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The teaching and assessment of computer aided design - a competence based or theory based approach?

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Abstract

The role of CAD within an overall Product Design teaching framework, at Higher Education level, is explored and reviewed. This is considered from three perspectives :

Student - their expectations in terms of theoretical knowledge and competence.
Academic - theory based requirements for successful achievement of learning outcomes.
Employer - vocational competence requirements for Product Design graduates.

With emphasis on the experiences of undergraduate and graduate Product Design students at the University of Derby, and prospective or actual graduate employers, the unique expectations and requirements within each category are considered.

The overall means of resolving these, often conflicting, requirements into the CAD teaching framework of a Product Design degree, operating within a modular scheme, are then explored. The implications of these demands on teaching and assessment strategies with the subsequent resource issues are also reviewed.

A teaching strategy with a well linked combination of both theory and competence with, where possible, cross-modular innovative assessment strategies is considered to be an effective approach

1.0 Introduction

It has become established practice that CAD (Computer Aided Design) should play a role of increasing significance within any Product Design curriculum framework [1]. The necessity for CAD knowledge and skills within the vocational product design environment is also recognised by professionals in the field[2]. Addressing the, sometimes conflicting, needs of the vocational environment in conjunction with the curriculum requirements of the academic environment is therefore an area that requires a high degree of attention.

It is also necessary to respond to the individual student needs and expectations coupled with the constraints that teaching within a modular framework may impose. To ensure satisfaction in both the learning criteria and the student learning experience, it is worth evaluating all of these requirements within an individual context.

2.0 Student Requirements

Discussions with students on both the Product Design Degree and BTEC programmes at the University of Derby revealed some interesting perceptions. The perceived requirements that seemed to be fairly common amongst the student population were:

- A desire to confidently write on a Curriculum Vitae, "conversant with.." a specific CAD package. Ideally this would be an industry standard package, e.g. AutoCAD. This would, they felt, stand them in good stead with potential future employers and/or placement employers for their optional year out in industry. The two most important factors were, that they could feel confident in their basic skills ability and knowledge of the software, coupled with the fact that it should be a well recognised CAD package within industry.

- There was recognition of the fact that most potential employers would expect a graduate to have the basic competence skills, combined with some theoretical knowledge of system operation. A graduate with in-depth theoretical knowledge but with little, or no, ability to apply this knowledge in practise was felt

to be disadvantaged.

- There was a strong feeling that the skills should be taught in an applied design format, i.e. competence should be developed by working on the design of real drawings and products. If CAD skills are taught by the creation and development of independent entities, this not only proves to be less interesting but also does not give a good indication of entity interaction in practice.
- CAD was felt to be a particularly popular subject area with the way in which it was taught bearing a strong influence on the level of student interest in the subject. A totally student centred learning approach, with appropriate teaching material, e.g. Computer Aided Learning (CAL), was not felt to be ideal. It was considered necessary to have tutor support during the learning process, especially at the beginning, as this was the time at which relatively simple errors, or lack of knowledge, could cause severe disruptions and time delays to the learning process.

In summary, the students felt that competence in a recognised system was the predominant learning requirement. This should be coupled with the basic theoretical knowledge of CAD systems and their inherent operational characteristics.

3.0 Academic Requirements

From an academic perspective it is generally accepted that a strong theory based approach to CAD is necessary in order to satisfy learning outcomes that will require sufficient academic rigour for their achievement. The need for this theoretical knowledge is backed up by recognising that, not only are there a large number of different CAD packages available, but that these are also being continually updated with new releases being made available at frequent intervals. This means that it is highly likely that a graduate may be asked to use either a different CAD package to the one with which they have become familiar or, at best, work with an updated new release of a familiar package.

In addition a graduate may be required to introduce or update the CAD systems within an organisation as part of their employment criteria. This requires both a broad knowledge base within the CAD field and an ability to be able to benchmark CAD systems against each other in order to make the optimum choice for a system. A sound theoretical knowledge base of generic CAD operational principles should therefore assist the student in rapidly assimilating competence in the use of new or previously unfamiliar systems.

The CAD student therefore needs to "learn how to learn", although with the current movement within Higher Education towards facilitated learning this requirement to impart study skills is already recognised and is normally addressed under the area of study skills.

Where CAD is taught as an independent module, within a modular framework of study, it is important that the student recognises the relevance and benefits of CAD usage to the work undertaken within other subject areas. Similarly the benefits that can be gained from incorporating skills and "design tools" from other subject areas into the learning process for CAD should be recognised and encouraged. Fagan[3] describes students as needing

> "CAD based design activity that will enhance their understanding of design and engineering in its wider sense".

One way in which this can be encouraged is by the use of cross-modular assessments which link subject areas and identify the interdependence of CAD and other design subject areas.

4.0 Employer Requirements

Discussions with employers reveal that expectations can vary widely in terms of required competence and required theoretical knowledge. A significant proportion of employers expect high levels of competence, and an ability to adapt and develop these competencies to suit the particular needs of their organisation.

There is also a proportion of employers who expect a graduate to be able to undertake a system management approach to CAD within

their organisations, where the need for "hands-on" competence is not essential. In the middle ground there are organisations that require a good mix of both theory and competence in CAD. This mix of competence and theory may be termed an integrated knowledge of CAD. The employer requirements can be summarised as follows.

4.1 Competence

The work entails skilled "hands-on" operation of a CAD system which is likely to be an industry standard package, e.g. AutoCAD. Competence in a two-dimensional environment is essential with, increasingly, a required need for competency in the three-dimensional environment. The work is likely to involve specific design skills and knowledge pertinent to the organisation or product. These will normally be developed through training. Employment in some cases may be contractual with a possibility of future permanent employment.

4.2 Integrated

The requirement is normally for good visual communication skills coupled with a reasonable degree of competency in one, or maybe two packages. Again there is a perceived increasing requirement for both two-dimensional and three-dimensional skills and also for the production of photo-realistic rendered models and animation. There is usually less emphasis on required competence in a particular package, although knowledge and competence gained within an industry standard package is normally preferred. Generic theoretical knowledge, and the ability to use this knowledge to quickly develop competence in a new package, is also very important.

4.3 Theory

Normally only a basic competence in CAD is required but the ability to take an overview of the operation and management of a CAD system is essential. The ability to conceptualise design work and communicate concept ideas by the use of manual techniques, e.g. marker pen rendering may be required. There is likely to be a need to instruct CAD operators, and therefore

rudimentary knowledge of the CAD package being used is necessary but, with good theoretical generic knowledge, this can normally be achieved relatively easily even with highly customised CAD systems. The high level of theoretical knowledge should enable the graduate to undertake system development, as required, as part of the system management process.

5.0 Teaching/Learning and Assessment Strategies

Considering the above mentioned range of vocational requirements, the following strategies would seem likely to best meet the categorised requirements.

5.1 Competence

This requires concentration on one system only which should be a recognised industry standard. Student learning is likely to be best accomplished by the use of CAL and a heavy dependence on tutorial based teaching. There would be an in-depth competence requirement in both two-dimensional and three-dimensional environments which should extend to the use of rendering techniques to produce high quality product models.

Assessment would be predominantly skills based and may be time constrained under examination conditions. This could take the form of a cumulative portfolio of work and may include the attainment of industry recognised qualifications in CAD.

5.2 Integrated

The use of two, or maybe three, industry standard packages needs consideration. This gives scope for the use of both PC based software as well as higher level Workstation based software. The student would need to be proficient in two-dimensional and three-dimensional modelling and be aware of the scope of current packages offering photo-realistic rendering and animation, with the more capable students making full use of these facilities. The use of taught lectures for a theoretical introduction to CAD followed by software specific tutorial sessions to develop competence would provide a suitable framework for learning.

Assessment could take the form of competence based assignments and either an examination or research assignment as a measure of theoretical knowledge.

5.3 Theory

It is not necessary, although would probably still be advantageous, to use industry standard software in the teaching and learning process. The theoretical knowledge required would encompass the creation of entities and their manipulation, two-dimensional and three-dimensional environments, Boolean operations, parametrics, etc. It would also be necessary to review hardware and peripheral requirements to gain a fuller understanding of the management of CAD systems. The bulk of this theory could be assimilated in a combination of taught lectures and a series of research assignments, interspersed with some tutorial use and practise using CAD software.

6.0 Preferred Approach

In determining a suitable curriculum for a CAD module it is felt to be unwise to opt for a "competence" approach as this would produce students who would be likely to have difficulties in working with unfamiliar CAD systems or undertaking CAD system management roles. Whilst a number of employers may perceive short term benefits to their organisation in having skilled "hands-on" graduates, their long term professional development would be hampered.

Similarly, if a "theory" based approach is taken this may be perceived as satisfying the requirements for academic rigour in the undertaking of the module, but is likely to produce graduates who are lacking in confidence in their skills and abilities to operate a CAD system within an organisation. From discussions with employers it has been ascertained that the majority would be wary of taking on graduates with a heavily theoretical based knowledge of CAD.

The preferred approach therefore would appear to be the integrated one, with a mix of both competence and theoretical knowledge as its aims. In order to ensure that this approach would have maximum benefit to the student, initially, and ultimately to their potential future employer, it is important to ensure that there are strong, well defined links between the taught theoretical knowledge and the skills application.

The achievement of competence in a particular CAD package can be aided by the use of CAL software, however the learning experience must be managed appropriately. Hodgson[4] identifies two key issues

> for CAL to be effective there is a need to correctly manage the learning and for pupils to take real responsibility for their own learning.

Furthermore the module should not be viewed in isolation, and should be considered within the context of the students overall programme of study within the design field. Design tools provided in other areas of study should be applied to the assessment strategy for the CAD module. In its basic form this could involve the use of standardised engineering drawing data within a two-dimensional CAD assessment exercise. In a more complex form it could involve the modelling of a product within certain industrial design criteria, combined with the design and modelling of integrated engineered design criteria for functionality. This could be a three-dimensional parametric model to provide visualisation, and possibly animation as required. This does therefore identify the need to consider cross-modular assessment to best relate both CAD competence and knowledge with good design practise.

7.0 The student learning experience at the University of Derby

Students are expected to gain competence in the use of CAD, initially within the two-dimensional environment, and then three-dimensional including the use of parametrics and visualisation techniques. Normally the student will have experience in two industry standard software packages which are currently Windows based AutoCAD and CADDS 5 running on a UNIX platform. Additionally the students can access alternative CAD/Visualisation packages, e.g. Microstation, 3D Studio on a limited basis in addition to their normal studies within CAD.

Teaching is predominantly tutorial based using staff developed tutorial manuals. Initially two-dimensional assessment was undertaken as coursework design exercises. This proved to be problematic with a number of instances of suspected plagiarism. Whilst plagiarism could normally be proven by investigating file structures this is obviously time consuming and undesirable. This form of assessment is no longer used and the use of time constrained CAD design assignments during class time is now current practice. This has proved to be a more successful form of assessment. A typical assignment would be the design of a toothbrush holder to suit a toothbrush exercise that would have already been drawn in class in AutoCAD.

Three-dimensional assessment normally takes the form of model development using CADDS 5. This would take place both during class time and outside and would involve theoretical model development using knowledge gained in other subject areas. An example of this might be an electric drill where the student is asked to specifically consider the industrial design criteria and the design of the gear train drive. These models are not assessed independently but are assessed as part of an overall major design project covering two or more modules. This has been found to help significantly in developing student awareness in the fuller application of CAD within the product design process.

Students are also encouraged to use CAD wherever possible for other assignment work undertaken during their programme of study

References

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