Assessing the Technology Management Preparation of Design Technologists

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Introduction

A longitudinal investigation into the technology management preparation of design technologists based on student performance on a technology management certification examination was begun in the spring of 2012. The objective was to ensure that all design technology graduates possessed an understanding of technology management practices in the areas of production, planning, and control; quality control; safety; and management specifically. The goal was to improve the level of understanding of technology management among graduating design technology graduates.

An initial study of the students’ performance was completed in the spring of 20121. In this study, the performance of design technology majors on their understanding of technology management was ascertained. The criterion for success included (a) a 91% pass rate for all who sat for the certification exam and (b) for those who did not pass the exam, the number of correctly answered exam items will fall within 10 correct answers of the passing score.

In this administration of the certification exam, 88.5% of the students passed. For those students who did not pass, all answered a sufficient number of exam items correctly to earn exam scores within 10 correct answers of the passing score. As well, it did not appear pursuit of a Business Administration minor by the students influenced certification exam performance.

In a post-exam survey, the students who sat for the exam noted that a variety of approaches were employed to prepare for the exam. While some prepared by themselves, most prepare with classmates. In response, actions taken (use of results) were identified and deployed based on what the students felt contributed to their performance. During the spring semester of 2013, which was when the certification exam was administered again, the students were informed of the approaches employed by the spring 2012 student in preparing for the exam.

This paper reports on the results of a subsequent study—the study of the spring semester of 2013 class—in which the outcome of the actions taken were examined and identified actions [to be] taken that, it is anticipated, will achieve the criterion for success.

Assessment framework. The following served as the framework for assessing the understanding of technology management by design technology majors:

Program Mission: The purpose of the BS in Design is to prepare individuals to apply technical skills to the management and creation of working drawings and computer simulations for a variety of applications. This shall include but will not be limited to instruction in specification interpretation, dimensioning techniques, drafting calculations, material estimation, technical communications, computer applications, and interpersonal communications.

Outcome: Graduates will exhibit an ability to understand professional, ethical, global, and social responsibilities.

Criterion for Success: Ninety-one percent of the BS in Design (architectural technology and mechanical technology) students who sit for the ATMAE CTM certification exam will pass the exam. The raw score for the students who do not pass will fall within 10 correct answers of the passing score.

Technology management preparation. The coursework that comprised the technology management preparation for design technology majors is depicted in Figure 1.

Regardless of whether the design technology students elected to pursue the Business Management minor, they were required to fulfill a seven, three semester hour management courses requirement and complete two, three semester hour management related general education courses. The total technology management requirement consisted of 27 semester hours of coursework.

Method

The population for this longitudinal investigation was comprised of design technology majors pursing a BS in Design, enrolled in a required senior level design course. In order to develop a profile of the students and in an attempt to ascertain the readiness of the students, a pretest and survey were administered during the course’s second class meeting. The students were only informed of the fact they needed to bring a bubble sheet and pencil for a pretest but were not informed of the nature of the pretest and survey.

The pretest was comprised of all 40 multiple choice items available in the certification exam study guide: ten each from the four certification exam content areas. The forty-first item sought...
information on whether the students were pursuing a minor and the remaining twelve items sought the status of management courses completion.

During the spring semester of 2013, the pretest and survey were once again administered and the class brief on the results. In addition, the 2013 students were briefed on the fact the 2012 students who sat for the certification exam noted that a variety of approaches were employed to prepare for the exam. While some prepared by themselves, the fact most prepare with classmates was emphasized.

**Results**

**Pretest results.** The pretest results for the two periods in which the pretest was administered are presented in Table 1.

Table 1. Pretest information.

<table>
<thead>
<tr>
<th>Test information</th>
<th>Spring 2012 (n = 25)</th>
<th>Spring 2013 (n = 24*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>15.92</td>
<td>16.46</td>
</tr>
<tr>
<td>Median</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Mode</td>
<td>14.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>3.41</td>
<td>3.56</td>
</tr>
<tr>
<td>Variance</td>
<td>11.66</td>
<td>12.69</td>
</tr>
</tbody>
</table>

*One of the students enrolled in the course was not present the day the pretest was administered.

The pretest data were subjected to an F-test and t-test to determine whether there was a significant difference between the two classes—spring 2012 and spring 2013. It was concluded that the variances and means of the two classes were equal.

**Survey results: management courses completed.** The status of management course completion by the two classes—spring 2012 and spring 2013—are presented in Figures 2 and 3 respectively.
Figure 2. Management course completion, spring 2012.

Figure 3. Management course completion, spring 2013.
In a visual inspection of the data, there does not appear to be a significant difference between the management course completion rate between the two classes—spring 2012 and spring 2013.

**Survey results: choice of minors.** The minors the students in the two classes—spring 2012 and spring 2013—were pursuing are presented in Figures 4 and 5 respectively.

![Bar chart for spring 2012 design technology students' minors](image1)

**Figure 4.** Minors being pursued by spring 2012 design technology students.

![Bar chart for spring 2013 design technology students' minors](image2)

**Figure 5.** Minors being pursued by spring 2013 design technology students.
The significantly higher rate with which the Business Administration minor was being pursued is probably due to the value of the minor reported by alumni, the fact the BS in Design advisor encourages students to pursue a minor, and the perceived value of this particular minor in the students’ academic preparation.

**Spring 2013 exam results.** During the 2013 spring semester, 21 of 25 students sat for the certification exam. Of the four who did not sit for the exam, three had already passed the exam. The fourth dropped the course.

Sixty-seven (67%) percent of the students passed (n=14) with threshold raw scores of 95 or better. The raw scores for 86% (6/7) the students who did not pass fell within 10 correct answers of the passing score (85-94). One of the students who did not pass, drop the course. Another who did not pass the exam took an incomplete for the course and eventually passed the certification exam and the course. The fact this student passed the exam is not reflected in these data.

As well, it did not appear pursuit of a Business Administration minor by the students influenced certification exam performance. The proportion of students pursuing a Business Administration minor who passed the exam was basically the same as the proportion of students pursuing some other minor or that were not pursuing a minor who passed the exam.

In a post-exam survey, 88% of the students indicated that they 'prepared' for the exam exclusively by themselves rather than with others, which is significantly higher than the more successful spring 2012 class. In addition, approximately 58% of the 2013 students reported needing to 'just fill in bubbles' to increase the likelihood of passing, which was the first time this approach to completing the exam was cited. That is, many ran out of time.

**Discussion**

The criterion for success for this program outcome was not achieved in the spring of 2013.

**Actions [to be] taken (use of results).** When this exam is be administered again—the 2014 spring semester—students will be more formally organized to 'prepare' for the exam. And even though an onscreen clock was provided by the test administrator, a greater effort will be made to provide students with countdown reminders while they are sitting for the exam.

**Conclusions**

Based on the students’ performance on the pretest, it appears the courses completed and being completed by the students is not sufficient to sit for the exam. However, it should be noted that the pretest is a closed book, unannounced pretest, whereas the exam, while time constrained, is scheduled and is an open book exam. So there may be value in the administration of the pretest and the subsequent discussion of the results.

It appears there is no relationship between the pursuit of a given minor and the students’ performance on the certification exam.
Bibliography


Graphics within Initial Technology Teacher Education: A Snapshot of Ireland and USA

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Dr. Theodore J. Branoff, North Carolina State University

Ted Branoff, Ph.D. is an associate professor in the department of STEM Education at North Carolina State University. He has been an ASEE member since 1987 and is the immediate past President of the International Society for Geometry and Graphics. Dr. Branoff’s research interests include spatial visualization in undergraduate students, 3D constraint-based modeling strategies, and the effects of online instruction for preparing teachers and engineers. Along with teaching courses in introductory engineering graphics, computer-aided design, descriptive geometry, and instructional design, he has conducted CAD and geometric dimensioning & tolerancing workshops for both high school teachers and industry. In 2013 he was elected as an ASEE Fellow.

Mr. Raymond Lynch, University of Limerick
Abstract

Graphical capability is considered to be of fundamental importance across multiple disciplines. It involves the ability to mentally orientate and manipulate geometry, interpret graphical information and communicate visual thinking. Exploring and learning through the medium of graphics begins in early childhood and continues throughout adult life. The role of the education system in developing and nurturing graphical skills is sometimes understated. This paper considers the treatment of engineering design graphics within Initial Technology Teacher Education (ITTE) at the University of Limerick (Ireland) and North Carolina State University (USA). An in-depth review of the nature and purpose of graphics between both institutions is presented. A number of pertinent questions relating to the definition of being graphically capable and curriculum planning are presented. This paper will be of particular interest to academics who teach Engineering Design Graphics, high school teachers and engineers.
Introduction

“Graphics” are the representation of visual images with the purpose of communicating some information. Representations differ vastly in their purpose, mode of creation and in their level of abstraction [1]. They can be in the mind (internal) or they can be physically perceivable (external). Internal representations are private in nature and stimulate internal dialogue and reasoning about one’s geometric problem solving and design thinking. On the other hand, external representations are public in nature and they form the basis for scaffolding internal dialogue and communicating graphical concepts [2]. Externalizations compensate for the limitations of inner representation and are the synthesis of graphical symbols. They can be elaborate, precise, detailed descriptions of a design entity, whereas others can be abstract in nature, varying in consistency, lacking scale and appear hurried. External representations take various forms which can include drawings, diagrams, charts, photographs, CAD models and sequential cartoons.

The externalization of images is a complex process which starts in early childhood. Exploring and learning through the medium of graphics is a fundamental part of a child’s early education. The first explorations which involve the use of a crayon or pencil to make marks on paper are considered important catalysts in learning to draw. During early schooling drawing promotes play and discovery while bridging imagination and reasoning [3]. In progressing from elementary school to high school level, graphics are used in many applied contexts. These include the communication and interpretation of data through graphs and charts, the graphical reasoning of mathematical and geometric problems through freehand sketching, and the communication of design ideas using digital software.

Across the globe, curriculum policy and planning largely focuses on the development and promotion of numeracy, literacy and articulacy skills [4]. However, research has identified the importance of graphicacy across the education system in developing well-balanced human citizens [5, 6]. This paper discusses the purpose and role of graphical education within the high school system with a particular focus within Initial Technology Teacher Education (ITTE). The development of graphically capable teachers within two four year undergraduate degree programs is discussed in terms of underpinning philosophies and curriculum planning.

Vocational Education in Ireland

Vocational education in Ireland has traditionally had a lowly position in Irish high (secondary) schools [7]. This is as a result of a historic divide between the philosophies underpinning the education provided in high schools and that provided by Vocational Education Committees (VECs). Following the establishment of the Irish Free State in 1922 the first Department of Education was formed and formal provision of high school level education was introduced [8]. In June 1924, under the Intermediate Education Act [9], the Intermediate and Leaving Certificate state examinations were launched. These examinations and their resulting qualifications were offered almost exclusively to students who attended private high schools [10]. By contrast vocational education differed in terms of its origin and
provision. Vocational Education Committees were established under the Vocational Education Act of 1930\[11\] and were responsible for developing the infrastructure required to support vocational education and technical training in Ireland. However, at that time, these technical schools were not permitted to present students for state examinations. Students of technical schools were required to sit the Day Vocational Certificate Examination, commonly, known as the Group Certificate examination which was introduced in 1947\[8,12\]. This resulted in a clear academic/vocational divide in the Irish Education system as highlighted by Raftery and Hout\[13, p.42\];

Those who complete their primary education follow one of three channels. Some terminate at the end of primary school, some enter an academic program in a secondary school, and the remainder receive specialized technical training and general course work at a vocational school.

Vocational and technical education also suffered from a lack of clarity as to what it involved and what pedagogical methodologies and strategies should have been employed to promote student learning. At the time there was a belief that the required skills could be best learned through formal apprenticeship and informal experience in the work place\[8,14,15\]. This divide in the role and function of high schools and technical schools remained, from a policy perspective and in practice, until 1966 when for the first time students from VEC schools were allowed to present for state examinations\[8\]. The following year saw the introduction of Donagh O’Malley’s Free Education Act\[9\] which resulted in greater access to education and a significant increase in student numbers at high school level. The changing role of technical schools, coupled with free education dramatically changed the face of Irish high school level education. This broadening of the focus of vocational education schools resulted in less definitive educational outcomes which were traditionally governed by the type of school attended. The need to create technology subjects that were comparable to the classical academic subjects challenged the nature of technical education in Ireland\[15\]. As a result technology subjects were redeveloped to reflect more academic constructs. This is evident in the introduction of senior cycle Technical Drawing as a state examinable subject in 1969. This syllabus attempted to make the subject more academic and as a result concepts and topics were deliberately addressed in more abstract terms in an effort to distance itself from the applied, vocational nature of its origins\[16\]. However, recent years have seen a shift in focus for technology education, and in particular graphical education, within the Irish high school level system. Design and Communication Graphics (DCG) was introduced in September 2007 and replaced the Technical Drawing syllabus which had not been revised since 1984. This new DCG syllabus reflected a design driven philosophy of technology education that endeavours to form part of the holistic education of all students. As discussed in the syllabus it is envisaged that the “design theme, which permeates the course, will empower the students to communicate their design ideas and solutions with accuracy, flair and confidence”\[17\].
Philosophy of Graphical Education within Initial Technology Teacher Education at University of Limerick

The University of Limerick (UL) is the sole provider of high school Technology teachers in Ireland. The University offers a four year undergraduate training program which qualifies students to teach a suite of high school Technology subjects which includes Graphics, Metalwork, Woodwork, Engineering and Construction Studies. Recently, the Technology teacher education program at UL was reviewed and re-conceptualized in order to meet the requirements of the national teaching council.

The philosophy of the Initial Technology Teacher Education program at UL is to provide students with a broad learning experience where they develop an in-depth understanding and appreciation of the principles of their subject discipline and pedagogy, refine and develop cognitive and psychomotor skills, while integrating this with the study of educational philosophy.

Treatment of Graphics within ITTE at University of Limerick

The focus of the re-conceptualization of graphics within the four year ITTE program was informed by findings from contemporary research and several meetings between experts in the area of technology education at UL. Three broad, fundamental competencies were identified to become an effective teacher of graphics at high school level (Figure 1).

![Figure 1 – Fundamental Graphical Competencies within ITTE](image)

It is important that teachers have a clear understanding of geometric principles and in particular the fundamentals of plane and descriptive geometry. Well-developed spatial visualization skills are critical in order to effectively manipulate and synthesize these principles while graphically problem solving. Finally, the ability to graphically communicate through various mediums such as freehand sketching, CAD and model making is important in order to support the internalization and externalization of visual thinking.
In order to meet the challenges of developing teachers who are graphically capable, a macrostructure of progression was developed (Figure 2). The philosophy of building, manipulating and synthesizing is integrated throughout the program. The initial focus is to develop students’ spatial visualization and graphical communication skills. Using these skills, the students begin to manipulate and synthesize their understanding of geometric principles through appropriate tasks. An integral part of the program is to expose students to the contemporary research related to graphics and technology education. Areas of study include cognitive development underpinning graphical capability, assessment within graphics education and subject specific pedagogy. Another critical aspect of the macrostructure and philosophy of the program is the increase in independent learning time for students as the four years progress.

**Figure 2 – Macrostructure of progression within graphics**

**General focus within each semester**

The four year ITTE program at UL consists of eight semesters in total. Students experience teaching practice over a number of weeks in semesters four and seven. The following is a brief outline of the focus of each graphics module within the semesters. It should be noted that each module is required and students do not take any elective modules.
Table 1 – Breakdown of key learning outcomes at UL

<table>
<thead>
<tr>
<th>Year / Semester</th>
<th>Key Learning Outcomes</th>
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</table>
| Year 1 / Autumn Semester | • Development of spatial visualization skills through specially designed activities focusing on the physical and mental manipulation of geometry.  
• Explore, interpret and develop a broad range of graphical data.  
• Develop perception based fundamental freehand drawing skills with specific focus on scale, proportion and relationships.  
• Develop graphical libraries of geometric information in long term memory.  
• Explore and communicate geometries through a variety of projection systems including orthogonal projection and perspective with concurrent analysis of advantages and limitations of each method.  
• Introduction to contemporary research providing an insight into the theoretical underpinnings associated with spatial visualization, cognitive architecture and freehand sketching. |
| Year 1 / Spring Semester | • Analysis of plane geometry principles and associated mathematical underpinnings.  
• With particular reference to Euclid’s Elements of Geometry, a grounded understanding of the principles associated with the construction of plane figures is developed.  
• Continue building spatial visualization and freehand sketching skills to support both internal dialogue and external communication of geometry.  
• CAD and other digital software are explored as media to aid in the dynamic communication of plane geometry principles.  
• Develop an appreciation for and apply drawing conventions and standards in communicating measured graphical information.  
• Further development of freehand drawing skills - retrieval and communication of imagery through activities focusing on the visuo-spatial sketchpad of short-term memory. |
| Year 2 / Autumn Semester | • Analysis of the philosophy and structure of lower level, high school Graphics curriculum.  
• Explore the application of plane geometry principles in a descriptive and applied context. Freehand and measured drawings, physical modeling and 3D parametric CAD are utilized in exploring various projection systems for the communication of descriptive geometry principles.  
• Analyze various projection systems and be able to make informed decisions when selecting a suitable system for communicating graphical information.  
• Utilize freehand sketching skills to support internal dialogue while graphically problem solving.  
• Explore different non-graphical methods communicating geometric information to different audiences across different disciplines. |
| Year 3 / Autumn Semester | • Analyze the upper high school level Graphics curriculum in terms of its philosophy and structure in addition to its progression from lower level high school Graphics.  
• Further develop freehand sketching skills through appropriate activities which facilitate the retrieval, manipulation and synthesis of geometric libraries - generating creative concepts and communicating these through ideation sketches.  
• Examine contemporary research relating to graphical communication and the role of human memory systems in supporting internal dialogue.  
• Analyze the different functions of design and explore the various stages using sketching, CAD modeling and physical modeling (including CNC).  
• Discriminate between different media and select as appropriate.  
• Further explore descriptive geometry problems with a specific focus on geometry in contemporary design. |
| Year 3 / Spring Semester | • Synthesize and challenge students understanding of geometric principles through applied geometry activities.  
• Demonstrate cognitive flexibility in solving a range of graphical problems in which various graphical principles are synthesized.  
• Explore strategies for stimulating pupil interest, discriminating between mixed ability learners and supporting the development of different abilities in a whole class situation. Consider graphical principles through various media in a pedagogical context and in particular focusing on the scaffolding of pupil understanding.  
• Discuss the design of appropriate tasks to capture graphical capability and understanding.  
• Synthesize experiences and knowledge of graphical principles together with a grounded understanding of cognition in designing suitable assessment strategies. |
| Year 4 / Spring Semester | • Students undertake an individually driven capstone project  
• The focus of this project centers around innovations that will contribute towards the development of graphical capability and the promotion of graphical subjects in high schools |

**Teaching practice placement takes place in Year 2 - Spring Semester & Year 4 - Autumn Semester**
Although the main focus of this paper is on the philosophy and nature of graphics at University of Limerick, it is also important to consider the treatment of graphics through an international perspective. There are several reasons for this including the fact that graphics is a global language and it could stimulate discussion at the conference in relation to curriculum influences and planning. The next section of this paper considers the role of graphics within an Initial Technology Teacher Education program at North Carolina State University (NCSU).

**Philosophy of the Technology, Engineering & Design Education Program at North Carolina State University**

The faculty of the Technology, Engineering and Design Education Program at NCSU believes that they are preparing the innovators of tomorrow. In order to do this, students must develop a broad range of knowledge and skills that help them be creative and productive. The goal is to prepare teachers and leaders for schools, industry, business or community who are knowledgeable, skillful, and innovative in their technology related professions. These individuals should be change agents to help advance their fields.

**The Role of Graphics Education and the Development of Graphical Competencies**

Since one of the goals of the NCSU program is to prepare innovators, many of the classroom and laboratory activities are based on engineering design processes where students create modeling artifacts to help develop solutions to problems. These artifacts include conceptual models, graphical models, mathematical models, and working models \[18\]. Graphics tend to be a large part of creating these models, so students need to develop competencies in a variety of graphical areas in order that they may apply them as cognitive tools (e.g., visualization sketching and concept mapping), design tools (e.g., design sketching, 3D modeling, electronic publishing, and design analysis), or documentation tools (e.g., rendering, animation, and engineering drawings) (Figure 3).
To develop these competencies, students have required courses in engineering graphics, 3D constraint-based modeling, architectural graphics, and imaging technologies (Table 2). They also have electives available in descriptive geometry, visual thinking, and advanced computer aided design. These electives, along with other technical electives in the program, allow students to specialize in either engineering design graphics or electronic imaging technologies.

**Table 2 - Competencies in Graphics Courses at NC State University**

<table>
<thead>
<tr>
<th>Course</th>
<th>Competencies</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied CAD &amp; Geometric Controls Required</td>
<td>Working drawings. Threads &amp; fasteners. Geometric dimensioning &amp; tolerancing. Constraint-based CAD concepts: design tables and configurations, programming, sweeps, lofts, assembly drawings.</td>
<td>Develop a complete set of working drawings of a 10-25 item assembly. Model all parts, create detail drawings of all non-standard parts, and create an assembly drawing of the final design.</td>
</tr>
<tr>
<td>Architectural Graphic Communications Required</td>
<td>Residential and commercial architecture standards and conventional practices. Floor plans, elevations, details, and plot plans. Introduction to AutoCAD.</td>
<td>Design a modest home. Include all required drawings necessary to manufacturing the dwelling. Build a prototype of the home.</td>
</tr>
<tr>
<td>Desktop Publishing and Imaging Technologies Required</td>
<td>Design principles in desktop publishing. Typography. Digital photography basics. Creating print-ready documents using Adobe InDesign, Illustrator, and Photoshop.</td>
<td>Work with a real client and develop a usable product for their company. Projects may include brochures, newsletters, menus, etc. All graphics must be original.</td>
</tr>
<tr>
<td>Course</td>
<td>Description</td>
<td>Examples/Assignments</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shortest connectors.</td>
<td>Angle between line and plane.</td>
<td>Intersections between surfaces. Developments – radial line, parallel line Civil engineering applications with the road defining the cut and fill at specified grades. Create a virtual model and a physical model of your solution.</td>
</tr>
<tr>
<td>Visual Thinking Elective</td>
<td>Sketching – perspectives, figure drawing, etc. Seeing, imaging and drawing.</td>
<td>Alternative strategies to foster productive creative thinking. Create a Visual Metaphor (or Prototype) which will be presented and group evaluated in class.</td>
</tr>
<tr>
<td>History of constraint-based CAD. Anatomy</td>
<td>Downstream uses of 3D models. Advanced tools in SolidWorks: Surface modeling, sheet metal, equations, analysis (FEA, CFD, etc.).</td>
<td>Team project: Reverse engineer a complex design; design divide design into meaningful subassemblies; reverse engineer individual parts; model parts; assemble parts; create documentation drawings and rendered images; present to class.</td>
</tr>
</tbody>
</table>

**Strengths of the Graphics Element at NC State**

The strength of the graphics element in the program at NC State is engineering design graphics and constraint-based computer-aided design. Since the program and faculty have a tradition of offering service courses in graphics to engineering and the rest of campus, students in the Technology, Engineering & Design Education program get a chance to interact with students from a variety of majors – especially engineering. Although they do not graduate as engineers or product designers, students in the program are learning how to think as engineers and designers. They learn to use powerful engineering design tools to create virtual prototypes and conduct complicated analyses on their designs.

**Discussion**

The purpose of this section is to raise some questions in relation to graphics within ITTE from an international perspective.

First of all it is important to consider the philosophy and nature of graphics education within ITTE at UL and NC State. Although great strides have been made in UL in modernizing the focus of high school graphics subjects, there still remains a profound focus on plane and descriptive geometry. It is considered important that in order to be graphically capable, students should have a good understanding of these principles. However, at NC State the study of descriptive geometry through 3D Spatial Relations is an elective module of study. This observation raises several questions… Is it important for students to study plane and descriptive geometry? Do students need to know the underpinning mathematical theorems relating to certain geometric principles if CAD systems can already do this?

It is notable that students at NC State have required modules and electives while students at UL can only take required modules and do not have the opportunity to take electives. How much of a focus is there on the national curriculum? What are the merits of having required
modules and electives? How can you ensure that teachers will be graphically capable when graduating from the program if they must choose between electives? Is it possible to develop innovative teachers who can think independently when they don’t have the opportunity to take electives?

The treatment of graphical communication between UL and NC State is interesting. Proficiency in freehand sketching and CAD applications is seen to be critical from a pedagogical and visual communication standpoint. It is interesting that freehand sketching skills are developed as part of an elective module in Visual Thinking at NC State whereas freehand sketching is integral to all modules of study at UL. In order to be graphically capable, is it necessary to have proficiency in all media? If a student has a keen interest in ICT (Information and Communications Technology) and well developed CAD skills, do they need to have the same level of expertise in freehand sketching?

The primary focus of the teacher education program at UL is on developing high school technology teachers. The focus of the teacher education program at NC State is on developing teachers and leaders for schools, industry, business or community. What are the merits of streamlining the development of teachers solely for high schools? Is there any risk of diluting the teacher as a professional if the focus reaches further than the high school system? Is it disadvantageous to solely develop students as high school teachers? What if they would like to broaden their career outside of the high school system during life? Is the four year program appropriate? Should teachers have a general degree and take a teaching qualification at post graduate level afterwards?

Finally, it is important to revisit the topic of graphicacy and what it means to be graphically capable. There is little doubt that being graphically capable has significant importance across multiple disciplines and that there are many cognitive and psychomotor benefits. However, it is apparent that there are some underlying questions which are of interest to people within engineering design graphics. What does it mean to be graphically capable? What are the core competencies of a graphically capable human citizen? How can these competencies be developed?
References

4. Moseley, D.H., Steve; Bramald, Rod; Hardman, Frank; Miller, Jen; Mroz, Maria; Tse, Harrison; Newton, Doug; Thompson, Ian; Williamson, John; Halligan, Jean; Bramald, Sarah; Newton, Lynne; Tynims, Peter; Henderson, Brian; Stout, Jane, *Ways forward with ICT: Effective Pedagogy Using Information and Communications Technology for Literacy and Numeracy in Primary Schools*, 1999, Durham Univ. (England). Curriculum, Evaluation, and Management Centre.
Considering cognitive load as a key element in instructional design for developing graphical capability

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Dr. Niall Seery, University of Limerick  
Mr. Raymond Lynch, University of Limerick  
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Considering cognitive load as a key element in instructional design for developing graphical capability

Abstract

Developing skills of graphical capability have been discussed as core competencies in the context of general educational provision by numerous authors in recent years \(^1,2\). The skills associated with this concept of capability include visuospatial reasoning and problem solving skills. Aligning with contemporary philosophies of educational provision, the flexible development of these skills is of core concern in a dynamically evolving societal context.

Given this focus, the nature of instructional design with relation to educational provision is of paramount importance. Previous research by Delahunty et al.\(^3\) has highlighted possible areas of concern in the application of theoretical graphical knowledge (developed through current educational practice) to applied problem solving activities. Further work has hypothesized the possible underlying variables which may be affecting the problem solving process including transfer issues and conceptualizations of educational tasks \(^4\).

The conceptualization of tasks is hypothesized to be a core phenomenon in the process of problem solving and must be investigated in the context of task design. However, in the context of designing tasks for learning purposes Sweller et al.\(^5\) discuss cognitive load as a further consideration which is often overlooked. It will be necessary to consider the two areas in parallel and in conjunction with efficacy of task performance in order to gain a deeper understanding of problem solving processes within graphical learning.

The research in this paper, which is part of a larger study currently underway at the University of Limerick, presents an exploration of cognitive load and its relationship to problem solving performance. It takes the form of a critical literature review on the nature of cognitive load and possible effects of graphical task design. Key points within this review are discussed in conjunction with previous exploratory work in the area of conceptualization. The paper concludes by presenting a promising approach to investigating underlying variables affecting problem solving efficacy within a teaching and learning context.

Introduction

The flexible development of a wide variety of cognitive skills lies at the heart of contemporary general educational philosophy. As discussed by McGilchrist\(^6\), this philosophy involves a reconsideration of cognitive values shifting from the more traditional verbal-analytical to embracing the more holistic-visual aptitudes. This paper focuses on educational research with the latter set of values comprising the principal focus. Visuospatial cognition has been presented as a key set of skills which are critical to a wide variety of human endeavors \(^2\). These range from simple everyday navigation to technologically advanced surgical research \(^7\). Given the paramount importance of these skills, their development is a core concern of general educational provision.

Previous research by Delahunty et al.\(^8\) has highlighted the existence of inefficient approaches to current styles of task utilized within current teaching and learning practices. A further study by Delahunty et al.\(^3\) investigated this general issue further within a tertiary context and specifically highlighted deficiencies in student teachers’ ability to apply theoretical knowledge to applied problems. Both these studies concluded with the acknowledgement of issues pertaining to surface approaches to problem solving among students but the exact nature of the issues are still
These studies took an investigative approach to problem solving strategies and have ultimately lead to the development of a research method centered on the use of electroencephalography to objectively examine cognitive function during performance. It is envisaged that this continuing work on students’ problem solving approaches will lead to a deeper understanding of the issues. However, the nature of the problem solving tasks used has not been a core focus within these studies and it is now necessary to consider this.

The conceptualizations of tasks have been discussed as a possible core phenomenon within problem solving and problem based learning particularly in relation to graphical education. However, an often overlooked area with particular relevance to pedagogical task design is that of cognitive load. Cognitive load theory is of critical importance in the design of educational tasks and especially when those pedagogical strategies are utilized under situational constraints such as class periods. The focus of this paper will be primarily concerned with the nature of task design housed in the context of teaching and learning. It will present cognitive load theory as a key factor for consideration in instructional design. The next section will review some of the literature on cognitive load theory and its relationship to learning.

**Instructional Design for Problem Solving**

Consideration of pedagogical strategy when designing appropriate instructional materials is of critical importance. Due to the applied nature of the philosophy of graphical education in Ireland, the use of strategies centered on problem solving are appropriate and widely used. Much research has shown that the use of such problem-based approaches has significant benefits for the development of flexible and adaptive knowledge and skills. As discussed by Williams et al. the use of problem-based learning (PBL) is synchronous with the overall aims of technology education and helps promote learning. Given the benefits of using PBL as indicated in the literature, the design of problem solving tasks for learning is a key area for consideration.

As alluded to by Delahunty et al., the conceptualization of tasks is posited to be a critical area of research within this area of PBL. However, another consideration, which is often overlooked in the design of instructional materials, is cognitive load theory (CLT). Sweller et al. outline the three main types of cognitive load as follows:

1. **Intrinsic**: This is imposed by the nature of the information (simple/complex, concrete/abstract) contained within the task or material
2. **Extraneous**: This is imposed by the design of the instructional or learning material and occurs where information irrelevant or unnecessary to the situation is present
3. **Germane**: This is a third category of cognitive load which is directly related to intrinsic cognitive load. It occurs when attention and resources are focused on the intrinsic nature of the learning material utilized and is considered relevant to learning

The type of load that is most relevant in the context of this paper is extraneous load as it is the one that is controlled directly by the design of the problem-solving task. It is crucial to consider extraneous load in the process of designing an instructional task in order to maximize the amount of germane cognitive load which can then result in maximum learning. Extraneous cognitive load becomes an issue when the working memory resources, which have to deal with all types of cognitive load, are exceeded.

It is difficult to completely eliminate all sources of extraneous load in the design of a learning task due to the idiosyncratic nature of the student population. Areas such as learning styles, cognitive style and epistemological orientation effect the manner in which an individual commits resources to a task. In designing a learning task or activity it is important to minimize the amount of
extraneous load so that more mental resources can be allocated to intrinsic and germane load. It is important to note that extraneous load does not always inhibit task performance as long as the working memory resources are not exceeded when intrinsic and extraneous cognitive load are combined. Extraneous cognitive load is the primary type that can be controlled in the instructional design stage and has an inverse function with germane load. In other words, as extraneous load is reduced germane load is increased which promotes higher levels of learning.

The intrinsic nature of the instructional design is determined by the number of elements contained within the material and their associated interactivity. As discussed by Sweller et al., elements which can be learned in isolation (such as the letters of the alphabet) do not demand a vast amount of mental resources. It is when the elements start interacting that the allocation of resources becomes critical (for example when learning words). As expertise in an area develops, mental schemas are constructed which can combine elements so that they now may be treated as one element in future situations. Therefore, reduction of extraneous cognitive load in the design of problem solving tasks is a core consideration in order to maximize the amount of working memory resources (germane load) which can be allocated to developing these schemas.

Cognitive load can be measured in a variety of ways. Some of the most common are the use of a subjective rating of mental effort and physiological indicators such as heart rate, eye tracking and EEG.

**Causes of Extraneous Cognitive Load**

There are a number of areas within the design of an instructional task which can contribute to an extraneous load. One of the most common issues is the presentation of irrelevant or unnecessary information within the task or activity. In such a situation, the learner has to allocate resources to processing the redundant information which monopolizes working memory resources. The core implication here in relation to task design for educational purposes is the loss of working memory resources which could have been devoted to the intrinsic nature. This is a clear case where poor task design can lead to an increase in extraneous load which may inhibit learning.

Another area which is closely related to this is the split-attention effect which is concerned with the modality in which information, within the task, is presented. It is widely accepted that working memory primarily supports two different modalities. As indicated by Baddeley, these comprise the phonological loop and the visuospatial sketchpad. Both deal with primarily verbal and visual data respectively. According to the split attention effect, if one of these channels becomes overloaded, as a result of task presentation, then extraneous cognitive load can be increased. A simple example would be presenting over complex written text and a visual representation which both have to be processed by the visuospatial component of working memory.

Again it is important to note that extraneous cognitive load may not become an issue as long as there are sufficient working memory resources which can be allocated to the task at hand. There are a variety of characteristics within a task which, combined with the introspective characteristics of the learner, can cause a detrimental extraneous cognitive load. It is must be acknowledged that not all extraneous cognitive load can be entirely removed however the general optimal approach is to reduce the effects as much as possible while enhancing the capacity to learn from the instructional design.
The Capacity to Learn

Outlined in the previous section was some of the pertinent literature on the nature of cognitive load, its various types and the complex relationship to learning and instructional task design. It is clear that reducing extraneous cognitive load is of paramount importance when considering or designing pedagogical interventions. This will aid in maximizing the working memory resources which can be focused on the intrinsic nature of the task (increase in germane cognitive load) leading to the development of robust mental schema. So far this paper has been focused on the empirical evidence already developed within the field of cognitive load theory.

Aligning with the perspectives of situated cognition and learning, it is necessary to consider empirical approaches to determining cognitive load effects so that tasks may be enhanced in an adaptive and flexible manner. Embracing the use of such approaches may ultimately enhance educators’ task/instructional design and maximize students’ capacity to learn from such tasks or activities.

A notable approach that should be considered is that of problem solving efficiency. Hoffman and Schraw\textsuperscript{19} discuss the importance of studying problem solving efficiency so that a deeper understanding may be gained of the time and effort required to develop knowledge and skills. This becomes particularly relevant within educational settings as there are often numerous constraints placed on the learning process such as class periods and state examination deadlines. Efficiency within a learning context is broadly defined as “the ability to reach established learning or instructional goals with a minimal expenditure of time, effort, or cognitive resources”\textsuperscript{19}

Understanding of efficiency within a PBL perspective may allow educators to critically evaluate their instructional designs and subsequently tailor them to student needs. By determining an optimal efficiency within a pedagogical intervention, the affect of extraneous cognitive load will be reduced and germane load will be increased. There are a wide variety of methods utilized to calculate efficiency scores and each has its own set of merits depending on the context of the study in question. It is beyond the scope of this paper to consider these empirical approaches in detail but an extensive review can be found in Hoffman and Schraw\textsuperscript{19}.

General Discussion

This paper has presented a brief overview of the pertinent literature on cognitive load theory and its relationship to learning. Of particular interest in the context of technology education is problem based learning approaches due to the applied nature of the subject area. Focusing specifically on graphical education, previous research by Delahunty et al.\textsuperscript{8} and Delahunty et al.\textsuperscript{3} has taken distinct approaches to studying apparent deficiencies within current educational practices. These included a focus on the predominant styles of knowledge implemented in the problem solving process and issues of transfer from graphical theoretical to applied tasks respectively. Stemming from this research, a core hypothesis surrounding the relationship between task conception and performance was formed and is currently under investigation \textsuperscript{4}. However, during the investigation of these various issues it has become clear that the area of task design for educational purposes is a core concern.

When considering task design, it is apparent that understanding cognitive load in conjunction with the conceptualizations of tasks will lead to a deeper understanding of instructional design. A core issue cited in Delahunty et al.\textsuperscript{3} was the use of inefficient approaches to an applied task. The underlying variables influencing these approaches still remain tentative but it is possible that a high cognitive load inhibited students’ conception of the task which forced the adoption of sub-optimal strategies to deal with the situational demands. The relationship between conception and cognitive
load is not well understood and could be a converse effect. In other words the conception of the task could be determining some of the cognitive load present in the solving of the task. High levels of cognitive load have been shown to lead to a reliance on the use of inefficient strategies when dealing with applied problems or tasks.\(^5\)

This relationship between conceptualization and cognitive load seems plausible when one considers the theory of entrenched conceptualizations.\(^{20}\) This refers to the automaticity at which some of our cognitive functions may be recognized and executed after a sustained period of practice and is a particularly useful trait in everyday practical situations.\(^{20}\) However, this may become a negative phenomenon in an educational setting when the goal is to develop adaptive and flexible problem solving skills. If tasks are constantly conceptualized in a specific manner (entrenchment) then there will be occasions when the cognitive load will be high and the subsequently adopted strategy will be sub-optimal. An inhibition of learning may then occur due to the extraneous nature of the cognitive load induced by that conception of the task. This theoretical relationship seems plausible when considering that the efficiency of processing within working memory is dependent on task complexity (e.g. conception) and demands (e.g. cognitive load).\(^{21}\)

As discussed, adopting an efficiency perspective within the instructional design stage may lead to a better understanding of conditions which can maximize the effect of the pedagogical design. This perspective provides a practical approach which can be used to examine the suitability of instructional interventions. As already discussed, there is evidence which may suggest the unsuitability of current task designs for developing graphical capability. Taking some of the perspectives from CLT and the efficiency literature it is now possible to evaluate task design practices so that a deeper understanding of instructional interventions may be gained.

In conclusion, it can be seen from the brief review of literature surrounding cognitive load theory that there are a number of important considerations which must be acknowledged in developing graphical tasks. Evidence exists to suggest deficiencies in the current state of teaching and learning within graphical education. A deeper understanding of the effects of cognitive load in conjunction with task conception should aid in highlighting some of the underlying variables of causation.

References


Incorporating Active Learning into the Graphical Communications Course

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Incorporating Active Learning into the Graphical Communications Course

Introduction

Active learning, is a student-centered learning strategy which has recently gained considerable attention in higher education. The literature has shown that active learning has led to better student attitudes and improvements in their thinking, communication, leadership, and writing skills. The core elements of active learning are student activities and engagement in the learning process. As more faculty look for alternatives to traditional teaching methods they have strongly advocated active learning. However, the potential challenges for faculty with such an approach cannot be ignored such as increased class preparation time, the risks of student dissatisfaction, the use of instructional technology, and increased lecture time.

The Graphical Communications course at Embry-Riddle Aeronautical University (ERAU) is a freshmen level course that is designed to familiarize the students with the basic principles of drafting and engineering drawing, to improve three dimensional (3D) visualization skills, and to teach the fundamentals of a computer aided design. The students meet the instructor twice a week in the laboratory during this three-credit-hour semester-long course with each class lasting two hours. The course is taught using traditional teaching methods with the introduction to graphics concepts and examples in the first hour, and tutoring the homework in the second hour. Students passively absorb the information and work individually to solve the problems. The limited class time means that not all students get the immediate help they need. In addition, many of them do not follow up during office or tutoring hours for additional assistance. Since it is early in their university career, they often are not mature enough to admit they are unsure of the material and need help.

Since the spring of 2011, this author has transformed guided, individual, final projects towards team-based open-ended final projects. The students now have an opportunity to apply the skills and knowledge they learned in the class to solve real-world problems, and to think as engineers. This has introduced a greater level of excitement and enthusiasm into the course by allowing students to explore the topics of personal interest and has enhanced their understanding of the concepts learned in the classroom. Since the majority of the students are freshmen, they do not know each other before this course and typically do not have any social links yet. To better enhance the performance of the teamwork, there is a need to help them to connect with each other from the first day of class.

Active learning techniques were incorporated into the class to establish a positive collaborative study environment, motivate their critical thinking skills, enhance the understanding of the course material, and improve the productivity of the teamwork. This paper describes how to incorporate some core elements of active learning into the traditional lecture. The effectiveness of the active learning was assessed by mid-term survey, the end-of-semester evaluation, student comments, and changes in the final grades.

Active Learning
Active learning is generally defined as any instructional methods that engage students to learn in the classroom\(^3\). By doing meaningful learning activities students can think about what they are doing and learning\(^1\). This author implemented core elements of active learning in the fall semester of 2013 and these include ‘The Name Game’, peer instruction, concept test, muddiest point, homework troubleshooting, and hands-on activities.

- **The Name Game**
  Dr. Raymond emphasizes the importance of getting to know one another by name on the first day of the class in his book\(^{12}\). He introduces ‘The Name Game’ which helps students to know other students in class by name and gives them an opportunity to support each other academically, socially, and psychologically. Following his insight, the author created a name card for every student which was displayed on their desk to be seen by other students. ‘The Name Game’ was implemented in the first few classes of the semester to help students know their classmates and make connections with each other. They worked in randomly formed groups and were required to remember the names of the other group members. The name cards were distributed to each student before the class started each time, which also helped the instructor check the student attendance. ‘The Name Game’ has proven to be very helpful in fostering bonding among the students and obtaining the academic support from each other.

- **Peer instruction**
  Peer instruction used here is different from the general definition that the instructor asks students to respond to conceptual questions\(^{13}\). Students were given either an incomplete or incorrect solution, they then formed pairs, discussed their answers, and presented their understanding by using an interactive SMART Podium to the whole class. The quick feedback greatly aided the instructor in helping students address a given misconception. Peer instruction promoted the collaboration, conceptual understanding, and problem-solving skills.

- **Concept test**
  In this method, the lectures were punctuated by multiple-choice conceptual questions to test student understanding of the material. Often the distracters (incorrect responses) reflect common student misconceptions\(^{14}\). Previous research has found that students attention spans during lectures is typically fifteen minutes long and after this time their attention begins to drop dramatically. Breaking up the lecture can refresh their mind and help to keep them engaged\(^3\). PollEverywhere.com, an online real time service for classroom response, was adopted due to its simple web interface and instant feedback analysis. Figure 1 (a) shows a snapshot of the concept test question on a power point slide and Figure 1 (b) demonstrates the corresponding student responses on PollEverywhere.com.
Figure 1. (a) a snapshot of concept test question on powerpoint slide, and (b) student responses on PollEverywhere.com

- **Muddiest point**
  At the end of every class, students were asked to provide their most confusing concept or other issues that arose during the class. Muddiest point responses were collected by PollEverywhere.com service. The information collected was used to address student most unclear point and their concerns in the next instructional class\textsuperscript{15}.

- **Homework troubleshooting**
  Based on the homework collected at the beginning of the class, the author introduced a 15-minute homework troubleshooting (TRBL) section before the new concepts were delivered to students. Students were asked to study the randomly selected student homework which was projected on the screen, and correct the mistakes. By doing the homework TRBL, students should have a better understanding of the common mistakes and avoid making same mistakes next time.

- **Hands-on activities**
  Some students struggle with visualization at the beginning of the semester, especially how to complete a missing multiple view or an isometric view of the orthographic projections. To facilitate their visualization skills, snap and build cubes were used to help students understand the formation of the isometric view and how to complete the missing multiple views. Figure 2 illustrates the relationship between the isometric view and multiple views by using the snap and build cubes. Red and white colors represent two separate surfaces at different levels.
Assessment

In the fall of 2013, a midterm survey was given to all students who were enrolled in Section 9 and Section 10 of the course and 38 out of 56 students completed the survey on the surveymonkey.com. Figure 3 shows the students response and analysis to liking active learning. 95% of students chose either “extremely liked” or “liked” them. In order to understand the effectiveness of the each technique of the active learning, at the end of the semester students were asked to rank the different techniques as to their perceived effectiveness in helping them learn the material. Finally open-ended comments were collected.

The question given on the end-of-semester course evaluation which was designed to collect student feedback on active learning is as follows: ‘In this semester, we have applied active learning in the class. We used name games, blocks, homework troubleshooting, concept test, muddiest points, and peer instruction on the smart podium. The purpose is to engage you to be more active in class, and to help you understand the concepts in a better way. Please share your thoughts with me and let me know if you like the active learning pedagogy’. A list of the teaching and learning strategies followed the question, and students were required to rate each as “Extremely likely”, “Very likely”, “Moderately likely”, “Slighty likely”, or “Not at all likely”.

Figure 3. Student’s response and analysis to active learning in the fall of 2013
On average 70% students completed the questions from two the class sections (N=60). Figure 4 shows the student responses to the questions which were collected at the end of semester. Among the traditional teaching methods, students rated in-class examples very high, with 100% of student liking it in various degrees from both sections. They believed that the clear, step-by-step, illustrations helped them understand how to solve the problem. One student commented that “it helped to understand the content more by showing me the way you would do it”. Among the active learning techniques, students rated the concept test highly, with more than 80% of students rating them as either “Extremely likely” or “Very likely”. Students commented that “the concept test not only lets students see if they know the content but gives the instructor a chance to see if all students understand the concept”. The muddiest point is the next favorable active learning technique. Even though there were only 45% of students rated it as either “Extremely likely” or “Very likely”, only less than 5% did not like it at all. Some of the comments are “I felt I was forced to come up with something when we did the poll.” and “It helped me understand the upside to CATIA, since all I have ever used before was AUTOCAD”. Students also preferred peer instruction with only 7% of students from both sections describing it as “Not at all likely”. Students commented that the discussion and the collaboration with their peers promoted concept understanding and increased their problem solving skills. Homework TRBL was preferred by some students since it helped them see their mistakes and understood the instructor’s expectation; however, others complained that too much class time was wasted in this area. Name card and the cubes/blocks activities were the two least popular active learning methods. Around 22% of students did not believe that the name card could help them know more classmates and 23% of students did not think the cubes/blocks could help them enhance their visualization skills. Students also mentioned that the lecture time was too long which did not leave them much time as they would have liked to work independently.

Figure 4. Student rating of various teaching and learning techniques in fall 2013. (N = 60)

Therefore, does the active learning help improve students final grades? Student final letter grades from spring 2012 to fall 2013 were collected and compared in Figure 5. Since this is a freshmen-level course, students who have a grade of D or below will fail the course. The failure rate remains less than 10% each semester. The figure only shows the student grades C and above.
Generally speaking, students in the fall of 2013 with the adoption of active learning have better grades than the students in the spring of 2013 and the year of 2012. However, more data will be collected to support the effectiveness of the active learning in the future.

Figure 5. Students final grades (C and above) distribution in each semester

Conclusion
This paper describes the experiences of incorporating active learning elements into a Graphical Communications course at the freshmen level. Historically the course is taught through a traditional teaching with the introduction to graphics concepts and examples in the first hour, tutoring the homework in the second hour. Overall students were exceptionally positive in their assessment of the active learning elements. They felt that active learning did help them understand the course material and improved their critical thinking skills. The only complaint was the extended lecture time which left less time for them to work independently in class. Incorporating active learning into a traditional lecture is not an easy to implement due to the additional class preparation time, fear of the uncertainty that comes with the change and a potential low course evaluation from the dissatisfaction of the students due to implementing new and untried course elements. However, this author believes that with a careful strategic planning process; active learning technique can be incorporated into the traditional lecture for improving student attitude, achievement, and fostering student learning process.

Bibliography


