DIFFERENT APPROACHES TO DEMOCRATISE DESIGN - ARE THEY EQUAL?

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ABSTRACT

The democratisation of design permits greater stakeholder involvement in what has traditionally been a domain reserved for experts; the design process itself. This is enabled by technological advances in fields such as 3D printing, virtual reality and high-speed peer to peer communication technologies which have fuelled the development of new and innovative design methods. This paper compares and contrasts different approaches to the democratisation of design, and in particular, those that aim to involve wider stakeholders in the design process itself. Three different approaches(design by play, design by generation and crowdsourcing for design) are defined and contextualised within existing design frameworks and their respective suitabilities to democratise different design phases are considered. An exemplar use case of each approach is presented in order to assess how stakeholder engagement is affected by each democratising strategy. The discussion compares and contrasts the approaches with respect to their applicability and utility for different stages of the design process and how the power dynamics of the design process are altered when the different approaches are employed.

Keywords: Democratisation of Design, Collaborative design, Crowdsourcing, Design process, User centred design

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1 INTRODUCTION

The democratisation of design (DoD) is defined as enabling "more 'non-designers' to become involved in idea generation, development and production of products, services or processes" (Fleischmann, 2015). It follows that the democratisation of design offers great value to the design community as it permits the creative power of the world to be harnessed. Diversity of thought is linked to the ability to innovate (Hewlett *et al.*, 2013) and as such, involvement of the general public is beneficial, as it offers access to a great diversity of perspectives and provides significant benefits in industry as these external connections enable the creation of better products (Huston and Sakkab, 2006).

Design approaches that represent the democratisation of design can be distinguished by three "facets" of design democratisation. These are the increased engagement of the general public, the reduction of prerequisite technical skills and the enabling input of many into one goal. Three approaches that have been identified using these facets; designing by play, deskilling through generative design and crowdsourcing for design. While they each increase public engagement, reduce the technical barrier to entry to a design task or enable the input of many, they do so in fundamentally different ways. Consideration of these approaches offers insight into how the design process can be democratised, this is achieved through method clarification, presentation of case studies and direct comparisons between the approaches.

2 LITERATURE REVIEW

Academic research into approaches to the democratisation of design can be segmented into two sectors; the presentation of new approaches for the DoD and comparison of current DoD approaches. Looking first at the former, research such as Tsang and Lee (2014) and Abras *et al.* (2004) focuses on identifying and addressing particular weaknesses of current DoD approaches via a new approach. Koch and Tumer (2009), for example, suggest that current approaches do not take enough inspiration from software while, Abras *et al.* (2004) suggest that DoD approaches should be driven by the need to involve customers. Papers in the latter area compare DoD approaches; such as by Howard *et al.* (2012) discussing different approaches to involving the crowd in the design process and Smith (2012) comparing several strategies to open design, with both suggesting how current approaches to DoD can be improved. Further, Zheng, (2009) discusses three "modes of open design"; crowdsourcing, open collaborative design and "individual effort".

Several key gaps emerge from this literature review. Firstly, current literature does not present DoD approaches in the context of the design process. This paper addresses this literature gap by describing how each DoD approach interacts with the design process. Existing design processes such as Pahl and Beitz (1996) are practised and understood by industry and therefore, to present research with impact, there is a need to recognise how new ideas interact with these existing approaches to design. Another gap in current literature is that academics have not compared approaches that operate in fundamentally different ways. For example, current literature compares crowdsourcing initiatives with each other and compares different approaches to deskilling but not crowdsourcing approaches to deskilling approaches. Finally, unlike any previous academics, the authors present ideas for hybrid approaches that recognise and capitalize on the different benefits these approaches to the DoD offer.

3 THREE APPROACHES TO THE DEMOCRATISATION OF DESIGN

This section introduces the aforementioned approaches to democratisation of design: crowdsourcing for design, design by play and deskilling through generative design. Each approach is described in the context of the prescriptive design process and includes a case study as a frame in which to discuss their effectiveness. The inclusion of alternative approaches and case studies are beyond the scope of this paper and have been identified as an avenue for further research.

3.1 Using the prescriptive design approach

A number of strategic approaches exist for defining the design process. These encourage a problem focussed, yet creative approach that is compatible with other disciplines. The formalisation of the process promotes best practice as it can be easily taught and learnt (Pahl & Beitz, 1996). For a comprehensive review see Howard *et al.* (2008). Pahl and Beitz (1996) separate the design process into four principle categories; clarification of task, conceptual design, embodiment design and detail design. Similarities can be observed in the way in which the design process is segmented. Whilst there exist a number of taxonomies for the design process, for the remainder of the paper we will use those of Pahl and Beitz (1996) to permit categorisation of design activities.
Figure 1 below, sets the applications of each DoD approach against the Pahl and Beitz design process. This serves as a preliminary comparison of the approaches as it demonstrates how they differ with respect to the phases of the design process they are best suited for. Design by crowd is best for task clarification and conceptual design, design by play for conceptual and elements of embodiment design. Finally, generative design is best suited for embodiment and detail design phases. The following sections provide a review of these DoD strategies and explore these identified suitabilities in greater detail with a number of case studies.

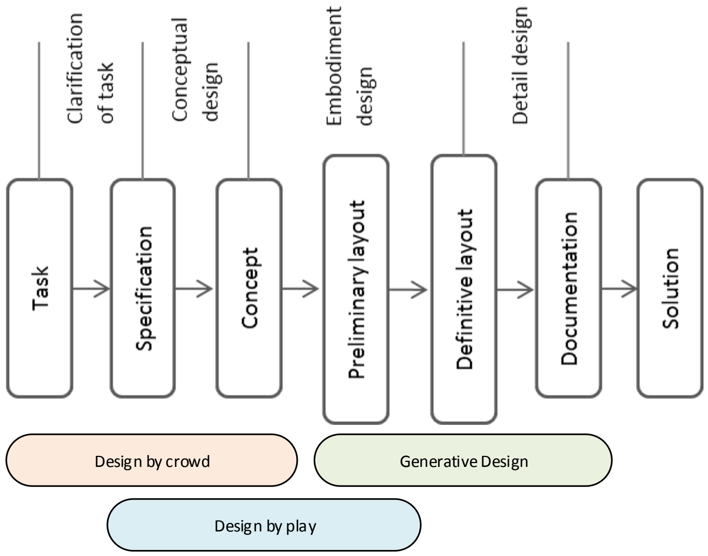

Figure 1: Three approaches to the democratisation of design set in the context of the prescriptive design approach

3.2 Crowdsourcing for design

Crowdsourcing is defined as "the process by which the power of the many can be harnessed together on the internet to build and to innovate" (Howe, 2006). Crowdsourcing democratises design by involving numerous and diverse perspectives in the design process. Contributors do not need to be educated in design, they rarely need specific skills and the process of contribution only requires an internet connection. While there have been examples of use in all phases on the design process, it is predominantly and most effectively used in the early design phases as a consequence of the inverse relationship that exists between the size of the qualified crowd and the level of skill required to contribute. For example, in concept generation, ideas are not scrutinised on their technical rigour or feasibility (Daly *et al.*, 2012). The number of those qualified to make these contributions is high and therefore the crowd available in this phase is large. As the design process progresses, knowledge of technical information, business context and organisational understanding becomes more important and the value that a non-designer can offer diminishes. Since both the availability and diversity of contributors decreases with subsequent design phases, crowdsourcing is most valuable in the early design phases, as emphasised by Figure 2 below.

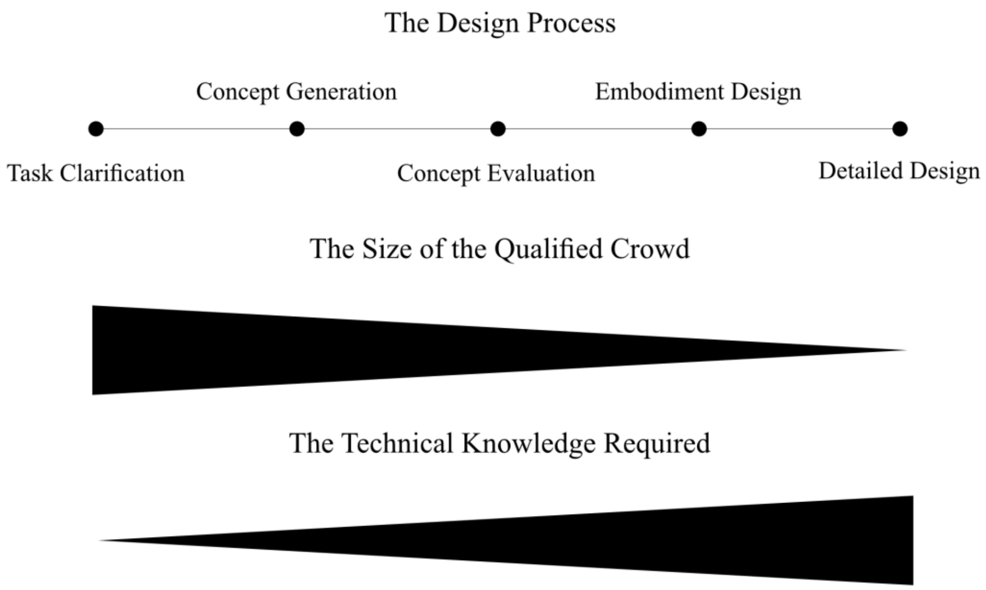

Figure 2: The inverse relationship between the size of the qualified crowd and technical knowledge requirements in the design process

An example of crowdsourcing in design is Procter and Gamble's Connect and Develop (C&D). It is an open call crowdsourcing initiative with indirect benefits (Panchal, 2015). Contributions can be made through their website (Dodgson *et al.*, 2006) and should a contribution be deemed worthy of pursuing, negotiations are initiated with the contributor. After negotiations with the contributor are completed, the contributor has no further involvement in the design process (Dodgson *et al.*, 2006). Procter and Gamble describes the process as capturing ideas and then using their own "R&D, manufacturing, marketing and purchasing abilities to create" products (Huston and Sakkab, 2006). The involvement of the non-designer is therefore purposefully limited to the early design phases.

Furthermore, Procter and Gamble limit involvement by only accepting submissions "with proven success" (Huston and Sakkab, 2006). This translates to a bias towards patented ideas which drastically limits those qualified to submit. This is representative of the way many crowdsourcing processes are now conducted because evaluating submissions is often a difficult and timely process. Submissions are encouraged, not the general public, but from "qualified crowds" such as universities and maker communities. While non-designers are acknowledged to add great benefit through crowdsourcing, unlike the other approaches presented, contributors to the design process are actively managed to ensure high quality submissions.

3.3 Design by play

Design by play, as a relatively new field, does not have academically postured singular definitions. It is posed here to be the abstraction or recontextualization of a problem to present complex constraints in a more simplified manner. Design by play has roots within gamification but is tailored specifically to support design tasks. Non-designers can contribute to the design process by becoming 'players' of the gamified activity.

Gamification, also commonly referred to as Serious Games, has gained significant traction both industrially and academically (Hamari *et al.*, 2014). Deterding (2011) defines gamification as 'the utilisation of game design elements in non-game contexts', Werbach (2014) specifies it as 'the process of making activities more game-like'. Gamification in practice requires some metacognition on the designer's part, understanding not just the minutiae defined in the task analysis phase but also what makes an enjoyable, engaging and importantly, a pragmatic activity. If these conditions are not unified in the activity, the output value may be insignificant compared to the input effort. Design by play can be a cooperative, competitive or a solo experience, but to succeed, it must have fun at its core. All shared play experiences abide to a set of rules defined and accepted by each player. The rules may evolve and expand, but they must not overbear or detract from the enjoyment of the players. Design by play democratises design by providing an accessible method for communicating and capturing task requirements or design intent.

A playful activity can support task clarification through the distillation of user requirements, either directly through analysis of the play session outputs or inferred through observation of participant engagement. Design by play can also be prescribed to conceptual design and early embodiment stages. The abstraction or recontextualization of a design problem can alleviate stakeholder preconceptions or deliberately exclude assumptions. A motivational affordance of a playful activity is the player awareness that they have the freedom to fail, promoting creative thinking around the problem space. With more constraints to the activity, non-designers can contribute through unstructured exploration of the solution space. A well-designed activity will provide motivational affordance (Deterding, 2011), providing satisfaction as a consequence of completion, as opposed to financial incentive or meeting a specification.

An example of design by play is City Blocks - a hybrid urban planning platform using Lego and Virtual Reality (VR) (Kent *et al.*, 2019). In the activity, a Lego city is built from bricks which are contextualised as city elements. Once made, the bricks locations are scanned, and a VR city is generated which can then be immersively explored. From this, high-level discussion of complex space planning can be encouraged. City ideation here is purely subjective, with only indications to the effect of the city block actors on the city as an entity. Players can work collaboratively or individually to develop their cities, using the tangible Lego based design kit to explore and ideate to their own specifications. Once satisfied with the design, the user scans their design which is analysed for feasibility and a series of scores are instantly presented to the user.

The playful design activity allows for user requirements to be gathered, individually by looking at each designed city, and collectively by identifying trends across all designs. The activity also depends on several gamification elements. By presenting scores as obfuscated percentages, there is a motivational affordance to 'beat' that iteration of the design. The Virtual Reality interface provides the user with a technological motivation, instantly being able to explore the highly abstracted digital interpretation of their physical creation. These gamified factors keep non-designers playing, converging towards a feasible solution within the provided constraints that they are satisfied with.

In this example of design by play, the process of city planning was gamified via means of a tangible, physical toolkit & VR to allow anyone to design. In doing this, the technical skill requirement to create and communicate a design was lowered and thus the design task showed increased stakeholder engagement, permitting collective input into the process.

3.4 Deskilling through generative design

Generative design is built on parametric concepts but transforms the computer from a modelling assistant to a generator, permitting the rapid exploration of a complex design space through the use of a defined set of rules (Shea *et al.*, 2005). It concerns the design of processes to generate objects (Hansmeyer, M., 2012) in order to allow human designers to explore a greater number of design possibilities and lowering the time between intention and execution (Pieters *et al.*, 2016). In doing this, it increases a designer's capabilities by reducing the skill required to undertake a design task.

Generative design tools can be considered to either automate the design process or augment a designer's capability (Pieters, R. & Winiger, S., 2016). Commercial generative design packages include Autodesk Generative Design which permits the generative design of structures but still retains a high barrier to entry (Autodesk Inc, 2018), and Shapeways which permits the customisation of aesthetic elements of products with minimal design knowledge.

In literature, generative approaches exist largely for later stages of the design process when the solution principles are known. These include the optimisation of printed parts for strength (Gopsill, J.A. & Hicks, B.J., 2016), mass distribution (Prévost, R. *et al.*, 2013) and moment of inertia (Bächer, M. *et al.*, 2014). In tandem with the development of these generative design approaches, platforms are necessary to enable the simplified exploration of the solution space. These include parameterized dashboards to allow the exploration of the 3D printing solution space (Goguelin, S. *et al.*, 2017) and for 3D geometric modelling, approaches exist that simplify the exploration of high dimension solution spaces via use of semantic deformation handles (Yumer, M.E. *et al.*, 2015a) or using learning algorithms to simplify to achieve dimensionality reduction (Yumer, M.E. *et al.*, 2015b).

An example of a generative design approach that seeks to democratise design is the use of a hybrid virtual-physical design methodology (Goudswaard *et al.*, 2018) to generatively design components for manufacture via Filament Deposition Modelling (FDM). The aim of the method is to permit non-technical users to design and manufacture functional components via FDM. This is done by automating the generation of component geometries and manufacturing parameters. It also permits iteration of the design in the instance that the generated part is unable to meet the requisite functional requirements. The method spans the embodiment and detail phases of the design process. It takes a pre-defined concept and uses genetic algorithms to generate an appropriate set of geometric and manufacturing parameters that would enable the realisation of a functional part. It combines parametrised geometric and functional models allowing simulation of a part's behaviour and generation of a structural instance.

A traditional design approach would require the user to undertake these decisions themselves and would therefore need to be well versed in solid mechanics, have an understanding of the FDM manufacturing process (in order to select appropriate manufacturing parameters) as well as being competent with CAD software. Each of these represents a high barrier to entry in itself and when all are combined, it yields only a small number of expert designers able to undertake such design tasks.

The benefit of this design method, and evidence of its ability to democratise design, is in the great reduction in designerly skills required of a user to design functional parts - something recognised as a key inhibitor to increased proliferation of additive manufacturing technologies (Goudswaard, M. *et al.*, 2017). By automatically generating geometries and manufacturing parameters, non-technical users are able to design for themselves, and as such, a far greater number are able to be involved in the design process.

4 DISCUSSION

Crowdsourcing for design, design by play and deskilling through generative design democratise design in fundamentally different ways. How they differ demonstrates the breadth of the DoD movement and also the many ways in which traditionally 'non-designers' can add real value through the design process.

Whilst each democratising design approach presented reduces the prerequisite skills necessary to undertake certain phases of design tasks, each approach will still require some degree of applied technical knowledge from the non-designer. This is dependent on the power dynamic between the ‘expert’ and non-designers. With crowd design, each participant is a suitably skilled and experienced designer capable of meeting the requirements of the earlier design stages. In the Proctor and Gamble use case presented in section 3.2, the designers require the technical skills to be able to ideate to a high enough quality that a patent may be awarded, with the crowdsourcer having absolute decision-making power. With the generative design use case (section 3.4), the parameterised geometric and functional design is preconfigured with the end user generating a customised design to meet their own specifications. The designer needs to understand their problem sufficiently enough to input their requirements, and identify whether or not a satisfactory item has been produced to enable iteration until a satisfactory solution is generated. With the design by play use case (section 3.3), the pre-requisite knowledge is lowered further, communicating designs through an abstracted and accessible toolset, where the designer may not even fully understand the problem they are trying to solve. The non-designer involvement of each approach could vary according to the value that the non-designer offers. Design by play, for example, is a DoD approach that offers value to designers because it allows fresh perspectives from non-designers throughout the design process. Non-designer involvement is therefore significant. Crowdsourcing on the other hand, is used by designers to capitalise on the diversity of the crowd, which is only fundamental in early design phases. Non-designer involvement is therefore limited. New DoD approaches could therefore be constructed by first considering the value the non-designer offers, in which phases this is most beneficial and the barriers that currently exist in each design phase for non-designer involvement. Design by play is perhaps a perfect example of how this has been done. Play with non-designers was identified as a new approach to requirement capture but in order to involve non-designers, the level of abstraction of design tasks had to be adjusted.

Another suggestion, for why non-designer involvement varies between these three approaches is the age of the research field. Crowdsourcing for design is a relatively mature research field and as a consequence, varying forms of crowdsourcing have been recognised which offer varying non-designer involvement. Furthermore, crowdsourcing has now been used in industry which allowed greater insight into the most impactful ways to apply the approach in design. Design by play, on the other hand, is a very new field which is yet to undergo extensive “testing” in industry and incremental change. Non-designer involvement in design by play may therefore alter as further research is conducted.

When considering the value each approach provides, the context of the design should also be considered. Industries will define their value of democratising design where there are positive and quantifiable impacts to time, quality and cost. Large scale design problems, comprising of complex and interfacing subsystems, will be significantly more difficult to fully democratise. Smaller items, such as consumer goods with limited functionality or items with aesthetic considerations are more suitable to be completely designed using a democratised design activity. Crowdsourcing for design is more beneficial to industries with fully developed concept realisation infrastructures, providing the resources for concept generators to submit their ideas. With design by play, the benefits can be seen where the task is complex, with stakeholder communication being integral to the design’s success. With generative design, the benefits are with bespoke consumer goods. Industries able to manufacture to order, utilising technologies such as additive manufacturing, could see benefit in providing opportunity for users to take ownership of their own products by designing them themselves.

Regardless of the method of design democratisation, there will always be a supporting expert designer. With design using the crowd, the expert designers are later in the process, realising the crowd-generated concept. With design by play, the experts define the problem space and analyse the users’ concepts and approaches post-activity. With generative design, the experts are those creating the parameterised and functional models for use by non-designers.

The strengths and affordances of each approach can be leveraged to support the DoD, with the application of each method enabling non-designers to ideate, generate and communicate designs, throughout the design process.

4.1 Hybrid approach

Whilst each approach presented stems from a fundamentally different branch of literature, they share a common goal of democratising design. Positive elements from each could be integrated into a hybrid approach that would enable further design democratisation. One possible hybrid of the three methods would be the gamified motivation of the crowd to populate design libraries with parameterised and functional dynamic models. Generative design tools, such as those explored in this paper, would then allow the de-skilled creation of end-use models by non-designers.

Through a design library platform, expert designers from the crowd could be used to generate these dynamic models by proposing or optioneering concepts themselves, or at the request of non-designers. Gamified elements such as leader boards, badges and achievements can be used to provide motivational affordances to expert designers.

4.2 Further work

The collation of further democratised design methods has been identified as an avenue for further work. Whilst the authors work in the field of engineering design, they recognise that work in several research fields could yield important breakthroughs in the development of further democratising design approaches. Whilst in this paper we have only considered design approaches, these don't represent the full picture. For example, in order to realise democratised products manufacturing solutions are also necessary. As such, the further development of open, flexible, local manufacturing technologies will drive the need for further design democratisation.

Design by play and crowd design both consider the involvement of additional stakeholders in the design process. To enable increased involvement of these stakeholders it is necessary to better understand their capabilities and motivations and how best they can be managed. Lessons can therefore be applied from fields of psychology and management. The development of intuitive human-computer interfaces is also crucial to the DoD. As shown in the design by play use case, Virtual Reality permits the immersion and exploration of a virtual world and is crucial in the assessment of the created world. As such, further advances in Human Computer Interaction will permit the inclusion of more users.

5 CONCLUSION

This paper has presented and contrasted design by play, generative design and crowdsourcing for design as three design approaches that represent the principle facets of design democratisation. Each DoD approach was contextualised within the prescriptive design process stages that each can democratise were presented and evidenced with a use case. The discussion contrasted the effects that the different strategies have on the design process and how the traditional design power dynamic shifts according to the use of democratising design approaches. It continued to propose a hybrid approach to demonstrate how the presented strategies can be combined to leverage the benefits of each methodology. Further work explored how advances in other research fields would enable the further democratisation of design.

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