A Threaded Approach to the Learning and Delivery of 3D Illustration within a HE Framework

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LIST OF FIGURES AND TABLES

GLOSSARY OF TERMS

Vector	- geometrical primitives based on mathematics to represent digital images
CAD/CAM	- Computer Aided Design/Computer Aided Manufacture
Unix	- operating system developed by AT & T at Bell Laboratories
3D Studio	- modeling/animation/rendering package from Autodesk Media & Entertainment
Form Z	- CAD design tool developed by AutoDesSys
Blender	- 3D modeling software released under the GNU General Public Licence
Cinema 4D	- modeling/animation/rendering package developed by Maxon Comp
Lightwave	- high end computer graphics program developed by NewTek
Solid modeling	- 3 dimensional modeling principle based on physical fidelity
NURBS	- non-uniform rational basis spline – mathematical representation of curves
ISO	- International Organisation for Standardisation
First Angle	- 2D projection where each view of an artifact is drawn in an opposite quadrant
Sectional	- representation of vertical/horizontal plane through an object to highlight t detail
Elevation	- 2 dimensional view of an object from a linear viewpoint
Orthographic	- means of representing a 3 dimensional object in 2 dimensions
Schematic	- diagram that represents elements of a system using abstract graphic symbols
Isometric	- 3 dimensional view where all three axes of space appear equal
Trimetric	- 3D view where all three axes of space appear unequally foreshortened
CNC	- Computed Numerically Controlled –machine tool automation by software
QAA	- Quality and Assurrance Agency for Higher Education
Surface Model	– collective term to describe an approach to represent 3 D geometry with NURBS
Class A Surface	- a set of freeform surfaces of high efficiency and quality
Poly modelling	– an approach to modelling objects by representing their surfaces using polygons
Mudbox	- 3 D digital sculpting tool created by Symatter and developed by AutoDesk
Z-Brush	- digital sculpting tool which combines 3D/2.5D modelling texturing and painting
3D Coat	- 3D modelling tool based on voxel (Volumetric Pixel) representation of form
Modo	- polygon, surface modelling and sculpting tool developed by Luxology LLC
Laser scanning	- a 3D scanning device used to analyse an object in order to collect data on form
VLE	- Virtual Learning Environment – on-line system to support teaching and learning
Youtube	- a video sharing website on which users can upload, share and view videos
Adobe Flash	- multimedia platform to add animation, video and interactivity to web pages
Virtual world	- online community in the form of a computer based simulated environment
Second Life	- a virtual world created by Linden Lab where residents interact via avatars

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CHAPTER 1 INTRODUCTION

1.1 ABSTRACT

This thesis represents a summary of a 12 month insight into a structure for the proposed delivery of a pathway understanding of the individually recognised approaches to 3 dimensional modelling for digital illustration. The proposal is based around a belief that many industrial professionals are lead down a path of development which does not consider alternative approaches to a sole 3D modelling technique.

Although such an insight might evolve for a number of reasons, the assumptions made at the point of undertaking this period of study is that this pathway has been determined by a pattern of emerging technologies.

In an attempt to address the phenomena, a prototype structure will be suggested which can be embedded into future higher education programmes in order to provide a more balanced and better informed overview of the principals involved and their abstraction.

Results have been collated throughout a series of experiments aimed at progressively introducing students to the fundamental engineering and perspective concepts which underpin modern CAD packages. These were then compared with the progress of a second cohort who had been introduced only to the discipline of solid modelling.

This undertaking aims to verify whether or not a structured traditional approach to generating and understanding three dimensional form from generic construction principles combined with an appreciation of engineering disciplines produces a more informed and versatile practitioner. This hypothesis is based on a belief that a wider overview of illustrative techniques, purpose and available tools will achieve this aim.

To complement any findings it is essential for students to comprehend the specialist and emerging technologies which define high end three dimensional modelling in terms of creation of form and capturing of data. There exists a plethora of contemporary opportunities for the modern illustrator in addition to those traditionally associated with the discipline and graduates must be able to focus their skills toward a variety of environments in order to remain credible.

Finally in acknowledgement of a contemporary teaching and learning environment it would be negligent to ignore the emerging methods of delivery which have become feasible as a result of the world wide communications network. Such opportunities take many forms with varying levels of control associated with them. In recognition of these it is suggested that any recommended curriculum structure must be conducive to adaptation into such a programme structure.

1.2 INTRODUCTION

A modern technical illustrator, is no longer just an Illustrator of technical objects but rather an illustrator with technical understanding and a disciplined analytical eye for accuracy. This can manifest itself in many ways, technical illustrators must be able to produce images both abstract and representational to a high degree of accuracy, These images may be constructed form orthographic plans or from the actual physical artefacts, they may also come from a mental theory or ideal given straight from the clients own understanding, either way they are not producing the images for ourselves but for an audience.

The Industrial requirements for a competent technical illustrator, have never been higher, they now service, architecture, both light and heavy engineering, consumer and military product design, TV, film and the computer games industry as well as general advertising and education. Their remit now covers general household and high end technical instruction manuals, cutting edge marketing visuals for both research and development. They must produce both still and animated imagery for final consumer presentation, as modern wide range disciplines incorporate broadcast and special effects.

The technical illustrator has to be able to find, digest and redirect the required information to produce these highly creative yet accurate images, on the face of it there seems to be little difference between illustration and photography. The difference comes in quantity and quality of the required understanding. The ability to utilise the technology and master these specific and transferable skills is highly sought after in the modern design studio, enabling graduating students to develop and explore their chosen career pathways to the full.

The pioneering exploits of key illustrators have been well documented already yet merit can still be found in an individual practitioner's journey through this evolution. Many illustrators own observations and experiences contribute to the inspiration behind this study and aspiration to development of a higher educational curriculum structure.

In the economic and educational climate of the early eighties, universities could afford to be more selective with their choice of undergraduate. The understanding in the sixth form colleges of the time was that the A-level system was a filtering process devised to sift through potential academics in order to occupy the, then, finite number of university places. This was despite the government initiative to introduce the phenomenon of the Polytechnic at this time.

For an aspiring illustrator, an introduction to the evolving desktop publishing software supported by the Apple Macintosh platform proved a great asset in the late 1980's. A familiarity with the underpinning concepts of such hardware allowed many to focus more on the geometrical construction of elements alone. Many of the observations of this period have been implemented into development of the curriculum outlined in this study.

The content of the qualifications in this period reflected the skills relevant to industry at that time. Much of the work was carried out using traditional media and medium. Simple vector based 2 dimensional software was available but the CAD systems capable of generating 3 dimensionally accurate models with user editable view points were still prohibitively expensive even for most art colleges. Prime's Medusa CAD system, AutoCAD and the Sun workstation's Apollo Intercap were Unix based and consequently unfamiliar to the casual user.

In the early 1980's the EU Approach Directives required that the manufacturer draw up technical documentation before being permitted to affix CE marking to their product. The purpose of the documentation was to provide information on the development, production and use of a product, and to ensure the accuracy of that information. This revision of the legislation signaled an increased need within many industries for the skills of the professionally trained illustrator.

Coinciding with this bountiful period came an era where profit and running costs were becoming the sole consideration for organisations. One consequence of this was a dramatic drop in quality standards across the technical publications industry. The structure of modern businesses was also moving toward a model where it was a financial incentive to outsource contracts to the lowest bidder rather than support dedicated in-house departments. The consequences of this trend were not instantly obvious but were evident only when no identifiable themes were detectable across the technical documentation of many global brands.

A natural evolutionary progression from this came about via the advent of affordable 3 dimensional modelling and rendering environments. Early versions of 3D Studio, Alias packages, Lightwave and Form Z were soon competing for their share of the market with more affordable and open source titles such as Cinema 4D and Blender respectively.

Outlets for practitioners with these skills were limited during this period except where traditional methods of capturing the operation of innovations were hampered by restricted access to subject. The 3D modelling environments of the time provided the perfect solution. Alternative openings centred on the computer games industry that collectively seemed to be embracing this new technology. However it can also be said that there existed a cavalier atmosphere within this industry in the mid nineties which witnessed organisations emerge and disappear with regular effect.

The programme recommended within this thesis is the result of eighteen months of development involving much liaising with industry. Currently under development is the Honours level progression route of the programme, a task which was a pre-requisite condition of the university senate at the time of validation of the preceding foundation degree programme.

One of the initial reasons for developing this new qualification in its fresh format was a faculty decision to deviate away from the disciplines which had defined the programme for so many years. The new structure was to take the form of an honours programme in General Illustration which focussed on a more fine art and graphics route including an opportunity to specialise in technical or scientific illustration in the final year. Many associated with the programme in the past and key personnel from our industrial counter-parts agreed that such a structure would not produce graduates with the skill set which would facilitated their seamless integration with industry.

These concerns have since been realised during efforts to re-establish links with the industrial partners who had been traditionally associated with the course. At the time of writing, 3 years have elapsed since the restructure of these programmes and the organisations which absorb the graduates annually are beginning to experience a new breed of illustrator with a lack of specialist skills. Illustrations once the benchmark such as Figure 1, have grown beyond the specialist capability of the general illustrator.

Despite this vindicating the decision to redevelop the Technical Illustration programme, concerns remain that these students still have 2 years of undergraduate study remaining. Hopefully the reputation of the programme in technical illustration will survive. The content of this study will be reflected in the Honours programme at Blackpool and the Fylde College. This is testament to the School of Engineering who have supported development of the new programme and the work of Andreas Asperl (2005), for providing an inspirational experimental structure to build upon.

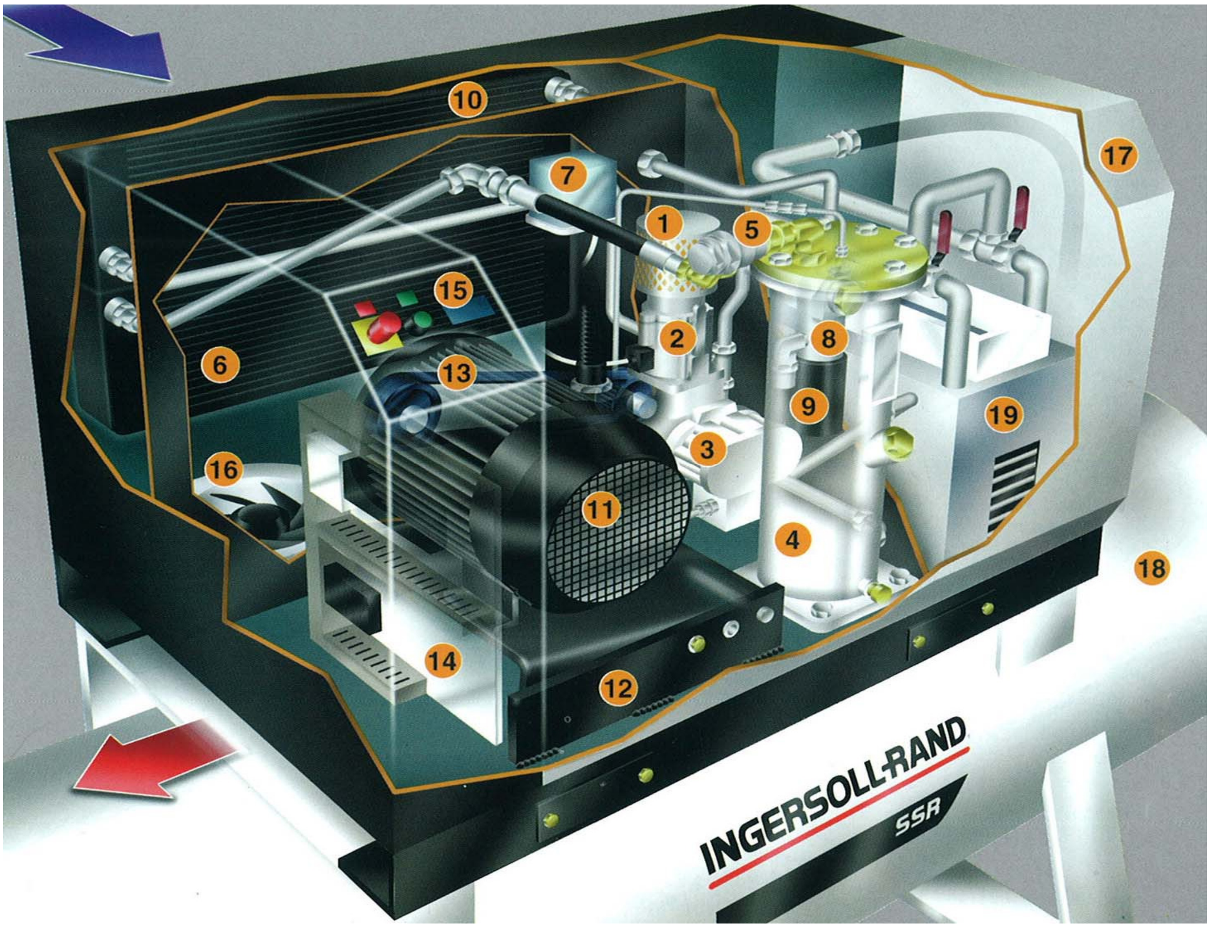


***Fig 1 –** A classic example of style*

1.3 OBJECTIVES

1. Develop of an outline structure with the intention of producing a more informed graduate capable of assessing a variety of construction environments suitable to individual task.
2. Assess and suggest a recognised overall pedagogical approach to complement the recommended curriculum framework.
3. Confirm how a structured curriculum of progressive modularised units might facilitate the development of a more informed illustrative practitioner.
4. Discuss the inclusion of evolving technologies and the diversity of techniques and assess the validity of transition to a digital media from analogous traditional disciplines.

1.4 METHODOLOGY

In order to establish an initial benchmark for subsequent findings an experimental strategy has been identified to provide a balanced and accurate data set for analysis. Part of the inspiration for undertaking this period of study is its coincidence with the Honours programme currently under development as a progression route for the active undergraduate technical illustration programme. The contemporary nature of this professional undertaking will complement these studies.

Having students already enrolled and one academic year into their studies, these present themselves as a group of individuals in an ideal situation for experimental abstraction. From this same perspective observation of their individual progress will provide a good insight into the range of entry skills and qualifications they come equipped with.

The group size of 8 represents a large enough number to discount the possibility of encountering freak and untypical trends of data and small enough to be able to profile each individual's background to a level which will give insight into their learning abilities.

The three strand approach adopted throughout this study will focus around conclusions drawn from existing published research, controlled classroom experiments and the results of the proof or otherwise of documented hypotheses.

Prior to examination of results of any experiments it is essential to acknowledge the importance of other factors which cannot be simulated but will, inevitably, affect conclusions drawn from these. Perhaps the biggest uncontrollable influence is the preferred individual learning style of each member of the student group.

There exist a number of experiments which claim to establish the learning style of individuals, although these can be fragile in their conclusions. Key staff will be able to take full advantage of their pastoral roles with these learners to monitor their progress at specified junctures in their development into informed visual communicators.

At this initial stage it is anticipated that each learner will progress at a different rate with the introduction of each new technological approach although it is important to remain open to verification or otherwise of such hypotheses.

A series of structured assessments were devised in order to plot the progress of individual students and as a complete cohort. Two groups of learners are to be considered from a preparatory perspective which relates to their introduction to a solid modelling CAD environment.

A complete set of primary data will be collated over a 12 month period in order to plot the progress of the main focus group as individuals. This is to take the form of an assessment of each learner's entry level experience applied to a series of disciplined specific tasks in an attempt to vindicate a structured order of linear progressive units.

In view of the aims of this study an empirical research strategy based on a measured observation of results from controlled experiments will form the larger part of the case study. The main focus group of students will be taken through a phased set of module disciplines culminating with an introduction to 3-dimensional CAD software. The programme structure outlined is designed to equip students with an understanding of illustrative principles which goes beyond a comfortable over reliance on a particular technology, package or set of construction techniques.

This is in order to create a more informed illustrator capable of applying a wider range of techniques and choice of tools appropriate to a variety of subjects. This highlighted skill set was echoed by a number of key employers included in later sections.

The group size of 8 will allow a depth of experimentation and analysis that would be unfeasible within a larger group given the time period of the project. By not being confined to taking all data at face value, focus on a smaller number of individuals will allow for a point of entry profile to be built around each. Such information might explain any noticeable anomalies within understanding with regard to background and pervious knowledge.

In order to measure the success of the suggested curriculum structure a second cohort of students, referred to as Group B have been introduced immediately to the same environment Group A have been exposed to only after completing subsequent foundation modules. Justification for a single figure group size comes by way of the number and complexity of experiments coupled with the level of profiling of each student.

This form of experiment will serve to test the hypothesis that exposure to just one genre of CAD environment instils a level of rigidity, not only in terms of interface familiarity, but also by way of the 3 dimensional conceptualisation highlighted as fundamental by many industrial partners. As Group B have been directly introduced to the principals of physical proximity that define a solid modelling environment, this method of visualisation and project planning will eventually hinder the flexibility of individual illustrators.

Each experiment is in the form of a set brief aimed at allowing students to demonstrate their understanding of a collection of principals and techniques corresponding to discipline, over a defined time period. Each subsequent experiment for Group A builds on skills demonstrated in previous assessments, while group B's brief will be based on one method only.

In summary, objectives 1 and 2 will evolve through a framework of standard principles derived from a scientific approach to similar research by way of acknowledgement to those who have developed parallel structures. It is anticipated that objectives 3 and 4 should be realised through continuous assessment and observation of focus groups.

CHAPTER 2 LITERATURE REVIEW

A study of this kind is in no way unique. Many parallels can be drawn from similar research by Al-Hamad (2008) in his study on integrated computer instruction in areas of engineering. Such similarities lie with the original hypothesis and form of experiments. It was anticipated that many of the concluding arguments might mirror those encountered within his study. Despite differences in specific aim and environment there exists sufficient material within both studies to suggest a good degree of similarity in conclusion.

Cheng (1997) attempts to apply accepted learning methodologies, which have proven to be effective in similar arena to the area of Computer Aided Design. This form of rationalisation is sound as an overview although it can be argued the specific subdivisions in technical approach suggest this form of learner categorisation might be over simplified.

In terms of the focus of this research, a marked disparity of successful understanding and subsequent application of delivered theory within individual students is evident. Such disparity vindicates further study into the nature of perceived learning styles in an attempt to conceive a more sophisticated approach to delivery and understanding of 3D modelling methodologies.

The authors suggest students become aware of patterns of learning and this ethos should be embedded into the programme of study. Individual observations further reinforce this evolution of ideas. It is this same evolutionary nature of learning which also reveals the difficulties associated with outlining the anticipated development of ideas to students.

Much emphasis is directed toward team activity. Such an approach is commendable but needs to be managed in order to avoid the suppression of the development of individuals. Group dynamics are, by their nature, governed by personality. Strength of personality is not a sole measure of ability.

A rigorous but sympathetic assessment process is perhaps the key to making students aware of the recognised pedagogy and serves also to correlate an individual with their own best learning style. This recognition of learning styles should evolve naturally and this is a process which could be embedded within individual focussed disciplines and guided by assessment strategy.

Qing-ni, Heng-zhen, Fei and Chang-de, (2002) examine the impact of emerging and more easily accessible technologies on the delivery of mechanical drawing programmes of study, current and proposed. Despite its focus on disciplined manufacture, many of its findings find pertinence with contemporary 3D illustrators.

The themes addressed support the development of the individual as an independent learner in isolation to the 3D CAD/CAM technologies they are ultimately directed toward. Focus is aimed toward developing graduates equipped with generic 3 dimensional visualisation skills.

This approach is echoed by many industrial partners in the form of reoccurring requests for practitioners with ability to visualise 3 dimensional form from a variety of source material.

Much merit and insight can be drawn from similar studies in specialist areas as highlighted by Clayton, Warden and Parker (2002) in Virtual Construction of Architecture using 3D CAD and Simulation. The structured experimental approach adopted, addresses more than 3D CAD discipline.

The author’s research constitutes an observation of student’s adaptation to CAD technologies based on an architectural approach. Regardless of the subject matter the paper represents a comprehensive overview of a complete process. In addition to logging the rate at which a student group gain an understanding of their chosen field with respect to emerging CAD technologies this article attempts to achieve more in terms of 3D modelling; namely animation of 3D imagery.

Further implications are considered by way of raising an awareness of the part played by teamwork coupled with an appreciation of the business structure and architectural legal implication of adopting these technologies. This increased awareness is to be commended but is beyond the remit of this study.

In contrast to this, Xiuzi Ye, Wei Peng Zhiyang Chen and Yi-Yu Cai (2003), adopt a more focused view of 3D curriculum development. Principals at the core of their studies reflect the suggested structure here. This is best described as developing a good understanding of the tools and techniques but also a sound appreciation of the underlying algorithmic consequences of their application.

Questions raised by Ye, Peng, Chen and Cai (2004), in “Today's students, tomorrow's engineers: an industrial perspective on CAD education”, closely reflect the focus of this thesis. Rather than to over pontificate about delivery of CAD techniques, and attempts to relate these with agreed learning methodologies, the author never loses sight of the ultimate aims of a group of learners.

2.1 CHOOSING A SYSTEM

Devon et al. (2007) focus on criteria for investment in a CAD system and the justification there of. The purpose of its inclusion is supported by the historical evolution of the CAD systems we are familiar with today. The ultimate choice of purchase will be determined by the purpose of its end use. This conundrum should be considered by tutors, students and practitioners alike as the consequences are relevant in an academic and professional environment.

Closer examination of CAD evolution reveals no small amount of political wrangling. Although it might be considered an issue away from the teachings of such systems, it can also be argued that the resultant commercial vision of CAD systems provides those unfamiliar with the monolithic tussles, a conceptual snapshot of the digital 3D modelling bias.

The balance of traditional and digital skills and the point of inflection from one to the other must be considered from a learner perspective. Unver (2006) discusses this implementation in detail in “Strategies for the Transition to CAD Based 3D Design Education”.

It is important at this juncture not to lose the focus of this study. It is intended that the conclusions reached will help form a framework, or at the very least provide a pointer for subsequent studies on methods of CAD delivery. The body of the referenced article views the implementation of CAD systems within post graduate academia from a design perspective. This reinforces the rhetoric of authors of similar published literature, in which the usage and teaching of CAD systems should be viewed as an element embodied within a larger process.

Similar studies contradict a transition of skills and instead advocate a more rigorous and disciplined adherence to the features available within a given CAD environment. These are highlighted by Company, Miquel, Agost and Vergara (2007), in “Assessment Strategy to Engage Students in Constraining Parametric CAD Drawings”. Although some parallels can be drawn from the suggested delivery and assessment strategy, the usage of CAD systems as a design tool will inevitably differ from their use as a visualisation tool.

Despite a number of valid arguments raised by the authors, the paper might not be considered as the oracle to CAD delivery methods. Results from similar experiments conducted in the case study element suggest that a period spent using the traditional tools dismissed by the author allow learners to appreciate geometric form and compound structures in a software free environment.

Data gathered from these experiments suggest vindication of these beliefs and this premise is further supported by Ault (1999), in “3D Modelling for the 21st Century”. Despite a design inspired evaluation of modelling methods, the focus of this paper has pertinence to all CAD learners. Visualisation of model construction is a key factor to the approach of any specified task within a CAD system and this is primarily conceptualised by the experience inspired approach of the end user.

A parametric approach does not account for this. Conclusions drawn from previous papers suggest that learners with a leaning toward a parametric approach to 3D modelling are influenced by software familiarity to some extent. This should not form a basis for delivery.

2.2 PEDAGOGY

Content and conclusions of a study by Fosnot and Twomey (1996), provide a starting point in an attempt to correlate accepted academic learning styles to successful delivery and understanding of concepts within a CAD environment. It is hypothesised by the authors that these guidelines might not hold within the boundaries of this topic as evidently they appear to in other academic areas.

An undeniable conclusion from a range of similar papers is recognition that the learning styles must be adapted to the practical nature of a 3D modelling curriculum. However, equally undeniable are clear outcomes which must form some measure of a successful graduate. What remains the issue is how to incorporate the established pedagogy into the delivery of a subject which lends itself toward some more than others.

Chester (2008), debates the limitations and suitability of adapting contemporary methods of delivery and assessment in “3D CAD: Modern Technology – Outdated Pedagogy?”. Much of the focus of this paper is the belief of the author that the time has come to view the teaching of CAD systems to reflect their balance of usage in an industrial context. It has long been considered that use of CAD systems is a specialised task available to the chosen mathematically inclined. This has been a misconception for some time. As highlighted in this article, the use of CAD systems more often plays a single part within a larger process of design or artefact visualisation. It is fundamental that the practitioner considers the usage of the 3D model at the point on inception, this concept lies at the core of this thesis.

Celani (2009), “Teaching CAD Programming to Architecture Students” advocates a project based approach, not only for familiarisation with software, but to encourage a deeper appreciative understanding of the parametric principals which underpin the manipulation of geometry. The logic similarities between the structured use of CAD systems and programming algorithms can be exploited by offering an explicit method of CAD teaching and learning. In essence, the concepts learned from tutorial exercises with no relevance to project have little longevity. A guided, structured approach which allows students to make construction errors and experience, in a limited way, the consequences of these has value as a simulation of real project experience.

In support of Remondino (2006), it has been possible throughout this study to draw on first-hand experience from an academic individual accredited with developing stand-alone and integrated CAD elements within the School of Engineering and Computing at Blackpool and the Fylde College (an associate of Lancaster University). This was a 25 year evolution and proved an invaluable resource.

It is anticipated that the conclusions drawn from Chester (2007), “Teaching for CAD Expertise” might reflect those resulting from experiments contained within the case study element. It is often difficult to correlate the successful progress of individual students with a method of delivery, as is the focus of this paper.

The Author acknowledges the specialised area of CAD (solid modelling) focussed on in the paper, but it can be said that the findings within the paper are applicable to other forms of 3D modelling. It can also be concluded that those learners equipped with, what the author refers to as strategic knowledge, adhere to a slower initial learning progression than those with command knowledge. Over a measured period of study those students with a strategic knowledge fair better.

It might be wise to consider how 3D modelling could be implemented into the wider art and design curriculum as Patera (2007), “The Potential of 3D Visualisation Technology in Art and Design”. Despite a noble statement of intent at the outset and a well structured and considered set of arguments’ this study is not beyond criticism. It’s perceived limitations lie within the tenuous correlation between the areas of focus and their influence on teaching.

As stand-alone topics; colour theory, colour experience and spatial understanding exist as pillars within all forms of art and design and their subsequent inclusion in experimental situations is valid. However the study loses focus in content and instead presents a reworked rhetoric of long established extensions to the colour wheel into a workable colour globe theory. Conclusions drawn from its content seem contrived and leave the reader wondering if the subject has been studied as a matter of interest and retrospectively inserted under a teaching and learning title.

Parallels can be drawn from Reffold (1998), study of “Teaching and Learning Computer-Aided Engineering Drawing”. Despite its age, justification for inclusion of this paper is based on its similarity with the student experience which contributes the case study section of this thesis. A number of similarities can be drawn from the recorded findings of this case study. In some ways the success of the programme can be attributed to the collective interest of the student cohort as suggested by a military academy. However such a regimented approach and considered delivery to a disciplined group should reveal a set of results free from external interference.

2.3 A GLOBAL APPROACH

In an attempt to present a balanced overview of the varied methods of teaching the elements of CAD, a panoramic insight should be considered prior to deriving any conclusions. Quantitative research was not possible due to the scarcity of published papers on the topic. This could be for a number of reasons including academic agreement on existing teaching methodology or more simply the globalisation of society achievable by technology.

Despite the deviation from CAD disciplines, the delivery related technological disciplines have been mapped to teaching methods and provide a model for comparison. As a qualitative exercise, their proximity to the focus of this thesis underlines many of the hypotheses under review.

The reviewed literature was produced for an audience in accordance with continental academic conferences. The relevance of their findings are significant to location despite no reference to location within title or abstract.

Williams (2007), opens further pedagogical debate in terms of teaching methods. Up to this point the topic of collaboration has not been considered in isolation. The cited article is in no way an isolated approach to teaching and learning strategy in North American institutes. The author equates much merit to the integration of collaborative projects within learning and other research identifies this as a common theme throughout other, non related academic disciplines.

Conclusions drawn from the observations following the case study, suggest a cautious approach to over reliance on this technique. Many other factors can contribute to the effectiveness of collaborative projects, not least being the cohesion of the cohort.

In a similar theme Cunningham (2008), complies with a contextual project based approach to teaching and learning in his article “Methodologies in Learning” featured at Siggraph Asia 2008. The use of computer graphics software and their resultant output must be viewed as an integrated process in concept visualisation rather than viewing the illustrator as a remote practitioner.

Away from the contextualisation of study matter, the author makes a valid argument by suggesting the informed learner should be equipped with an insight into the computational overhead of their work. This point has particularly value with certain aspects of 3D modelling and reinforces the pertinence of this paper.

In a broader sense educational establishments are bound by the bodies appointed to their governing. This can curtail their capacity for developing better teaching and learning strategies bespoke to disciplines. A modern Europe has become synonymous with its plethora of legislative boundaries and the impact these might have over a longer period have yet to be determined.

It is the concern of many in education that the bureaucratic nature of a united Europe might serve only to confine the innovators of tomorrow. In a globalised society brought about by the advent of modern network technologies, innovation should flourish. However this set against a backdrop of autocratic watchdogs can negate itself. By admission, this is a cynical view or potentially a warning.

Gálvez, Iglesias and Corcuera (2008), attempt a comparison with related trans-continental research in “An Introductory Computer Graphics Course in the Context of the European Space of Higher Education: A Curricular Approach”. Set against a rhetoric of harmonisation, a European vision of teaching and learning strategies remains unclear against a backdrop of political correctness and bureaucracy.

ACMSIGGRAPH

Fig 2. *Siggraph conferences act as a forum of much digital graphics and educational debate*

CHAPTER 3 EXPERIMENTS

3.1 NATURE OF EXPERIMENTS

A similarly cautious approach was taken with each of the controlled classroom experiments for reasons of consistency. Perhaps the most poignant observations are best mirrored by Reffold (1998), in 'Teaching and Learning Engineering Drawing'. Despite the advances in hardware and software since its authorship, many of the report's conclusions still have relevance.

Reference is made to 'What to Teach?' It is important to point out at this juncture that the test bed of learners already mentioned, are enrolled on a programme of study which allows little deviation from a validated syllabus. Despite this constraint, the programme structure referred to offers an ideal range of associated disciplines to provide a broad subject base for comparison of teaching methods. These are highlighted as:

- Orthographic Engineering Drawing
- Isometric Technical Illustration
- Perspective Illustration
- 3D Vector Illustration
- Learner assigned specialist projects

Observations made during delivery of these preparatory disciplines have so far provided an insight into some of the limitations of applying these same teaching methods across a range of approaches to teaching 3D illustration. The structure of the programme referred to is one which emphasises the importance of building on the knowledge gained from more basic complementary elements.

A series of six experiments have been designed to map the progress of each student in order to determine how much merit can be apportioned to a linear pattern of building on principals learned from previous modules. As ISO compliant orthographic plans will essentially be source data on most projects it is fundamental that the all students be familiar with their conventions. This can be best achieved via an activist task as in Experiment 1.

Once familiar with this standard representation of form, students will be tested on their interpretation of such information by way of visualisation of given data in a three dimensional form as with Experiment 2. These same visualisation skills can also be demonstrated in a more fluid format as in Experiment 3, as both methods of representation of form are equally valid.

Construction methods learned from Experiment 2 along with interpretation of information from Experiment 1 will be tested with in a two dimensional digital environment in Experiment 4. It is anticipated that an introduction to construction, free from the constraints of software familiarity might aid in the learning of each skill separately.

When isometric theory and practice have been consolidated, Experiment 4 is designed to introduce and test the understanding of a form of 3D construction free from the constraints imposed by this form of representation. This will take the form of disciplined illustration of a collection of elements using the trimetric scale. Experiment 6 provides an opportunity to further consolidate learning to date via a student initiated and tutor agreed illustrative project. The outcome of these projects should go some way in to measuring the success of the proposed progressive curricular approach.

3.2 CANDIDATES

In order to justify the test group of learners as suitable, individual profiles have been included on the educational and professional history of each. It is deemed at this juncture that an insight into a candidate's personal background would have no benefit on any conclusions drawn from test data.

CANDIDATE 1 **Age:** 22

Academic background: This candidate was moderately successful with his A level studies which provided the option to attend Art College as a Graphic Design undergraduate. By his own admissions, he had not realised fully his own ambitions at this time but the experience had aided to focus him away from this route and in turn guided him toward a career in technical illustration.

Professional history: No professional background details to date due to age of candidate.

CANDIDATE 2 **Age:** 30

Academic background: On interview this candidate demonstrated that despite the lack of formal qualifications, here was the most prepared and determined individual of the group. His recruitment was justified on the basis of his portfolio and mature student status.

Professional history: The candidate has spent most of his working life in the building trade.

CANDIDATE 3 **Age:** 21

Academic background: Only moderately successful in their A-level studies. Despite the course being away from the focus of previous studies the illustrative and engineering aspect of the programme matched the candidate's personal interests.

Professional history: No professional background details to date due to age of candidate.

CANDIDATE 4 **Age:** 27

Academic background: Despite academic 11-16 experience being grounded in art and design, this candidate chose to pursue an alternative career in catering. This individual was accepted on to a similar programme which did not deliver the syllabus outcomes promised. As a result of this transferral onto the programme in focus was seen as a natural progression.

Professional history: Previously employed, full-time, in a non related discipline.

CANDIDATE 5 **Age:** 30

Academic background: This candidate had previously embarked upon a similar programme at level 2 from leaving secondary school but had to discontinue due to personal reasons. Returning to education 8 years later as a mature student this individual has successfully progressed from a related level 3 qualification onto the programme.

Professional history: At this juncture the candidate's professional details are undisclosed.

CANDIDATE 6 **Age:** 26

Academic background: Candidate 9 undertook a very pertinent level 3 course before signing up to the Undergraduate programme which was the intended progression. Despite cohort protestations over the change of direction of the programme this student transferred in order to pursue his interest in Technical Illustration..

Professional history: Managerial role within catering in order to support studies.

CANDIDATE 7 **Age:** 22

Academic background: Initially there was little indication for the inclination for this candidate to choose an Undergraduate 3D programme. On interview it became apparent that application was based on an illustration rather than graphics progression for the A level grounding.

Professional history: No professional background details to date due to age of candidate.

CANDIDATE 8 **Age:** 22

Academic Background: Following on from an unrelated Level 3 qualification this candidate decided to pursue a career in Technical Illustration. This had evolved from a hobby coupled with an interest in engineering spawned from earlier studies.

Professional History: No professional background details to date due to age of candidate.

At this juncture there remains scepticism about the contribution that factors such as learning styles have on measuring the success of delivery approaches within this type of subject area. This outlook has evolved from experiences within other Post Graduate studies of this nature. Data collected and rationalised on similar previous occasions demonstrated little correlation between learning style and method of delivery.

In once sense a focus group of just eight might seem a slim sample of learners when compared with experimental candidates of similar studies but justification of volume must be considered along side other factors. Due to the live nature of the project, a lengthened period of exposure to the students would make a much larger group unfeasible. The group are embarking on a programme of undergraduate study which will provide an opportunity to track a cohort free from simulation.

3.3 SUBSIDIARY FOCUS GROUPS

In addition to the main focus group, a subsidiary student group has been identified as ideal candidates for study. The group are made up of 9 students 19+ and based on current academic benchmarks these individuals are not high achievers. It is hoped at this juncture that their progress with a more practical discipline might reveal patterns in learning which can be correlated to methods of delivery.

These are day release students who are on apprenticeship programmes. Although the disciplines involved in the unit in focus are not practiced daily in their work place, the contributing disciplines and engineering understandings are. The contrasting backgrounds and age category of each group is justification for their inclusion.

3.4 TIMESCALE

A timescale to correspond with the planned structure follows in an attempt to justify time spent on individual elements. This conforms to the original plan to evaluate the success of teaching various forms of illustration measured by data gathered from a variety of sources. Continuing from a preliminary study of similar research, theories and subsequent conclusion will be derived from an extended observation of real-life learners in a controlled environment coupled with any insight gained from this research.

YEAR	PERIOD	PRODUCT
2009	Jan - May	Programme development and internal validation Preliminary dates which conform to pre-arranged college policy Rationale for programme must be ratified by internal college board
	June	External university senate validation of programme Applying amendments which have come about from internal validation Ratification of programme by university senate with/without conditions
	July - Aug	Research into availability of academic alliances with software distributers Liaison with industrial counter-parts to confirm relevance of software Installation, networking and configuration of platform and software
	Sep- Dec	Principals of engineering drawing, product illustration and technical illustration Controlled assessment of tasks in accordance with given project briefs Assessment, correlation and reflection of final test results
2010		
	Jan - Apr	Principals of perspective, technical illustration 2 and student lead project Controlled assessment of tasks in accordance with given project briefs Assessment, correlation and reflection of final test results
	May- Aug	Correlation, rationalisation and comparison of experimental data Development of honours programme as progression route for students Overall conclusions drawn and contextualised in discussion format

Table 1 – Experiment timescale

3.5 EXPERIMENT 1 – ENGINEERING DRAWING

The students were supplied with a series of ISO compliant parts drawings from which they were to generate three assembled, sectioned engineering drawing views in order to describe the form and dynamics of a component. A correct assembly is featured in Figure 3.

The complete component is a worm reduction gear and is assembled as follows:

The worm wheel and shaft run in bushes set in the gear housing. The worm runs in bushes set in the casing and bearing support. A thrust face fits on the shorter end of the worm shaft. The worm wheel has twelve teeth. The worm tooth has a rack section.

3.5.1 DELIVERABLES

Students were expected to provide the following set of elements which are intended to assess their range of engineering understanding.

- First angle sectional front elevation, from the centreline of the worm with parts assembled.
- First angle sectioned end elevation from the centreline of the worm wheel with parts assembled.
- Project a full, non-sectioned, first angle plan view using data from front and end elevations.
- Complete the drawing by including a title bar/border, a list of parts with corresponding annotations, and ten important dimensions.

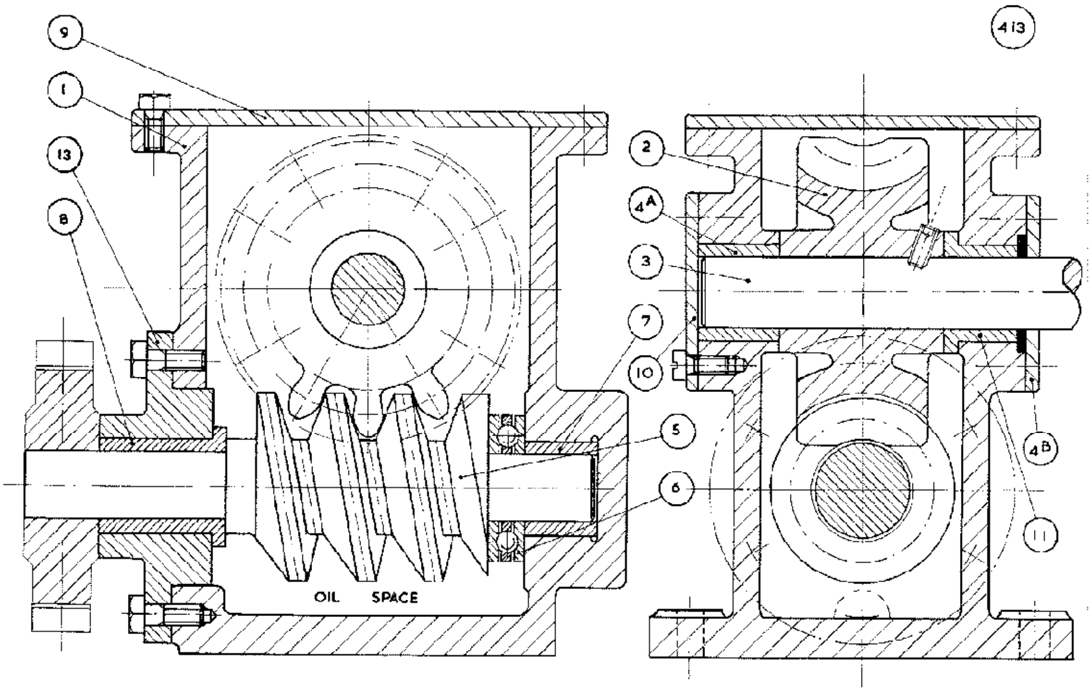


Fig 3 - Correctly assembled components in accordance with BS and ISO standards.

3.5.2 RESULTS AND FINDINGS

A collective review of the exercise feedback reveals a number of common themes prior to correlating individual comments with associated students. Perhaps the most alarming of these was the low levels of accuracy despite the high quality of the provided equipment. Inaccuracy within illustration using traditional methods translates itself to similar indiscipline using digital media. This is based on observations made in many professional environments over a fifteen year period as an active practitioner.

The importance of this observation lies with the reality that some digital environments will tolerate such inaccuracies as the intended design decisions. This can only be viewed as a missed opportunity to maximise the levels of accuracy provided by most digital vector environments.

In contrast to this, however, are the non-tolerant computer systems where failure to exercise absolute accuracy is a barrier to learning.

Following a review of feedback, a number of common themes run through each set of comments, perhaps the most alarming of these is the lack of attention to detail. This demonstrates a lack of understanding of basic engineering principles. This concern had been highlighted prior to any experimental studies based on industry observations.

The omission of seemingly insignificant parts, such as positional grub screws, which play fundamental roles in the operation of the assembly along with a misunderstanding of the need for surface tolerances and lubrication sumps, was evident across the cohort.

One firm recommendation as a result of the comments above would be to include fundamental engineering principals prior to any concentrated CAD tuition. Proficient CAD users must think as engineers in terms of dynamic operation of elements when interpreting schematic data. This is essential in solid modelling CAD environments, where it is anticipated any output might well become CAM/CNC prototype material.

3.6 EXPERIMENT 2 – PRODUCT ILLUSTRATION

The project is to conceptualise and rationalise to a group of individuals the concept of an early 21st century game console control. This is to be based on a Play Station 2© compatible hand held device as featured in figure 4.

In order to convey the form and function of the artefact, students are to create a colour, 3 dimensional representation using an appropriate scale and form of perspective. The illustration is intended to represent a prototype image and therefore a disciplined finish is not desired.

Include each stage of the development and annotate with a brief explanation of the function of each design element. (This does not refer to the various functions of each button on the control but rather a justification of the major design elements that make up its form – ergonomics).

3.6.1 DELIVERABLES

Students were expected to provide the following set of elements which are intended to assess their range of visualisation.

1. A set of initial sketches which suggest an informed plan of the final illustration.
2. A line construction of the artefact in you chosen method of 3d projection.
3. A colour rendered representation based on your own construction and including any areas of focus in order to enhance the products design features.

Fig 4 – Play Station 2© hand control, the subject of Product Illustration exercise.

3.6.2 RESULTS AND FINDINGS

With only two exceptions the students performed poorly in this task, although others demonstrated a willingness to experiment with techniques beyond the syllabus with good effect. There might be many reasons behind this disappointing outcome, which could include the technical construction bias of the majority of students.

Fig 5 - An impressive first attempt

On observation some seemed reluctant to sketch freehand for fear of inaccuracy. This resulted in a very structured appearance to finished pieces. Although this level of accuracy is to be encouraged in many areas of technical illustration, this form of the craft does not benefit. Quite often clients wish to see a more indeterminate visual as this suggests a level of fluidity in which the client still retains control. Such fluidity is evident in Figure 5.

Fig 6 – A self initiated stylised variant

Another observation was student's unwillingness to express a single uniform surface in anything but its base diffused colour. This suggests a fundamental misunderstanding of the principals of ambient light; this was despite a delivered explanation of the complexities of how colour is perceived by the human eye. As the Digital Rendering module is the next module in this thread, it is hoped that constructive feedback and practice will reinforce these fundamentals.

As the students progress to utilise the rendering capability of many of the featured packages the principals learned to date will become invaluable. Light and shade will be generated according to the physics of environmental locality and it is intended that students develop a critical eye for the sophistication of such elements. Students are encouraged to develop their own rendering style as is demonstrated by the efforts of candidate 1 featured in figure 6.

Despite the limitations of the final hand renderings and the absence of any representation of texture, the views chosen to represent the artefact demonstrated a sound grasp of basic perspective along with an understanding of transfer of information.

The craft of marker pen rendering is notoriously difficult to master, especially over the short period of time allowed for this experiment. However inclusion of such modules is paramount in order to form a platform for later modules to build upon as figure 7 demonstrates.

Fig 7 – Despite some minor errors in perspective, an encouraging understanding of concept shown

At this embryonic stage in their development as illustrators Photoshop rendering techniques, with or without the aid of specialist hardware such as tablet and pen, were discouraged for this project. The principals learned here will complement any studies which focus of usage of such resources when the time is appropriate. Regardless of a learners familiarity with such tools this experiment is intended to develop the learner's motor skills.

3.7 EXPERIMENT 3 – TECHNICAL ILLUSTRATION

From the ISO compliant orthographic drawings featured in figure 8, students are to construct an exploded black and white illustration in order to describe the form and function of the complete component. The illustration is to be constructed using a traditional (non-digital) technique in isometric projection.

From this construction, communicable representation of the product was required. This included any line technique in order to emphasise surface textures, chamfering or inside/outside edges.

3.7.1 DELIVERABLES

- Construction work on tracing paper.
- Line work on transparent drawing film complete with line technique and annotation.

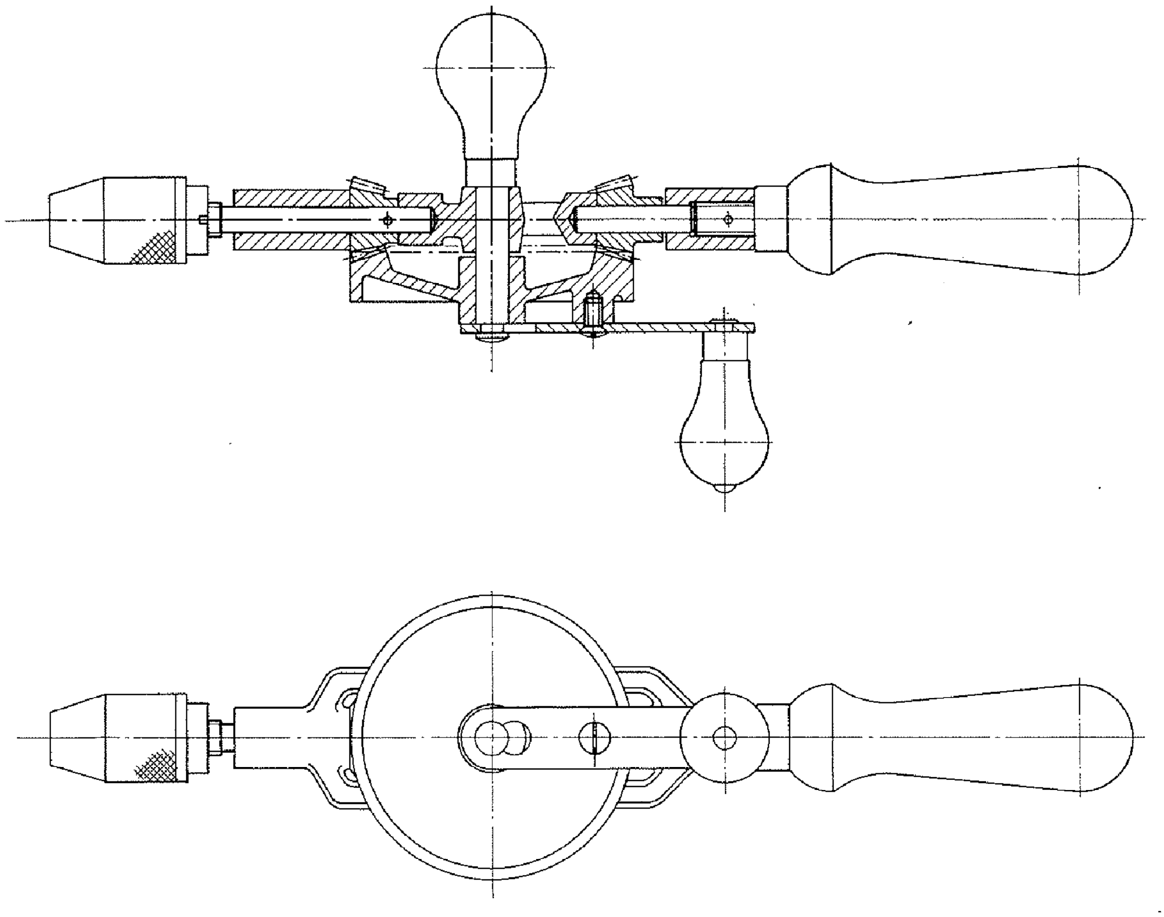


Fig 8 – Orthographic, assembled representation of task

3.7.2 RESULTS AND FINDINGS

The cohort represents a variety of experience, a fact which prompts natural pre-expectations of their performance across varied disciplines. It was anticipated at the outset that those with an understanding of engineering drawing conventions might be able to switch focus early to developing other skills. This was not always the case as the results of assessed work revealed.

The ability to visualise and represent three dimensional form remained an issue to those students who had excelled in the production of engineering drawings. Despite their proven ability to interpret schematic representation of structure this did not transform naturally to the concept of depth. Basic cylindrical elements did not prove problematic except where construction involved interpenetration of these.

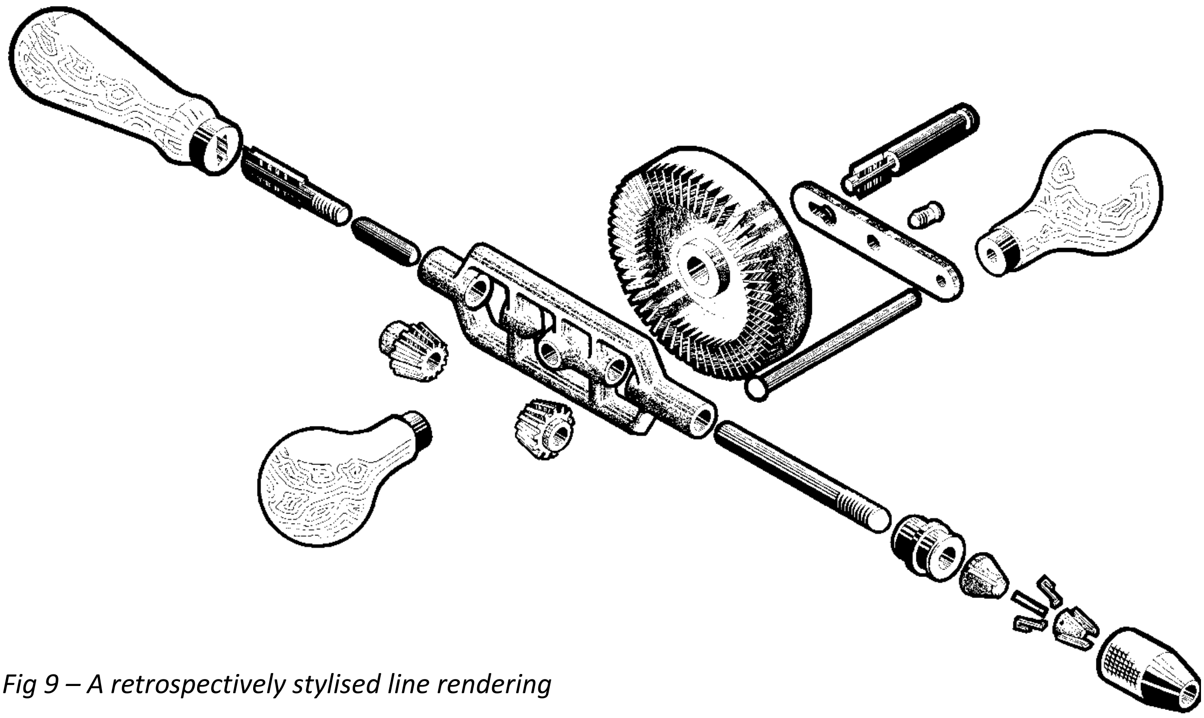


Fig 9 – A retrospectively stylised line rendering

This observation highlights a need to focus more on geometrical principals into subsequent delivery of the Engineering Drawing module. Another concern, which was reinforced through observation of the subsidiary focus groups, was that of over reliance on CAD software to describe geometric form.

One observation common to all was that of attention to detail. It was anticipated that the Engineering Drawing module would emphasise the importance of element engagement such as tolerances and manufacturing consequences such as chamfering and filleting. The absence of this detail might be a consequence of focus on construction but inevitably this needs to be addressed as a primary concern of true representation.

In order for students to practice and understand the fundamental role of gearing, a challenging high teeth ratio component was included into the experiment. The size and number of teeth required a level of repetition to ensure familiarity and needed to be constructed accurately in order to demonstrate the function of the component. This was completed well by all students.

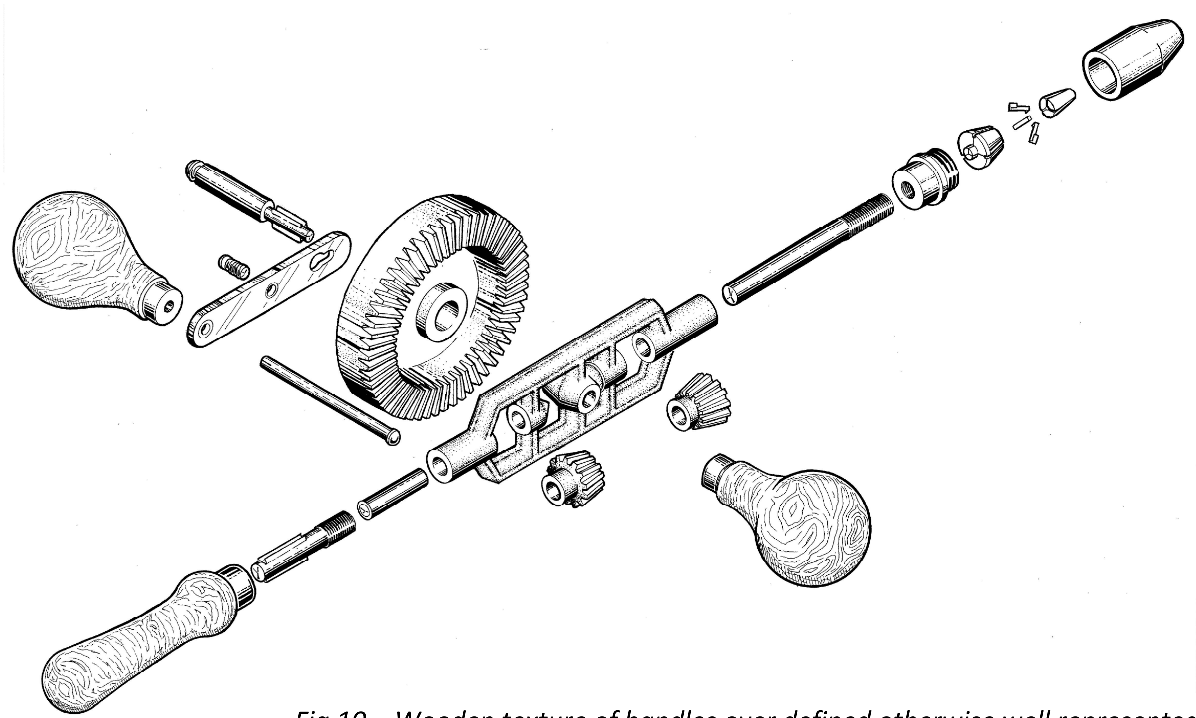


Fig 10 – Wooden texture of handles over defined otherwise well represented

Once constructed, rendering of the element provided an opportunity to express and develop their own inking style, within the boundaries of the anticipated end use of the illustration. With only a few exceptions this must be recorded as a missed opportunity. The representation of elements was unimaginative and undisciplined. Those who excelled, however, chose to adopt a retrospective stylised theme. Such an approach was welcome as the experiment was designed to encourage the development of unique style free from contractual restrictions. This part of the experiment was best demonstrated by figures 9 and 10.

3.8 EXPERIMENT 4 - TECHNICAL ILLUSTRATION 2

From the ISO compliant orthographic drawings featured in figure 11, students were to construct an exploded, cut-away and ghosted black and white illustration to describe the form and function of the complete component. The illustration was to be constructed in a 2D vector environment using isometric projection.

From this construction students were required to provide a communicable representation of the product. This should include any line technique in order to emphasise surface textures, chamfering or inside/outside edges.

3.8.1 DELIVERABLES

- Digital vector and printed A3 exploded, cut-away and ghosted illustration

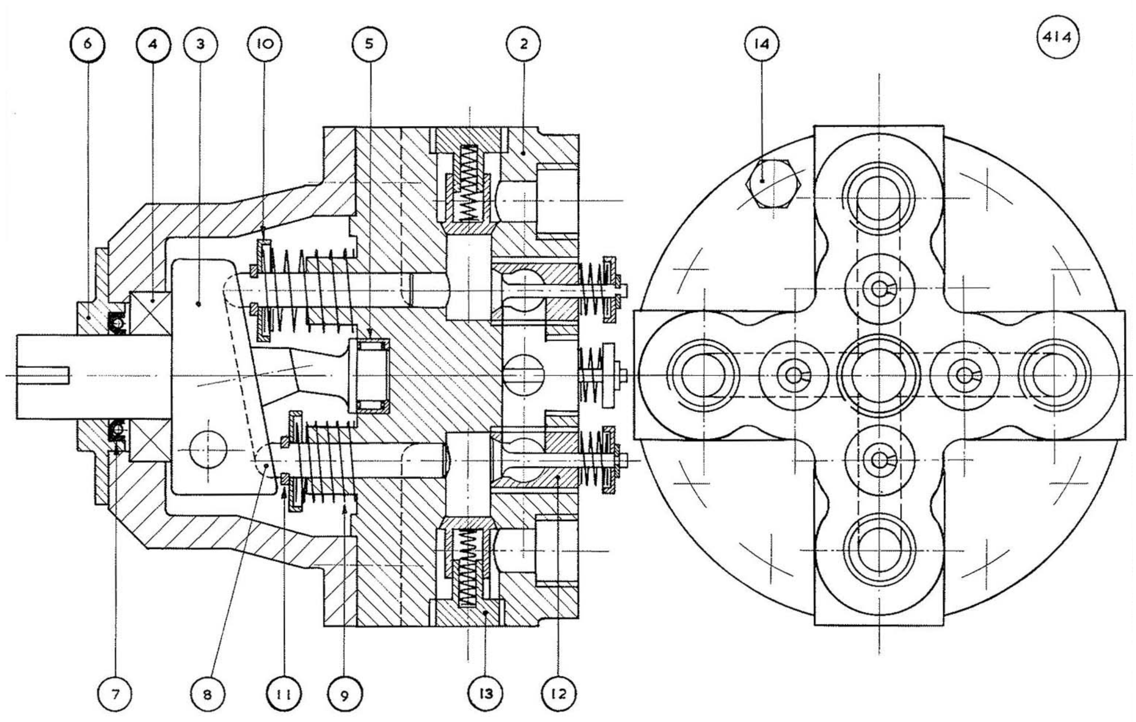


Fig 11–Orthographic representation of assembled parts

3.8.2 RESULTS AND FINDINGS

Having previously relied upon their own discipline and accuracy when constructing form using traditional tools, the students were able to appreciate the levels of technical accuracy offered by the digital environment. In contrast to this, a digital environment can be intolerant of inaccuracy. As vector information is represented mathematically it is possible to examine geometry in the finest detail. It was hoped that students would use his capability to their own advantage.

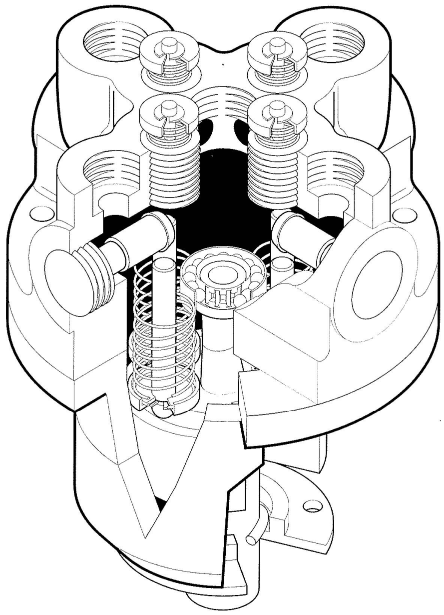


Fig 12 – Irregular cut-away technique

Perhaps of most concern were the fundamental node alignment errors which, although were undetectable in a fully rendered view, would prove problematic when both editing and construction of sub-components. Such errors are brought into focus with cut-away or ghosted representations – see figures 12 and 13.

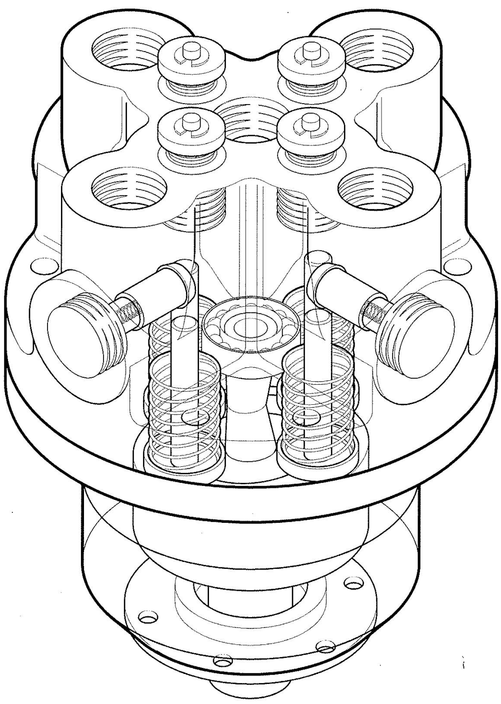


Fig 13– Early attempt at ghosting

A small number of students were by now considering composition. Although not related directly to construction the layout of individual components suggests a reasonable understanding of the dynamic principals of the component and the ability to prioritise the fundamental features of each sub-component. This positional understanding is shown in the exploded representation in figure 14.

On examination of vector construction it became apparent the benefits of path tracking had been missed. This is a concept which will be reinforced in later units in order to generate planar surfaces of an object for specific rendering techniques. Path sutures must be incorporated in order to ensure fluidity of line work and the principals involved here will differ from the preparation of construction for digital airbrush rendering.

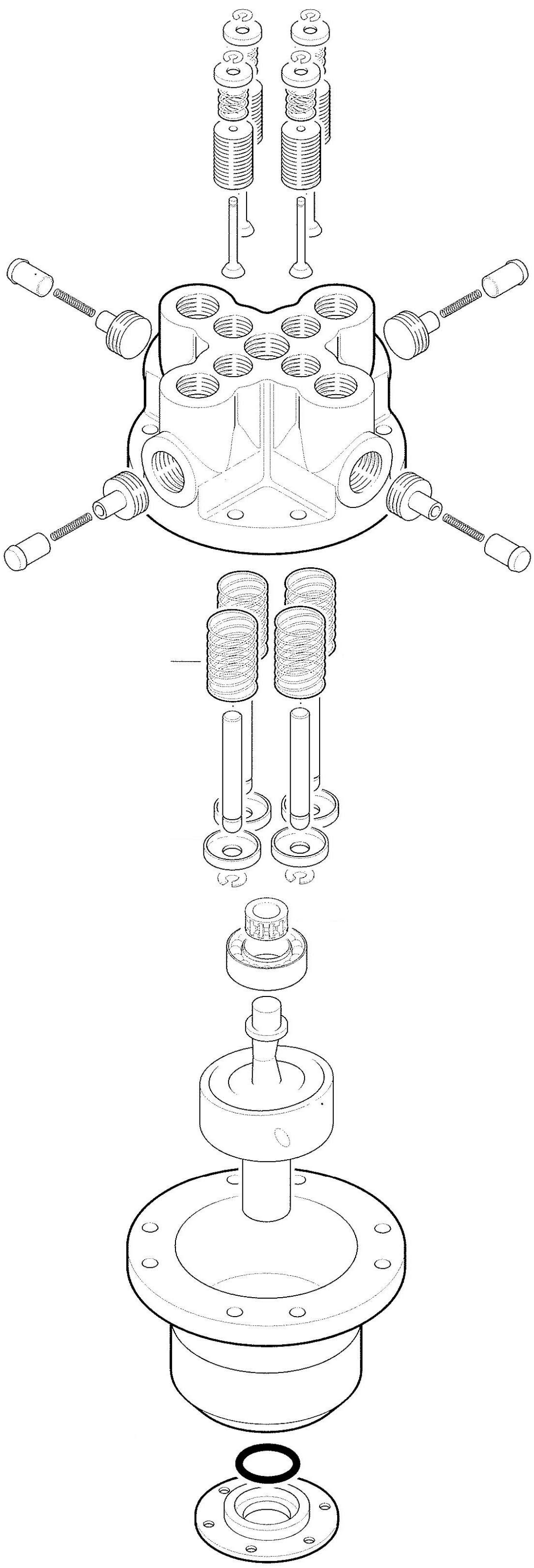


Fig 14 – Exploded representation of parts

Line rendering technique on completed projects had evolved in line with the tools available. The experiment provided a further opportunity for students to develop their own rendering style and most had chosen to adopt a contemporary uncomplicated industry standard.

In discussion this adaptation of style had come around due to an evolving understanding of artwork reproduction at reduced scale. Students had experienced the lack of clarity of over detailed components once these were incorporated into overall composition.

Generating a ghosted representation of the assembled component, as in figure 11, had proved a challenge in terms of understanding. Some confusion remained with the operation of elements due to the inexperience of the illustrators. Despite this, it was encouraging to discover the inventive use of layers some had adopted in order to create the effect of ghosting. This suggested a level of comfort with the package which is essentially two dimensional.

In summary it appears the principals covered in earlier modules have become more than a sum of their constituent parts. Overall the work produced represents an amalgamation of techniques and a confidence to experiment with these in order to generate a visual understanding.

3.9 EXPERIMENT 5 - PERSPECTIVE

From the ISO orthographic featured in figure 15, students were to construct a cut-away, ghosted or combined line illustration to describe the form and function of the assembled component.

The illustration was to be generated with traditional media and medium and constructed using trimetric projection methods in accordance with a chosen viewpoint.

From this construction, communicable representation of the assembled components was required. This can include any line technique you wish to adopt in order to emphasise surface textures, chamfering or inside/outside edges.

3.9.1 DELIVERABLES

- Assembly components constructed in accordance with a chosen point of perspective.
- Traditionally inked or digitally generated, black and white rendering of construction detail.

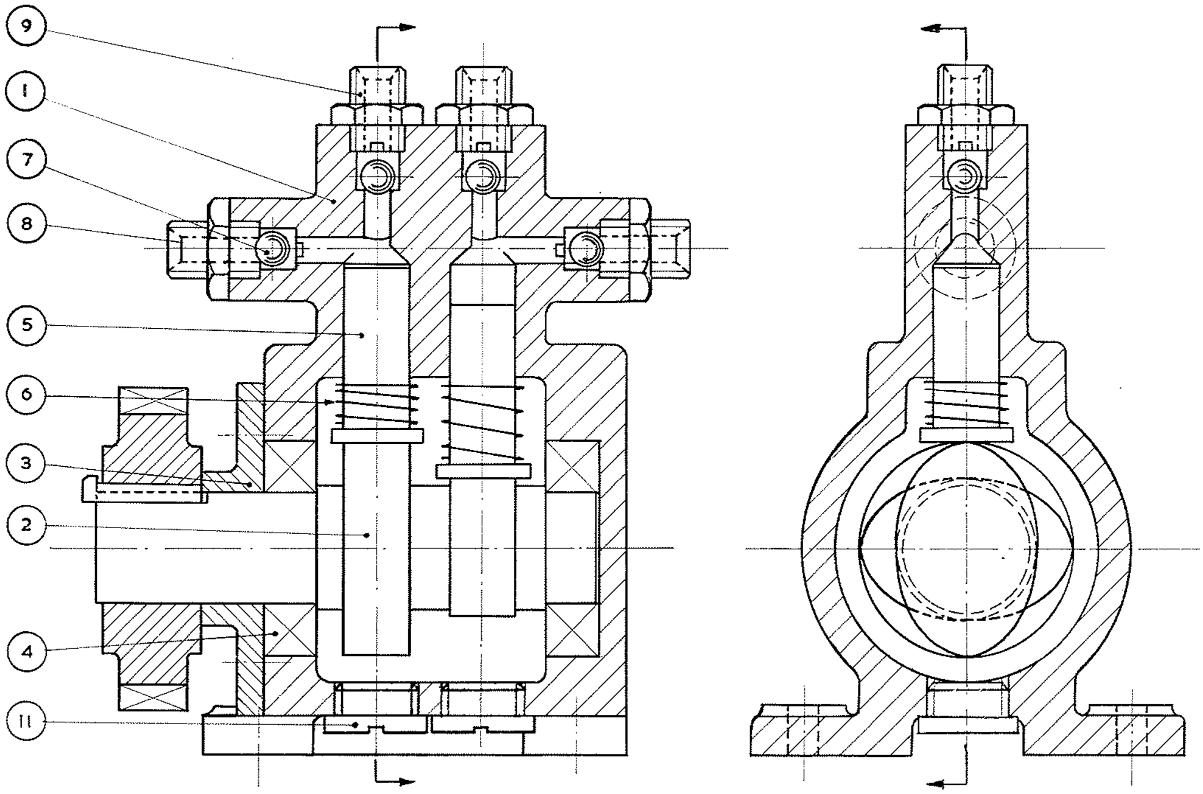


Fig 15 – Orthographic assembly of individual components

3.9.2 RESULTS AND FINDINGS

Perhaps unsurprisingly, due to the complexity of the underlying principles, students struggled to grasp the concept of the trimetric scale. Individuals were left to choose a viewpoint from which to generate a perspective grid. After manually constructing grids, some students immediately discovered the value of a sound planning phase to projects. This aspect is demonstrated by the progression in figure 16.

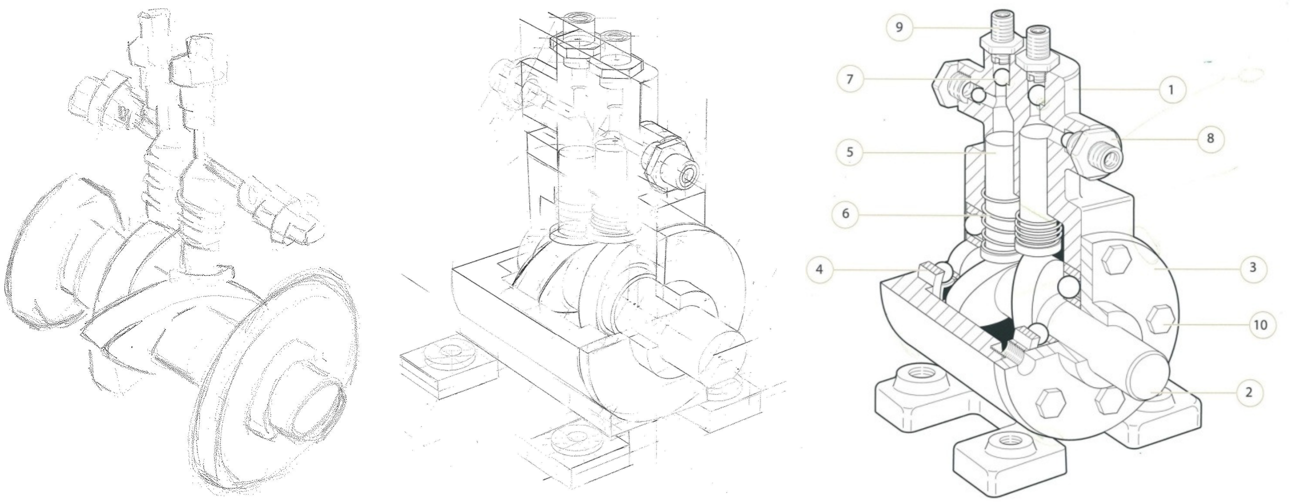


Fig 16 – Progression of illustration from initial concept

Significantly, those students who had adhered to good practice by generating preliminary sketches benefited ultimately from these by way of a more informative viewing angle of the final rendering. Despite reiteration of this advice is appears that some individuals display negative activist traits by their ability to learn only from their own mistakes.

3.10 EXPERIMENT 6 - ILLUSTRATION PROJECT

Following a period of analysis and tutor consultation, students were to choose an agreed engineering topic in line with a pre- determined range of complexity and scope.

From this documented research they were to produce a set of exploratory illustrations with the intention of conveying the form and function of their chosen study.

Illustrations must be arranged into a format which most appropriately conveys the function of the featured artefact. A final artwork in the form of a printed, colour, A2 composition was required.

3.10.1 DELIVERABLES

- A documented body of research complete with collated source information.
- A series of illustrative studies which reflect the content of the presentation.
- A completed final A2 artwork which represents a summary of the project.

3.10.2 RESULTS AND FINDINGS

A review of submitted work revealed a good deal about the progress of individuals. While some had chosen to consolidate their learning to date, as displayed by figures 17 and 18, others sought to use the lack of restrictions to explore software and techniques not covered to this point.

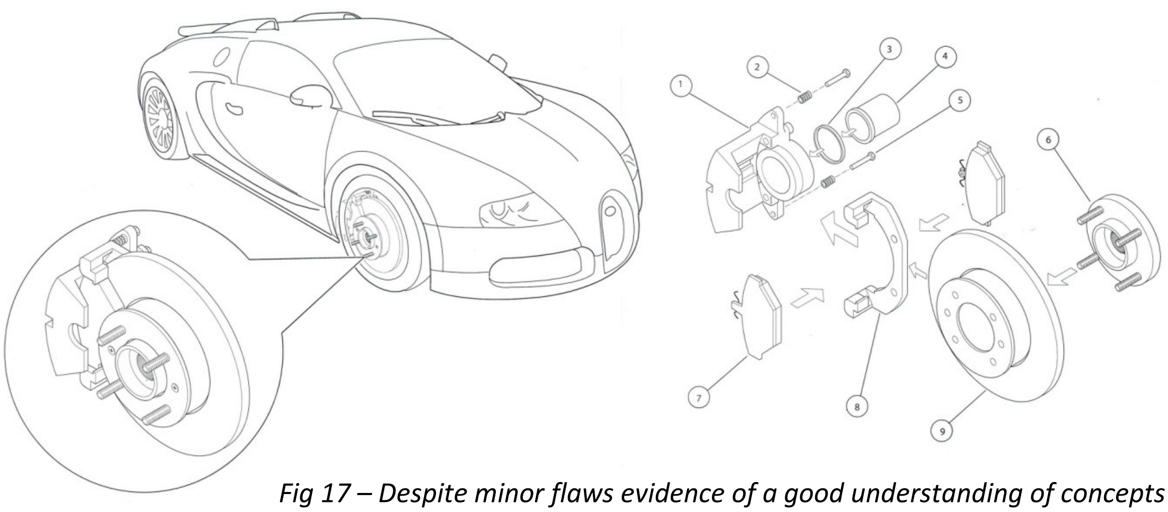
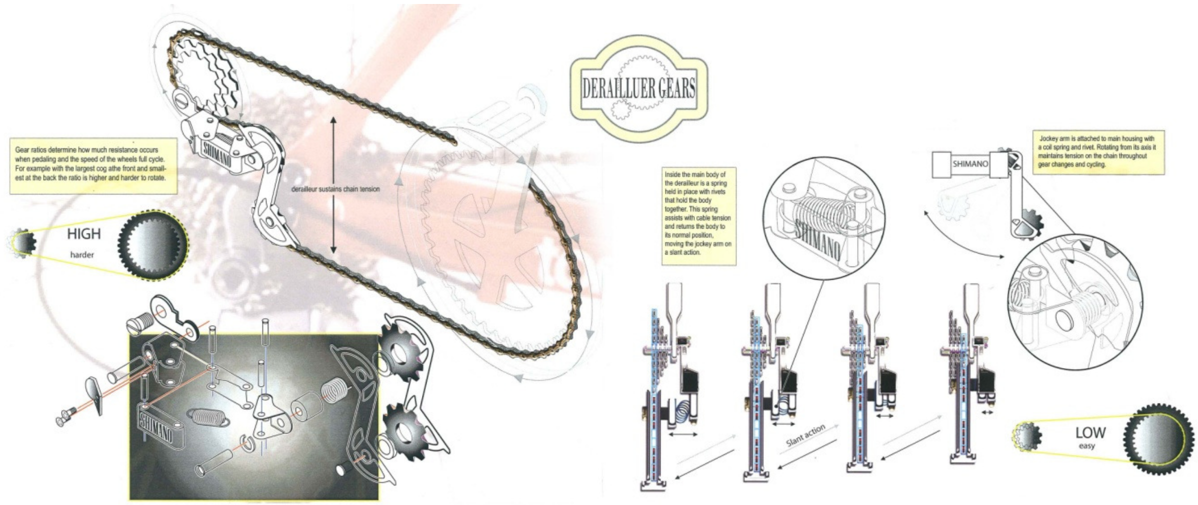


Fig 17 – Despite minor flaws evidence of a good understanding of concepts

This experiment, on a micro scale, provided evidence in the form of student understanding of the linear approach to delivery outlined in the study.

Occasionally the merit of a project can not be judged by final rendered output alone as can be seen by Figure 19. On inspection despite being well constructed in terms of geometric form the number of vertices required to describe this form proved to reinforce why a structured introduction to such technology is the focus of this study.



Many of the Boolean operations used to generate the model have consequences in terms of computational efficiency. Despite rendering being the final stage of a project it is one factor which must be considered at the beginning. A student must understand the consequences of over complicated 3D geometry and the effect this has on later phases of development.

A second student's attempted to utilise a solid modelling environment in order to describe a more ambitious engineering component served to highlight another concern which prompted this study. Armed with some understanding of a polygon based 3D package this individual attempted to achieve similar results using solid modelling tools. This turbo charger project is featured in fig 20.

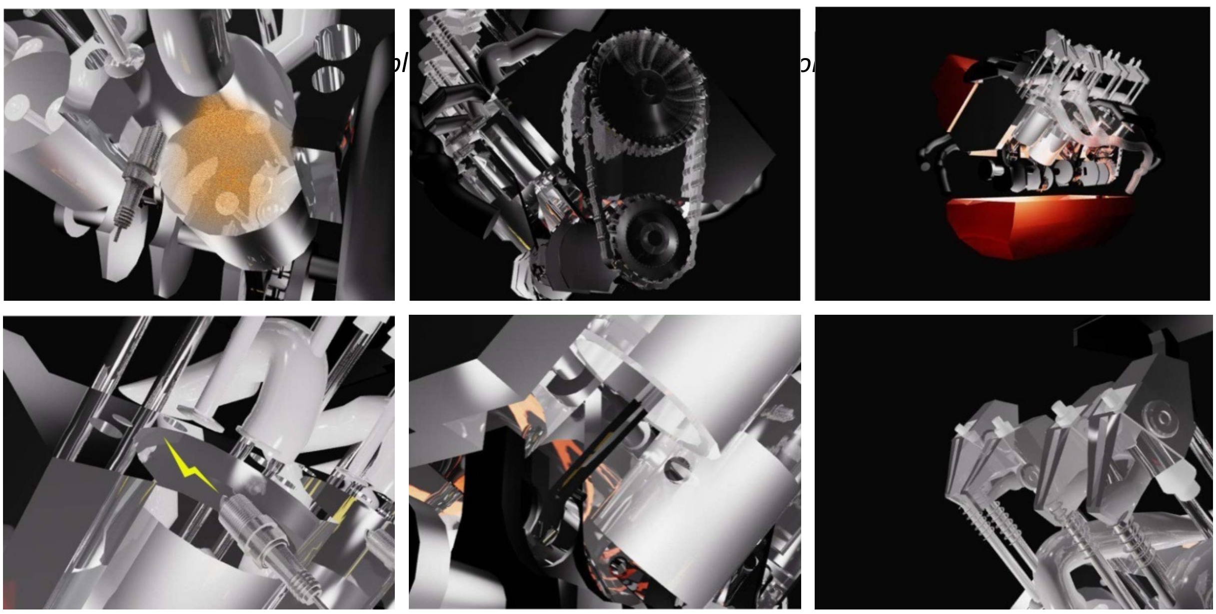


Fig 19 - Effective resultant image but expensive in terms of polygon count

Despite eventual success the student reported that the biggest obstacle to learning the package was a pre-assumption of which would be the correct method to achieve the end result. This sort of reaction has acted as a barrier to learning in this instance and goes some way to vindicate the modular curriculum structure advocated within this thesis.

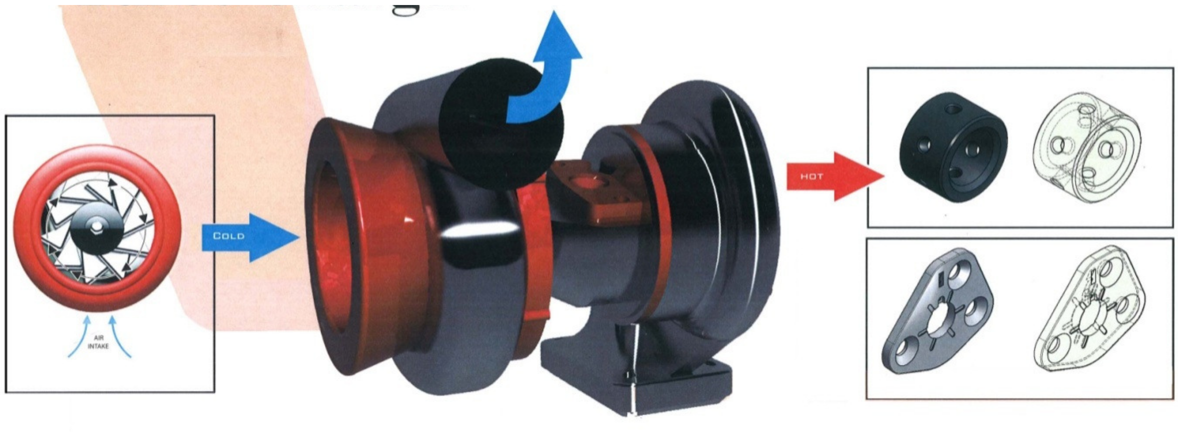


Fig 20 - Solid modelled geometry rendered in a polygon modelling environment

CHAPTER 4 CHALLENGES

Prior to a finer grained analysis of factors affecting successful delivery of CAD technologies it is important to adopt an overview of factors which could potentially impact on any technology based programme of study.

4.1 SIZE OF COHORT

A direct correlation between the size of student cohort and their associated retention and success is undeniable. Over a five year period professional observations confirm this pattern. Enrolled cohorts in excess of 18 learners invariable result in a retention of 15 to 18 after the first year of many higher education programmes.

Away from idealistic delivery of curriculum is the realistic target focussed nature of modern business, and academic establishments are not free from these constraints. The observations on the success of a student cohort based on size, act as guidance only and do not address the larger issues which are the concern of higher academic management.

4.2 LECTURING STAFF

Teaching staff involved with the academic structure proposed in this thesis need to be both specialist and resourceful. This team structure and ethos is to be encouraged.

Despite this, it is vital that the team as a whole can withstand, at least for a definite length of time, the unavailability of any individual member for any number of reasons. It is unlikely this level of flexibility will evolve naturally and certainly should not be left to do so. The price of these assurances is investment in staff development to a level of more than an appreciation of the specialised discipline of another team member. The details of such a programme of staff investment training are beyond the remit of this study although such elements would be noticeable by their omission.

Both teaching staff and technical support staff must have structure. A team with no direction is not a team. Direction must come in the form of defined leadership and a cascading model of delegation. The modern business model for providing such structures comes in the form of Service Level Agreements. Although this model is more tenuously associated within a teaching team the ethos of adherence to guaranteed benchmarks and levels of professionalism must be maintained.

4.3 TECHNICAL SUPPORT

Of equal importance in a curriculum which relies heavily on tangible technologies is the support for such equipment. A team of well equipped and available technicians is fundamental. In terms of the cohort of learners at the centre of this paper’s observations, this has been well catered for.

Hardware systems and associated communications are bespoke to the range of software they must support throughout the programme. In a period where advances in hardware and software seem to be exponential it was essential to invest in resources suitable for specialist usage. This has been achieved thorough planning and the support of college senior management.

The remit of any technical support team is to ensure the smooth running of hardware, software and communication systems at all times and allow the initial investment to evolve in order to meet advances in technology to accurately reflect similar industrial progression.

4.4 SOFTWARE LICENSING

Another issue at the heart of any CAD related programme, and one which must be considered at an embryonic stage, is software. In the case of the focus group, the choice of software titles in some ways determined the investment in hardware platform.

Over recent years many competitive software packages have been procured by competing organisations and in some cases amalgamated into a single drawing package. The consequences of such evolution can be perceived in a number of ways and many of these are of no consequence to the outcomes of this study.

One aspect worthy of consideration, however, is the impact and availability of software. Earlier research suggests a pattern of re-evaluation of CAD delivery methods at various points over the last 15 years and despite the radical differences in application capability most of the findings support the suppositions of this study. Despite this, it is important to acknowledge the variety and extended capability of affordable packages and the consequences this widespread availability has on any structured teaching of their usage.

It can be argued that the accessibility to the multi-national conglomerates and their distributors is hampered by the automated nature of their business structure. However it is equally important to acknowledge the availability of academic licences for their software suites.

It can also be alleged that such alliances with educational establishments have a mutual benefit for learners and industry alike. The students of today are the captains of business tomorrow. When these individuals are in key positions to influence software procurements for their own concerns, a cherished familiarity with particular software titles is in the interest of distributors.

4.5 SPECIALIST HARDWARE AND PERIPHERALS

To some extent the choice of software will determine the platform and technical specification of the hardware deployed to operate it. The focus of learning to operate any CAD system lies in the need to generate 3 dimensional digital imagery via the skills and vision of the operator.

There does, however, exist, other technologies for capturing and certainly outputting such imagery. It has long been the concern of many 3D visualisers that the advent of 3D scanners would curtail their professional opportunities. More recently the collective view of such technology is, arguably, no longer a threat but an extension of the tools available to a practitioner.

Whatever the outcome of this debate, one thought for further consideration is that the existence of such technology must not be ignored in order to develop a more informed graduate. Expensive scanning booths are now accompanied by more affordable and portable hand held scanners.

The effectiveness of such technology remains up for debate but their existence is fact and so should be embedded into the curriculum. Training in their usage might provide a welcome deviation from more static means of image capture. Such technologies are addressed directly in Chapter 6.

An associated technology, which cannot be ignored, is the role played by Computer Aided Manufacturing machinery in a CAD/CAM relationship. Such technology is not in its infancy although its usage is limited to prototype creation or short volume production due to the unit cost of output.

4.6 VISUAL PLAGIARISM

One consequence of the plethora of tutorials available on line is the issue of visual plagiarism. Many such resources are complete with digital files associated with the focus of the tutorial. Inclination to include these is unclear other the ethos behind other forms of open source digital phenomena or perhaps the motivation for an individual artist's desire for peer recognition. Regardless of the reason for their publication their existence is undeniable and presents assessors with a modicum of doubt.

Their currently exist a number of software plagiarism detectors which are available to tutors and students alike in order to ensure identified limits of referenced materials in academic papers. Often the sophistication and coverage of such software comes as a surprise to undergraduate students on demonstration and acts as an early reminder to abide by accepted academic guidelines. However at the time of writing, no such apparatus exists for the detection of illustrative plagiarism.

Rather than viewing the issue of visual plagiarism as an overlord to be obeyed such a system can also be a protector of intellectual property, provided associated images have been registered in any such repository. Although development of such software or its design lies beyond the remit of this study, denial of such practices and failure to address the possibility of visual plagiarism would be negligent.

In the absence of any recognised specialist software it becomes the responsibility of the assessors to do all to point out the guidelines of avoidance and the consequences of breaching these. Proof of plagiarism remains difficult in terms of images and ultimately individual cases should be judged in accordance with existing academic guidelines where reasonable doubt can be established.

The linear developmental nature of the featured experiments allows to some extent an opportunity to monitor progress and thereby minimise the potential impact of visual plagiarism.

CHAPTER 5 PROGRAMME SPECIFICS

The following quotation encapsulates the philosophy of the Higher Education curriculum as it is applied in a vocational and technological context. It is our aim to provide a liberal education through specialist studies.

> *"The habit of apprehending a technology in its completeness: this is the essence of technological humanism and this is what we should expect education in higher technology to achieve. I believe it could be achieved by making specialist studies the core around which are grouped liberal studies which are relevant to these specialist studies. The path to culture should be through a man's specialism, not by-passing it……A student who can weave his technology into the fabric of society can claim to have a liberal education; a student who cannot weave his technology into the fabric of society cannot claim even to be a good technologist"*
>
> (Lord Ashby, Technology and the Academics).

This proposed structure is designed to meet the strategic objectives of higher education by developing new undergraduate programmes that not only build on existing strengths but also takes into account employer needs. Through the programme in technical illustration it must be possible to offer a contemporary course and obtain efficiencies whilst still remaining effective. Economies may be derived from the opportunity to share modules across programmes. The core modules are common, with generic indicative content, but subject tutors must contextualise the delivery to emphasise the relevance of the core subjects to applications in the field of technical illustration.

Any programme proposal should address several of the issues raised by QAA, regarding degree programmes, namely; higher level intellectual, analytical and reflective skills; progression to a recognised degree; qualified staff; work-based learning and assessment and involvement of employers. These issues remain prominent throughout the development of this programme.

Flexibility is built into the programme. In the light of evaluation of similar level courses a new approach has been adopted. The traditional curriculum for engineering requires students to absorb detailed theory before encountering the applications. Many learners are intimidated by this approach. The proposed course structure allows the student to tackle practical applications of technology in simple, everyday systems. Once they have become familiar with some of the principles underlying the disciplines of mechanical systems through practical experience, they will be better able to cope with the theoretical and mathematical concepts. This "inverted curriculum" approach suits the learning styles of many non-traditional learners. The programme has been designed with these learners in mind.

The underlying philosophy of the programme is to develop the learner's sense of personal worth, confidence, achievement and satisfaction, through the acquisition of knowledge and employability skills. As learners progress they will become increasingly independent, evaluating their progress through reflective practice and accepting responsibility for their own learning. The course is structured to encourage the progressive development of judgement of technical problems. Ultimately students must progress with a blend of knowledge and skills to suit their career goals. They will have the flexibility to adapt to the rapidly changing world of work and enough faith in their own abilities to accept the challenge of a career in engineering or technology.

The primary admissions criteria are the ability to benefit and the ability to contribute. Graduates of the programme must have sufficient subject knowledge to interact effectively in industrial and technical environments. They will develop skills for analysis and critical evaluation. By the end of the course they must have acquired a wide range of abilities, experience, a range of personal skills and an understanding of the relationships between technological industries and society.

The high degree of employer engagement should ensure that there are abundant career progression opportunities. A strong foundation in practical, work-related aspects of the curriculum will ensure that graduates have the requisite technical knowledge and transferable skills required by employers.

5.1 LESSON STRUCTURE

Beneath the abstraction of any generic teaching and learning recommendation must lay a pattern of individual lesson structure in order to provide credibility to any such research. This study attempts little deviation from established pedagogy in terms of learner inclusion and periodic evaluation of learner comprehension. The observations made are subject specific and serve only to facilitate the understanding of technology and appreciation of its environment of application.

Most geometrical artefacts can be constructed by various approaches. Reasons behind each of these are many. The challenge of successful delivery of construction principals lies within practitioners not becoming the slaves of the software but rather developing a method of thinking appropriate to the construction of a range of geometry.

A 3D illustrator will inevitably become a product of their experiences. A normal pattern of evolution of any skilled practitioner is to improve as a result of successful or inappropriate use of technology to task. The role of an instructor is to condense this period of enlightenment through guidance.

During the advent of affordable 3D visualisation software, already highlighted in the introduction, a culture began to emerge of the successful illustrator being those who were relentless in their pursuit of a working knowledge of the leading titles. This proved to be no easy task as these leading titles jockeyed for market dominance with each revision of their product. This situation contradicted the model of an illustrator’s worth being directly related to their experience as highlighted above.

At the time of writing, a level of market settlement seems to have been reached, a situation which allows the established leading titles to evolve in line with associated hardware advancement to produce products of benefit to users and their beneficiaries alike. This represents a swing back toward a consolidated and focussed progression of an individual illustrator’s worth.

In terms of teaching and learning specifics it is the challenge of instructors to guide learners into developing an inquisitive but logical based approach to geometric construction. Preliminary results suggest such guidance might be best achieved through project work of increasing complexity. Despite the temptations of learning through tutorial, such methods rarely offer the opportunity to discover new methods by overcoming problems. The nature of problems must be managed.

When the scale and number of challenges within a task appear insurmountable, students do not learn. Where the solutions to previous problems provide the key to solving new ones this approach can be justified. This progressive and re-evaluative approach to assessment must aid in developing a lateral and more informed approach to learning.

5.2 COMPARISON

For the subsidiary focus groups, four projects were set. A solid modelling environment was used for these projects due to the of the programme area of these focus groups.

The first of these projects involved the assembled parts of a simple bench vice. The individual components were sufficiently simple in their construction to allow students to focus on developing their 2 dimensional drawing skills using the tools within the environment with the intention of adding a third dimension to these cross sections via extrusion.

A second project built on the confidence gained from repeated application of this fundamental construction method but included various abstract deviations in order to challenge the learner to investigate alternative construction techniques. These involved sweeping geometry along user defined paths in order to generate form and determining intersection points on curved surfaces.

Later, learners were introduced to a project which necessitated the use of the content of the global database of pre-defined industry compliant components such as fasteners and running gear. This enforced the principals and importance of adherence to international engineering standards.

A fourth project involved disciplines learned from each of the preceding projects combined with some amount of learner resourcefulness in terms of choosing the form of fundamental missing components. Individual elements were more organic in form and required the application to a combination of methods to construct them.

In addition to the accurate construction of constituent parts, students were required to generate an assembled operational virtual model of each project. The merits of this approach were obvious in isolation but it is important to highlight the distinction between this experimental group and others. The CAD modelling approach used throughout this experiment will not be deviated from.

5.3 ASSESSMENT FRAMEWORK

In their role as specialist technical illustrators the study group at the heart of this investigation must become proficient in the use of a variety of CAD packages. This aspect lies behind each assessment within the programme, but in turn each strand of illustration is viewed as a unique practice.

Common to each approach is the progressive project based form of assessment already highlighted in the preceding section. Allowing for the range of relevant experience which accompanies each learner, assessments are structured in a way which will challenge some but not discourage others.

In most cases the modules must be delivered by a combination of lectures and seminar/workshops. These may be supplemented by guest speakers/lecturers as appropriate. Each module has been designed in such a way that it would be possible for it to be delivered by less conventional means, for example to be delivered in the workplace.

5.4 PROGRAMME STRUCTURE

The suggested programme structure is made up of 2 years of study which are sub-divided further into 2 semesters. At any point in the programme, learners will have 4 separate units running concurrently. Each is different in nature but maintain a common illustration thread. Successive semesters continue this theme as each module builds on skills developed in a matching earlier unit.

Three of the threads aim to develop the illustration disciplines and the fourth provides the support knowledge and business practice awareness expected of today's graduates.

Sem	Thread 1	Thread 2	Thread 3	Thread 4
1	Engineering Drawing	Technical Illustration	Product Illustration	Capital Mgt
2	Perspective	Technical Illustration	Illustration Project	Mathematics
3	Engineering CAD	Intro to 3D	Digital Rendering	Health and Safety
4	Rapid Prototyping	Major Project	Lighting & Texturing	Project Mgt

Table 2 –Programme structure

5.5 UNIT CONTENT AND OUTCOMES

On examination of the specifics relating to the main student cohort under study it is difficult not to develop pre-expectations of their performance within particular modules. Motivation behind using the results of the experiments is an attempt to evaluate established methods and suggest a framework for the delivery of future CAD modules.

The programme of study embarked upon by this focus group is modular in outline. This structure has been developed with adherence to QAA guidelines and validated by an awarding university.

5.6 SELECTION PROCESS FOR STUDENTS

At the outset of this period of study a number of hypotheses were highlighted in order to generate an improved teaching and learning structure to suit each category of learner. It was anticipated that extended related research would confirm or require revision of these. Details of the student cohort under study have already been addressed, but reference must also be made to them here.

One reason for their selection was the diverse nature of their academic and professional experience prior to undertaking their chosen course of study. This was not engineered but was, admittedly, a welcome set of circumstances.

Future similar sized cohorts might benefit from considered selection. It is anticipated that conclusions drawn from this research will profile a type of learner more suited to comprehension and practice of CAD theory and subsequent teaching methods might be tailored to accelerate this.

There is no intention to exclude some learners on the basis of superior candidate filtering. Education must be accessible for all and it is important to acknowledge that learners develop at different pace. There is also, however, an argument for setting up a programme of study which learners might wish to aspire to. The ethical rights and wrongs of inclusion are beyond the scope of this study, however subsequent sections which focus on the number of learners within a particular cohort.

CHAPTER 6 SPECIALIST AREAS

6.1 SURFACE MODELLING

Martin, Cohen, Fish and Shirley (2000), deviate somewhat from the modelling aspect which lies at the core of this study, although its inclusion is justified by the common thread binding each CAD methodology; that of rendering. It would be wrong to address the questions raised within this study without acknowledgement of how construction methods affect subsequent rendering of resultant geometry. AutoDesks's Alias Studio provides one alternative to polygon modelling; see figure 21.

As already highlighted, choosing an appropriate construction technique and therefore platform must be determined by first considering the ultimate usage of any digital image. It is also important, at this juncture to consider this next process in order to provide a complete insight.

Liang, Rajeswari and Khoo (2002), reinforce the concepts outlined at the outset of this study. Through a deep focus on geometric experiments, the author successfully verifies his hypothesis that NURBS can accurately represent captured image form in a digital format. These findings serve to emphasise a need to become a practitioner armed with a panoramic overview of CAD technologies. Any informed user requires knowledge of the range of tools available to realise a specific aim.

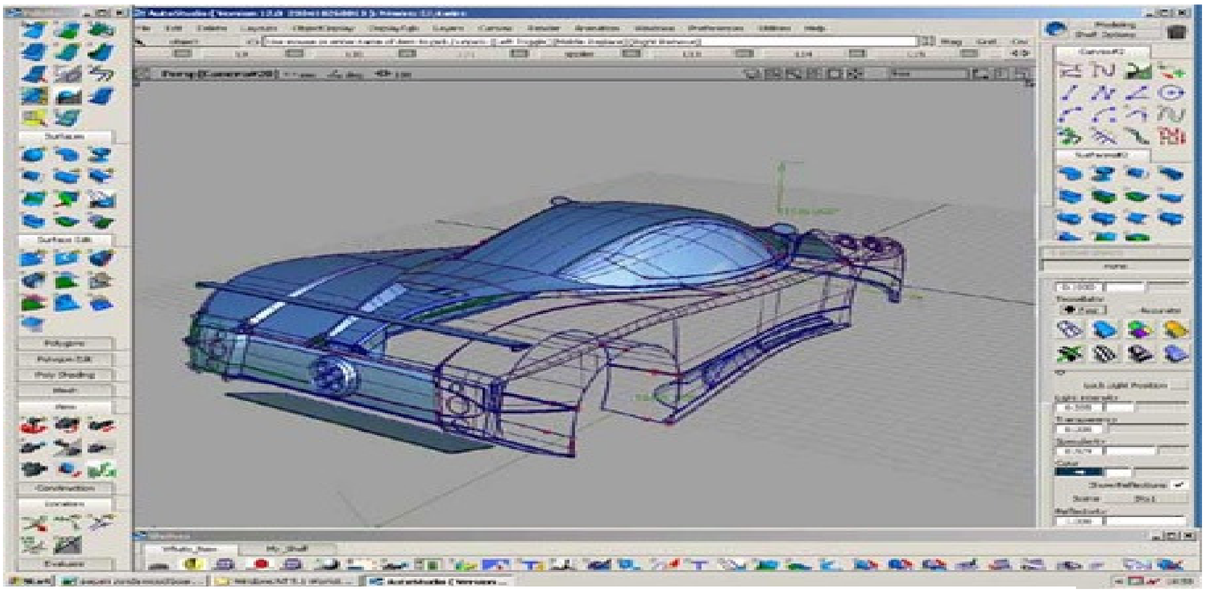


Fig 21 – AutoDesk Alias Studio interface

The concepts addressed by Aristides, Requicha and Rossignac (1992), serve to mirror conclusions drawn from others flirtations with solid modelling software. It can be said that the algorithms examined within the study are not unique to this type of 3D geometric construction. The resultant geometry, however, seems to dictate the approach to model generation.

Vignesh, Suganthan and Prakasan, (2006), perhaps most accurately reflect the focus of this research. They make the point that any valid programme of education must have structure, particularly those heavily underpinned by technology. All CAD systems are essentially a digital representation of the collection of mathematical algorithms which make up the form of elements. In contrast to this, most CAD users are neither aware nor concerned with such detail. With this in mind the introduction of such systems to practitioners must be sympathetic to the needs of these users.

It is neither mathematicians nor software developers who would normally be concerned with CAD, but more likely the designers, architects and illustrators of our time. These same users will most likely be familiar with a more organic freestyle approach to their projects. The process of generating class-A surfaces in order to simulate the traditional techniques associated with their own discipline is evident in the genre of software which is the focus here.

Packages capable of manipulating class-A surface models still remain expensive due to the computational complexities of their operation. This observation seems to be in contrast with the simplicity of the practice of sketching it is synonymous with. The transfer of manual skill to software/hardware application should aim to be as simple as possible, which is the case with similar artistic practices and their associated bespoke digital counterparts.

A number of de facto packages owe their acceptance as industry standards to their adherence to the fluidity of operation and ease of transfer of traditional skills. Perhaps the best known example of this lies with Adobe Photoshop which has been embraced by photographers and illustrators alike. It is the ease of use and the embracement of transferable skills which have introduced the colloquial phrase 'photoshopped', when applied to a suspect media image, to a non-specialist public. Class-A surface focussed software attempts this same level of resemblance to freehand sketching.

6.2 LASER SCANNING

Intermittently over the past 20 years it has been a consensus among illustrators, that the coming of age of laser scanning systems will curtail the arena of the 3D illustrator. Although tangible form must exist to be scanned, in some specialised areas, the emergence of such technology has generated artistic casualties.

The aftermath of each prediction has proved such hypothesis to be unfounded. Laser scanning systems have either proved to be merely at a non-threatening embryonic stage or more encouragingly presented itself as technology to be embraced, in particular in the realm of education.

It is vital that the progressive forces in education maintain a positive approach to each emerging technology and continue to view these as new tools to be used to enhance the capability of the 3D artist. Failure to adopt such an approach must only feed a Luddite attitude toward similar tools.

Unver, Atkinson and Tancock (2006), acknowledge this method of data capture as reverse engineering. Artefacts must exist in order to be scanned. This brings into question the pertinence of such equipment in a design environment. Many of the outlets for the 3D illustrator will remain in design, which by nature will be more concerned with the visualisation of ideas rather than the generation of geometry from existing physical objects.

This does not, however, justify omission from the syllabus of such technology. Its inclusion encourages an understanding of the processes related to the generation of 3D geometry. Rapid prototyping has already been recognised as a fundamental concept in any CAD related syllabus and acknowledgement of the part played by 3D scanners will have consequences.

This role takes the form of capturing tangible design with the goal of editing its form digitally. Figure 21 features the scanning of an artefact, a hand held laser scanner and a digital representation of a previous collation of scanned data.

What remains a frequent source of misunderstanding in relation to hand held scanners in particular is that of points of reference. Many of the technologies at the time of writing employ a method of manually introducing reference points which can be strategically placed on a target in order to cluster areas of complicated or important form information.

The process of laser scanning comes with its own set of concerns, many of which rely on a set of primitive avoidance methods to counter these. Shiny or transparent surfaces present their own problems for optical technologies. One technique to negate the reflective effects is to apply a matt, white coating to such surfaces in order to allow light photons to reflect in a more predictable manner. Varying levels of detail will be captured based on the reflective colour of an artefact, an aspect which adds a level of concern to over reliance on laser scanners.

A further limitation of this technology is its ability to collate data only of surfaces which are not visually obscured due to the optical nature of data collection. This limits usage to outline form and can result in over clustering of coordinates in areas of true or perceived complex geometric form. This makes post editing of collected data necessary or which adds a further process.

A hand held device must overcome the deviation from a static reference gathering of co-ordinates which would inevitably result in inaccuracies if not addressed. In line with manual techniques, many viewing parameters must also be considered; these are the responsibility of software to interpret.

Son, Park and Lee (2002), suggest a series of measures which indicate a return to a more static method of capturing data using laser technology. It would be wise to advocate the inclusion of such devices with an emphasis on limitations and highlight their role as one part in a much larger process. Lee and Park (2000), revisit the debate in “Automated inspection planning of free-form shape parts by laser scanning”, where the implementation of their original findings are examined in more detail.

Generators of 3-dimensional imagery over a sustained period can recall a number of occasions when the advent of new technologies has been greeted with a mixture of optimism and uncertainty. This was based on a concern that a hard learned understanding of construction techniques might become redundant in a world where immediate realisation of 3D form became automated.

This concern came in many evolving guises, more recently in the form of the 3D scanner. What now for the skilled illustrator? History has, many times, proven such concerns to be unfounded and their associated technology has been embraced by an inquisitive and innovative audience. See figure 22.

In an educational context, all such technologies need to be encapsulated within a structured curriculum in order to present a balanced overview of available methods but any summary of these technologies must include the current boundaries.

Fig 22 – Scan in progress, hand held device and similar detailed output

6.3 3D SCULPTING

It is essential to establish curriculum boundaries in order to set the disciplines which will define the parameters of the programme. As highlighted throughout this study, such boundaries have become increasingly blurred as 3D geometric representation has been incorporated into diverse areas.

More than a passing reference needs to be made to a number of related fields in addition to allowing individual learners the opportunity to pursue research into chosen specialist areas. The Honours structure under examination is designed to facilitate this level of flexibility.

One such area which represents such a tenuous association is that of digital sculpting. This form is best described as a freeform set of tools designed push, pull, grab and pinch digital geometric form as if manipulating traditional tangible materials.

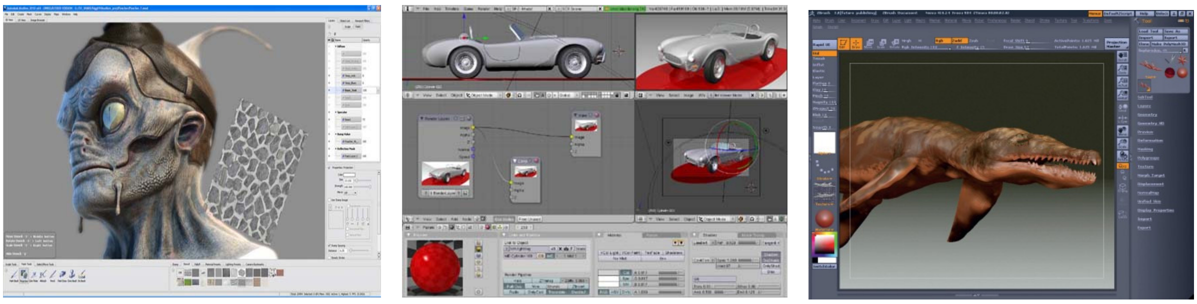


Fig 23 –Mudbox, Blender and Zbrush are examples of 3D sculpting software

It is important to address the sub-division of underlying geometric principals which define individual digital sculpting environments. Many of these environments use mesh based operations while others adopt a voxel representation. A third genre of software employs a combination of these along with a limited NURBS facility.

It can be argued an appreciation of the principals of digital sculpting reflect on a smaller scale the deeper generic understanding of 3 dimensional modelling as a whole. Mesh geometry is analogous with the methods which underpin polygon modelling environments while voxel geometry is comparable with volumetric modelling principals.

Despite the restrictions imposed by the use of the interface peripherals, manipulation of form with these packages does reflect the natural process of intuitive interaction. This evolution of traditional freeform skills onto a digital representation is mirrored by the migration from free sketching to the use of class-A surface based environments and provides a parallel insight of the possible transition.

Software which employs digital sculpting tools includes; Mudbox, ZBrush, Blender, Silo, 3D-Coat and Modo, a number of these tools have been successfully employed by the movie industry. Each of these can be considered as stand-alone packages unlike the Graphite Modelling tools incorporated into the more recent releases of AutoDesk's 3D Studio - See figure 23.

A generic baseline was established by Rossignac et al (2003), in "Finger Sculpting with Digital Clay: 3D Shape Input and Output through a Computer-Controlled Real Surface", which focused on the design, prototyping, integration, and validation of a computer-controlled physical device capable of taking any of a wide range of possible shapes in response to changes in a digital 3D model or to changes in the pressure exercised upon it by human hands.

6.4 BESPOKE SYSTEMS

During the course of an individual student's development they might wish to pursue a specialist area and the Honours dissertation becomes an ideal vehicle to realise this aim. On interview, a number of the candidates under observation expressed, as long term ambitions, their desire to become involved in the area of computer generated imagery for television and film.

In view of this a useful insight into the bespoke systems used by some of the major production houses would provide an informed appreciation of the benchmarks for the industry. By their nature, these systems would not be available to learners but an outline of their capabilities is justifiable.

By their own admission, Pixar's Marionette proprietary software is not available for sale and has been developed for exclusive use by Pixar Studios alone. One of the reasons for this is to allow manipulation of the underlying algorithms in order to achieve results required for individual projects as demonstrated by the exaggerated expandability of Elastigirl from the Incredibles in figure 24.

Fig 24 – Pixar's Marionette software Dreamworks's ToonShooter and Elastigirl

Pixar's main competitor for market share of feature length three dimensional animated sequences is DreamWorks Animation SKG. An organisation responsible for many of the globally recognised productions, Dreamworks is an amalgamation of DreamWorks and Pacific Data Images in 2004.

Despite being reluctant to release the name of their main animation software, the company admits to the use of a proprietary set of modelling animation and rendering tools. Their justification for this is identical to that offered by Pixar. This is essentially that the systems have been developed to mirror the traditional generic animation processes which have served them well in the past.

CHAPTER 7 ALTERNATIVE STRATEGIES

As the title suggests, virtual learning might be viewed by some as a revolutionary approach in terms of its deviation to traditional methods of delivering subject matter. The Benefits of embracing this resource are outlined by Shrank (1997), "Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce". Such technologies remain in a state of flux due to the pace of development afforded to them by evolving communications infrastructure. The very nature of this fluidity might suggest a more cautious approach than that suggested by Shrank.

This reluctance is not born from Luddite cynicism but rather an unwillingness to use learners as test data. The focus of the group under study is that real students being trained to integrate with a real industry and at this juncture many remain unprepared to incorporate emerging methods of delivery.

The remote nature of virtual learning suggests the potential for students to study in isolation, should they choose to do so. As a programme wide policy the benefits of flexibility might be outweighed by the loss of student interaction within a group.

The paper outlines the sound learning methods which the teaching resources are based around and suggests that as part of an integrated programme of study might prove successful. Mention is made of the suitability of this type of training in conjunction with subject matter. Three dimensional modelling does not exclude itself from benefiting from virtual learning by its nature, what does remain a concern is the potential for developing a blinkered view of available methodologies and techniques which arise in an isolated learning environment.

Individual methods of delivery are a consequence of programme structure and provide subject matter for further research. However, it is perhaps wise to integrate such methods of delivery into a programme in a staggered pattern and perhaps in tandem with more traditional methods by allowing the learner to choose between inter-personal or remote engagement.

7.1 VIRTUAL LEARNING ENIRONMENTS

The existence and acceptance of the value of Virtual Learning Environments in a modern educational setting is questionable. Informal polling of opinion within academic communities provides no clear indication of their level of effectiveness.

A similar subjective approach does not seem to have been adopted throughout their implementation. These structures have been incorporated as a feature in most college's network support infrastructure and staff strongly encouraged to utilise them. It can be argued that the organisations have not afforded the courtesy of consultation with a wide range of front-line academic staff.

Sharing of resources is to be encouraged within individual members of a faculty in order to enhance learning. Publication of resources needs to be spread evenly across a department in order to consolidate the team ethos Virtual Learning Environments exist to facilitate. When this ethos is not a shared one an environment of tension can evolve.

It can be argued that the introduction and use of Virtual Learning Environments as a college resource is not an optional one. Many fear that the intellectual property of individual lecturers is not respected within most college policies. From a student perspective, despite the formalisation and corporate identity of the structure, the fundamental nature of remote access to educational resources is nothing new.

Fig 25 – The Virtual Learning Environment is integrated into many HE programme deliveries

7.2 ON-LINE TRAINING MATERIALS

The internet by its very nature is notoriously difficult to police. This is not an ethical declaration but is based upon the fundamental operation of its hardware infrastructure. The global phenomenon of the 'world wide web' is in a prolonged state of flux, a fact which can be viewed in two ways. Some see it as a cauldron of sinister origins and a forum of like-minded undesirables. Others view it as long awaited opportunity for creative ideas to flourish and a mouthpiece for democracy.

Despite this simplistic outlook a more balanced overview might be that the internet has become an integral part of many individuals day-to-day life and a resource others would be reluctant to forgo.

It can be argued that a higher level of control could be administered over the content of the internet but governing bodies who are financial beneficiaries of its more sordid content are reluctant to impose tighter restrictions. However, such speculation is beyond the remit of this study.

Examples of the implementation of such phenomena include 'Digital Tutor' available on-line at http://www.digitaltutors.com and The University of Huddersfield's Blackboard facility. In addition to this, most of today's leading software is accompanied by a training video.

Perhaps the most encouraging aspect of on-line resources is the potential of introducing a degree of flexibility into a programme which will feature a work experience element. A number of programme structures which the one under consideration have benefited from have used a model which focuses on work experience. Unver and Taylor (2009) also suggest a structure which would facilitate this same level of industrial focus by the implementation of an element of virtual learning.

7.3 INTERNET RESOURCES

Arguably the most widespread distribution of on-line training material is hosted by the video sharing website known as YouTube. The phenomenon was originally the concern of three former PayPal employees in 2005. A year later YouTube LLC was bought by Google Inc. for $1.65 billion. The company, which is based in California, uses Adobe Flash Video technology to provide access to a variety of subject matter.

The plethora of commendable learning materials are too numerous to name and the fluid nature of YouTube content do not permit the inclusion of individual examples in this study. However failure to acknowledge this as an alternative learning resource could be considered negligent.

Despite the more sinister usage of this resource, it remains a useful repository for on-line tutorials. Perhaps to dismiss YouTube on these grounds of would be folly in terms of its widespread notoriety and availability. Whether or not it would be prudent to integrate this resource or advocate its usage is questionable on the grounds of its less suitable content.

The YouTube organisation imposes some restrictions on its content based on morality issues. This mostly takes the form of a membership scheme which entitles only over 18s to view material categorised as suitable only for adults. At this point in time it might not be prudent to host official tutorial material on YouTube as a matter of policy, but remain open to periodic review.

7.4 EDUCATION BY VIRTUAL WORLDS

Despite reservations, the existence of virtual worlds must be acknowledged if only by way of their undeniable levels of subscription. So rather than adopting a sceptical view of this phenomena it would be more constructive to view these as a viable teaching resource.

Perhaps the best known of these is Second Life. This digital experience owes its existence to the Linden Lab, a North American internet company. It was initially launched in June 2003 but has evolved rapidly in line with its popularity and has even spawned similar virtual worlds aimed at smaller, more specific target audiences.

As its name suggests, Second Life is a virtual world where subscribing individuals can act out a parallel existence to their own via a personal avatar. Individual avatars are referred to as residents which are free to socialise, trade, explore and participate in group activities with other virtual characters supported by a client program known as the King Bee.

Interaction within second life is made possible by two main factors. The first of these is an embedded 3D modelling tool which allows participants to use simple geometric entities in order to generate the virtual objects they require. Once created, the remaining feature of the Second Life toolkit, the Linden Scripting Language, can be used to give dynamic properties to these artefacts. In support of these, sculpting tools also exist to generate the form of more organic elements.

The educational potential of virtual worlds such as Second Life must not be ignored and arguably it was inevitable that its existence became another area of development in contrast to some of the more sinister ones. Thus the New Second Life Educational Micro site was launched in March 2010 and includes an educational directory for institutions to discover the existence of participants.

In order to retain a modicum of balance throughout this paper, neither “Second Life”, featured in figure 26, nor its lesser known peer worlds need to be studied further at this juncture. As the publication dates suggest, this is an emerging phenomena which is still very much in its infancy. Further study in this area might provide reason for extended study at a later interval.

One issue is the ethical implications which will inevitably accompany any form of virtual world. In recognition of the fact that such virtual worlds are open to exploitation in its many forms, the hosts of Second Life have placed participation constraints on its use by the way of age restrictions.

Fig 26 – The Virtual World that is Second Life

CHAPTER 8 DISCUSSION

Many practitioners who have witnessed the transition from traditional to digitised methods of geometric model production have benefited from these emerging technologies. It can also be said that these same professionals have failed to gain a panoramic insight of the methods available. Much of this can be attributed to the fact that this transition has come about post completion of their undergraduate studies.

It can be argued that those who have embraced such technology have done so on a ‘need to know’ basis in order to integrate these tools into their workflow. Despite the validity of this natural process, deviation from a commercially influenced directive can be difficult to justify. The net result of this can be over reliance on a single method of 3D geometric construction regardless of suitability.

The experiments conducted within this thesis were designed to introduce learners to the available tools and techniques in a threaded manner in order to gain an appreciation of method. A strict engineering thread runs through the proposed programme in order to help students understand the relevance and application of solid modelling. A second thread focuses on an understanding of the various forms of perspective and their appropriateness to subject. Finally the programme supports the more freestyle disciplines which are often associated with prototype visualisation.

In order to prepare individuals and map their progress toward a broader understanding of technical illustration, a series of preparatory tasks were devised to provide an insight to their development.

Experiment 1 was included simply because a generic visualisation of 3-dimensional form derived from 2-dimensional information is fundamental. The exercise was designed to give an early insight into each learners understanding of engineering concepts. An individual’s attention to detail was an added factor that might be assessed this way.

Experiment 2 was designed to assess a different set of illustrative skills but remained pertinent by virtue of the similarity of discipline with Surface Modelling based CAD systems. Such systems are designed to simulate a more free style approach to geometric design. On occasion, the modern illustrator will be required to generate visual representations of prototype form at short notice in order to demonstrate form and purpose. Much can be achieved using simple traditional tools along with an understanding of light and shade with diffuse or ambient colour.

It is important to keep sight of the fact that graduates from the proposed programme will most likely become technical illustrators. This implies they require a wider understanding of construction in a number of ways and must have the ability to visualise complex structure without over reliance on software. This hypothesis is echoed by all industrial partners associated with the programme and experiment 3 is included as a method of measuring this understanding.

The software package used for experiment 4 will feature in many ways throughout an illustrator’s career so it was important to become familiar with its capability at this early stage. The subject had a higher degree of complexity than previous experiments although the grounding established in the previous Engineering Drawing and Technical Illustration 1 experiments should have created a suitable platform to be successful in this project.

Building on principals highlighted in earlier tasks, experiments 5 was designed to take the student away from the consistency associated with isometric projection and impose a method of perspective which accounts for diminishing scale. The exercise also offered an opportunity for those who had not fully grasped the art of ink rendering a second attempt.

Students were introduced to the trimetric scale in order to appreciate the consequences of a user defined view. An understanding of these themes will prepare for a more informed grasp of navigation in a three dimensional environment. This experience is intended to develop an illustrator's sense of composition.

This final experiment was designed to offer each student the opportunity to collectively use the principals learned so far and focus these on a project of their own choice. The scale and complexity of the project was to be agreed between student and tutor in order to maintain feasibility.

The choice of media and medium were left open in anticipation of discovering where students believed their own strengths lay. It was hoped the results of this experiment could be mapped against those of earlier units in an attempt to trace a pattern of learning.

8.1 PROGRESSION

The programme structure has been specifically designed with the intention of seamless progression to the Honours programme outlined in this document. A number of underlying threads have been identified as specific areas of study and the development of each has been addressed throughout the programme structure.

The modern technical illustrator must be familiar with a plethora of engineering principals, most of which are featured in each section of the suggested programme. In order to expand the underpinning knowledge of the individual practitioner, the tools and techniques appropriate to each sub-element of engineering should also be clear.

It is desirable that illustration graduates are not only equipped with the visualisation and realisation skills to generate accurate three dimensional imagery but are also able to discriminate between the available methods of creating such imagery.

An informed practitioner will be expert in their craft both in terms of construction of elements and choice of methodology. Armed with such an overview of practice, the illustrator becomes a valued professional not only in terms of visualisation skills but also judgement in choice of environment.

Often the intended purpose of a three dimensional model or its behaviour will determine its method of construction. The aim of a progressive, threaded approach to the whole programme is designed to allow students to grasp the basic individual illustrative approaches and continue through to the current technology imposed boundaries.

Specifics of individual modules are outlined in the relevant section of this document. Instantaneous visualisation of form and the effect light and texture has on geometry is a recognised skill of any illustrator. A natural progression of these skills is their reproduction in a two dimensional digital environment. The proposed Honours programme builds on this by introducing learners to the three dimensional environments which have been specifically designed to digitally simulate these skills.

Despite the distinction between technical visualisation and design engineering, many of the Computer Aided Design tools are common to both disciplines. This method of virtual artefact realisation might ultimately result in generation of prototypes. The specifics of the rapid prototyping technologies associated with this type of model generation must be understood in terms of the mathematical algorithms which underpin them. One important aspect of the undergraduate programme lies in its ethos of exposure to specialist tools only when these principals are achieved.

Prior to model generation, the consequences of an uninformed approach to the use of such specialist tools must be considered. An informed practitioner should be armed with a range of construction techniques in order to maximise the anticipated final use of generated imagery. The progression programme is designed with ethos at its core.

A technical illustration graduate will retain knowledge of the underpinning digital structure of a range of three dimensional models and the ultimate consequences of applying individual techniques inappropriately. Such an evaluative approach to selecting possible solutions to a given task can only serve to emphasise the professional worth of a skilled practitioner.

The structure of the proposed programme is designed to encourage a degree of independent learning from students. It is anticipated that individuals will have determined particular areas of interest as a result of their exposure to these. The programme is designed to allow these students to pursue this focus in order to further specialise. The nature of any specialism will allow tutor guidance toward the feasibility and scope of their focus early in the programme.

A process of iterative consultation formed the basis of the validation of the feeder qualification to the programme in focus here. A similar and broader cast consensus has been gathered in order to guarantee the pertinence and validity of the course structure. The highlighted programme has been the subject of scrutiny from local, national and international industrial counterparts. From an agreed outline of the graduate skill set, each element of the programme has been designed to fulfil this profile. The focus on practical and academic balance has been assured by the combined project and research based assessment strategies.

As justification of its threaded nature, representative clientele from each specialism covered in the Honours programme have been consulted. Selected students from the undergraduate programme will undertake a three to four month residential placement with each of these organisations commencing June 2010. In order to maintain continued relationships with the Technical Illustration programme and these companies, their experience and expectations of potential employees have been polled and their conclusions form a basis for the proposed Honours programme.

Technical Illustration as a profession is slave, to a great extent, to the emerging technologies which are inevitable in such a digitally focussed arena. However the underlying physics of each strand of 3 dimensional digital modelling are well established. A sound understanding of these principals is at the core of each of the specialised units on the programme.

During the research phase of this proposal many of the programme contributors highlighted the need for qualified individuals equipped with generic visualisation skills which can be realised regardless of implementation environment. This need has been reflected by not specifying software titles throughout the programme but instead addressing the genre of geometric construction tools.

However, in order to best equip its graduates for seamless integration into their choice of specialism, industry standard titles in each area have been integrated into the curriculum.

The programme aims to prepare learners not only for the core skills that define a modern technical illustrator but also addresses the need for the individual professional skills which define a complete practitioner. The focus on the associated support skills which define a professional throughout the undergraduate programme are developed further at Honours level.

FOUNDATION DEGREE STRUCTURE

Year	Semester	Thread 1	Thread 2	Thread 3	Support
1	1	Engineering Drawing	Tech Illustration 1	Product Illustration	Managing Human Capital
	2	Perspective	Tech Illustration 2	Major Project	Mathematics
Work Placement – including report					
2	3	Engineering CAD	Intro to 3D Modelling	Digital Rendering	Health & Safety
	4	Rapid Prototyping	Major Project	Lighting &Texturing	Project Mgt

HONOURS DEGREE STRUCTURE

3	5	Solid Modelling	Architectural Visualisation	Dissertation
	6	Surface Modelling	Interactive Animation	

Table 3 – Structure of proposed progression

8.2 WORK EXPERIENCE

A retrospective admission of many a graduate is that they relearned their profession once in industry. Rather than being a damning indictment of their individual academic programmes this phenomena can be viewed as an inevitable readjustment to specific work practices. This is certainly the case in many areas of digital 3D modelling and animation.

Much of the value of an individual's length of service can be measured in terms of client or contract familiarity. This is one aspect which, for obvious reasons, cannot be a guaranteed expectation from each graduate. A familiarisation with the less predictable nature of a work environment is possible and its omission from any higher educational programme of study could be considered negligent.

The cohort of students which make up the focus of this paper will each undergo a three month residential industrial placement. In line with the proposed structure of any CAD curriculum the placement opportunities must consider a range of illustrative disciplines in order to present a balanced overview of industrial experience.

In an attempt to gain an unbiased experience free from the potential of personality conflict, students were placed into individual organisations for a period of three months. Students were numerated for their contributions to production for reasons of legality and authenticity.

The value of a period of genuine work experience can not be underestimated in terms of each of the elements already highlighted. As such a number of commercial institutions agreed to provide this element of work experience with an agreement to simulate an industrial contract.

8.2.1 PLACEMENT 1 - OSW TECHNICAL OCUMENTATION, GERMANY

A technical publication bureau situated in the south of Germany, OSW has an impressive array of clientele. These include; many heavy engineering, military, automotive and domestic concerns. The focus of their services is the preparation of technical documentation in line with current European legislation. This commitment involves the production of assembled and exploded parts illustrations.

Initial feedback from students confirms the role contract familiarity must play in any industrial environment and goes a long way to justify that inclusion of a work based element in any higher educational programme to be essential. Furthermore the strategic timing of such an experience has the opportunity to instil these concepts at an early stage.

Despite the limited time period, the confidence gained from each learners attempt to integrate into a new work environment also situated in an unfamiliar culture seemed to benefit each individual in terms of personal confidence. Although this outcome might be considered inconsequential to the purpose of a placement period, its transferable value should not be underestimated. This is reinforced by comments made by the founder of OSW:

> *"For over 30 years OSW as a company have benefited from the relationship between ourselves and the English colleges. Each year we were able to rely on the traditionally trained illustrators to hit the ground running with our contracts. It has taken some time to recognise the absence of illustrators with these skills. This remains a long term concern."*
>
> *Herr Franz Kocher, MD, OSW, Germany*

8.2.2 PLACEMENT 2 - STUDIO LIDDELL, MANCHESTER

The concept of Studio Liddell was originated by Tom Liddell, lecturer and renowned technical airbrush artist. The sons of this individual realised this concept and brought Tom's artistic flair and attention to detail into a digital arena. The organisation has long since broadened the nature of their specialism to encompass many forms of computer generated imagery. This made Studio Liddell an ideal candidate for placement of students with an inclination to television based work.

Prior to acceptance, benchmark quality were set which students must aspire to. This provided the first challenge and echoed the words of the lecturers trying to prepare under graduates. This period involved iterative resubmission of projects which demonstrated progression in student's perception of environment and craft in modelling.

Perhaps the greatest enlightenment gathered from student feedback was the levels of sophistication expected by a demanding client base. The experience proved to reinforce the concepts of specialisms in terms of the subtleties of animation. This came mainly in the form of character animation. Despite no focus on this element within the curriculum the example demonstrated proof of the complexity of project elements and justification of sub-contractual specialists. The following quote from company director Jon Liddell emphasises this:

> *"Graduates of recent years have become less proficient with the fundamentals of 3 dimensional structure. In the past students have had an ability to visualise and conceptualise form away from the computer screen. These qualities are still essential in a modern studio but sadly lacking in today's graduates. Too many illustrators come to us with a good working knowledge of 3D Studio. This is welcome but more important is the generic understanding of modelling which can be applied to a changing software market."*
>
> *Jon Liddell, Studio Liddell, Manchester*

8.2.3 PLACEMENT 3 – CITYSCAPE, LONDON

Cityscape represent one of a number of evolving 3D modelling studios offering a specialist architectural visualisation service. The disciplines involved in this area highlight most of the main principals already emphasised within the curriculum. The facility to view a virtual model of building proposals prior to investment is proving invaluable for planners and developers alike.

The two students placed into this environment had expressed a specific desire to pursue this form of large scale geometric construction. On reflection of their experience, these students expressed a realisation of the level of rendering accuracy demanded by the industry.

There exist a number of tools to simulate realism which incorporate factors previously not addressed by the students. In this way the placement opportunity served to encourage individuals to consider factors beyond geometric construction and polygonal economy. As a result the students returned with a more critical eye and a level of appreciation of detail which would serve them well throughout their studies and their profession.

"As a result of a policy of amalgamating several illustrative disciplines into one stream we have not been impressed with the students or work from colleges which have traditionally excelled in technical illustration. This seems to be the result of diluting the focus and providing only a limited opportunity to specialise. Students are often unfamiliar with the concept of large scale visualisation. Our clients are mainly from an architectural background and the nature of these contracts requires a good understanding of large scale structures.

These are the skills important to CityScape as such projects come with considerations of their own. The ability to visualise can save hours of time and cost prior to implementation of concepts. The visual nature of today's software titles serves only to flatter the user by allowing them to create structure instantly with little understanding of the principals of perspective."

Peter Landers, Managing Director, CityScape

8.2.4 PLACEMENT 4 – WILSON PUBLICATIONS, LANCASHIRE

Wilson Publications operate as an umbrella group which represent a number of illustrative and technical publication disciplines. The business model is one of a central administrative hub served by a number of satellite micro-concerns. This structure allows the business to expand and contact with workflow and in turn offer its clients a full service based on the collective specialism of its associates.

This experience not only provided the students with a platform on which to refine illustration techniques but become more familiar with the working practices within a modern studio. Intermediary feedback suggested a realisation of the time constraints which need to be adhered to in order to remain commercially competitive. No such restrictions would be imposed in an academic environment beyond assignment deadlines. Despite the best efforts of teaching staff this element of a student's journey seems only to be gained by a period of industrial experience.

A second factor which would benefit the student throughout their studies and in the long term is the combination of tools in order to achieve project completion. The candidates were involved in manipulation of images using a variety of programs and processes. Some of this would involve using individual environments merely as a transitional interface in order to alter geometric format. This introduced a sense of adaptability and innovation which could only be hinted at academically.

"In reminiscence of my own career in illustration which now spans over 20 years there seems to be a commonality that bonds individuals as a group. Technical illustrators are born to follow their discipline whether by way of a childhood curiosity of how things work or a fascination with geometric principals in their relation to art.

What remains a constant is the continuous development of individuals provided they come equipped with the appropriate engineering know how and a willingness to transfer this knowledge to the ever changing digital environments."

Tim Wilson, MD Wilson Publications, Lancashire

CHAPTER 9 CONCLUSIONS AND FURTHER WORK

CAD technologies by their nature lend themselves to a practical based mode of delivery. However, as previously acknowledged, CAD systems and their applications form only part of the tool set of the modern illustrator. In order to assess suitable methods of delivery and lesson structure it is necessary to pursue a finer grained examination of specific module detail.

From the outset a number of hypotheses were highlighted with the intention of developing a prototype teaching strategy designed to produce a more informed technical illustrator against a backdrop of ever evolving digital capability. After analysis the following questions remained:

Does an individual set of geometric construction techniques, defined by a given 3D modelling environment, produce an illustrator with little or no lateral concept of method in isolation?

Can this over reliance on a single method of 3-dimensional visualisation be avoided by an early, separate introduction to the individual techniques and environments in order to produce a more informed graduate?

How can alternative methods of teaching and learning be integrated into a contemporary technical based discipline?

Which other logistical factors need to be addressed in order to create a successful higher education programme which focuses on the emerging digital technologies synonymous with generating 3-dimensional imagery?

It was presumed that students would gain a deeper understanding of 3D illustration if introduced to the underlying principals of 3 dimensional geometric form in a progressive manner. Also an engineering based generic understanding of form is fundamental to a wider understanding of the range and suitability of technique and environment. This was best displayed in the final experiment of the study where students were free to choose a method of construction and environment in order to realise a self originated aim.

The multi-threaded linear structure of the proposed programme of study seems justified by way of correlation of project focus with method of construction. Students displayed, not only an understanding of the functional importance of detail, but also an appreciation of which methods of construction were most suitable to each individual subject matter. This was an encouraging vindication of a phased, traditional based approach to illustration.

Initial consultation with a number of high ranking industrial professionals within illustration suggest that despite the benefits, which accompany much of the digital technology which have opened up new horizons of possibility, what remains a fundamental requirement of the modern technical illustrator is a generic understanding of 3-dimensional form.

Comments from many industrial counter parts support the inclusion of team projects as a means of developing a graduate with a balanced set of skills. Contrary to this might be the fact that an extended period of study should also provide an opportunity for individual learners to explore their discipline free from the commercial constraints they inevitably must adhere to. A 3D illustrator is not just a computer operator, they need a thorough understanding of illustrative standards techniques and style.

This requirement is substantiated by the approach many students adopted when given the freedom to choose their own modelling environment and method. Overall, despite some difficulties with interface unfamiliarity, students demonstrated the underpinning knowledge to be able to dismiss known methods of construction in order to selectively create an image suitable to their own brief.

In direct comparison with group B, who had been introduced to a single method of modelling, individuals were able to consider alternatives technique or use multiple environments in order to create geometry for sub-elements. This outcome also brings into focus digital interchange formats.

Regardless of curriculum content a supportive framework is essential to any successful educational programme. The individual elements identified in earlier chapters exist in order to remove any logistical concerns from the learners. This infrastructure must be underpinned by a managerial hierarchy in order to react to logistical issues in a manner transparent to students. Such a framework must not be allowed to evolve as a matter of consequence, but should be engineered in a professional manner.

Course delivery must be tailored to help a diverse population of learners to develop the learning skills and style that best suits the individual. Generally the learning will be based on work related projects and case studies, to give a vocational emphasis to the programme. Group work is an important feature of the course, developing the team working skills that employers require. Learners must have access to resources including practical equipment, simulations and work placement.

Learners enrolled on programmes in cohorts of less than 18 tend to have a retention rate of almost 100% over a similar time period. Success tends to be higher in cohorts of this size. Causes behind such figures are not too difficult to interpret. It is the practical nature of the subject that determines the time tutors need to spend with individual students in the early stages of practical based HE programmes.

The evolving alternative teaching and learning tools which are becoming common place in education need to be integrated into the modern curriculum. To deny the existence of these serves only to lose them as a resource. All of these identified in chapter 7 owe their existence to modern networking technologies and underlying infrastructure. By definition this represents an area of technology which will become more widespread and should be embedded within the modern curriculum.

Although it is essential to define the boundaries of any academic curriculum it is equally important to give students an appreciation of disciplines closely related to their own. Specific to the suggested curriculum outline under review, this must include an understanding of the sculpting tools available along with elements graduates are unlikely to encounter early in their career. Students require a phenomenon to aspire to and often production of high profile cinematic titles provides this.

It is important to acknowledge at this juncture that few lecturers can be expert in all fields but it is accepted that each member of a course team will inevitably have a specialist leaning as a consequence of the focus of their professional posts to date or periods of advanced academic study.

Despite the unavailability of the bespoke software which is the preserve of the companies associated with high end cinematic productions, the principals these are based on are incorporated into more attainable packages such as AutoDesk's Softimage and Maya as featured in see figure 27 and 28. It can be argued the focus of such packages lie beyond the remit of the technical illustrator, but the inclusion of such technologies can be justified by way of a pattern of students choosing to pursue this specialism.

One element not featured until this point is the motivational aspect of the individual learner. Chester (2007) attempts to address this matter by considering a student's need to learn a CAD system from the outset.

It can be argued that this resource offers no substitute for the personal experience of learning. The journey to successful graduation can be measured in more than just academic fulfilment. Human group dynamics during any period of study often dictate a level of an individual's social development. At the time of writing, the student cohort under observation, seem to be evolving as a unit as an un-measurable momentum toward achievement builds. This observation is vindication of a belief that the student experience can be completely engineered.

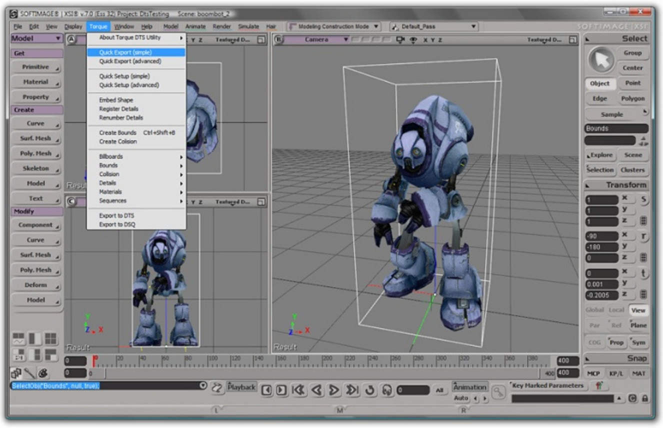


Fig 27 – Autodesk Softimage interface

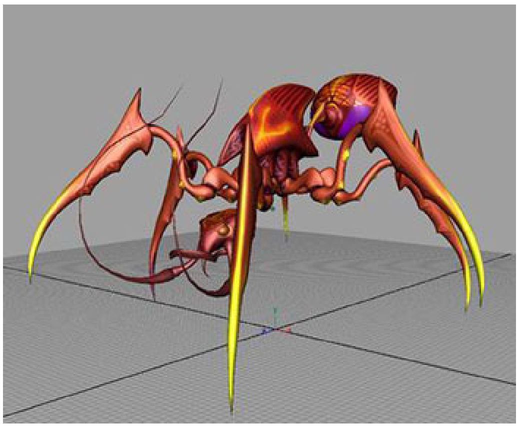


Fig 28 – A Maya generated 3D model

Inclusion of all resources within the framework of a Virtual Learning Environment takes no account of the consequences of students who choose to use this technology to its ultimate conclusion. Early observations suggest a pattern of student work which lacks the benefits of peer inclusion in their assessed projects. Those students who use the publication of learning materials as reason to study remotely loose the benefits of peer review and discovery. The concept of a shared resource of educational material has its benefits, but should be utilised with caution and in no way become a mandatory repository of academic material.

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APPENDIX I – PROGRAMME MODULES

ENGINEERING DRAWING

The aim of this unit is to develop communication skills and knowledge of the techniques required for the production and interpretation of engineering drawings in accordance with British standards and accepted practice and conventions.

It is fundamental the learner is equipped to interpret and apply these industry standard conventions as a method of transferring accurate detail and instruction between plan and illustration.

It is equally important the learner can produce detailed plans in the process of collecting source data for illustration purposes. This is achieved via a practical approach of producing drawings for specific elements to accepted standards.

SYLABUS

Produce and interpret engineering working drawings: 2D orthographic projection; views typically positioned relative to each other according to the rules of first or third angle projection in order to show all features.

Engineering drawing design: Understand the broader aspects of design and identify the role of the engineering drawing office. To identify the underpinning geometrical dimensioning and tolerance used to define parts and assemblies.

Geometrical Constructions: Produce and interpret basic geometrical constructions relevant to working drawings in accordance with standardised conventions for layout, nomenclature, interpretation, appearance and size.

Dynamic elements: Understand the importance of dynamic elements in relation to adjacent parts, accurately and unambiguously capture the geometric features of a product or component and fully and clearly define requirements for engineered items.

PRODUCT ILLUSTRATION

This module addresses the need to graphically represent design prior to manufacture. The practical uses of these skills are aimed at individuals with limited understanding of traditional orthographic representations.

Learners will examine methods of representing prototype design and thereby develop the skills to create pseudo three dimensional images from varied source imagery. Consideration will be given to techniques to illustrate projects in a functional and favourable light. A number of construction techniques will examined in order for learners to choose the most appropriate for a particular project.

Basic rendering techniques will be highlighted in accordance with the intended final use of a product illustration. A range of approaches will be considered and learners will be introduced to the rationale behind the appropriateness of each. Projection methods addressed include are isometric one and two point perspective and trimetric.

SYLABUS

Explore product Illustration Environments: Explore the various environments product illustrations are used in including fully rendered artworks of products prior to manufacture and transformation of ideas into professional product representations.

Investigate a range of construction methods: Their suitability to individual projects, including isometric, diametric, trimetric, one two and three point perspective along with true 3d.

Assess a range of basic rendering techniques: Their appropriateness to subject. The rendered images are to contain texture, lighting and shading information in order to describe 3-dimensional objects effectively.

PERSPECTIVE

All illustrators need an understanding of perspective theory. This brief will be supported by a workshop building on knowledge already gained earlier in the course. During the workshop the learner will be taught basic techniques for creating images that will reflect the 3-dimensional nature of a subject on a two dimensional surface.

The learner will be made aware of the historical development of perspective theory.

This project gives the student the opportunity to develop their own drawing skills and helps build an understanding of perspective illustration. By producing a number of illustrations the individuals will learn how to analyse and interpret information.

The learners are encouraged to experiment with constructions in order to further their own style and confidence. Learners will also be given a set of engineering drawings from which they are expected to produce a technical illustration.

SYLLABUS

Demonstrate the ability to analyse and interpret information: An object is often not scaled evenly: a circle can appear as an ellipse and a square can appear as a trapezoid. This distortion is referred to as foreshortening and if fundamental.

Demonstrate the ability to construct a perspective illustration: All perspective drawings assume a viewer is a certain distance away from the drawing. Objects are scaled relative to that viewer and illustrations must convey this concept.

Develop a working practice you are confident with: Considering all forms of perspective correspond only to the viewing lens, learners will become aware of a range of perspective construction methods and their associated attributes.

Demonstrate progression in your drawing skills: Perspective drawings typically have an implied horizon line which line represents objects infinitely far away. This concept must be at the core of the illustrator’s considerations.

Demonstrate a clear understanding of perspective theory through practice: Any perspective representation of a scene that includes parallel lines has one or more vanishing points which are fundamental in its construction.

TECHNICAL ILLUSTRATION 1

This unit enables the learner to acquire relevant skills, knowledge and understanding in a range of study areas. The emphasis will be experimental and exploratory offering the opportunity to develop a visual language and an enquiring approach to design and illustration.

The unit is designed as an introduction to those students who have no or limited experience of technical and information illustration and its complementary disciplines.

The module aims to introduce learners to basic isometric projection using traditional media. Principals contained within this unit will enforce technical accuracy in a software free environment in order to fully understand these principles.

SYLLABUS

Demonstrate orthographic plan reading and accurate illustration skills: Interpretation and transferral of representative standardised orthographic drafting conventions on to a three dimensional representation of the same subject matter.

Understand the need for accuracy in transferring data from orthographic to 3-dimensional format: Despite the intention of illustration to have a visual impact the need for accurate representation of detail must be appreciated and practiced regardless of illustrative style.

Practically and aesthetically demonstrate an artefact's purpose of function: The professional illustrator must be able to convey, accurately and simply, the intended operation of technologies via a variation of representative means.

Demonstrate progression in your final rendering techniques: The modern illustrator must be equipped with a range of rendering techniques in order to show products or concepts in favourable light according to purpose.

TECHNICAL ILLUSTRATION 2

This is where the illustrator can build on the methods introduced in other modules in a 2 dimensional vector environment. The focus of this module is to introduce the learners to the tools offered by a vector package and encourage them to use these to their full capability to practice construction and accuracy on a series of short projects.

The unit is also designed to incorporate an understanding of vector technologies and their associated scripts. This will provide an insight into batch editing techniques.

The unit also offers the opportunity to broaden the subject content of their portfolio through the production of commercial self-promotional imagery. The planning and preparation of a representative portfolio of work supported by a package of self-promotional material focussed toward potential employment is encouraged.

SYLLABUS

Understand the methodology of working with the appropriate software: An introduction to geometrical vector concepts, their underlying mathematical transformations and the resultant ease of editing of resultant artworks.

Produce vector based artwork from plans using illustration techniques from previous units: Those same techniques developed using traditional media and tools will be transferred to industry standard, digital 2-dimensional environments.

Appreciate the levels of accuracy attainable in a digitised format and fully utilise this capability: The mathematical nature of digital environments allow for a level of accuracy which should be maximised by the disciplined illustrator. Encourage the illustrator to combine visual and parametric creation and transformation of elements.

Experiment and apply line rendering techniques synonymous with conventional illustration styles: Learners need to adapt this new illustration format to organisational drawing standards as well as creatively develop their own adaptable techniques.

ENGINEERING CAD

This module will give the student an introduction to Computer Aided Design, Solid Modelling and other ancillary techniques by covering a range of Computer Aided Design Principles which underpin the design and operation of engineering systems used in industry today.

The intended outcomes will enhance the ability of the student to understand these principles and apply them to their working environment to maximise the contributions they can make within the work place.

SYLLABUS

Create a 3D model with complex surfaces: Use the following modelling tools to generate a component with complex surfaces: - Extrude, Revolve, Shell, Loft and Sweep.

Generate a 3D assembly: Create the components and then assemble them into a fully or part working model. Use the correct constraints to hold model and allow some movement of parts.

Discuss the problems with generating the primitives required to construct the details generated in the Models: Identify the methods used to create the primitive used in above models and how the construction of the models affects the assembly of the components.

Identify how CAD systems control manufacturing process: With reference to Computer Aided Manufacture, Rapid Prototypes describe how the design of the model can affected, also how the design of a component can affect the manufacturability. How are tolerances applied when constructing a 3D model.

RAPID PROTOTYPING

This module covers a range of Design Principles which Manufacturing industries, research and development engineers and technicians alike, have to be able to manufacture ‘one offs’ on demand, to underpin the design and operation of engineering systems used in industry today.

The use of high definition 3D printers to deliver the speed, low operating costs, and high-quality models that are required is fast becoming an essential component in successful research and development activities.

This module is designed so the student can put into practice the skills gained through 3D Computer Aided Design activities.

The intended outcomes will enhance the ability of the student to understand these principles and apply them to their working environment to maximise the contributions they can make within the work place.

SYLLABUS

Use an industry standard CAD software package to design a complex 3-dimensional object to meet a design brief: Interpretation of CAD drawings and specifications

Discuss the manufacturability of the object: Complex 3D CAD modelling, CAD File transfer and suitability audit

Produce a 3D model using industry standard Rapid Prototyping equipment: Model production using suitable Rapid Prototyping equipment

Evaluate a finished item: Testing and verification, Monitoring and Performance

DIGITAL RENDERING

The traditional airbrush rendering techniques developed by observation and experimentation can be seamlessly adapted to a digital environment. Such skills can be successfully reproduced by modern raster based editing environments in order to fulfil a commercial requirement.

Often the geophysical accuracy of image produced by 3D software applications can contradict an illustrator's design intention. These designs can be realised by editing photographic or photorealistic images to suit an original purpose.

The availability of such packages allow the illustrator to selectively edit images in a conventional way although in more accuracy tolerant environment.

SYLLABUS

Explore and produce digital techniques that reflect and build on the work of the traditional airbrush artist: Reproduce and improve on rendering techniques employed by conventional airbrush artists in order to better represent 3-dimensional form.

Investigate and understand a range of methods to digitally edit existing computer generated output: The unit aims to manipulate digital imagery to represent, in a more favourable light, objects for purposes of comprehension and commercial benefit.

Explore and practice new techniques that have become available within modern raster environments: To experiment and implement new rendering techniques or combine these with existing ones to further enhance the realistic presentation of illustrated elements.

Understand and appreciate the benefit of using new tools to exercise traditional skills: Maximise the benefit of a digital environment to edit and re-edit artwork in order to fully utilise the technologies underpinning this method of rendering outside a 3-dimensional environment.

INTRO TO 3D MODELLING

3D modelling applications are better understood and more effectively utilised once their underlying fundamentals are understood. By introducing the software at this stage learners will be equipped to maximise the capabilities of these applications.

This unit provides the opportunity to position yourself and your work to reflect the current market opportunities as a modern commercial visualiser with a particular focus towards the moving image.

The preparation of a creative, informative and original presentation is required that includes associated contextualisation, an effective interface that will satisfy the demands of a chosen market.

SYLLABUS

Demonstrate an understanding of computer generated three dimensional construction techniques: These include a range of CAD technologies including lofting, morphing, meshing, skinning and non uniform relational B-splines among many others.

Create three dimensional, accurate representations from orthographic detail: Employing combined techniques use the 3d environment to construct accurate representations of elements from conventional sources.

Explore new uses for a combination of modelling techniques and modification processes: As a modern image creator with vast resources we must be able to self develop our creative style whilst embracing the ever developing commercial changes in both style and technology.

Investigate the base technological strengths and appropriateness of a range of 3D software packages: Despite being based on a range of algorithms individual software products distribute their strengths in accordance with their target audience. An overview of these specialities and appropriateness to task is essential.

LIGHTING AND TEXTURING

Alongside the rapid evolution and availability of modern 3D modeling packages are the techniques to digitally recreate realistic texturing and lighting effects. Several different rendering methods have been developed. These range from the distinctly non-realistic wireframe rendering through polygon-based rendering, to more advanced techniques such as: scanline rendering, ray tracing, or radiosity.

Models of reflection/scattering and shading are used to describe the appearance of a surface. Although these issues may seem like problems all on their own, they are studied almost exclusively within the context of rendering.

Techniques have been developed for the purpose of simulating other naturally-occurring effects, such as the interaction of light with various forms of matter. However, the rendering process is computationally expensive and must therefore be considered.

SYLLABUS

Explore the range of texturing and lighting solutions available in modern 3D Modelling environments: Prior to applying non-default lighting and texturing to elements a thorough understanding of the extent of what is achievable needs to be outlined in order to maximise the use of these facilities.

Investigate and understand the geophysics of natural and studio replicated lighting schemes: The learned needs to consider aspects of the phenomena they are attempting to replicate. In order to achieve this light and its diffusion on a variety of surface textures must be examined prior to implementation.

Explore and produce photorealistic textures for application to modelled elements: From an understanding of geophysics and software capability the learner will be able to recreate a range of realistic texture and lighting effects by experimentation.

Understand the effects technologies such as ray-tracing have made feasible: An understanding of the science underpinning light and shading parameters is fundamental to appreciate the computational overhead involved in generating these effects digitally.

ILLUSTRATION PROJECT

Mechanics operate according to fundamental processes, governed by the laws of physics. As illustrators we will be called upon to describe or explain a machines purpose or its resultant gain. To do this we must be able to locate and comprehend the necessary information required to complete the project.

Illustrators must bridge the gap between the science and engineering worlds and the general public. To do this we must be able to liaise fully with scientists and engineers enabling us to redistribute the required information to the desired audience.

This project is structured to draw upon skills explored in complementary modules study by further developing the required traditional and digital based skills needed to complete a professionally structured project.

SYLLABUS

Develop and understand a range of base concepts in engineering science: To integrate these with areas of traditional engineering such as research, design and analysis whilst conveying these working concepts through the medium of illustration.

Represent graphically a predetermined mode of mechanical operation: This can be achieved by utilising a number of techniques introduced in previous modules. These can include digital variations of exploded, cut-away and ghosting techniques.

Pursue a critical and analytical interest in the technological design world: Applied analysis is useful in formulating new ideas and theories, discovering and interpreting phenomena, and representing these through innovative and descriptive illustration styles.

Selectively choose a subject to focus illustration techniques and presentation skills: Learners are free to choose from a number of electives to pursue their area of interests. Typical projects will fluid dynamics, solid mechanics, operations research, information technology engineering and dynamical systems.

MATHEMATICS

As part of Manufacturing industry, research and development engineers, and technicians alike have to be able to competently software packages. The successful utilisation of these software analysis packages require an in depth knowledge of complex mathematical calculations. This module has been designed to encompass all mathematical processes which underpin the design and operation of engineering systems used in industry today.

The intended outcomes will enhance the ability of the student to understand these principles and apply them to their working environment to maximise the contributions they can make within the work place.

SYLLABUS

Functions: Algebraic, Trigonometric, Exponential and Logarithmic functions. Evaluation of expressions and formulae involving indices (positive, negative and fractional), The exponential function, logarithms, trigonometric functions. Graphical Representation of functions.

Algebra: Transposition of Formulae, Laws of Indices, Laws of Logarithms. Solution of equations involving exponential and logarithmic expressions. Complex numbers: Real and Imaginary parts of Complex Numbers, Notation, Cartesian and Polar Forms, Addition, Subtraction, Multiplication and Division in these forms.

Trigonometry: Sinusoidal Functions, amplitude, frequency, phase angle, radian measure. Graphical synthesis of sinusoidal functions.

Calculus: Introduction to differentiation, Derivatives of Standard functions. Second Order Derivatives, Rates of Change. Introduction to Integration, Indefinite and Definite.

APPENDIX II – ENGINEERING DRAWING FEEDBACK

CANDIDATE ONE

SIDE ELEVATION
Pinion – inconsistent construction but correctly spaced teeth, outline and PCD must be centreline.
Worm gear – some line-overlap but generally well constructed (some detail missing).
Fasteners – over chamfered screw heads and proportionally incorrect.
Casing – fillet detail and radii missing. Screw boss and oil space included. Careful with dimensioning.
Sectioning – consistent spacing. Bearing needs attention.
Running gear – gap in bearing included and bush should extend to casing.

END ELEVATION
Pinion – Line of symmetry. Gear should but up to casing. Missing cut out.
Worm gear – not aligned with shaft. Use correct format for centre lines.
Casing – missing fillets, radii and internal boss; this has knock-on consequences.
Fasteners – over chamfered screw heads and proportionally incorrect. Remember to round of bolt threads and tap through holes.
Sectioning – Don't section gear tooth. Section bush fully to display as one part.
Running gear – positioned and dimensioned correctly but could be neater.

PLAN
Parts – all included except bearing support fixings and hole bosses.
Casing – no chamfering or fillets included.
Fasteners – incorrect positioning of cover plate fixings and poor construction of bolt heads.

DETAIL
Title – all data included. Try to integrate projection icon into table.
Annotations included but no dimensions. Terminate annotations lines within part.

CANDIDATE TWO

SIDE ELEVATION
Pinion – correct position but teeth profile inconsistent with some confusion with regard to outer radii
Worm gear – mesh angle good but should be consistent throughout the gear.
Casing – internal boss missing, pay attention to casting radii, screw holes for casing too large
Fasteners – screws too large as with holes, thread lines are common to screw and casing. Careful terminating threads.
Sectioning – consistent spacing but be sure to keep section lines within outline.
Running gear – be careful with dimensional accuracy, bushes should lie adjacent to shaft.

END ELEVATION
Pinion – take care with dimensional accuracy and positioning, form and grub screw good.
Worm gear – centre line missing but dimensionally and positioned correct.
Casing – internal flange boss missing, this will affect all moving parts, be consistent with casting radii.
Fasteners – screws too large as with holes, thread lines are common to screw and casing. Careful terminating threads.
Sectioning – holes should not be part of section, ensure each component is sectioned completely.
Running gear – careful with dimensions, positions all correct

PLAN
Parts – all components and fasteners present, no bolt heads need to be shown.
Casing – radii missing and flange should extend further, hole bosses should be rounded
Fasteners – incorrectly positioned and constructed without chamfer.

DETAIL
Title – tidy but key information missing. Projection icon missing.
Annotations – tidy but try to annotate with dots and dimension with arrows.

CANDIDATE THREE

SIDE ELEVATION
Pinion – positioned correctly but inconsistent tooth profiles. Include centrelines.
Worm gear – dimensional inaccuracy causes incorrect profile.
Casing – careful with fillet tangents. Always consider machining of components.
Fasteners – Run out within space ! Proportionally correct but over chamfered.
Sectioning – housing should be sectioned as one part. Boss not sectioned completely. Bearing not sectioned
Running gear – bush should extend to inner casing. Always centre bearings.

END ELEVATION
Pinion – extra contour included on tooth. Make centre line a dashed line. Hole for grub screw included but no screw.
Worm – positioned and dimensioned correctly but make centre lines dashed.
Casing – end plates missing, no radii included.
Sectioning – housing should be sectioned as one part. Section pinion completely.
Fasteners – Run out within space ! Proportionally correct but over chamfered.
Running gear - Consider bush and seal profile. Be more accurate with dimensions.

PLAN
Parts - all included except bearing support fixings and hole bosses.
Casing – no chamfering or fillets included. Flange incorrect width.
Fasteners – positioned correctly but inconsistently drawn.

DETAIL
Title – some redundant data included whilst fundamental information missing.
Annotations – consider priority of dimensions and never cross annotation lines.

CANDIDATE FOUR

SIDE ELEVATION
Pinion – Construction good but clearer pencil work needed. Dimensions all ok. Consider centre-line format. Worm – Constructed well except for consistency of tooth width. Casing – Well constructed casing but fillets could benefit from more detailed attention. Fasteners – Chamfering included but lacks consistency. Run-outs included and well proportioned. Sectioning – incomplete (bush and bearing not included). Running gear – Drawn correctly. Careful with neatness.

END ELEVATION
Pinion – grub screw correctly positioned and well constructed. Pay more attention to line work. Worm Gear – Correctly dimensioned but remember to use correct format for centre line. Casing – radii better than side elevation. Proportionally correct and clean line work. Fasteners – Chamfering included but lacks consistency. Run-outs included and well proportioned. Sectioning – some components not sectioned. Careful with section lines running outside profile. Running gear – some dimensional inconsistency but otherwise well constructed.

PLAN
Parts - Shaft should but up against main casing. Casing – Casing hole boss should be partially visible. Fasteners - all correctly positioned and constructed but some missing.

DETAIL
Suggestion – construct 3rd angle icon, otherwise all ok. Annotations – address arrow head consistency and prioritise important dimensions.

CANDIDATE FIVE

SIDE ELEVATION
Pinion – tooth profile inaccurate and position incorrect, line work incomplete.
Worm gear – tooth profile incorrect and dimensionally inconsistent.
Casing – boss missing, no evidence of filleting, gear overlapping with casing.
Fasteners – double head depth, no threads included, hand drawn chamfers
Sectioning – incorrect angle, bearings only half sectioned, top cover plate sectioned as being part of casing.
Running gear – freehand bearings, bush should butt up to casing, etc

END ELEVATION
Pinion – position ok but not symmetrical, grub screw missing, curves hand drawn.
Worm gear – dimensions incorrect and no centre lines
Casing – fillets and bosses missing, incorrect dimensions and outer form is hidden by lines running through.
Fasteners – no threads, run outs or chamfering
Sectioning – all sections should be at 45 degrees, section all parts as complete.
Running gear – bush should butt up to gear, dimensionally inaccurate.

PLAN
Parts – form completely inconsistent with engineering drawings provided.
Casing – incomplete and inconsistent with engineering drawings provided.
Fasteners – octagonal nut heads !

CANDIDATE SIX

SIDE ELEVATION
Well constructed and positioned correctly.
Tooth profile accurate but remember not to neglect shaft position and centre lines.
Worm gear – overall good with slight variance in dimensions
Casting – overall form correct, internal boss present, some fillets missing
Fasteners – bolt head depth too large, careful with threads, chamfering good
Sectioning – should always be at 45 degrees, section adjacent parts in opposite direction
Running gear – bush should butt up against casing, generally well drawn

END ELEVATION
Pinion – well drawn but grub screw should penetrate shaft
Worm gear – drawn correctly, includes centre line
Casing – accurately represented and complete with fillets, careful with thread run outs
Fasteners – bolt head depth too large, careful with threads, chamfering good
Sectioning – should always be at 45 degrees, section adjacent parts in opposite direction
Running gear – correctly constructed and dimensioned

PLAN
Parts – all present and correctly constructed
Casing - left support boss needs centring and incorrect right boss dimension
Fasteners – non symmetrical bolt heads – be careful with positioning

DETAIL
Title – Neat and inclusive but include ‘correct’ projection icon
Annotations – clear but be careful where dimensions terminate Too much emphasis on arrow heads
Linear distances are not diameters. Part numbers lines should terminate within parts

CANDIDATE SEVEN

SIDE ELEVATION
Pinion – middle gear tooth profile incorrect otherwise reasonably well constructed. Worm gear – some accuracy issues but overall construction good. Fasteners – screws head chamfered but some dimensional inaccuracies. Casing – some missing fillets otherwise well constructed. Boss for screw head included. Sectioning – consistent spacing but bearing not sectioned. Section within part boundaries. Running gear – all correctly constructed and neatly represented.

END ELEVATION
Pinion – correctly positioned and constructed. Careful with line neatness. Worm – correctly dimensioned and positioned but centre line missing Fasteners – screws head chamfered but some dimensional inaccuracies. Running gear – bush positioning incorrect. Casing – missing fillets and holes which should not be included. Line work messy. Sectioning – section within part boundaries and differentiate parts through section line variance.

PLAN
Parts – all parts included except bearing support cover plate fasteners. Casing – no boss facing included and shaft should butt up to casing. Fasteners – correctly positioned and reasonably well constructed.

DETAIL
Title bar – missing data (materials) but correct projection indicator. Annotations – consistency with arrow heads and remember to terminate annotation lines.

CANDIDATE EIGHT

SIDE ELEVATION
Pinion – correctly positioned and teeth profiles consistent, centre lines included. Worm gear – well constructed and consistent measurements – random line ! Casing – fillets missing or inaccurate and some discrepancies with screw holes. Fasteners – inconsistent measurements and screw ends wrong profile Sectioning – inconsistent line spacing and remember to draw section lines of adjacent parts in opposite directions Running gear – bearing support completely missing, bush should but up to casing

END ELEVATION
Pinion – accurately constructed and positioned but boss ends missing, grub screw positioned correctly but too long. Worm gear – correctly dimensioned and positioned, make centre lines clearer Casing – radii and fillets missing along with internal boss, these parts are essential to the assembly operation. Fasteners – huge bolt heads and inconsistent sizes for an identical part Sectioning – all hatching should be at 45 degrees and be clearer with small parts. Seal missing. Running gear – difficult to distinguish small parts, pay attention to dimensioning

PLAN
Parts –bearing support omitted Casing - flange on bottom side missing and no fillets included Fasteners – positioned correctly but circles should describe inner tangent of bolt heads, other bolt heads missing.

DETAIL
Title – all data included but use upper case only Annotations – match up diameter symbols with diameter lines, all parts listed.

APPENDIX III – PRODUCT ILLUSTRATION FEEDBACK

CANDIDATE ONE

INITIAL SKETCHES
Suitability of chosen view – your perspective is exaggerated enough to emphasise the form of the object and still maintain its perception of scale Quality of initial sketches – it appears you have had faith in your initial choice of view point, you have been successful in this instance but don't be afraid to experiment with alternatives at this early stage

METHOD OF PERSPECTIVE
Appropriate representation of scale – good use of scale, a viewer should feel they can appropriate the use of the artefact Accuracy of perspective – the overall form of the control is good and there is evidence of considered construction with vanishing points. Take care that ellipse values of detail match those of the main object. Inclusion of detail – some good level of detail included but try to maintain consistency of identical parts even if this is at the cost of detail Sub study 1 – areas chosen for sub-studies are well thought out in terms of non-visibility or lack of emphasis on the main view Sub study 2 – you are developing a good style with this less disciplined approach to illustration without compromising accuracy

RENDERING
Representation of surface texture – although you have captured the matt texture of the plastic it might have been a good idea to exaggerate the micro grain Representation of light and shade - although dark it is possible to represent this black with the use of other colours as indicators of reflection Good use of media – you are to be commended for your willingness to experiment with and combine difference forms of media. You might decide to abandon some but will still have an informed opinion in the future as a result Sub-study 1 – brave attempt to use a full greyscale within a single study in order to emphasise operation, attention to printed/embossed detail good Sub-study 2 – subtle fluctuations in ergonomic form are difficult to represent and again you have made good use of mixed media, try to use shade to describe the outer edges as opposed to hard lines in order to avoid a cartoon effect

CANDIDATE TWO

INITIAL SKETCHES
Suitability of chosen view – despite the appropriateness of your chosen view it is always a good idea to consider alternatives prior to deciding on a view, this is good practice and can reveal other ideas
Quality of initial sketches – you seem to have worked detail into your initial rough sketches this is to your credit but remember not to compromise time

METHOD OF PERSPECTIVE
Appropriate representation of scale – this is a hand held device and your choice of perspective reflects this well, however this top down view tends to make the rendered view a little flat
Accuracy of perspective – the balance and consistency of detail is constant throughout, this is often a downfall of otherwise well constructed images
Inclusion of detail – careful with spacing, the distribution of parts is as important as their construction, over detailing of parts only emphasises this
Sub study 1 – good idea to include HCI in these, hands are notoriously difficult to draw, but don't obscure component detail as a consequence of their inclusion
Sub study 2 – there is continuity between your main illustration and sub-studies, however don't be afraid to deviate from this in order to describe form/operation

RENDERING
Representation of surface texture – the form of the initial sketch has not been fully transferred to rendering, this is a very stylised approach but does not necessarily reflect the materials used to manufacture the control
Representation of light and shade – don't be afraid to introduce different colours to represent black which is often represented by the background it reflects
Good use of media – encouraging to see you are prepared to experiment with a variety of media, even if you choose to abandon some techniques you will develop a more informed approach to this style of illustration
Sub-study 1 – the style of the sub-studies are arguably more appropriate than the main illustration, these capture the fluid styled of this form of illustration,
Sub-study 2 – remember to include the main control body in these for situational reference

CANDIDATE THREE

INITIAL SKETCHES
Suitability of chosen view – your willingness to experiment is reflected in the progression of your illustration skills, this is an attribute which will serve you well throughout your studies, appropriate final view chosen Quality of initial sketches – you have taken care to develop each attempt despite their flaws

METHOD OF PERSPECTIVE
Appropriate representation of scale – although slightly exaggerated in size the scale represented by the perspective and view angle serve to represent a hand held device Accuracy of perspective – some very basic errors in early attempts but successive ones demonstrate a learning curve from evaluation of each phase Inclusion of detail – although the important sub-components have been included equal emphasis must be paid to their positioning as well as their construction Sub study 1 – no initial thought has gone into sub-studies and perhaps schematic views are less appropriate for these Sub study 2 – this is a missed opportunity to enhance the main image with views of components not visible from this

RENDERING
Representation of surface texture – consider using colour to represent the environment reflected in the control surfaces, try to represent the granular texture of the artefact through rendering Representation of light and shade – some evidence of highlight and shadow observation despite not knowing how to recreate this illustratively, be careful not to emphasise main features and highlights in the same manner Good use of media – despite not the perfect outcome you have demonstrated a willingness to experiment with different media, some have worked better than others but on the hole you will benefit from this diversification Sub-study 1 – very basic rendering of sub-studies Sub-study 2 – difficult to render schematic views

CANDIDATE FOUR

INITIAL SKETCHES
Suitability of chosen view – very good final view chosen, this seems to be as a result of your consideration of alternatives Quality of initial sketches – a balanced level of detail included in all experimental sketches, this demonstrates some experience and is always good practice

METHOD OF PERSPECTIVE
Appropriate representation of scale – despite the exaggerated size of the artefact your chosen perspective still suggests this is a hand held device Accuracy of perspective – the overall construction of your object shows correct construction methods have been considered throughout despite the sketchy nature of this assignment Inclusion of detail – perhaps the most effective focus of your illustration is the consistency and spacing of repeating parts, this can make or break a drawing Sub study 1 – a good choice of areas of focus in terms of non-repetition Sub study 2 – well drawn but this is an opportunity to reveal areas of the control hidden by the chosen main view

RENDERING
Representation of surface texture – little consideration given to the material texture of the control, this could have been easily achieved by texture rubbing with a semi-opaque white on top of the finished illustration Representation of light and shade – rudimentary but effective, might have benefited from the inclusion of a base shadow Good use of media – marker pen media used to good effect, even if you choose not to adopt this as your preferred style you will become a more informed illustrator as a result of this Sub-study 1 – a stylised approach to the sub-studies, this works well Sub-study 2 – some confusion with the grip in terms of its relation to the main illustration but the style fits in with the image

CANDIDATE FIVE

INITIAL SKETCHES
Suitability of chosen view – not the most imaginative view chosen for the final illustration but this does give the viewer some idea of scale
Quality of initial sketches – an alternative view has been considered and the initial sketch suggests consideration has been given to basic construction

METHOD OF PERSPECTIVE
Appropriate representation of scale – the perspective representation of the final artwork is reflective rather than dramatic, this suggests this is a hand held device
Accuracy of perspective – some of the ellipse values that lie on the same plane in close proximity do not share the same values or axes, this suggests movement of the original object out of its plane of construction
Inclusion of detail – just as important as the accuracy of detail is its spacing, this was good on the initial sketch but has not been transferred to the rendering
Sub study 1 – despite their orthographic nature, good emphasis has been placed on inclusion of sub-studies
Sub study 2 – try to use templates for basic shapes until you feel confident enough to create these convincingly by hand

RENDERING
Representation of surface texture – more directed familiarity of similar artefacts in different environments will improve your rendering skills and observations
Representation of light and shade – some attempt to represent highlights has been included, also consider the value of re-creating a shadow for the object
Use of media – most encouraging is your willingness to experiment with technique, this is all experience you will benefit from throughout your studies
Sub-study 1 – some of the rendering of the orthographic sub-studies is better than that of the main illustration despite choosing an unusual medium
Sub-study 2 – an adventurous technique used to highlight these which would be more effective in smaller scale.

CANDIDATE SIX

INITIAL SKETCHES
Suitability of chosen view – well thought out perspective view although it is also good practice to consider others prior to embellishing one and including these Quality of initial sketches – this is about the right level of detail to include in an initial sketch, its economic nature suggests some experience in this area, emphasis here should be on correct proportions and layout of sub-components

METHOD OF PERSPECTIVE
Appropriate representation of scale – a good balance has been struck between representing the size of the artefact and showing it in its best light Accuracy of perspective – ellipse values on the right side of the control should almost match those on the left or perhaps be a little tighter, otherwise sound Inclusion of detail – a good balance of detail has been reached on sketch and render, this seems to be a result of considering their planes of construction, more important than individual detail in this type of illustration is consistency of form Sub study 1 – your sub-study of constituent parts is very stylised, this is to your credit and a mix of 3d and schematic is successful on this occasion Sub study 2 – the theme of consistence has been carried through here also

RENDERING
Representation of surface texture – again stylised and no small amount of evidence of prior experience, the overall effect is impressive and good to see you have considered non greyscale tones to represent black Representation of light and shade – good use of banding to represent highlights and encouraging to see you have declined from over using outlines to define form Use of media – a confident use of media, some very subtle but effective touches of dark greys in detailed regions and a good combination of media used Sub-study 1 – omission of detail is part of the stylised nature of your work and this has been acknowledged, however try to maintain line weight consistency Sub-study 2 – tip – type any characters on a computer, distort and trace them

CANDIDATE SEVEN

INITIAL SKETCHES
Suitability of chosen view – it is evident and very encouraging to witness the evolution in your work, you seem prepared to acknowledge your mistakes and judging by the work submitted are prepared to learn from them Quality of initial sketches – you are developing a good style and the ability to focus on the fundamental issues of form, proportion and balance

METHOD OF PERSPECTIVE
Appropriate representation of scale – a balance of proportion and perspective have been combined effectively to convey the concept of a hand held device Accuracy of perspective – it's acceptable and a good idea to use rulers and ellipse guides at this stage of your development until you feel competent to do without Inclusion of detail – at this point you have benefited3 from the practice of aligning repeating parts to common construction lines, careful with ellipse axes Sub study 1 – you have attempted a basic ghosting technique in order to show hidden detail, this is to your credit as is inclusion of hands for scale Sub study 2 – don't be afraid to improvise by tracing over distorted digital type

RENDERING
Representation of surface texture – a very commendable first attempt at rendering, it is often a good idea to simulate surface textures by rubbing over regularly grained surfaces with a lighter semi opaque shade Representation of light and shade - the overall effect is a little dark in parts and could have benefited from some hard highlights in order to emphasise edges Good use of media – despite some of the banding being a little rudimentary you are to be commended for your efforts with a notoriously difficult media, you will benefit from this exercise Sub-study 1 – similar style used for sub-studies as for main illustration, the most impressive aspect is the evidence of your evolving observational skills Sub-study 2 – try to maintain consistency of illustrative style throughout and try to keep lines clean

CANDIDATE EIGHT

INITIAL SKETCHES
Suitability of chosen view – a nice well balanced viewpoint which shows the main features of the controller, despite its appropriateness it is normally good practice to experiment through sketching alternatives Quality of initial sketches – good to see you have used some construction to create the form of the artefact, be careful to observe uniformity

METHOD OF PERSPECTIVE
Appropriate representation of scale – an important aspect when choosing scale is to represent the object as a hand held device, your chosen perspective achieves this despite looking a little chunky Accuracy of perspective – on the whole ok but remember to use matching perspective for control panels and the corresponding controls on these, also be aware of repeating elements like the thumb controls Inclusion of detail – a good balance of detail met in terms of the inclusion and omission of detail, any more would be overkill and any less anonymous Sub study 1 – it is very encouraging that you have considered the value of choosing the correct elements to highlight and how to represent these Sub study 2 – good focus on control panel but it might have been more beneficial to include controls not already featured in the main illustration

RENDERING
Representation of surface texture – not the strongest area of this project, this type or rendering takes a while to master but a definite style will evolve in time Representation of light and shade – a reasonable attempt to represent areas of light and shade but your rendering style needs a little more discipline Good use of media – good to see you have been prepared to experiment with media, you will benefit from this experience in the long term Sub-study 1 – although well thought out the rendering of these elements seem to have been rushed Sub-study 2 – the style of each of your illustrations does not match, they should be very similar or identifiably different according to style

APPENDIX IV – TECHNICAL ILLUSTRATION 1 FEEDBACK

CANDIDATE ONE

INTERPRETATION
Casting – a basic understanding of the form of this component has be followed although much of the minor detail has been omitted such as chamfering
Gears – again basic form is sound but much of the manufacturing consequences are missing, it is important to consider how this detail adds to the realism
Handles – orthographic detail understood but minor detail not observed
Chuck – operationally understandable despite omission of important chamfering
Threads – all threaded sections included on appropriate components
Shafts/cranks – shaft positions and dimensions interpreted correctly

CONSTRUCTION
Casting – many fundamental details missing from the construction of this element which has lead to a number of ambiguities in its construction
Gears – proportionally correct despite the lack of discipline in their individual construction, this is a fundamental element of the mechanical operation
Handles – the lack of detailed observation already highlighted has lead to incorrect representation of the form of these elements
Chuck – proportional correct but undisciplined in terms of alignment
Threads – all internal and external threads are inconsistent and crudely formed
Shafts/cranks – mostly well constructed but no third dimension applied to crank

LINE INKING
Line accuracy – this is a very rudimentary attempt at inking your construction, the well constructed elements have suffered as a consequence of this
Ellipse accuracy – mostly concentric but be careful to consider how the back end on these will join against adjacent geometry (eg. top handle, back chuck plate)
Technique – despite some attempt at ellipse tapering it is very difficult to distinguish between inside and outside line weights

ANNOTATION
Numbers – no annotations included
Lines and spacing – although misguided, some you have included leading lines to indicate the order of assembly, annotation lines are missing as are annotations

CANDIDATE TWO

INTERPRETATION
Casting – a reasonable attempt at a challenging project except for one section of the casting which appears to have no support contrary to the supplied plans
Gears – the form of the gears has been understood and replicated correctly
Handles – one of the handles is missing, despite its similarity to another element, its inclusion as separate elements on the parts list justifies its individual inclusion
Chuck – key elements have been omitted from the back plate in the chuck assembly (see below), despite this all parts have been included
Treads – threads have been included on most elements, but as mentioned above it is essential the chuck back plate threads into its housing for correct operation
Shafts/cranks – all shaft form and dimensions correct, crank ellipse axes wrong

CONSTRUCTION
Casting –some geometric confusion with regard to chamfered edges and radii formed as a result of casting has been omitted, be careful to join lines neatly
Gears – main gear positioned incorrectly despite being constructed correctly, there appears to be some discrepancy between pinion teeth size and their intended meshing partners
Handles – you seem to have grasped the construction of their ergonomic form
Chuck – be careful tangential lines between ellipses, otherwise all ellipses are concentric and you have benefited here from the scale of your construction
Treads – these have been distributed inconsistently and do not represent true half ellipses, consider representing these as if they feed into each other
Shafts/cranks – take care with alignment but on the hole a some neat work

LINE INKING
Line accuracy – joints and tangents need to be more accurate especially where numerous lines are involved, be careful with line consistency
Ellipse accuracy – despite the crank ellipse issues already highlighted, all other ellipse seem ok, take care with concentric alignment of holes and their surround
Technique – some attempt has been made to taper the outside edges of ellipses and skew some to appear as threads, good balance between thick and thin lines

ANNOTATION
Numbers –annotations included and circles used as good practice
Lines and spacing – annotation lines consistent and dashed assembly included

CANDIDATE THREE

INTERPRETATION
Casting – all elements of this component have been transferred to 3D, each sub-element is dimensionally correct and in proportion
Gears – the most encouraging aspect of this is the fact that the teeth are the correct proportion to mesh together, all collars interpreted correctly
Handles – good to see you have identified that one of the handles is bored through, this kind of attention to detail is fundamental in illustration
Chuck – mostly ok but some detail missing in the form of a removal cut-out and external thread on the clutch back plate
Threads – threads have been acknowledged in terms of their location on individual components except for the part mentioned above
Shafts/cranks – al proportionally accurate but important to remember the role of chamfered ends on these components

CONSTRUCTION
Casting – well constructed, this is a neat and accurate representation but remember to show the filleting detail which suggests it's method of manufacture
Gears – your line work is neat and considered which is very important, however it is equally important to represent the tapered nature of each individual tooth
Handles – on the whole well constructed but be try to replicate any symmetrical construction on each side
Chuck – you have benefited from you neatness here by the fact you can represent the finer detail of this assembly, take care with line/ellipse tangents
Threads – consistency of spacing key to representing threads, it a good idea to tilt the axis of the ellipse and construct to the juncture of the previous thread
Shafts/cranks –issues with the crank, the depth of the component is greater than the holes through it and it's form is not meant to be tapered from back to front

LINE INKING
Line accuracy – some freehand line have been included and the hole in the crank is in the wrong perspective despite it being correct in your construction
Ellipse accuracy – some of the screw threads are missing and those present are a little crude, careful where lines are supposed to be tangential to ellipses
Technique – you have attempted some highlights on internal screw threads and this is to your credit, also god to see you have persevered with multiple attempts

ANNOTATION
Numbers – no annotations included
Lines and spacing – no corresponding annotation lines of assembly lines

CANDIDATE FOUR

INTERPRETATION
Casting – all data has been interpreted correctly from the orthographic provided, be sure to include all junctures between surfaces even if these are filleted Gears – the teeth are a little too deep otherwise this component is technically correct, try to reserve any technique for inking up of your construction Handles – good to see you have considered the step between the wooden carving and the steel cap where the tang inserts Chuck – no inclusion of chuck spring at this point and don't forget that the internal thread in the clutch housing is fundamental to its operation Threads – some of the threads have been shown and some omitted Shafts /cranks – all shafts dimensionally correct and positioned correctly, careful with the axes on any drilled holes and always address chamfering

CONSTRUCTION
Casting – a very neat construction of this component, from this you should see the benefit of constructing most hidden detail Gears –well constructed but are not in proportion with the rest of the assembly, exaggeration is acceptable in some circumstances but unnecessary here Handles – these have been correctly constructed throughout but remember always use templates for any curves Chuck – very neat construction but some essential information missing, namely chamfering on the clutch back plate ant the cut-out mechanism for fitting Threads – only two of these included on construction, their inclusion is important at this stage as the inking is just a reproducible representation of this Shafts/cranks – be careful with tangents between ellipses and straight lines

LINE INKING
Line accuracy – a very good first inking although some of the line-work seems to be freehand, unless for a specific effect this is never a good idea Ellipse accuracy – be sure to always use ellipse guides throughout inking, especially on threads, this detail can often define the quality of an illustration Technique – this is a terrific exercise in line work, it seems you have taken the time to research and experiment with a number of inking techniques, well done

ANNOTATION
Numbers – no annotation have been included Lines and spacing – no corresponding annotation or assembly lines included

CANDIDATE FIVE

INTERPRETATION
Casting – hole missing in top of casting and some of the spacing is questionable
Gears – proportionally sound and positioned correctly difficult to assess the accuracy of tooth profile due to their construction
Handles – the form of these only vaguely resembles their orthographic profile
Chuck – all detail correct except from internal and external thread for fitting
Threads – evidence of threads determined by single positional ellipses only
Shafts/cranks – all elements present but again it is difficult to establish the accuracy of these when no centre lines exist to measure from

CONSTRUCTION
Casting – some of the line do not meet and remember never to remove construction lines that might be needed for reference later
Gears – these have been hand drawn which is never acceptable as the pencil construction is the foundation for you inking
Handles – hand drawn ellipses are not acceptable
Chuck – some good work here which should serve as a benchmark for all your construction, good idea to enlarge the chuck jaw detail but springs missing
Threads – all threads missing, only positional indicators included
Shafts/cranks – some indication to shaft end tapering although this is guessed and the holes in the crank are sketched and have random axes

LINE INKING
Line accuracy – it is important to acknowledge the incompatibilities between recommended media and medium at this point which have contributed to many wasted hours, in light of this a reasonable first attempt under the circumstances
Ellipse accuracy – most of these have been drawn with ellipse guides which is better than the construction phase, be more accurate at juncture points
Technique – good to see you have attempted some line technique, this was an opportunity to experiment with this free from contractual constraints

ANNOTATION
Numbers – good to see have included annotations but consider using a stencil
Lines and spacing – no annotation lines, but full use made of assembly lines

CANDIDATE SIX

INTERPRETATION
Casting – all elements interpreted correctly from orthographic just be careful not to compromise form at the cost of technique at construction stage
Gears – all correct except for length of collar on upper pinion gear and the teeth on the main gear are deeper than shown on the plans
Handles – all detail included but consider the rounded edges of the steel enc caps
Chuck – apart from the slot in the chuck back plate this has been well understood
Threads – proportioned and positioned correctly, careful terminating threads
Shafts/cranks – form understood but the tapered ends have been exaggerated

CONSTRUCTION
Casting –well constructed but reserve the shading technique for the final piece
Gears – your line work is excellent, you will benefit from this here because of the intricacies involved in a component such as these
Handles – very well constructed except the shaft on the winding handle should enter the handle from the opposite direction and terminate beyond the crank
Chuck – drawn and spaced consistently but clutch springs should be rounded
Threads – these have been very well represented with offset ellipse axes
Shafts/cranks – apart from the counter sunk hole for the crank being on the wrong side this element is flawless

LINE INKING
Line accuracy – a very stylised approach to line work, this was an opportunity to experiment with this and has been fully utilised. It would have been a good idea to vary the line weights on some of the smaller parts the emphasise their fragility
Ellipse accuracy – some of the ellipse edges vary in thickness, particularly toward their tangent points, but otherwise well inked
Technique – you use of material representation is remarkable, although this has been at the cost of composition near the gear, full credit for experimentation

ANNOTATION
Numbers – no annotations have been included
Lines and spacing – no corresponding annotation lines or assembly lines

CANDIDATE SEVEN

INTERPRETATION
Casting – all information transposed from orthographic including the minor detail which suggest its form of manufacture (eg. rounding of casting burrs etc.) Gears – good to see you have correctly read the depth of the teeth on the main cog, in future include the inner tooth base line to avoid appearance of distortion, no collars have been included on for pinion gears Handles – the form or the handles has been correctly observed except for the hole which should go all the way through part 10 Chuck – all parts included but essential elements missing off the clutch back plate, remember this is to be screwed into the clutch housing in order to hold the assembly together, this justifies the thread, cut-out and counter-sunk hole Threads – positional indicators only on shafts and missing from clutch back-plate Shafts/cranks – all included and proportionally correct

CONSTRUCTION
Casting – this has been very well constructed, in particular the sutures between the geometric primitives and the frame Gears – here you have benefited from the disciplined approach to your pencil construction Handles –well drawn but remember to pay attention to ellipse tangent points Chuck –very light and some misalignment of ellipses, otherwise well drawn Threads – the axes of the chucks internal thread is skewed a little too much, threads on the shafts have been represented by position only Shafts/cranks – attention to detail on shaft tangs is excellent, careful again with alignment of ellipses especially with shaft end chamfers

LINE INKING
Line accuracy – some inconsistency in line weight and be careful at junctures Ellipse accuracy – practice needed with ellipse tangents, but on the whole good Technique – thick/thin technique employed successfully, don't be afraid to experiment with representation of some surface textures

ANNOTATION
Numbers – included and not interfering with main illustration which is the key Lines and spacing – no annotation lines required, all assembly lines included, careful with composition of parts (screw and top shaft)

CANDIDATE EIGHT

INTERPRETATION
Casting – hole missing from top cylinder section form and interpenetration of elements good, all spacing of sub elements accurate
Gears – good proportions between pinions and main gear teeth however this main gear is not concentric with its hole and boss
Handles – correctly interpreted but remember to include any rounding of the steel reinforcement in the tang area
Chuck – parts assembled in the wrong fitting order, the clutch jaws do not correspond to the plans and the hole and cut-out are missing from the back plate
Threads – all threads have been included an positioned appropriately on their constituent components
Shafts/cranks – shafts and their chamfers are all included but no third dimension is present for the crank

CONSTRUCTION
Casting – some good line work and attention to detail, there is evidence of plotting each intersection and the form of component has benefited from this
Gears – again the neatness of pencil work plays an important role when construction a component with this level of detail, this will benefit inking
Handles – good to see you have taken the time to construct the ergonomic profile of each handle and maintained the symmetrical nature of these
Chuck – despite the inaccuracies already highlighted this sub-assembly has been constructed well, be careful with alignment of ellipses
Threads –represented well, this includes their distribution and skewed axes
Shafts/cranks – constructed accurately but it might have been a good idea to draw those shafts with tang grips at a different angle to demonstrate their form

LINE INKING
Line accuracy – the neatness of your construction has not been transposed to you inking, take care with ellipse tangents and line junctures
Ellipse accuracy – some misalignment issues throughout and two of the components have been represented in the wrong perspective
Technique – very little thick/thin technique used, some highlights on inner ellipses and threads and parts beginning to overlap one another

ANNOTATION
Numbers – no annotations included
Lines and spacing – no corresponding annotation or assembly lines included

APPENDIX V – TECHNICAL ILLUSTRATION 2 FEEDBACK

CANDIDATE ONE

INTERPRETATION
Understand and accurately transfer schematic dimension and form to isometric representation of assembled parts. Some confusion over the outline shape of main casting; the front flange should not run smoothly into the spurs and the form of these has been misinterpreted. These should have a flat outer surface and a straight edge. Front cover plate should form a tangential suture with the main body. Flange/body fillet missing.

CONSTRUCTION
Use correct isometric conventions including any oblique projections necessary to generate an exploded representation of parts. All components positioned in accordance with final assembly. Some essential finer details missing but on the whole a good first attempt with this medium.

Use correct isometric conventions including any oblique projections necessary to generate an exploded representation of parts. No marks can be awarded for this outcome as no illustration has been submitted. This represents a missed opportunity as each part has already been constructed.

Use correct isometric conventions including any oblique projections necessary to generate a ghosted representation of the assembly. Good understanding and implementation of isometric throughout. Inconsistent dimensioning of inset valves. And no indication to the number of outlet valves. Threads missing from all valves and head depth too shallow.

LINE TECHNIQUE
Use of line work technique in order to differentiate between constituent parts and represent engineered finish of surfaces. An alternative technique has been adopted in order to represent ghosting. Outside edges of non internal components should be solid and internal line dimensions would benefit from being finer. Where outer lines run over inner ones convention dictates a white line halo should be used to suggest depth. These are inconsistency in line weights which represent inner and outer edges.

COMPOSITION
Consistent numbering of individual components within the assembly appropriately lay out within the allocated artwork area. Good use of available space. When overlapping elements try to use a space stand-off in order to differentiate between elements. No annotation or leader lines included and be consistent with tapering of apertures and ellipse edges.

CANDIDATE TWO

INTERPRETATION
An accurate transfer of data from orthographic to 3 dimensional representation. This suggests a developing understanding of engineering principals and plan interpretation. Threads are unrealistic in valve seats and absent in corresponding valves. Finished output is inconsistent with digital files!

CONSTRUCTION
All ellipses are formed well despite some of the path choices being questionable. The mass of nodes in the outside casting is normally a result of imported CAD data or auto-trace functions. Otherwise a good understanding of assembly.

You have developed a good understanding of ghosting techniques and their implementation. The next phase is to determine, through experience, which detail to include and which to assume. Function still needs to be represented which suggests inclusion of threads. No need to ghost through main shaft.

LINE TECHNIQUE
An interesting technique of shadowing repeated parts. Your innovation is to be commended but the effect questionable. Try to adhere to convention with this genre of illustration. A good balance of line weights but consider line tapering.

COMPOSITION
Well balanced layout but don’t be afraid to overlap parts where detail ill not be obscured. It is also acceptable to move sections of an assembly and indicate their position with the use of leader lines. Good balance of clear annotations.

CANDIDATE THREE

INTERPRETATION
The inner flange detail of the casting is absent; this should be raised in order to locate the casing. Despite some parts drawn from another side, their construction is accurate. Form of the main casting valve seats is good.

CONSTRUCTION
Isometric conventions have been adhered to throughout. The assembly of parts has been misunderstood in terms of order of valve parts; this is fundamental to their operation. Springs are missing from outlet valves. Although constructed correctly the holes which facilitate connection between casting and housing are misaligned.

No cutaway has been attempted and consequently no marks can be allocated for this outcome. This is a missed opportunity as each element has been illustrated.

No ghosting has been attempted and consequently no marks can be allocated for this outcome. This is a missed opportunity as each element has been illustrated.

LINE TECHNIQUE
A consistent line technique has been adopted throughout. It might have been more prudent to differentiate this further to suggest solidity and material. Spring have been drawn solid but could have had more detail at this scale. Ellipse tapering attempted in parts but others have no line differentiation.

COMPOSITION
Well laid out in terms of use of pace. More use could have been made of leader lines and don’t be afraid to overlap parts where this is not detrimental to detail. Remember to annotate all parts and don’t rely on vicinity of numbers to parts.

CANDIDATE FOUR

INTERPRETATION
All parts have been included. Threads have been omitted from internal and external valves and their corresponding seating. It is acceptable to omit repeated elements as long as an indication is given to suggest the existence of multiple parts. Inlet valve springs seem too large to be seated in their housings.

CONSTRUCTION
All parts well constructed with a minimum of nodes used. This is to an industry recognised standard and should benefit any future alterations. Grouping of elements is also conducive to editing and use on associated illustrations. All fasteners have been included despite their dubious location indicators.

No cutaway has been attempted and consequently no marks can be allocated for this outcome. This is a missed opportunity as each element has been illustrated.

No ghosting has been attempted and consequently no marks can be allocated for this outcome. This is a missed opportunity as each element has been illustrated.

LINE TECHNIQUE
Well balanced line work. Differentiation between inside and outside edges suggest form and is consistent. This balance should also suggest areas which might benefit from less detail. Most ellipses have been tapered and a similar technique could have been applied to ellipse/line tangents.

COMPOSITION
A good layout, but consider overlapping some of the larger parts so long as detail is not obscured and each can be distinguished from one another. This would allow each part to be larger. Annotation lines too long and do not join their part.

CANDIDATE FIVE

INTERPRETATION
End plate too thick. Misrepresentation of hole in main shaft. Incorrect form of spring plate. No screw holes included in end housing for attachment to main assembly. Clips will not fit the pins they are designed to secure. Valves not in correct proportion with seating. Introduction of non-existent spring locators.

CONSTRUCTION
Despite the flaws already highlighted, individual elements have been soundly constructed. Careful with misalignment of ellipses and un-filled back edges. There exist some proportional issues which suggest a misunderstanding of engineering principals. Fasteners have been placed in the incorrect location.

Although you have attempted a cutaway this seems to have been an after-thought and completely misunderstood. More work in this area needed.

An attempt has also been made at a ghosted illustration. Regardless of the overall effect this exercise has required you to assemble all parts in situ. Mostly this has been successfully but should have served to highlight misunderstandings in associated illustrations. The concept of layering has been missed here.

LINE TECHNIQUE
Based on the exploded illustration you seem to understand the concept of line weighting but this need be more consistent. The effect of fading repeated parts is resourceful but not common practice. No tapering of ellipses or tangents has been attempted and some main elements have only been half line rendered.

COMPOSITION
Annotations included but inconsistent. Don’t be afraid to overlap some parts to gain more space so long as no important detail is obscured. Make annotation lines touch the part they reference and ensure equidistant spacing of numbers.

CANDIDATE SIX

INTERPRETATION

A very good representation of parts which suggests a sound understanding of the underlying engineering principals. No fasteners have been included and the transposed hole in the shaft is incorrectly represented. Good to see you have considered the smooth form of casting. Valve heads incorrectly dimensioned.

CONSTRUCTION

You are beginning to understand the importance of node alignment to elliptical axes and the benefits of grouping individual parts. You have adopted some well improvised methods of tapering lines but remember to consider component scaling before implementing these in every situation. This is demonstrated mostly in the fine line weights of the main shaft at higher resolutions.

An excellent interpretation of a cutaway of a complicated assembly. This not only suggests a sound understanding of assembly but is encouraging in terms of evolution of your own style. This illustration justifies the value of cutaways by the way in which he viewer can comprehend the operation of the assembly.

A good clean illustration but the fundamental issue of ghosting has been missed. To suggest the encapsulation of some components within others white stand-off lines need to be used to differentiate inner and outer parts. Use of this technique also brings to light which detail can be omitted to describe function.

LINE TECHNIQUE

A very stylised approach which corresponds to all your work. The evolution of your own style is to be encouraged so long as you remain adaptable to contractual obligations. Your representation of threads is retrospective and tends to exaggerate their role in the scope of the whole assembly.

COMPOSITION

Well laid out in terms of use of space and good to see you have made selective use of overlapping. This is in no way detrimental to detail and to be encouraged. Try to resist the temptation to align annotations, although this discipline is good the effect is distracting from the main illustration.

CANDIDATE SEVEN

INTERPRETATION
Main shaft bush has been drawn in proportional to fixing. All individual elements have been included and illustrated in accordance with schematic dimensions. Transposed hole missing from main shaft otherwise all information well interpreted and represented.

CONSTRUCTION
All parts have been arranged in the correct order of assembly except for the spring plate retainers. Try to understand the role these play and their position. Each component has been well constructed in terms of node economy and alignment. Consider grouping of completed elements in order to facilitate reuse.

A good basic attempt at ghosting. In subsequent projects don't be afraid to be more ambitious in cut away section in order to better describe the function of the assembly. Most encouraging from this is the correct assembly of parts.

No ghosting has been attempted and consequently no marks can be allocated for this outcome. This is a missed opportunity as each element has been illustrated.

LINE TECHNIQUE
Although a variation in line differentiation have been included and used consistently throughout your illustration the end result is ineffective. This will come with experience and experimentation. Sometime is permissible to vary line weighting in accordance with part size to avoid filling in of detail. Consider representing springs and threads in a way which describes their form better.

COMPOSITION
Well laid out and encouraging to see you have used 'dog-legging' of leader lines to make more efficient use of space. Consider using annotation lines to guarantee correlation between component and label. Don't be afraid to overlap larger parts so long as this does not compromise detail.

CANDIDATE EIGHT

INTERPRETATION
All parts included despite some being misinterpreted from plans. Each of these is positioned correctly in assembly order. Fundamental misrepresentation of form of main casting. This part has been represented correctly in other illustrations. Spring pins should have a domed end in order to fix circlip.

CONSTRUCTION
Despite the casting misrepresentation the construction of individual elements is excellent. A minimum number of nodes has been used to generate each piece but it would have been good practice to group each of these. Many parts should be four in number and evidence of some non-joined paths.

Threads are missing from all the valves. Cut of main casting is accurate in terms of following isometric planes. The form of the casting in this illustration is more detailed than the exploded representation. Some confusion with regard to the end plate detail and bearing depth.

Threads missing from valves again. Repeated detail missing. Although their omission arguably simplifies understanding the existence of these parts must be represented in some way as they are fundamental to its operation.

LINE TECHNIQUE
Good balance of thick and thin on exploded illustration but less so in cut-away. Form of springs is good but a thicker representation would be more appropriate. Ghosting of outer components is good but such featured parts should still have heavier outer lines to suggest their importance. No tapering of holes or tangents.

COMPOSITION
No annotations included. Some of the more important leader lines are missing. Valve parts have leader lines which lead only to each other and there are areas of wasted space between parts. This can be reduced by dog-legging these.

APPENDIX VI – PERSPECTIVE FEEDBACK

CANDIDATE ONE

INTERPRETATION
As a general comment there is far too few constructed elements to form opinion of progression on. No tapped holes on front face of casting and no hexagonal heads or threads on unions. There is no representation of underside detail and valve springs have no thickness. At least one of these should be in a state of compression. Take care with intersection of holes and the resultant form.

PROJECTION
The correct ellipse values have been used at construction stage but have not been carried through to your rendering. There is little line work to form an impression from. Much of the detail has been transferred directly onto the rendered piece. The union housing section is inconsistent in thickness.

CONSTRUCTION
Construction does not match finished rendering. Despite the lack of detail there exists evidence of some disciplined in pencil work. Working at a scale like this is not conducive to inclusion of detail. Included elements have been constructed well, suggesting time issues and not inability to implement.

RENDERING
No differentiation between line weights. Untidy sutures. Hand drawn annotations. Some attempt at ghosting made. Remember to include stand offs for annotation lines. Little depth indicated by the absence of shadows. No textures have been included to suggest materials used. Cover plate is barely disguisable and is attached by no fasteners.

CANDIDATE TWO

INTERPRETATION
No fasteners have been illustrated at construction stage despite their inclusion in the parts list. No threaded holes of centre point indicators are present also. Roller bearings have been used rather than the ball bearings shown on the plans.

PROJECTION
Ellipse values are accurate throughout and casting is dimensionally correct. This element suggests a sound understanding of the principals which define use of the trimetric scale. Diminishing scale used to good effect on this project.

CONSTRUCTION
The construction phase is incomplete and its casual form is more representative of a sketched study than a preparatory illustration. Although it is encouraging to witness that you are able to visualise form, the purpose of this exercise is to generate a template from which to render.

RENDERING
The bosses are out of proportion and not in perspective. The cut-out profile has some edges obscured by other components. Representation of threads are inconsistent and some over elaborate. Some issues with tangential alignment of casting. Hatching is not normally used in perspective illustration.

CANDIDATE THREE

INTERPRETATION
You have endeavoured to construct each element at construction and rendering stages. Feet should protrude from front face of casting. No hexagonal heads on plugs. No fasteners included. Plugs misinterpreted as two separate parts. The only concern is your representation of the union elements as two separate parts which suggests more experience needed with reading plans.

PROJECTION
Ellipse values correct in relation to point of perspective. Lines run along perspective and, on the whole, you have observed the rules of diminishing scale. The front casting foot appears smaller than the rear due to construction errors.

CONSTRUCTION
This is a very encouraging construction. All ellipse axes have been included which will aid later rendering. Your pencil work is becoming neater and ellipse tangents are mostly good. All parts have been constructed on grid and in accordance with their final location. This is fundamental to retaining their perspective.

RENDERING
No internal detail shown on rendering and interpenetration of elements of casting are incomplete. Non uniform representation of spring coils. Casting fillets have been constructed with radii template. There is evidence of some freehand lines but you have attempted to demonstrate depth by the use of line weights.

CANDIDATE FOUR

INTERPRETATION
All parts included and dimensionally sound. Each element has been positioned according to assembly. No threads have been included on valves, unions and plugs.

PROJECTION
Appropriate amount of perspective chosen in order to demonstrate the functionality of the assembly. Ellipse values mostly accurate some suspect.

CONSTRUCTION
Line work good. Might have been a good idea to choose a ghosted or a cut-away view and not combine both. Good detail has been included on individual elements in terms of chamfers and fillets. Major and minor axes included.

RENDERING
This seems to be an after-thought or did you run out of time? Some attempt made at line weight differentiation but the end effect is insignificant. Fasteners appear to have been hand drawn. Threads missing from valves, unions and plugs. Bearings sketchy and would not normally be sectioned. Springs need to be emphasised more to suggest their key function.

CANDIDATE FIVE

INTERPRETATION
Inner chambers of main casting included on final illustration but omitted from construction stage. Fasteners and hole sized of cover plate misrepresented entirely. Too little detail on valves and unions. Springs are not representative of their actual form.

PROJECTION
A good projection chosen for an assembly of this size and a suitable view angle. All ellipses appear to be of the correct values despite some being missing. It would have been a good idea to construct this at a larger scale in order to demonstrate its finer points of operation.

CONSTRUCTION
To many missing elements. Major and minor axes have been included on major ellipses despite some of these being slightly out of alignment – be careful. Some evidence of considered construction but too many errors in proportional accuracy. Cam should not have holes drilled into it.

RENDERING
You have chosen to illustrate the final piece in a digital environment. This is acceptable, but arguably a missed opportunity to hone your hand skills. Perspective illustrations negate the advantages of duplicating parts. Although you have used a file type which is tolerant of scaling the print is pixilised.

CANDIDATE SIX

INTERPRETATION
We must assume plugs have been constructed in-situ because of their absence as an individual component. Some detail missing from inner chambers on both construction and rendering.

PROJECTION
Suitable choice of view to describe functionality of assembly. Good use of artwork in terms of spacing. Unfortunately as no grid has been included, this makes it difficult to correlate construction and plans. Other evidence suggests a sound understanding of trimetric scale principles.

CONSTRUCTION
A disciplined approach. You seem to have benefited from your decision to construct this at a larger scale than the plans. Threads missing from valves and unions. Bolt heads fully constructed but smoother construction of cams needed. Good breakdown of bearing components.

RENDERING
Little differentiation between thick and thin lines. Springs should appear as a consistent diameter regardless of viewing angle. No threads have been included on valves and unions. Plugs could be interpreted as hole as they have been represented in situ. Some confusion with bearing seating. Annotations included.

CANDIDATE SEVEN

INTERPRETATION
No bearings included in construction. Front s spring in incorrect location. Feet should make more contact with main body. Underneath plugs included but no indication of location. No fasteners included. Valve balls missing.

PROJECTION
Ellipses constructed in correct perspective.

CONSTRUCTION
Pencil work needs to be neater.

RENDERING
Cut away constructed on rendering. No chamfering of bolt heads and some distortion on form. Plate holes tapered but don't align with threaded holes. Line weights included.

CANDIDATE EIGHT

INTERPRETATION
Bearing not included in construction. Cover plate must be constructed in proportion in order to maintain true perspective. Holes missing from casting. Dimensionally sound. Although it is tempting to only include some detail in final rendering in order to avoid repetition, this template might be intended for completion by another or at a later date.

PROJECTION
Ellipse values are correct but casting bosses are not aligned with perspective. Rear foot appears larger than front foot. Cam profile has been plotted but consider exaggerating narrow ellipse to emphasise function.. Bearings, fasteners and valve balls missing. Method of projection understood and implemented.

CONSTRUCTION
Despite being incomplete, you pencil work is accurate. Don't worry too much about representation of threads on construction stage. Springs appear flat! Ellipse and line tangents are good and ellipse axes included.

RENDERING
Springs are transparent. Detail of bearings is vague and one is completely absent. Line weights included but inconsistent. Cover plate not in proportion. Unions are not the same size of proportion even after allowing for diminishing scale.

APPENDIX VII – ILLUSTRATION PROJECT FEEDBACK

CANDIDATE ONE

RESEARCH
Your research suggests comprehensive understanding of the project beyond what the illustrative focus suggests. Good use of referencing and evidence of a breadth of research. Although the textual explanation of function is accurate and comprehensive it is to associate this with the illustration.

CONSTRUCTION
No construction. Smaller studies are just repetition of larger. Except from schematic. Detail is good but his is someone else's presentation. This can only be judged as a measure of your tracing skills. Reliant on the accuracy of someone's construction. Other than some minor errors line work is ok.

RENDERING
Flat and clean but a missed opportunity to convey texture and form, shadows. Individual elements have been isolated by tour rendering. Colour scheme is complementary and aesthetically pleasing.

COMPOSITION
Insets are bleeding out into background. The dynamics of Individual components would benefit from annotation and directional indicators. Good use of environmental graphics. Positional struts appear as a second set of blades and no indication of how the unit is fastened to the aircraft.

CANDIDATE TWO

RESEARCH
Some misunderstanding in terms of research. This has been documented entirely as a learning log rather than a collection resource material. You have undoubtedly done this but evidence is required in order to gain credit.

CONSTRUCTION
Isometric is an ideal perspective for this scale. Some issues with projection of back faces of some components. Not enough teeth on gears, these seem to be because of duplicated scaling of an original. No convoluted profile on teeth. Chain does not follow complete path. Filled in apertures in derailleur. No centre axes on cogs. Main spring does not align to other components. Both sides of chain are unattached.

RENDERING
Be careful with lower line width. Ensure solid fills in main body of components and holes are holes. Ghosting of chain set good but be consistent with layering of components. Remember to match gradient styles to form of component. No need to draw so much attention to leader lines.

COMPOSITION
Good use of schematics throughout. A missed opportunity to demonstrate use of graphical composition. Type appears as an afterthought despite being technically correct. Individual elements are good but composition needs guidance. Interesting background graphics which are not distracting.

CANDIDATE THREE

RESEARCH
Excellent research into construction and assembly of components. Only submission to look into depth of materials. Missed opportunity to demonstrate your project was based on a disassembly of the artefact. Photos to be enough.

CONSTRUCTION
Excellent drawings submitted. You have attempted and succeeded in drawing and assembling some difficult and varied components. An opportunity missed to draw a fully assembled or a different drawing technique.

RENDERING
Line drawings completed by hand and very clean and clear. Some tricky details a little scrappy but otherwise very controlled. Shame only one technique.

COMPOSITION
No real attempt at a composition beyond construction of basic drawing. Main sheet good with informative annotations but missed opportunity to create visually interesting artwork. Care should be taken over application of cables.

CANDIDATE FOUR

RESEARCH
Some fundamental misunderstandings suggest too little emphasis on the research element of this project. No documentation was submitted for this outcome as an operational model was used for reference.

CONSTRUCTION
Break calliper assembly has been located too far outside the wheel and in some places beyond the tyre. Balance of detail is consistent throughout. No obvious misalignment of components. More thought needed into layout of individual parts. Threads needed on bellow fasteners. Good representation of threads on main hub. Assembly order of piston and housing misunderstood and detail missing.

RENDERING
Clean modern line work and well balanced. This style would be more suited to an assembly manual than an illustrated project. A missed opportunity to develop your own illustrative style on this display piece. Location indicator a little rushed.

COMPOSITION
Layout reasonable in light of basic nature of project. Text appears in a book like format. This is a missed opportunity to demonstrate your own graphical skills. Some of the technical details are inaccurate and the general arrangement does not suggest any form of dynamics.

CANDIDATE FIVE

RESEARCH
Despite being a little thin on source material this report is concise and suggests a sound underpinning knowledge of your project. You have highlighted the materials used in manufacture which should aid you in reproducing their effect.

CONSTRUCTION
You have attempted to use knowledge of previous disciplines in order to construct this project. As a result you have been able to attempt a reasonably complicated project. You have achieved an understandable assembly regardless of construction method. You have been recognised for the ambitious nature of this project and the construction of each part. Some elements are under facetted.

RENDERING
Rendering corresponds to this form of digital construction although this has been successfully stylised. Aesthetically balanced and ambient despite some fundamental misunderstanding of engineering principals and materials.

COMPOSITION
A somewhat random approach to composition in which text does not clearly correlate to illustration. Some inconsistency in terms of study representation.

CANDIDATE SIX

RESEARCH
The depth of your research suggests more than just an operational knowledge of your chosen subject. This needs to be translated into a graphical representation in order to fully gain the benefit from this. Despite the scope of your investigation it is important only to focus on the data pertinent to an understanding of the operation of the device.

CONSTRUCTION
A good clean construction which suggests a level of comfort with your chosen development environment. A deeper examination of construction displays an encouraging indication of your disciplined approach to illustration. Each element has been constructed with a minimum of vertices; this is a feature which will complement any future similar projects.

RENDERING
A very stylised approach to rendering. This project has allowed you to indulge your interest in retrospective line techniques. Freestyle projects provide an ideal platform for this form of experimentation as long as you do not loose sight of the corporate rendering styles which have become synonymous with modern illustration.

COMPOSITION
A well considered graphical representation which demonstrates your abilities in this area. Your project provides a good example of how a balanced representation can complement an illustration.

CANDIDATE SEVEN

RESEARCH
Very good focussed research into the mechanical and operating principals of how slot machines work, well done. Good understanding has been achieved although a little more technical nomenclature on components and actions would be helpful.

CONSTRUCTION
Isometric drawings all seem well constructed with good line weighting and consistent attention to detail. You have not shied away from drawing assembly mechanisms. Some areas a little over simplified hand drawn insets are clean and informative.

RENDERING
Illustrator drawings are detailed and well angled to inform observer. Hand drawn elements are clean and tight, but could do with a little more definition, maybe by increasing contrast to visually balance against line work.

COMPOSITION
Final sheets, although very clean and clear, but conveys very little information. Image needs to be accompanied by text and/or annotations based on excellent information in research.

CANDIDATE EIGHT

RESEARCH
Research into subject area excellent. You have made a great effort to make contact with industry experts and gain real information of existing applications of your chosen system. It might make sense to pair the bulk of your learning log don if being handed in as part of the research material. Source material too scrappy to hand in.

CONSTRUCTION
Construction of technical isometric drawing looks good. No attempt to draw assemblies even though captions describe the function of multiple parts. 3D models look sound, but difficult to assess with no marked dimensions attempt to show internal process/construction.

RENDERING
Rendering of images good although computer generated. Nice use of solid rendering/iso-line work shows form and function of individual components.

COMPOSITION
Sheet has clear, clean look. Simple graphic guides render well. Written text a little thin on overall fact and yet bogged down in small detail. Nice to see different drawing types, although these could clearly be generated by the same 3D model. Would be nice to see ghost/cutaway to graphically back-up text. Shows principle fairly well to observer.