Accommodating Different Learning Styles

Ovesen, Nis

Published in:
Design Education & Human Technology Relations

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Ovesen, N. (2014). Accommodating Different Learning Styles: Bridging Math and Form. In E. Bohemia, A. Eger, W. Eggink, A. Kovacevic, B. Parkinson, & W. Wits (Eds.), Design Education & Human Technology Relations: Proceedings of the 16th International Conference on Engineering and Product Design Education (Chapter 17, pp. 714-719). [139] Glasgow, UK: Design Society.

ACCOMMODATING DIFFERENT LEARNING STYLES: BRIDGING MATH AND FORM

Nis OVESEN
Aalborg University, Denmark

ABSTRACT
Design engineering educations often struggle to accommodate a highly diverse group of students as it combines an equally diverse range of topics in one education. This paper investigates how a specific course, *Mathematics and Form*, integrates two distinct areas into one course with the aim of facilitating learning across this diverse group of students. The paper is based on a survey with 99 former participants of the course as respondents. The results of the survey imply that certain types of students benefit from the combination of mathematical theory and practical exercises related to basic shapes and form, whereas other types of students do not. The results thereby underpin that learning is typically based on individual preferences and that cross-disciplinary educational programmes have to accommodate this.

Keywords: Design education, mathematics, form, Grasshopper 3D, learning

1 INTRODUCTION

Higher educations within the field of industrial design engineering often experience a dilemma when developing curriculums that need to accommodate two distinct archetypes of students: the mathematically oriented and engineering-focused students on the one hand, and the design-focused and aesthetically oriented students on the other. In the Industrial Design engineering curriculum at Aalborg University several courses are developed to bridge the relatively wide span of heavily engineering related content with traditional design methods, tools and aesthetics. However, the large diversity in students makes it difficult to plan and conduct teaching activities and facilitate learning spaces that are ideal for all types of students at once.

At the second semester of the bachelor education a mathematics course is held with a focus on introducing the students to fundamental mathematical concepts, methods and tools in order to enable them to carry out calculations with vectors, matrices and various algorithms. This course is thereby laying the ground that later engineering related courses build on. However, students have earlier criticised the course for being too disconnected from the education's focus on design and architecture. For the last couple of years, the course programme has therefore been slightly changed with the underlying purpose of *also* establishing a foundation for seeing and understanding form as representations of mathematical expressions and algorithms. Thereby hopefully preparing the students for more skilled and knowledgeable use of 2D and 3D modelling software in a design-related context.

A series of workshops were introduced as part of the course and acted as an introduction to generative modelling of digital form with the use of a plugin called *Grasshopper* [1] for the 3D modelling suite *Rhino*. Grasshopper is a graphical algorithm editor that with only little or no skill in programming and scripting allows users to generate shapes and form from mathematical expressions. As an output of the course, the students developed a series of mathematically defined shapes and thereby established the valuable connection between mathematics and form through own experiments and applied theory.

Among other related areas, previous research efforts have been looking into some of the implications of digital versus tactile learning [2] and how to break down barriers between virtual and physical models [3]. It has also earlier been investigated whether or not 3D graphics is beneficial when learning advanced mathematics [4]. However, research on learning about form through mathematics seems to be lacking. This research paper aims at this gap and is driven by the following question: *Does the combination of learning mathematics and "algorithmic form generation and visualisation" improve the design students' understanding of form?* The paper provides an in-depth description of the motivation and rationale behind the course and an evaluation of the experience and learning output of the students.

The rest of the paper is composed as follows: In the following section 2, the structure, aims, and content of the course is presented as well as some of the work made by the students. Section 3 presents the research setup and the applied research method. The results of the research effort is shown in the fourth section, and finally is section 5 concluding the paper with a discussion on the use and impact of using algorithmic form generation in bridging the gap between math and form.

2 COURSE STRUCTURE, AIMS, AND CONTENT

A mathematics course has always been part of the second semester at the architecture & design engineering educations, but a recent curriculum revision has slightly broadened the scope of the course to also include aspects related to digital form. The course were retitled *Mathematics and Form*, and the aim and of the course were rewritten: "*Students should obtain insights in fundamental mathematical concepts, methods, and algorithms that are necessary for efficient use of digital tools for 2D- and 3D modelling in a design related context.*" The new learning goals of the course further explicated the strong relation between math and digital modelling.

The full course programme contained 15 lectures and 7 workshops. Three of the lectures and five of the workshops were directly related to generating and analysing form with the Grasshopper plugin, whereas the rest of the lectures and workshops were about basic linear algebra and vector functions for describing curves. Figure 1 below illustrates the structural layout of the course.

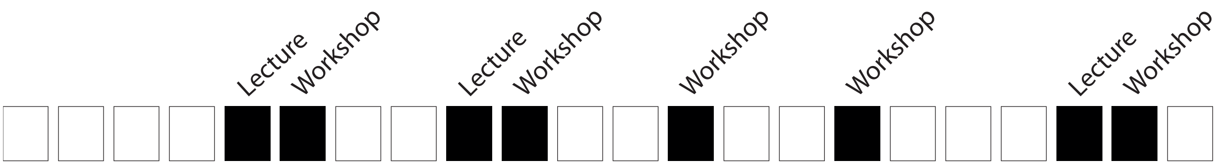

Figure 1. The layout of the course with black markings indicating activities related to form generation with Rhino and Grasshopper

2.1 Exercises with generating form

During the course, students worked with exercises that illustrated the mathematical concepts through visual representations with Grasshopper. Two exercises are exemplified in Figure 2 below.

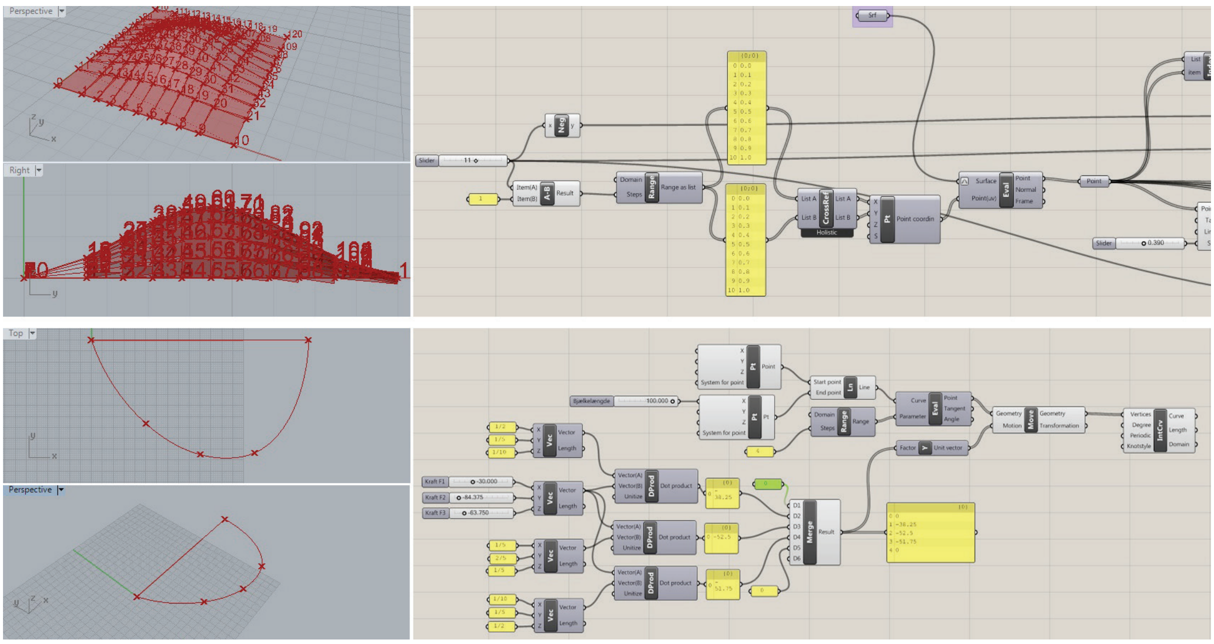

Figure 2. Exercises from two of the workshops in the course programme. To the left are visual representations generated in the 3D modelling software Rhino from the graphical algorithm editor in Grasshopper shown to the right

The basic forms and shapes were generated from the scripts made in the graphical algorithm editor during five workshops with supervision. The cumulative work made by the students during the workshops was used as the basis for an individual, oral examination in the whole course programme. The students were able to solve the assignments in the workshops without any prior skills in programming. As it is exemplified in Figure 3 below, a script is built up by dragging various tools or functions to the grasshopper canvas and adding inputs to each of them in order to produce the wanted output.

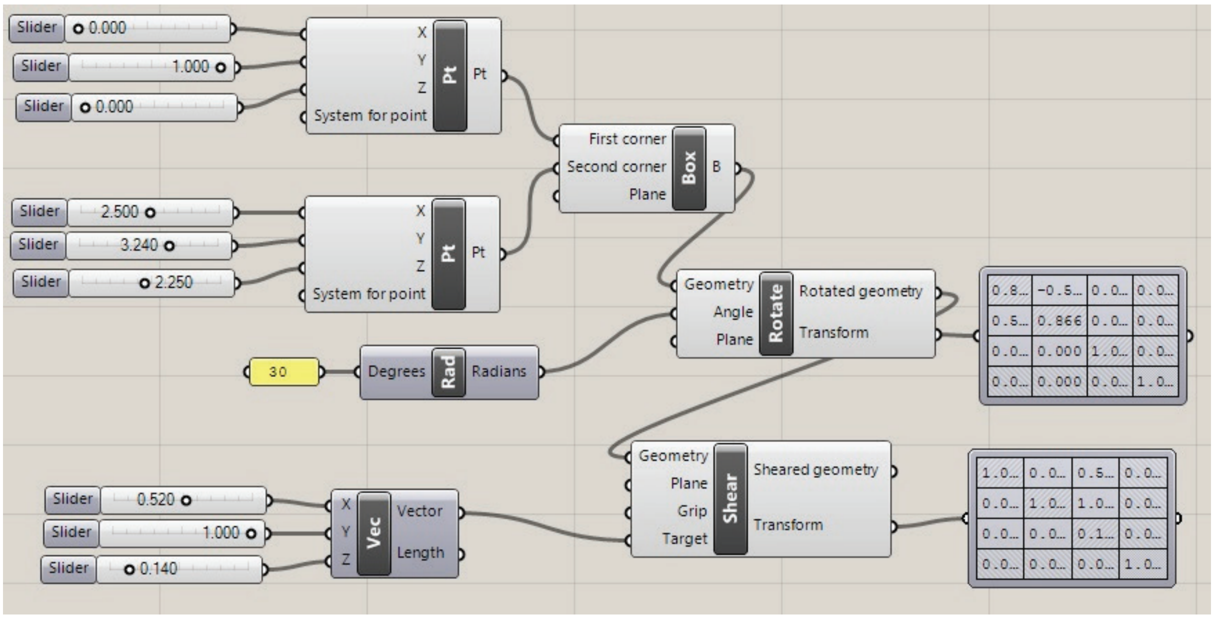

Figure 3. Various tools and functions are dragged to the grasshopper canvas. Input/output-flow goes from left to right, and finally creates the wanted shapes through various tools for drawing geometry

3 RESEARCH METHOD

A part of the motivation for this research project has been a recent curriculum revision and the idea for the study has sprung from this. It has been carried out primarily as a survey-based study [5] with earlier participants of the mathematics and form course as respondents, supplemented with an interview with the coordinator and primary lecturer of the of the course programme. The students on the 2nd semester bachelor in participated in the course over a period of three months in the spring 2013, and the survey was carried out during the following winter. In the survey, the students were presented to a total of 10 questions. Of these, the first three questions focused on the students' relation to the education and participation in the course. The next six questions concerned the students' experiences and learning related to the combination of math and exercises on form generation. The last question sought to uncover how the students would define their favoured ways of thinking; primarily mathematically oriented and engineering-focused or primarily design-focused and aesthetically oriented. A total of 175 students participated in the course programme and 99 of these completed the online questionnaire for this study.

As mentioned, the survey was supplemented with an interview with the course coordinator and primary lecturer in order to get a more qualitative view on the students' learning output. This was carried out as a semi-structured interview [6] as a written correspondence.

The further work with the survey data has been carried out manually through a process of looking for significant deviations or interesting results from graphical representations of the data sets.

4 RESULTS OF THE INVESTIGATION

In this section, some of the results of the survey will be presented and crossed in order to illustrate the most significant results.

The first year of the bachelor programme is a common education for all students at Architecture & Design. After this year, students choose either an Arch/Urb programme or an industrial design programme. This survey is focused on a 2nd semester course and therefore includes students from both programmes. The distribution is shown in Figure 4 below. Approximately two thirds of the students typically choose to study on the arch/urb programme after the first year, and the respondents in this survey also represent this division. However, when crossed with some of the key questions in the survey, the choice of specialisation does not seem to influence the results significantly.

Figure 4. Two thirds of the students in this research project study arch/urb and there is a slight overweight of female students

When asking the students about whether or not the relation between math lectures and exercises in Rhino/Grasshopper gave them a better understanding of form and curvatures, the answers were rather ambiguous. However, when crossing the answers with the question on preference in way of thinking, a tendency seemed to be revealed. As it is shown in Figure 5, students with a preference in mathematical/logical thinking clearly found the combination more fruitful in relation to their understanding of form than the students rating themselves as create/aesthetically oriented. 44 % of the mathematically oriented students answered that the combination *to a high degree* or *to a very high degree* gave them a better understanding. This number is significantly lower for the students with creative/aesthetic preference. The tendency is seen in the lower end of the bars in Figure 5. Only a few students could not identify themselves as any of the two categories, and these are not represented in the figure.

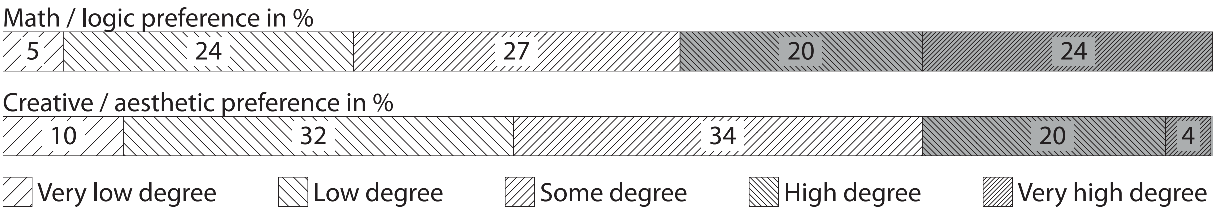

Figure 5. Answers on whether or not the combination of math lectures and Grasshopper workshops improved the students understanding of form

A plausible reasons for the tendency illustrated in Figure 5 could be the distribution of the students' preferences regarding modelling tools. In Figure 6 below, it is clear to see that students with preference for mathematical/logical thinking to a large extent prefer digital 3D modelling software to pen and paper or physical models. Based on this, it can be argued that it is typically students with an existing preference on digital tools that find the combination of math and Grasshopper exercises fruitful.

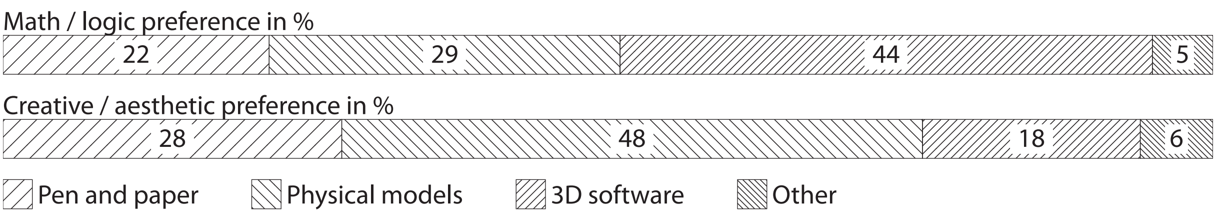

Figure 6. Students' preferences on modelling tools combined with "thinking preference"

The data does not clearly document this, but combining the insights from Figure 5 and Figure 6, it can be argued that it is the preference in digital tools rather than an actual improvement in understanding and working with form that drives the interest.
Regardless of what may drive the students to like or dislike the combination of Math lectures and Grasshopper exercises about form generation, most students seem to agree that they are not becoming better designers solely because of the gained competences in describing form through mathematical expressions. This is seen in Figure 7 below, where students – despite thinking preferences – tend to

agree that they as a result of the course programme only to a *low* or *very low degree* becomes better at creating form.

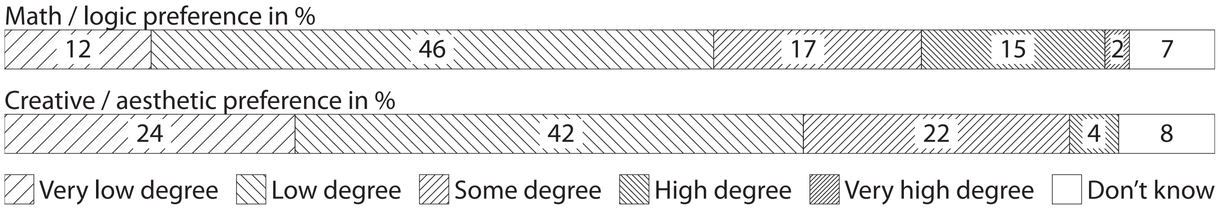

Figure 7. It is a clear tendency that students do not see themselves as better designers after the Mathematics and Form course programme

5 DISCUSSION AND CONCLUSION

This paper has presented the challenging dilemma of developing a design engineering curriculum that has to accommodate two distinct archetypes of students. The paper has furthermore described a specific course programme developed to cross over between the two distinct areas of *math* and *form* in an attempt to meet the interest of the two types of students. Through a survey, it has been investigated whether or not the combination of learning mathematics and algorithmic form generation improve the design students understanding of form, and the result of this survey will be discussed in this last section of the paper.

5.1 Answering the research question

As it has been showed in the previous section, the answer to the question about an improved understanding of form, points in two different directions depending on which type of students we ask. According to the gathered data, the mathematically oriented students implied that the combination gave them a better understanding of form, whereas the same point of view was significantly less distinct in the group of students seeing themselves as create/aesthetically oriented. However, both groups of students seemed to agree that the course did not improve their practical skills as designers, creating form. The students' clear distinction in their answers about *understanding form* and *creating form* indicate that they are quite well aware on *what* they have learned about form during the course, and perhaps also what kind of learning that this course format is probably *not* good at facilitating.

5.2 Learning about form through math or math through form

So, should we continue to combine distinct topics as math and form in our courses? After all, it only seemed to be the one group of students (the math/logically oriented students) that really benefited from the combination and ended up with a better understanding of form. Looking broadly at the results of the present study, the answer should probably be *yes*, as the most important learning from the data actually might be that students *do* learn differently due to their different preferences, and that teaching should accommodate learning about form in a range of different ways in order to reach all types of students in this cross-disciplinary field. The main perspective in this paper is "learning about form through math", but looking at the same course in a different way, the main perspective could have been "learning math through form." Looking at the students' experiences in that perspective, it is likely that the students benefiting from the use form to facilitate math learning would be the ones that are create/aesthetically oriented. However, this has not been investigated in this paper.

Returning to the discussion about teaching students in "form," it is clear that students to an increasing extent work with this area in virtual environments. It can therefore also be argued that form should be taught in a virtual environment: Just as we educate design students in understanding the logic, benefits, and limitations of traditional design tools like pen and paper, we aught to do the same in the virtual environment where the logic is not based on mathematical expressions and Boolean operation rather than three-point perspective and pen thicknesses. Whether such topics should be included in a course on basic math or a traditional design course – or a course combining the two areas like in the Mathematics and Form course – is difficult to say based on study presented in this paper. But it seems likely that topics such as *math* and *form* move closer together due to the increasing emphasis on software tools as an integrated part of the design practice.

5.3 Critique of results

Leaving the discussion about combining math and form for a while in order to take a critical look at the investigation itself, it is clear that the respondents rather positive towards their own learning outcomes from the course. It is very likely that the students actually gained a lot from the course when it comes to understanding and generating form through mathematical expressions, but the results could also be biased due to the fact that it was the students themselves that had to evaluate their own learning in the survey.

It is also likely that the students answer the questions more positively if they get the impression that it would benefit the investigation, even though the authors have not been involved in running the course. During the interview with the course coordinator and main lecturer, a slightly different picture of the students learning outcomes was presented. On the question about whether or not he think the combination of math and form benefits the learning outcome, he answers:

"What has perhaps earlier been perceived as tough square-bashing now makes sense on an earlier state. But I have to say that the effort – to a large part of the students – is sporadic. And at some point they loose track."

He continues to comment on the group of students in general:

"I don't think that these students are a homogeneous group. Together, they form a highly varied group – which is good, I believe. But they also vary much when it comes to their perception of geometry and relation to mathematics."

The comments from the course coordinator indicate that the students' own perception of their efforts and learning outputs may be biased to some point.

5.4 Concluding remarks and future research efforts

Referring to the title of the paper, it can be questioned whether or not the gap between math and form has been successfully bridged? According to the present research effort, it can be argued that the course programme "*Mathematics and Shape"* on the Architecture and Design bachelor education at Aalborg University is a thorough attempt in doing so. From the survey, it can also be argued that the students with a preference in logic/mathematical thinking have gained a better understanding of form as a result of the course. The gap, however, also refers to the diversity in the student group at cross-disciplinary educations such as the industrial design engineering programme. The results of this paper may therefore also act as a simple reminder of the fact that students have different learning preferences and perhaps more importantly: This should be reflected in the curriculum of the education.

Hopefully, this paper will serves as a starting point for a discussion on how we can plan and conduct courses at university level in order to facilitate learning for all types of students – regardless of learning preference.

ACKNOWLEDGEMENT

For a very constructive involvement in the data collection for this paper, the authors gratefully acknowledges all the students at the 4th semester bachelor education in Architecture & Design as well as lecturer and course coordinator, Associate Professor Martin Raussen.

REFERENCES

[1] Davidson, S. Grasshopper 3D, http://www.grasshopper3d.com, 06-03-2014.

[2] Kremer G.E., Tucker C. and Jackson K. Student Preferences on Tactile versus Digital Learning: Implications for Conceptual Design. In *International Conference on Engineering and Product Design Education, E&PDE'13*, Dublin, September 2013, pp.735-739 (Design Society, Glasgow).

[3] Hejlesen A. and Ovesen N. Tangible 3d Modelling: Bridging The Gap Between Physicality And Virtuality. In *International Conference on Engineering and Product Design Education, E&PDE'12*, Antwerp, September 2012 (Design Society, Glasgow).

[4] Elliott J. Design of a 3D interactive Math Learning Environment. In *Proceedings of the 4th conference on Designing interactive systems: processes, practices, methods, and techniques, DIS'02*, June 2002, pp.64-74 (ACM, New York).

[5] Dillman, D.A. *Mail and Internet Surveys: The Tailored Design Method*, 2000 (Wiley, New York).

[6] Kvale S. and Brinkmann S. *InterView – Introduktion til et håndværk, 2nd ed.*, 2009 (Hans Reizels Forlag, Copenhagen).