but one can argue that their observations can be applied to the emerging focus of computer graphics technology as well. Such programs often consider Accreditation Board for Engineering and Technology (ABET) or National Association of Industrial Technology (NAIT) accreditation. Both ABET and NAIT require assessment data. ABET (2005) particularly requires outcomes based assessment data.

According to Wiggins (1990), assessment is authentic when we directly examine student performance on worthy intellectual tasks. Authentic assessments achieve validity and reliability by emphasizing and standardizing the appropriate criteria for scoring varied products—not one-right-answer tests. Authentic tasks involve “ill-structured” challenges, which mirror real life challenges. Performance assessment is a recognized method of classroom assessment in technology as demonstrated by Slater (2005). Performance assessment can mirror the ill-structured real life challenges of authentic assessment.

To acquire course consistency throughout a program it is imperative to develop comprehensive program-wide assessment tools. The objectives are to develop learning-outcome-based assessment tools and adapt them for the use of a specific CGT program. These learning outcome-based tools are then built into a comprehensive program assessment, which ultimately forms the basis of accreditation for a program. This task can be daunting to new and existing CGT programs, and needs to be implemented in a way that all faculty can easily understand and perform. Providing a

platform where all faculty have input within their charge courses is important, but consistency within the overall evaluation process is also essential. To obtain the commitment of all faculty it is best to start out with a designated number of courses within various levels of the degree and create a “project team.”

The approach discussed in this paper uses six flexible, adaptable assessment tools, consisting of a critique and rubric for two projects in each of three successive courses. The project team of faculty teaching the courses, or faculty and graduate assistants, produces assessment tools in the form of performance assessment based critiques and rubrics which document student learning. The team documents the use of the developed assessment tools, in a way appropriate for this type of assessment tool, and also prepares all necessary documentation to prepare other faculty to use the assessment tools in a responsible manner. The team contributes to the literature on assessment practices, which is then disseminated to all program faculty for use in their target courses.

For example, in order to develop learning outcomes based assessments for a constantly-updated CG or CGT program, Purdue University Calumet’s CGT faculty developed the following three-year plan:

1. Create a classroom environment that incorporates cooperative or clustered learning and experimentation by students; (already in progress)
2. Create a structured critique process based on performance assessment for CGT, developing a rubric for the critique which takes into account program objectives and which documents student learning; (created and in use in some classes) and,
3. Eventual integration of the critique-based learning outcome assessment into the program assessment for eventual accreditation. (planned for the future)

The CGT program at PUC is currently in year one of the three year process described above. PUC’s initial example of this process was to create an integrated set of rubrics for a mid-semester and a final project in each class (total of six critiques and rubrics) for the following courses: CGT 111, CGT 211, and CGT 346 (see course descriptions

and sample rubric below). The rubrics and assessment tools document progressive student learning throughout the program. The rubric and critique method could be adapted to any CG program by choosing an entry-level course, a mid key course and a comprehensive course that incorporates and builds on the previous two course levels. The decision to approach the assessment process in this way was based on the logical progression of classes, and on its feasibility as a “first step” in total program assessment. In order to make the task of program assessment less overwhelming, the series of courses which most students take upon entering the program was chosen as a logical starting point.

The critique and rubrics have been created for the following courses at Purdue University Calumet (total of six critiques and rubrics):

**CGT 111: Design for Communication and Visualization:** An introductory design course for computer graphics majors. Students develop an understanding of the basic design elements, principles of composition and typography through exercises and projects. The focus is on visual thinking, exploring the relationship between type and image, and developing multiple design solutions to a given problem. [No prerequisites—entry course into program]

**CGT 211: Raster Imaging For Computer Graphics:** Digital images are produced using a variety of computer technologies focusing on raster imaging and process. Advanced color theory, surface rendering, and light control are emphasized in relation to technical illustration, hardware characteristics, and software capabilities. [Prerequisite—CGT 111]

**CGT 346: Digital Video And Audio:** Covers the use of digital technologies for video and audio focused on raster imaging, vector imaging, design, composition, motion graphics, multimedia, hypermedia and animation. Students examine the methods of creating, sampling and storing digital audio and the constraints placed on these media assets when used for media based products. Emphasis is placed upon the technology of digital video and audio including formats, data rates, compressors, and the advantages and disadvantages of the different technologies. [Prerequisites—CGT 111 and CGT 211]

The third course, CGT 346, incorporates learn-

ing from CGT 111 and CGT 211 into new concepts, thus building on previous learning based outcomes and creating further assessment measures for all courses. Because the courses are sequential levels in the program, the critiques and rubrics document progressive student learning within the program. The performance assessment critiques and rubrics are linked to course objectives for each course, and also to overall program objectives. These courses are used primarily and almost exclusively for CGT majors, although occasionally students outside the program take a course.

Rubrics (or “*scoring tools*”) are a way of describing evaluation criteria (or “*grading standards*”) based on the expected outcomes and performances of students (Ebert-May, 2005). Typically, rubrics are used in scoring or grading written assignments or oral presentations; however, they may be used to score any form of student performance. Each rubric consists of a set of scoring criteria and point values associated with these criteria. In most rubrics the criteria are grouped into categories so the instructor and the student can discriminate among the categories by level of performance. In classroom use, the rubric provides an “objective” *external standard* against which student performance may be compared. Students learn to communicate about the relevant subject matter in a variety of ways. The quality of students’ reasoning and logic increases. Instructors gather a variety of data about students’ understanding and performance. Developing effective rubrics requires revision based on feedback from students; the best rubrics are products of an iterative effort (Ebert-May, 2005).

According to Moskal (2003), objectives written for rubrics should describe measurable student outcomes. When the goals and objectives of the assessment are focused upon complex learning outcomes, such as those in a CG or CGT program, a performance assessment is likely to be appropriate. Performance assessments require students to demonstrate the application of knowledge to a particular context. Through observation or analysis of a student’s response, the teacher can determine what the student knows and does not know and what misunderstandings the student might hold with respect to the purpose of the assessment. Scoring rubrics are one method, which may be used to evaluate students’ responses to





Sample scoring rubric taken from (Schafer, 2004)	
Happy Face Quality	Example
4 - Displays amazing detail and color; highly elaborate theme; unique and original	
3 - Displays detail and color; theme is present with some elaboration; displays initiative to develop original work	
2 - Displays some detail and/or color; theme is present but not fully developed; evidence of some initiative to develop original work	
1 - Displays a lack of detail, color, and theme; very little or no initiative in developing original work	

Figure 3.

performance assessments. Rubrics may be either analytic or holistic. Analytic scoring rubrics divide a performance into separate facets and each facet is evaluated using a separate scale; holistic scoring rubrics use a single scale to evaluate a larger process. In a holistic scoring rubric, all of the facets that make up a task are evaluated in combination (Moskal, 2003).

Sample critique questions for the assessment of projects are contained in Tables 1-3 below. These particular critique questions relate to mid-term and final projects in the course CGT 211 mentioned above and are already in use. The tables contain follow up questions for the critiques for later on in the semester. These critique questions were developed by Whittington (2004) for use in her CGT courses. The author drew upon industrial, art and technical educational experience to prepare projects and the criteria for effective critiques.

In the latter part of the semester the instructor may ask for more course assessment type feed-

back.

### Tracking Assessment Results

In the Fall 2002 semester, PUC began a trial of online course assessment tools using the survey function in Blackboard. Blackboard is software used for online teaching and learning within campus communities. With the Blackboard survey feature, the instructor knows if a student has taken the assessment, but all student answers are grouped together so individual student responses remain anonymous. This tool is broken down into four parts: Student Self-assessment, Program, Course Management, and Course Objectives. Although much modified, it is based on the work of Land and Hager (2002). The course assessment tool is part of a larger project to perform integrated, on-line assessment of all courses in the Manufacturing Engineering Technology and Supervision (METS) Department, which now houses the CGT program.

To compare the instructor's assessment of the

Sample critique questions
<b>Critique assessment</b> The following are <b>general</b> assessment questions an instructor might ask.
What do you (the student) feel was your most successful concept of this project?
What was the most challenging but rewarding part of the project?
Was there a particular required concept or technical skill that you feel was not relevant to this project?

**Table 1.**

Course assessment critique questions
Did any project relate directly to another course you have taken or are currently taking? Were the objectives of the projects helpful in other courses?
What aspects of a specific project helped you at work or in another course?
Were there any technical skills you felt you needed to complete the assignment?
Are there any projects in this course that helped you accomplish a goal at your present place of employment?
As a result of what you have learned in this project is there another new concept you would like to learn to build your skills?

**Table 2.**

course with the students', an Excel spreadsheet consisting of three parts has been developed to track the data. Much research on course assessment tools of this type is available (Henderson, et. al. 2002), and this is among the simpler types. The authors intentionally created a simple form because these forms must be generated for many courses at the same time, and the faculty felt a short, simple form would be the best place to start. These forms have been refined and continuously improved for the past three years.

Part 1, shown in Table 4, lists the scores from specific assignments that the instructor uses to measure each course objective. The students' eval-

Student focused critique questions
As you (the <b>student</b> ) are working ask yourself these questions about your design
Does the project have a focal point?
Where does the eye go at first glance?
Does the eye move to a secondary position?
How do the hues and textures effect the overall composition? What is the prominent color composition?
What are the prominent shapes?
What makes the design interesting?
What gives the design unity?
Does it have rhythm and balance?

**Table 3.**

uation of how well they felt the course met each objective is listed as well. Part 2, shown in Table 5, lists the students' perception of how well the course met the ABET a-k criterion. The last part, shown in Table 6, provides a place for the instructor to record course changes and improvements. The METS Department is in the process of creating similar forms for each course and then linking the data to the web page for each course. This will provide a convenient method for storing course data and making it easily available to instructors and ABET teams.

A sample Excel spreadsheet with the most recent three page assessment form is available at: <http://technology.calumet.purdue.edu/met/abet/METbachelor/METCourseupdateandassessmentformsampleDecember2004.xls>

Purdue University Calumet's CGT116, Geometric Modeling for Visualization and Communication, served as the sample course for the course embedded assessment techniques shown here. Several semesters worth of assessment data for this course is available at: <http://technology.calumet.purdue.edu/cgt/cgt116/index.html> and then clicking on "Course Assessment Data." The data shows a steady progression of continuous improvement for this course as it changed from lecture to



cooperative learning, new texts were incorporated, and the assignments were fine tuned. Assessment, evaluation, and improvement continues for this course.

This assessment data is analyzed three different ways. First, the faculty responsible for the course evaluates the data and may decide to make changes based on the available data. Second, each program has a fall retreat to compare data from all courses with each other and with program objectives and outcomes. Third, any information that may need outside evaluation is presented at one of the programs semi-annual advisory committee meetings. Input from these three sources is compared and changes are then made in the course and/or program.

### Conclusions

The information in Tables 4-6 is gathered for all courses supporting the CGT program in the Engineering Technology and Organizational Leadership and Supervision programs. Table 7 is a blank template for others to use. Other templates are available at the websites listed above. The rubrics and critiques will be developed and refined for the CGT program courses, and can be further developed and refined as assessment tools in other CG/CGT courses. The critiques and rubrics lend themselves to flexibility, a requirement in a rapidly evolving field like CG. These assessment measures can help track the changes in and improvement in the program, and also form the basis for an eventual accreditation effort.

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CGT116 Geometric Modeling for Visualization & Communication – Instructor and Student Course Objective Assessment													
Semester:	Spring 2004	Supported Criterion	Supported Related Outcome	Course Embedded Assessment of Student Performance			Instructor: Rickerson/Higley			Student Evaluation (%)			
				Assessment Tool	Score (%)	Assessment Tool	Score (%)	Assessment Tool	Score (%)	E	G	A	P
1. To understand the primary differences between wireframe, surface, and solid modeling and their application to various communicative problems and tasks.	a	1.1 Technical Proficiency	Week 5 Team Assignment	89	Week 6 Team Assignment	89	3	47	34	6	3	9	4.0
	g												
2. To develop 3D spatial environment understanding and mental visualization ability.	a	1.4 Open-ended Problems	Lab Assignment 1	89	Lab Assignment 2	96	Group Project	38	50	6	0	6	4.1
	d	2.3 Project Management											
	g	2.4 Self-Learning											
3. To develop an understanding of 2D and 3D geometric entities and their application in graphic communication.	a	1.1 Technical Proficiency	Week 4 Team Assignment	87	Week 5 Team Assignment	89		38	44	12	0	3	4.1
	b												
4. To achieve competence in utilizing CAD tools to develop wireframe, surface, and solid models through demonstrations, assignments, tutorials and practical examinations.	a	1.1 Technical Proficiency a,b,c,d,f	Inventor Lessons	80	Midterm Practical	89		53	22	19	0	6	4.2
	b	1.3 Computer Applications											
	g	2.4 Self-Learning											
5. To develop an appreciation for graphics as a communication medium in various application areas through demonstrations and assignments.	g	1.1 Technical Proficiency a,b,c,d,f	Midterm Written	83	Final	84		31	50	12	0	6	4.0
Instructor Comments for needed changes: This class went well with the objectives covered appropriately.										Number of responses:			32

Table 4 - Course Objective Assessment

CGT116 Geometric Modeling for Visualization & Communication Course Assessment Tool							
ABET Criterion Assessment							
Proposed ABET Criterion Satisfied: a,b,d,g							
Instructor: Rickerson/Higley	Criteria	Semester: Spring 04					Composite
		E	G	A	P	NA	
a.	As a result of this course, my mastery of the knowledge, techniques, skills, and modern tools of the Mechanical Engineering Technology discipline can be described as.	34	31	16	0	19	3.6
b.	As a result of this course, my ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology can be rated as.	22	25	19	0	31	3.0
c.	As a result of this course my ability to conduct, analyze, and interpret experiments and apply results to improve processes can be rated as.	16	31	16	0	34	2.9
d.	As a result of this course, my ability to apply creativity in the design of systems, components, or processes appropriate to program objectives can be rated as.	34	44	12	0	9	3.9
e.	As a result of this course, my ability to function effectively on teams can be rated as.	50	38	6	3	3	4.3
f.	As a result of this course, my ability to identify, analyze, and solve technical problems can be rated as.	41	31	16	0	12	3.9
g.	As a result of this course, my ability to communicate effectively can be rated as.	38	31	22	0	9	3.9
h.	As a result of this course, my recognition of the need for, and an ability to engage in lifelong learning can be rated as.	44	28	3	0	25	3.7
i.	As a result of this course, my ability to understand professional, ethical, and social responsibilities can be rated as.	25	28	9	3	34	3.0
j.	As a result of this course, my respect for diversity and knowledge of contemporary professional, societal, and global issues can be rated as.	25	31	3	3	38	3.0
k.	As a result of this course, my commitment to quality, timeliness and continuous improvement can be rated as.	41	38	12	0	9	4.0
Instructor Comments: The scores agree well with the intended criterion except for b, e, f, and k scored well as secondaries.							

Table 5 - ABET Criterion Assessment



<b>CGT116 Instructor Update Information</b>	
<b>Date Submitted: 05-12-04</b>	<b>Date to be Reviewed: 08-23-04</b>
<b>Responsible faculty for the review: Rickerson</b>	
<b>Type of Update</b>	
<input type="checkbox"/> New Edition of the Text	<input type="checkbox"/> New Text Adopted
<input type="checkbox"/> New Laboratory Equipment	<input type="checkbox"/> Lab Material Update
<input type="checkbox"/> New Software	<input checked="" type="checkbox"/> Teaching Method
<input checked="" type="checkbox"/> Teaching Initiative	<input checked="" type="checkbox"/> Other
<b>Description of Condition Prior to / After Update:</b> Rick Rickerson and Jim Higley each taught this course this semester, and all data is pooled. We tried modifying the class project to have the individual groups pick topics, and it went well. There was a good variety of projects. We'll do this again next semester.	
<b>Assessment Method Used to Evaluate Short or Long Term Results:</b>	

**Table 6 - Course Update Form**

Semester: Fall 2002																			
(Course Name/Number) Course Assessment Tool – Instructor and Student Course Objective Assessment																			
Course Objective	Supported Criterion	Supported Related Outcome	Course Embedded Assessment of Student Performance			Instructor:													
			Assessment Tool 1	Assessment Tool 2	Assessment Tool 3	Score (%)	Score (%)	Score (%)	E	G	A	P	NA						
Instructor Comments for needed changes:																			
Number of responses:																			

Table 7 - Sample Blank Template