Designing for additive manufacturing technologies: a design research methodology

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Abstract: The poster presents a design research methodology of a doctoral granted ongoing research aiming to explore how product design can take advantages of Additive Manufacturing (AM) potential. Research methodology in design field is one of the main difficulties faced by new Ph.D design students. Present work proposes a carefully planned methodological approach with different data collecting methods that will be applied to achieve design knowledge in three main categories: praxeology, epistemology and phenomenology including interviews, focus groups sessions, think aloud protocol studies and final artefacts analysis. Data collecting instruments to be applied on phase one are already being tested in classroom context with design students developing a project lead by AM implications on design.

Keywords: Design research methodology, Product design, Additive manufacturing (3D-printing), Design process

1. Introduction

Due to the 3D-printing technological shift from a rapid prototyping technology to an additive manufacturing (AM) technologies, new forms of innovation are now possible, as well as other functional features and customized products that could hardly be achieved by conventional manufacturing processes. Seen as a disruptive technology (Kietzmann, Pitt, & Berthon, 2015; Prince, 2014), AM enables advantages, like the possibility of uniqueness, complex geometric shapes and non-assembly models, that require the development of design strategies to explore the potential of a fabrication technique with unlimited design freedom. For years, product designers were forced to adapt their design concepts to a possible manufacturing process with formal restrictions leading to cognitive barriers. By providing the possibility to overcome those barriers, AM technologies open a new creative space for design. “How should designers adapt or change their way of working and thinking to AM?” (Doubrovski, Verlinden, & Geraedts, 2011). How could they be able to overcome...
“cognitive barriers imposed by past experience and conventional fabrication techniques?” (Thompson et al., 2016). Those are questions not fully explored by the current state of the art about AM technologies. Present work is part of an ongoing doctoral research aiming to contribute to the theme through a practice based research.

At the same time, it is recognized that planning the research methodology, including data collection and analysis methods, can constitute one of the main struggles of new doctoral students (Friedman, 2003). By presenting the methodological approach and the process behind it, present work intends to (i) contribute with an actual example of carefully planned design research methodology and (ii) disseminate the doctoral project and its aim to enlighten AM contribution on design practice.

2. Research methodology proposal

Research methodology design was based on the explicit formulation of research question: “Which are the main contributions of 3D— printing technological shift to product design, perceived by designers?” Taking in consideration design knowledge dimensions proposed by Cross (2006), research questions was subdivided into three questions about praxeology, epistemology and phenomenology. After that, a research matrix (table 1) aligning each research question with research goals and method was developed.

Table 1. Research methodology matrix.

| Which are the main contributions of 3D— printing technological shift to product design, perceived by designers, in which concerns to: | Design knowledge (Cross, 2016) | Nature of research | Research goals | Research methods |
| --- | --- | --- | --- | --- |
| Design methodology | Praxeology (process/ methodology) | Research thought design (Frayling, 1993; Findeli et al., 2008) | Collect subject perceptions about AM implications on design process | — Record through individual project notebook; — Post— intervention interviews (design students, product designers) |
| Individual design cognition | Epistemology (people/ designers) | Collect subject perceptions about AM implications on design cognition | — Record through individual project notebooks; — Protocol studies — Post— intervention interviews (design students, product designers) |
| Final artefacts | Phenomenology (products/ artefacts) | Products evaluation regarding complexity, customization, assembly, and others | — Focus group with external specialist (product designers, product engineers, AM specialists) — Matrix evaluation |

From the research methodology matrix, a research “through design” two-phase project, following the “practice based research” concept (Frayling, 1993; Findeli et al., 2008) was conceived. On phase one, two groups of subjects (higher education design students and professional designers) will receive a project brief forcing AM technology as main manufacturing technology. Throughout the
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3. Expected results

Aiming to explore design possibilities allowed by AM, a practice based research is being conducted. It is expected to produce knowledge concerning to project methodology, individual cognitive process and produced artefacts.

Starting from the clear formulation of research questions and aims, research methods were clearly defined. By recording and analysing subjects’ actions and strategic thinking throughout the design process it is expected to explore AM praxeological and epistemological implications. Finally, the analysis of the resulting concepts/artefacts should contribute to understand AM phenomenological consequences on design.

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KEYWORDS
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INTRODUCTION
3D printing technological shift from a rapid prototyping technology to an additive manufacturing (AM) technology allows new forms of innovation, enabling product design creative space. Seen as a disruptive technology (Kietzmann, Pitt, & Berthon, 2013; Frincu, 2014), AM provides the possibility to produce unique and complex geometric shapes, as well as other functional features and customized products that could hardly be achieved by conventional manufacturing processes.

How should designers adopt or change their way of working and thinking to AM? (Doubrovski, Verlinden, & Geraedts, 2011). How could they be able to overcome cognitive barriers imposed by past experience and conventional fabrication techniques? (Thomson et al., 2016) and explore the advantages of unlimited design freedom?

METHODOLOGY
RESEARCH THROUGH DESIGN / PRACTICE BASED RESEARCH

PHASE 01
ALONG DESIGN PROJECT
• Knowledge from designer activity (Cross, 2006)
• Subjects groups
  • Design students
  • Professional designers

PHASE 02
OUTLINE RESULT
• Knowledge from artefacts (Cross, 2006)

RESEARCH METHODES
• Protocol studies
• Interviews

Research methodology proposal
Proposed research methodology fits on research “through design” concept (Laing, 1995; Finon et al., 2006) following a “practice based research” that takes advantages of the design project to establish new knowledge within the discipline.

Two groups of subjects (higher education students and professional designers) will receive a project brief forcing AM technology as main manufacturing technology. Throughout the project development, AM implications on design will be evaluated in relation to the three dimensions proposed by Cross (2006): praxeology, epistemology and phenomenology.

Different data collecting methods will be applied including interviews, focus groups sessions, observation protocol studies and artefacts analysis.

Those are questions not fully explored until now as AM research has been mainly focused on technology and materials development. A doctoral research aiming to enlighten the above-mentioned issues has recently earned a grant from Portuguese Foundation of Science and Technology (SFRH/ BD/115246/2016). As a starting point to the ongoing research, a clear and well established research methodology was designed.

Because methodology is precisely one of the main difficulties faced by new Ph.D design students (Friesland, 2003), presented work focus on the methodological approach, including data collecting and data analysis methods and expected results.

3D-PRINTING
[ADITIVE MANUFACTURING TECHNOLOGIES]
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