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Spatial Visualization and Professional Competence

The Development of Proficiency Among Digital Artists

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ISBN 978-3-319-91288-2 ISBN 978-3-319-91289-9 (eBook)
https://doi.org/10.1007/978-3-319-91289-9

Library of Congress Control Number: 2018950209

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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Abstract

The teaching of digital artists has received ongoing criticism from industry sources, who feel that graduates are rarely well prepared for employment. This is a problem for students when they seek employment, for employers who must hire qualified digital artists, and for the reputation of educational institutions that provide instruction in this domain.

Students from the Netherlands' International Game Architecture and Design (IGAD) visual arts programme participated in research designed to investigate how proficiency develops in the technical and creative discipline of digital art. This study used an exploratory mixed methods design that triangulated archival data on 625 digital art students, who have attended IGAD with qualitative data collected from 20 current students, 5 digital art supervisors and 5 employed IGAD graduates. A mixed methods design was chosen so that historical performance could be compared with data collected directly from student participants, particularly on the subject of how prior experience influenced later development.

Student participants provided information relevant to their learning process, industry supervisors evaluated student work against professional standards, and employed graduates provided a perspective on the transition from student to industry practice. Data collected for the quantitative study was in the form of archival records regarding prior experience and later performance. The qualitative study utilised learning logs, progress reports, project files and interviews with all participants. Correlation and analysis of variance (ANOVA) tests were used in the quantitative phase of the study. Case study analysis was used for the qualitative phases of the study.

Based on the data gathered, visualisation of surface deformation and topology are obstacles to developing proficiency in the digital art specialty of NURBS modelling. Student digital artists developed proficiency as NURBS modellers through three specific types of visualisation skills. These allowed them to become proficient rapidly and produce work that showed the hallmarks of professional practice in the digital art.

This research adds to existing work on spatial visualisation, threshold concepts and the development of expertise by demonstrating how a type of spatial visualisation can function as a threshold obstacle to the development of proficiency and expertise. The original contribution to knowledge is that visualisation of surface deformation is shown by this research to be a threshold obstacle to developing proficiency in the digital art specialty of NURBS modelling.

Keywords Assessment · Computer graphics · Expertise · Industry
Proficiency · NURBS · Spatial visualisation · Technical education
Threshold concepts · Topology · Transfer

Chapter 1
Introduction

This is a study about the nature of proficiency in digital art as a professional practice, how it is developed in an educational setting, and how teaching practitioners assess developing proficiency. Study participants were recruited from a digital art training programme that is situated within the norms of professional practice found in the computer graphics industry, making it an appropriate subject for the research questions posed in this study (p. 8). This study is about proficiency in a specific commercial industry: what it is, and how it is developed, measured and evaluated. It is situated within a particular domain of professional and artistic practice, and within an institution, department and curriculum that prepares students for that practice.

The Computer Graphics (CG) industry employs digital artists who work with 2D and 3D imaging software to create graphic elements for special effects in feature films, video games, military simulations, and industrial visualisations. Digital artists must be proficient to fill industry positions, yet university programmes designed to educate digital artists are notorious among industry professionals for producing inadequately prepared graduates (Flaxman 2003; Livingstone and Hope 2011). Although secondary school graduates eagerly apply for admission to digital arts programmes available around the world, few of their graduates successfully enter the industry as digital artists.

My goal in making this investigation is to observe digital art students in an educational setting to learn how they develop industry-standard proficiency. If this process can be better understood, it may be possible to restructure curricula so that digital arts programmes more adequately prepare graduates for professional work in the industry. This would increase the number of employable graduates and qualified working professionals. Both universities and industries benefit from a larger pool of proficient graduates; therefore, the results of this study have implications for curricula design, learning studies, proficiency research and the local and international digital arts industry.

A. Paquette, *Spatial Visualization and Professional Competence*,
https://doi.org/10.1007/978-3-319-91289-9_1

1.1 Conflict Between Academic and Workplace Learning

Historically, some industries have preferred workplace learning to university education. For instance, during the Industrial Revolution, scorn for university-trained engineers was so great that independent training centres were created by the industry as substitutes for university education (Wellens 1959). This was due to a preference for 'practical' rather than 'college-trained' employees among employers (Musgrave 1966). The same reaction found in these older technical education studies is visible in the domain of digital art, where new technology has created problems for educators in higher education (McCracken 2006).

It is implicit in the context of modern competency-based standards endorsed by the UK government (Blackwell et al. 2001; Tight 1998) and accountability requirements in career and technical education set by professional associations (Castellano and Stringfield 2003; Hargraves 2000; IGDA 2008) that workplace education should fulfil unmet industry needs. This is reflected in a pair of government reports published in the UK, known as the Dearing Report and the Fryer Report, each of which supports more workplace-centric education (Blackwell et al. 2001; Tight 1998). The focus in these reports and the government initiatives that inspired them is on improving the quality of technical education by bringing students into the workplace (with internships) or by helping educators improve the quality of education in universities by providing industry-specific recommendations.

1.1.1 Digital Effects Industry Reaction to Digital Art Education Programmes

According to the U.S. Bureau of Labor Statistics (2012), employers of digital artists do not require a college degree from applicants, but they look for workers who have a good portfolio and strong technical skills. Artist demo reels provide a way to measure the success of digital art instruction. A demo reel is a collection of edited video clips that represents a digital artist's best work. Unlike in other professions, an artist's CV and educational background become relevant only if the demo reel is sufficient to demonstrate that the artist can meet industry quality standards. However, 'despite a growing market overall…hiring managers report that they must sort through hundreds of demo reels before finding a single qualified applicant' (Flaxman 2003, p.1). Based on feedback from industry sources, few digital art programmes produce graduates that meet professional standards (Ip 2012). Schools that provide inadequate instruction are described as 'get rich quick institutions' that ignore industry standards and teach software instead, resulting in 'completely unprepared' graduates (King et al. 2008, p. 1). Graduates find it difficult to find entry-level jobs because their qualifications 'fall short' of industry standards (McCracken 2006, p. 1), prompting industry experts to call for digital art programmes that include a core set of competencies (King et al. 2008).

In the UK, a review of game design and computer graphics programmes was conducted by Livingstone and Hope (2011). The review was conducted at the request of the UK Minister for Culture, Communications and Creative Industries. The results describe significant shortfalls in the way educators in the UK prepare undergraduates for careers as digital artists. The authors point out that despite a large number of available university programmes relevant to digital artists, graduates have poor job prospects due to flaws in their courses (Livingstone and Hope 2011). The problem is even more urgent because computer graphics tools and techniques migrate from entertainment-related industries to other industries that use the same technology, such as medical research, military simulation, education and product visualisation. Livingstone and Hope's conclusion that digital artists are ill-prepared for careers in the industry is consistent with the findings of McCracken (2006), who claims that 'with the reality of poor job placement, it is clear that the present model of [digital art] education is insufficient for its graduates' (p. 9).

Poor placement of digital art programme graduates in industry jobs is a well-known problem in this education sector. An example of this is provided by the rapidly growing UK industry, where artists are hired from overseas due to local skill shortages (Livingstone and Hope 2011). This is consistent with Flaxman's (2003) claim that only one out of 'hundreds' of applicants in the U.S. and abroad is qualified to work in this industry. The reason jobs remain unfilled despite willing applicants is that 'even entry-level positions have extremely high standards' (McCracken 2006, p. 8). That these jobs are left vacant despite the number of programmes graduating students in the UK every year implies that UK universities are not providing their digital arts graduates with the skills needed to be employable in the industry.

The interests of educators and students are ill-served by programmes that produce graduates who are not qualified for their target profession (Cranmer 2006). As Livingstone and Hope (2011) report, after interviewing over half of the UK's visual effects and video game industry employers, there is real dissatisfaction with the local talent pool. To improve education in the computer graphics sector, educators need to address the problems found by prospective employers. However, the approach to a solution is not consistent due to differing perspectives on the problem.

1.1.2 Conflicting Explanations for Digital Art Education Shortfalls

A study conducted in the UK analysed the curricula of 242 undergraduate game-orientated programmes and compared them with recommendations from the industry. The study found that the curricula in digital art programmes rarely coincide with industry expectations (Ip 2012). This was unexpected because digital art programmes are designed to produce work-ready graduates for industry, yet in the majority of cases do not incorporate advice from industry professionals and then produce unsatisfactory results. Why do so many digital art programmes fail to follow industry recommendations when designing their curricula?

McCracken (2006) suggests that digital art programmes should be subdivided so that 3D art and animation are not taught together as part of the same programme. He emphasises that in separating these disciplines, schools should remember that educating digital artists is as much about art as technology. In contrast, the thrust of recommendations from Livingstone and Hope (2011) is that digital art students have a deficient understanding of science, technology, engineering and math (STEM) and must therefore be encouraged to study STEM courses. This conclusion is almost the opposite of McCracken's art-centric recommendation, thus putting the two proposed remedies in conflict. If schools were to use their resources to emphasise STEM classes, those same resources cannot be applied to enhancing the art-centric classes advocated by McCracken.

The International Game Developer's Association (IGDA) published a curriculum framework for educators in 2008 to help steer university curricula in a direction more compatible with internationally-recognised industry requirements. While acknowledging that no curriculum can equally serve the needs of all industry members, it provides general guidelines for game programmers, designers and digital artists. For artists, the IGDA emphasised that teaching students visual design principles in classes such as drawing, painting and sculpture was more important than training students to use specific software applications (IGDA 2008). This emphasis on core art training instead of technology is representative of a dichotomy found when reading about education for digital artists in the literature.

According to McCracken (2006) the demands of learning digital art technology are so daunting that a four-year bachelor's programme does not provide enough time to become proficient in any given specialty, let alone provide the artistic sensibility needed to make good use of one's technical skills. On this subject he writes, 'So many courses were deemed necessary that a bachelor's student would have to attend school full-time for eight years before graduating!' (p. 9).

Ip's study (2012) of 242 game development programmes in the UK found that courses designed for visual artists only rarely matched course recommendations by IGDA or SKILLSET in the UK. For instance, in the first year of undergraduate art programmes, a maximum of 24% of taught curriculum content matched recommendations from the industry. This was particularly surprising for art programmes where art classes might be expected to be the focus on the basis of industry recommendations from the UK and abroad. The same thing was found in engineering courses where educators were

> required to reduce the total number of credits to graduation, often resulting in fewer credits available for graphics instruction. Secondly, pressure was exerted on graphics educators to include additional topics such as CAD, design, and creativity in their introductory courses. (Sorby 1999, p. 21)

Sorby (1999) and Ip's (2012) findings highlight a problem described by McCracken (2006). Any attempt to obtain a broad education as a digital artist is bound to be difficult and is unlikely to succeed because students are inevitably given too many subjects to master in depth in the time available (McCracken 2006). How then can an undergraduate digital art programme best prepare its students for careers in the various CG industries that employ digital artists around the world? A way to better understand this question is to look back at the origins of the CG industry and how early adopters of CG technology became proficient in its use.

1.1.3 Influence of the CG Industry on Education Options

The modern era of CG images in film started in approximately 1989, with the release of the film *The Abyss*, directed by James Cameron. The popularity of CG visual effects in the film and video game industries in the early 1990s created a need for skilled artists to work in the medium, but at the time (as today) the number of skilled digital artists was insufficient to supply the demand (King et al. 2008). Each technical innovation added to the possible level of sophistication and quality, thus raising expectations for digital artists and increasing the number of specialties available to learn. For example, hair and cloth simulations became separate specialties when advances in technology made this distinction possible. This makes the field of digital art progressively more fragmented and unwieldy for students and educators.

Although updated CG technology has made new things possible, it does not necessarily make them easier to do, nor does it always take the place of something else. For these reasons, CG projects become more complex and more work overall, because there are more elements to keep track of. New technology does replace old technology in many ways, thus making it hypothetically easier to accomplish tasks that were more difficult when using older software. However, the new technology tends to render the old technology and the tasks associated with it obsolete, while adding complexity that requires more work to exploit. Therefore, the outcome is higher quality and more variety in the type of effects that are possible, but no net gain in efficiency.

1.1.4 Differences Between First-and Current-Generation Digital Art Education

Artists who want to work in digital special effects must learn how to use the relevant equipment and software. For most of the 1990s, three companies made the dominant animation software in the feature film industry: Alias, Wavefront and SoftImage. All three applications ran only on UNIX computers manufactured by Silicon Graphics Incorporated (SGI). The popular SGI Indigo2 workstation was originally priced at over $100,000 when loaded with any one of these applications (Pahler et al. 1994; Seastrum et al. 1994).[1] Among less powerful PC- and Mac-based alternatives, the

[1]This price is converted from Japanese Yen.

most popular was Autodesk's DOS-based 3DStudio software. It was used primarily for architectural visualisation and games, and released in 1990 at a price of about $4000. These prices, even for the comparatively inexpensive 3DStudio, represented significant investments for anyone without a serious interest in the medium, particularly students, and that does not take into account the time or effort it would have taken to learn how to use the software.

Visual effects artists and animators with studio jobs had access to equipment and training at their workplaces, but others did not have this luxury. At the same time, the world's first web browser, Mosaic, had only just been launched (in 1993), and the large Internet-based support structure of user forums, developer FAQs and assistance chat lines that exists today had not yet been developed. Any person who wanted to make 3D digital art for video games or film in the early nineties had very few options beyond making a significant financial investment and then learning on his or her own or via on-the-job training at an employer that was switching from 2D to 3D animation. The need for affordable digital art education was partly answered by the first degree-granting digital art bachelor's programmes, which were introduced in the UK in 1989 and the US in 1994 (Comininos et al. 2009; Digipen 2011), but these two programmes were too few, too small and too unknown to deal with demand.

The difference between learning computer-aided design (CAD) and animation software in the nineties and today goes beyond lack of access to well-designed training materials and expensive software and hardware. Many of the people who learned digital art techniques in the nineties had at least one significant advantage not enjoyed by contemporary students. CAD users in the 1990s typically had degrees in architecture or mechanical engineering and used the technology to test the manufacturability of existing designs, as opposed to making the entire design in the software (Brown 2009). For them, CAD skills were not the basis for their employment, but one of many tools they used in their work to accomplish goals they understood from years of experience in their field.

At Industrial Light & Magic (ILM), employees trained as 2D animators or practical visual effects artists were already employed as professional artists when they were provided access to digital art software and training. At Disney, artists with decades of experience timing, posing and animating cartoon characters merely had to adapt a new tool to their existing knowledge of animation. They did not have to learn the principles of animation from scratch or pay for expensive new equipment (McCracken 2006). Early adopters of CAD and 3D animation software were learning a new tool to enhance careers that had already developed to the point of proficiency or expertise. In contrast, many contemporary students enrol in undergraduate digital art programmes as soon as they graduate from high school. When they enter a digital art programme, they have no prior experience as working professionals, nor any prior supervised training at a university.

The difference between these two generations of learners is that the first generation of digital artists had to acquire knowledge of new tools in service of existing expertise, but the current generation must acquire the knowledge and skills of an artist at the same time as they learn how to use computer-based tools. Tool knowledge may be all that is required for individuals who have well-developed art skills, but an education