Challenges of Using Digital Fabrication Techniques for Design Education in Countries with Developing Educational Level

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Abstract

Arts and Design education in countries with developing preliminary educational level often follows traditional methods of teaching, similar to and partially adopted from programs in the United States and Europe. Unfortunately, these teaching paths often pay no great attention to the specific preconditions that preliminary education in these parts of the world entails, but that constrain the intellectual capabilities and mechanical skills of the local student body. Whilst students in the Western world are usually equipped with a good level of craftsmanship, students in these countries often fundamentally lack these skills. Using the example of the United Arab Emirates the paper discusses our experience with students missing these life experiences through which others gained the mechanical skills necessary to design or craft models, prototypes or products of their respective arts or design discipline. Many of these students have never renovated an apartment, repaired a bicycle, fixed a broken toy, or even felt an absolute necessity to develop these skills. Our research addresses the educational challenges and opportunities that arise from the use of innovative fabrication technologies, especially robotics, in an environment with suchlike limitations. We research the impact of these technologies onto the quality of the students´ work and derive answers from these works to adjust or maintain the direction of current and future curricula.

Keywords: *Digital Fabrication, Robotic Machining, Craftsmanship;*

1. Context of the research

This research is built upon observations made with a cohort of 19 students from a Furniture Design class at Zayed University in the Spring 2018 semester. Some observations are manifested through experience with individual students the authors mentored over the last 2 years. The paper describes the author´s observations of output and occurrences during this class. The research is the beginning of an empirical study, with evidence being collected in coherent classroom environments.
The demographic of this cohort was a homogenous group regarding gender (female), age group (20-23), discipline (design 95%, art 5%), year of study (semester 7 of 9), and degree (BFA). All students of the cohort are Emirati nationals that underwent similar preliminary and university education, with the majority of students not having had much experience with skilled manual work, such as household repair or renovations works. None of the students had ever operated a Robotic Machining Center, very few (≤ 5%) used a 3D Printer beforehand, but all students had used a laser cutter. All students gained former training in graphic software such as Adobe Illustrator, Photoshop, and InDesign. All design students (95 % of the cohort) took a mandatory class in Computer Aided Design as a basis for graphical data input.

2. Rationale and technology integration

2.1 Rationale behind the research

The rationale of the research is based on selected theses [1], that address the demographic background of our students, their preliminary education, social trends, as well as traditional and modern pedagogical approaches. None of the below aspects that led to the formulation of the theses is by default good or bad, right or wrong. Aspects that where lacking in a student’s education and that one might see as a deficiency to reach a certain educational goal, might have never been an important element of family or school education for very good reasons. By way of example, in an environment with harsh climate the opportunity to ride a bike is minimal, thus the necessity to repair a bike is almost never given. Thus, the skills to fix a damaged bike, to develop alternatives in case spare parts are not available, to re-think a bike´s method of operation - as a placeholder for any other technical object - are not practiced. Activities that are culturally not endorsed might also be cogent reasons for not gaining a certain skill. The theses help to identify causes for some of the issues the educational

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system faces, when traditional practices that worked for decades in the Western world fail in the local environment. They are intended to identify alternative methods of instruction and should challenge those that teach in similar environments to reflect on their own practices.
Thesis 1 - Preliminary education in the UAE through schools and families pays minor respect to the development of manual crafting techniques. Thus, the level of craftsmanship amongst local students is considerably low.
Thesis 2 - The lack of manual crafting experience results in a lack of understanding of how objects are principally designed and constructed. Thus, the results of student work where these principles apply are often of poor quality.
Thesis 3 - Within the given timeframe, traditional university education in the UAE cannot make up for skills that Western students gained through 20 years of life experience. Therefore, it is necessary to develop alternative methods of instruction.
Thesis 4 - Digital Fabrication techniques and robotics have proven through industry applications that they are well suited for the creation and assembly of products. Thus, it is likely that these techniques can also be successfully applied to those Art and Design disciplines that use similar processes.
Thesis 6 - Students can operate digital devices without an understanding of their inherent principles of operation. Thus, traditional approaches where students must read a manual or get a formal training first, might render obsolete. This might not be true for the operation of devices that are a potential safety hazard.
Thesis 9 - Many disciplines in Art and Design share the same principles. Thus, Art and Design education should be less oriented toward individual programs, but more toward the development of competency in these shared principles.

2.2 Technology integration

The technology used in the course can be divided into low-tech and high-tech machinery and tools. Low-tech devices are common tools such as electric drills, cordless screwdrivers, sanders, as well as non-electric hand tools such as saws, hammers, screwdrivers, torches, brushes, and glue. High-tech machinery that was available to be used in the course were the 8-axis Robotic Machining Center (Fig.1.), a laser cutter, 3D printer, and a 3D scanner. Students used all low-tech machinery, and selectively the robot and the laser cutter. Operations were mainly milling, drilling, cutting, and assembling parts for different furniture items.

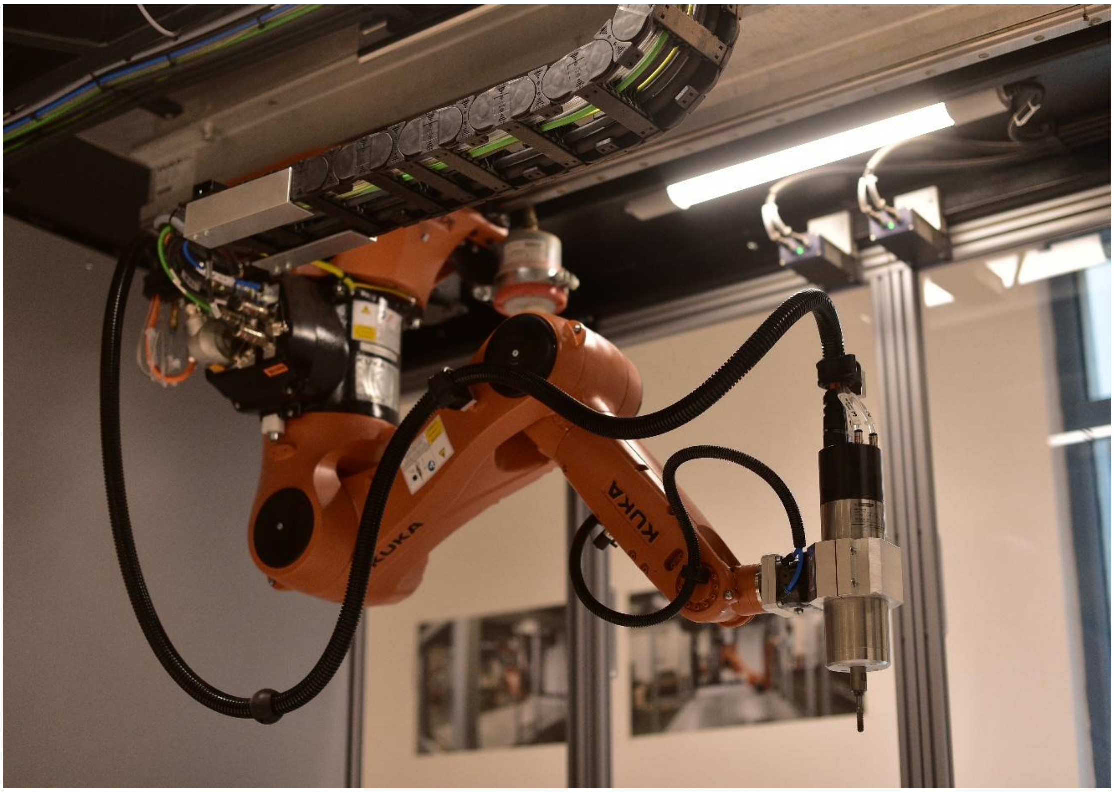

Fig.1. The 8-axis Robotic Machining Center with a KUKA Agilus Robot, Prof. Thorsten Lomker

3. Observations and implications

3.1 Interaction with technology

It wasn´t unexpected that students were not averse in using high-tech machinery such as the Robotic Machining Center (see Thesis 5). They were very engaged in all aspects of setting up the robot base, positioning the part to be machined, as well as operating the robotic device. It is assumed that this is since failure in the robotic operations are often not immediately observed as someone´s personal failure. When the robot quits an operation or halts, it could be due to many things. It is not entirely clear if it is because of a person´s mistake, a software or machine error. Failure is part of the process and we never observed a situation where someone was personally made responsible. It is more a shared responsibility between a single or group of students and the machine. This is entirely different with low-tech devices, were the source of the problem is usually evident. It is often one single person that is not able to hold a hammer, not strong enough to use a saw, not knowing the direction of how to tighten a screw. In rare cases it could indeed also be a malfunctioning tool. However, some students were practicing the usage of low-tech tools after hours to avoid compromising themselves during the class. It appears that through the usage of high-tech devices that fear can be overcome. Familiarity with digital technology provides students with an easier starting point and without stoking fears of failure. We came across a student using a portable 3D scanner for the very first time without encountering any issues. The operation of the device requires coordination of at least four tasks at the same time, i.e. holding the scanner in a position with the correct angle, adjustment of a level bar on the computer screen in between a minimum and maximum value, holding the correct distance from the object to be scanned, and paying attention to the scanned object as well as to its digital representation on screen. Most likely all of this whilst moving around the object to be scanned. Our observations showed that students had little issues operating the device, especially those with an intense gaming background.

Fig.2. Students cleaning a robotic engraved pattern with compressed air, Prof. Thorsten Lomker

3.2 Misinterpretation of facts

Even though this cohort of the students was formally trained in a wide variety of different software packages, we encountered that they often chose the wrong tools for the tasks. They were indeed also trained in sketching and manual drawing techniques, but both, the digital and the manual techniques often did not display proper instructions on how the furniture objects were designed or constructed. Our assumption was that this made it difficult if not impossible to build them using either low- or high-tech machinery.

We encountered all the above, sketches that didn´t work, incorrect or imprecise drawings, produced with the wrong software packages, as well as constructive shortcomings. Astonishingly, all these aspects that were indispensable to be correct in former times turned out to not be too much a problem when it came to the fabrication of the furniture objects. This applied to low- tech as well as high-tech machinery. When students started the manual crafting of the furniture, they figured out by doing where the obstacles in their design drawings were and they overcame these by choosing alternative routes. They learnt to some extent about the mistakes in their drawings, and that they had to develop alternatives on the fly, which they did and mostly succeeded. It was one of the most astonishing encounters when we saw that drawings with insufficient accuracy, errors in scale, or similar issues, did not hinder the students to fabricate the objects with the robot, resulting in a machining process that wasn't as accurate and efficient, but nevertheless produced acceptable results. This is equally true for other devices and techniques used such as the laser cutter.

3.3 Plagiarism - or learning from others

Plagiarism is indeed an issue that happens in many institutions around the world. Familiarity with digital technology also has its downside in terms of students having access to a plethora of different sources. It is not rare that the borders between reasonable design influence and inspiration on the one side, and intolerable plagiarism on the other, dilute. It is beyond all question that plagiarism cannot be in accord with a university´s code of conduct. However, having a look at countries such as the UAE, reveals a multitude of influences in all aspects of life, that do not originate from the region. Architecture, food, transportation, business concepts, people, all of these constitute an environment almost incomparable to any other region in the world. Understanding what a tolerable, desired influence is, in contrast to an intolerable replica, is sometimes difficult to grasp for those that grew up in a rapidly changing society. We suggest an approach were influences from other works - if not completely plagiarized - can be accepted as a basis for further development. Often the referenced works can be improved. This way students learn from the mistakes others have made. They also understand that uncritical copying of someone´s work might have negative implications. It is a thin borderline between the tolerable and intolerable use of other party's work, but openness is the best approach to this issue. There is no doubt, that the sheer number of possible sources for plagiarism online, puts faculty at a disadvantage compared to former times, when design knowledge was transmitted in books or magazines with simply either regional or reputed international works.

4. Summary of findings

Do not lose momentum - is maybe the most important finding from this class. One must avoid everything that is hindering the students to progress with their works. This can be simple things such as the availability of material resources, or even a plagiarized work that the students then turn into their own with the aid of the faculty, carving out aspects to be improved, aiming at the student understanding the principles, and then use these to develop original work that is truly their own.
Let failure happen - do not solve every problem before students encounter it. Again, not losing momentum is key.
Use what is available - restrict the usage of materials and tools to what is at your disposal. Selecting from a wide variety of opportunities often demands too much from students, resulting in stagnation.
Foster "Stegreif designs" - let students work in a restricted period on a design problem. Do not give them access to other resources than pen and paper. This is indeed a traditional approach, but it avoids plagiarism, and helps students to focus on what really matters - the development of their own skills.

References

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