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TRIANGULATION FIRST: TEACHING RESEARCH IN A MULTIDISCIPLINARY DESIGN AND ENIGINEERING ENVIRONMENT

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ABSTRACT
The absence of a shared language and set of values about research among teaching staff is a core difficulty in teaching (applied) research in a multidisciplinary design and engineering context. In this paper we argue for a 'triangulation first approach' in which the Development Oriented Triangulation (DOT) framework is introduced as a lingua franca for research education. We promote practical, mixed-methods research from the beginning of the curriculum and focus on stimulating and nurturing an open-minded research attitude, before actually teaching specific methods. In this paper we explain our approach and report on a first year course as a case study. We found, first, that students and teachers of diverse backgrounds understand and value the DOT-framework easily. Second, it is a helpful research planning tool. Third, the framework helps to highlight the connection between research and the practice of designing. Fourth, it broadens students' and teachers' views on research and it helps them appreciate approaches other than their own. In summary: to alleviate the linguistic and axiological confusions, inherent in teaching research in a multidisciplinary program, we need a different start of the curriculum first.

Keywords: Design Research Education, Mixed-method Research, Triangulation First, Development Oriented Triangulation Framework.

1 INTRODUCTION

Research education inevitably assumes a *research paradigm*. Thomas Kuhn [6] introduced this term to refer to a shared set of practices and (implicit) epistemological beliefs of a scientific community; including the questions worthy of examination and the acceptable methods for answering them. Paradigms are taught through examples of scientific research in textbooks. These serve as models for research in a particular field and they are important in building scientific values, thinking and research rigor. Paradigmatic examples of research are the seeds for coherent traditions of scientific research.
The difficulty in a multidisciplinary teaching environment is that different members of teaching staff have been trained in different research paradigms. Our institute, for example distinguishes host staff from at least three design traditions: 'applied arts', 'engineering design' and 'human-centred design', each with its own research culture [see: 2]. Meeting teachers from different traditions, students are often confronted with differing, sometimes sweeping, opinions about research throughout their education. As such it must be hard for them to integrate and combine the underlying lessons, leading to suboptimal knowledge transfer. Nelson & Stolterman, call this a 'soft-centre' curriculum [9, p221]: students are immersed in a Babylonic environment and are left to their own devices, to integrate the different pointers they get. Our premise is that a 'liquid-centre' curriculum, where we support students in integrating the diverse inputs they get [9] is far more effective for research education.
Our approach rests on two basic ideas. First, the Development Oriented Triangulation framework is introduced as a *lingua franca* for design research throughout the educational program. Teachers from different backgrounds all use the DOT-framework so students learn to combine different viewpoints. Second, we use the *triangulation first* principle, promoting a mixed-method research approach and nurturing a practical and open-minded research attitude, from the very start of the educational program. These two anchor points are explained in more detail in section 2 and 3 of this paper. Next,

we illustrate our approach with a case study of a first year course and end with a reflective discussion of the benefits and drawbacks of our approach.

2 INTRODUCING THE DOT-FRAMEWORK

2.1 The DOT-Framework

The Development Oriented Triangulation (DOT)-Framework (see Figure 1) was created as part of a long-term research effort addressing research in Human Computer Interaction (HCI) and research education for design professionals [10,11]. It presents a synthesis of literature, most notably Wendy Mackay's work on triangulation in HCI [8] and Alan Hevner's work on design science research [4]. This introductory section is necessarily brief. For a full description we refer to earlier work [10,11].

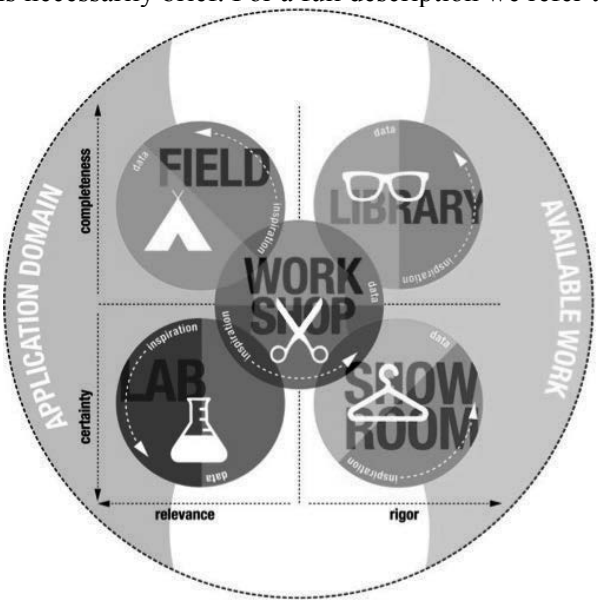

Figure 1. The DOT- Framework

The DOT-Framework can be seen as a typology of research methods in which each research type entails a coherent answer to the three basic questions one could ask about research: *what* (to research), *how* (to approach research) and *why* (this approach over others).

The bottom (ontological) layer addresses the first question: "what to research". This layer makes a distinction between three domains of design research. The *domain of available work* consists of all work that has been done before including theories, guidelines, or design patterns but also archetypical examples of design or the work of competitors. Research about *application domain* is concerns the context in which the solution will eventually be used (e.g. current work practices). Between these two domains lives the *innovation space,* where the solution under development can be researched.

The middle (epistemological) answers the question "how to approach the research" by distinguishing between five research strategies. The *Library* strategy focuses on gaining an overview of existing work such as a literature search or a competitor analysis. *Field* research helps to get an overview of the application context, for example through surveys or ethnography. With *Lab* research one can test a design proposition in the application context, such as through a usability test or an A/B test. *Showroom* research helps to compare the design proposition with existing work, such as in a heuristic evaluation or peer-review. *Workshop* methods aim at (iteratively) exploring the innovation space, for example through ideation or morphological techniques.

The third (axiological) layer addressed the question "why this approach over others". It identifies three trade-offs of design research. Each trade-off consists of a pair of opposing values, which are equally important but cannot be optimized simultaneously within a single research method. Therefore, method triangulation - combining methods from each end of the value pairs - is necessary [11]. The three trade-offs are defined as follows. First, horizontally in figure 1, we find, *rigor versus relevance*, differentiating between a focus on existing work versus a focus on the application domain. Second, on the vertical axis, we find *completeness versus certainty,* distinguishing between trying to get a

complete picture of the context as a whole versus the aim to test certain aspects of the design proposition. The third distinction is between *inspiration oriented methods* and *data oriented methods*, separating methods that promote (subjective) researcher involvement from those who target objective, neutral, or detached results (depicted in the diagram by splitting each circle in half).

2.2 The DOT-Framework as a 'lingua franca'

The advantage of the DOT-framework for our purpose is that it allows teachers to support the research values belonging to the tradition they were trained in, without obscuring the possible value of other approaches. Consider two teachers: one being a strong advocate of hypothesis testing, the other favouring qualitative interpretive research. Without the framework these conflicting views, may confuse students. However, if both teachers use the framework as a background, their differences are more easily recognized as belonging to either the lab or field strategy. With the framework the teachers' narrative shifts from "this is how to do research, period." to "the type of research I teach is done like this". This encourages knowledge transfer between different parts of the curriculum. Moreover research shows that many research traditions already follow a mixed-method approach [10]. Social scientists, for example tend to use a combination of library, field and showroom (called 'field reframing'), whereas engineers often prefer the combination library, workshop, lab (called 'validated solution'). So, even if teachers rely solely on their own tradition, a mixed-methods account is suitable.

Although much of our staff immediately saw the potential of the DOT-Framework, introducing it in the organization required a large-scale narrative intervention. Seeing the value of an approach is different from changing the language in which you teach. Of particular concern was the question how, and where in the curriculum, the framework should be introduced to students. An early introduction was needed for the framework to be effective as lingua franca. Students needed knowledge of the framework to understand teachers' references to it. However, in many curricula the existence of multiple approaches to research is introduced late in the program so an early introduction of mixed-methods methodology was quite unconventional. Wouldn't the DOT-framework be too abstract and its purpose too difficult to understand for students who were still unaware of the problems associated with multidisciplinary design research? In order to address this question, we needed to rethink our approach to research education in general.

3 THE 'TRIANGULATION FIRST' PEDAGOGY

The 'triangulation first' pedagogy originated from both practical and theoretical considerations which we will briefly elaborate on in this section. Our approach might be best understood in comparison to a more traditional structure of the curriculum. We would describe traditional research education as *skills-centred.* Skills-centred research education uses fairly closed problems and small scale research exercises to enable the students to master the skills and knowledge needed to carry out a particular method. Gradually, students are granted more freedom and they get confronted with problems of bigger complexity in order to expand their skills and to apply them more strategically. In the skills-centred approach (rule-based) knowledge and skills are seen as the most important components of research competence and research attitude is seen as the closing entry. In this view, developing a research attitude is seen as a *result* of acquiring and applying research knowledge and skills.

Our approach, in contrast, is *experience-centred*. We treat a research attitude as the *basis* for the acquisition of research experience and, in turn, treat research experience as the necessary ground for the (deep) learning of research knowledge and skills. We choose examples rather than rules as a form of knowledge to teach. We start the curriculum with open problems and student-defined questions which stimulate students to solve research problems in their own way. Teachers support this by asking critical questions about student's choices and by giving them pointers to possible alternatives; but on the whole we are fairly undemanding about the students' methodological choices. Although this experience-centred approach is unconventional, there is some evidence that it leads to deep learning, increased retention and knowledge transfer, provided that students have access to good role models and just-in-time teaching to address specific knowledge needs [1, 3, 5, 7].

The 'triangulation first' pedagogy can thus be characterized as follows:

1. Using the DOT-framework as a basis, we favour a practical and pluralistic view of research.
2. A mixed-methods approach is advocated for solving real world problems.

3. At the start of the curriculum: nurturing an open minded research attitude has precedence over teaching specific methods, building experience has precedent over building knowledge and example based knowledge has precedent over rule-based knowledge (like research prescriptions).
4. In the later stages of the curriculum, all research is taught with reference to the DOT-framework.

4 CASE STUDY: MEDIA QUESTIONS

4.1 Setup of the course

In this section we illustrate the triangulation first pedagogy with the research course called Media Questions. Media Questions is a first year course of our bachelor program in Communication and Multimedia Design (CMD). CMD is certainly not the only application area of the DOT-framework. Several universities of applied sciences use the DOT-framework in disciplines as diverse as interaction design, software engineering, mechanical engineering, electronics and industrial product design. Also, Media Questions is presented as an example and it is certainly not the only possible implementation of 'triangulation first'. Others, embracing the pedagogy, have used a series of workshops throughout the first year or theme weeks as an introduction.
Media Questions is a course of 7.5 ECTS (210 study hours). Its central theme is the influence of new media on society. We introduce several topics related to the theme and we teach about the DOT-framework in a short series of lessons. These two topics are glued together in integration workshops. In these workshops students approach a new media topic using one of the five research strategies. Finally there are guest lectures from researchers in the professional practice of the students (wiki talks). A fair amount of the course is dedicated to independent research by the students (Table 1).

Table 1. Set-up of the Media Questions course (in 2015)

<table>
<tr><td>Week 1</td><td>Week 2</td><td>Week 3</td><td>Week 4</td><td>Week 5</td><td>Week 6</td><td>Week 7</td><td>Week 8</td></tr>
<tr><td>Media History</td><td>Professional & Amateur</td><td>Wisdom of the Crowds</td><td>Innovation challenges</td><td>Wiki-talk</td><td>Wiki-talk</td><td>Test-Preparation</td><td rowspan="3">Finalization and presentation

Research project.</td></tr>
<tr><td>Introduction DOT-Framework</td><td>Introduction Showroom and Library</td><td>Workshop & Lab</td><td rowspan="2">Research project plan.</td><td colspan="3" rowspan="2">Research project.</td></tr>
<tr><td>Integration Field Research</td><td>Integration Showroom Research</td><td>Integration Workshop Research</td></tr>
</table>

Each week of the course consists of three workshops lasting half a day. In these weeks the first workshop addresses a development in new media, the second introduces a part of the DOT-framework and the third glues them together by approaching the new media topic employing one of the five research strategies. In all lessons, we focus on the versatility of research giving many examples of research in practice and we do not teach specific research methods.
From week 4 on, students work on their own research project in small groups of four to five students. Students have to come up with their own questions, inspired by their personal interest within the broad theme of new media in society. We encourage them to answer these questions using multiple research strategies of the framework. We supervise the projects in a nondirective way. We allow students to make mistakes. A common pitfall for students, for example, is that their research questions are too vague, ambitious and broad. Teachers highlight this as a concern, but students are allowed to proceed. Along the way they will discover by themselves that they can achieve less than they expected. We thus apply a policy of discussing possible pitfalls with students without demanding mastery of any aspect of the research before allowing them to proceed. We stimulate students' initiative, responsibility and decision making throughout the project. This may come at the cost of a lesser quality of the research outcomes. However, the benefit is that we build an experience base needed to truly appreciate lessons in research methodology in the rest of the curriculum.
In week 8 of the course students present their results. Apart from reporting their research in a traditional research report, we invite students to present their research in an original and activating way to the class. This freestyle presentation exercise helps students to bring the content of their research to life, which is worthwhile for students' motivation and for the quality of the work presented. Students attend presentations of other students and they are asked to prepare questions for

other groups. This enables them not only to see how other forms of research work out but also to discuss benefits and pitfalls of other approaches.

4.2 Results

We have run the media questions course for three cohorts of about 300 students, employing 8 to 10 teachers every cohort. Each cohort we administer a student evaluation with both generic and specific questions about the course. It turns out the course is highly appreciated by both students and teachers. Students grasp the DOT-framework easily and they experience the activating lessons as a positive surprise. Before the course media questions they were only familiar with the library and lab strategy and their view of research was negatively coloured:

"At first, media questions appeared to be a course without any challenge. I expected to spend the course period writing papers with information from the internet".

But this changes quickly:

"I could not have been more wrong. I learned how much fun doing research can be. You just need to make it more fun by giving it a creative twist"

The DOT-Framework acts as a catalyst for this change. Students are quick in getting a grasp of the novel types of research in the framework and they appreciate this broader view.

"Before the start of the media questions course I had never heard of these research spaces. I would always do research using a library strategy. I would find information on the internet and would draw my conclusions from this. Because of the DOT-framework, but also because of the guest lectures I started to realize there are much more ways of doing research. This is why I used all five research strategies in my research. This was a nice challenge because, in this way, we did research in many different ways".

Or put simply:

"The DOT-Framework does not limit my possibilities but it provides me with opportunities for research"

Students also like the chance to do their own research. A frequent comment from student evaluations is whether there is a possibility to start the research project earlier on in the course. In their view three weeks is too short to do research. This is in part because of their broad and hard to operationalize research questions. One group, for example, wanted to know which reasons people have for choosing either illegal downloads or streaming services. Another group wanted to learn about the effect of new media on romantic relationships of students.

The diverse questions of students also lead to a wide range of research approaches. Many students choose a field strategy (the survey is a popular method), but the 'digital romance' students, for example, applied the lab strategy by asking students to withdraw from digital contact for a few days. It turns out to be easy to motivate students to strive for quality in their research if they choose a truly interesting subject. This is also reflected in the discussions at the final presentation. Students do not use methodological jargon, but they do fire epistemic questions at each other: can this be inferred from these results (?), would a different type of research not have been more effective (?), are these experimental conditions suitable (?), and so on. We also see that knowledge introduced in supervision sessions, is shared with the classroom. Students jump at the opportunity to present their results in an original way, ranging from to quizzes to role-playing, live experiments and many other forms.

5 CONCLUSIONS AND DISCUSSION

In this paper we introduced the 'triangulation first' pedagogy, illustrating it with a freshmen course about design research. Although we haven't done a detailed comparison, we are fairly confident our findings are generalizable across different implementations of 'triangulation first'.

First, we found the DOT-framework is easily understood and valued by students and teachers. We found one workshop to be enough for students to get a first grasp of the framework and the different research strategies it represents. Clearly this does not lead to a full understanding of the framework and its uses. In fact the simplicity of the framework is deceptive. To fully understand the three layers of the framework and to learn to employ a pragmatic and sophisticated mixed-method strategy takes at least the whole study. This is also recognized by some students, who ask for more depth in discussing each strategy after having completed the media questions course. Although teachers have an intuitive grasp on the framework, some express a recurring difficulty to distance themselves from their own educational background. In these cases the common combinations of research methods within the

framework, identified by van Turnhout et al. [10], which show the usual way of working in these disciplines, turn out to be a helpful reference.
Second, the research strategies of the DOT-framework help students to operationalize their research questions and vice versa, supporting research planning. The writing of a research plan, in which students use the framework for the first time, supports students to understand it better.
Third, the DOT-framework helps understanding the relationship between research and the practice of designing. Students report to find it easier to recognize research activities in projects (later in the program). This is an important finding, as making the connection between research activities and the practice of designing is important in a university of applied sciences.
Fourth, the DOT-framework broadens students' and teachers' views on research and helps them to recognize other approaches than their 'own'. We have illustrated this point with student quotes: students tended to see research as either library or lab based and they value the discovery of the field, workshop and showroom. Teachers value the DOT-framework as a shared language, although the names of the strategies spark of some debate and not all teachers share the pluralistic values underlying the framework.
Many of the practical concerns that we had during the design of media questions have been addressed above expectations. The quality of the results of media questions, suggest 'triangulation first' is an adequate alternative to more traditional skill-based approaches. There is some research suggesting such an approach may lead to 'deep learning' of research [3,5,7], but clearly we have not collected the evidence to either support nor deny such a claim. In part, the success of the triangulation first pedagogy depends on the way teachers - later in the curriculum - manage to relate to and build upon the knowledge and experiences students have gained in the first year. Training skills and teaching rule based research knowledge is needed there and it is not trivial to make good use of the experience base that we build in the first year. Although some teachers in the second year, report their students have a much more open and positive attitude towards research, their claim that this helps their methodological lessons still needs to be substantiated.

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