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Toolkits, cards and games – A review of analogue tools for collaborative ideation

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Abstract

Analogue tools offer distinct benefits for collaborative design ideation and can take a variety of tailored forms including card decks, templates, toys and board games. However, owing to the disparate and multidisciplinary sources of these tools, there is currently no easy way to gain a coherent view of the tool landscape. To resolve this, we conducted a survey of analogue ideation tools within the design and HCI literatures, and within commercial practice. Of 3,395 results, 76 met the inclusion criteria. The resulting collection is presented and classified according to 10 descriptors including a novel taxonomy for distinguishing 7 tool types (methods, prompts, components, concepts, stories, embodiment, and construction). We also discuss gaps and opportunities for future tool development in inclusivity, cultural-tailoring and embodiment. Our aim is to help designers and design teams more fluently select, customize, critique, analyse and/or build tools to support collaborative designerly inquiry.

Keywords: design tools, toolkits, ideation, creativity, method cards

1 Introduction

Analogue (i.e. non-digital) tools continue to dominate the early stages or 'fuzzy front-end' of the design process (Borum, Petersson, & Frimodt-Møller, 2014) in particular for collaboration (Inie, & Dalsgaard, 2017). Aside from classic generic tools like pencil, paper and sticky notes, there is a growing number of tailored tools specifically designed to support ideation, for example, IDEO's *Methods Cards* (IDEO, 2003), Dan Lockton's *Design with Intent Toolkit* (Lockton, 2017) and the *LEGO Serious Play* kits (LEGO Group, n.d.) to name just a few. Despite the existence of many well-crafted, sometimes well-researched, and often cost-free tools, awareness of these resources is limited by cross-disciplinary silos, lack of consistent terminology, and lack of promotion. This makes it difficult for designers to select or compare tools, for example, based on practical features such as: available research evidence, existing case studies, format, cost, or context-specificity.

Therefore, in order to foster knowledge and reflection around instruments for ideation, we conducted a comprehensive review of the current landscape of analogue ideation tools. Our aim is to assist in the advancement of both research and practice by making existing tools and tool research more accessible, and by identifying areas where further work would benefit the design community.

In section 2 we look at previous work and at the unique role of analogue tools in the collaborative design process. In section 3 we outline research questions and provide detail regarding definitions of key, and potentially ambiguous, terms including, 'ideation' and 'tool'. In section 4 we describe the methods used to carry out the review, including the step-by-step literature review process, inclusion/exclusion criteria and the development of a taxonomy for categorising tools. Results are presented in section 5, while section 6 presents some philosophical and practical issues surrounding ideation tools, as well as opportunities for future tool development. Section 7 summarises limitations and opportunities for tool research, and section 8 concludes.

2 Background

2.1 The role of tools in design

Design tools, in serving to make the external world a part of cognition (Gedenryd, 1998), provide a diverse range of benefits to the design process. Dalsgaard (2017) describes these 'instruments of inquiry' as consisting of five qualities including perception, conception, externalisation, knowing-through-action, and mediation. Freach (n.d.) highlights the value for teams describing tools as useful for catalysing interactions, building relationships, and enabling diverse communities to creatively take action and innovate. In Freach's terms, they provide benefit in that they:

- Allow framing or reframing of problems from multiple perspectives
- Externalization of insight to facilitate dialogue
- Provide a way to use existing knowledge that may have been dormant
- Offer frameworks for visualizing problems and solutions
- Equip teams for learning about people's experiences

Physical artefacts also allow groups to think *through* design–a kind of exploration in which the designer 'plays around' with materials without knowing what will come of it. This type of

‘thinking through making’ is evident in the participatory work of Sanders and Stappers (2014a, 2014b) in which participants are encouraged to ‘play’ with combinations of abstract and ambiguous materials, in order to begin an interactive conversation between individual, materials and co-designers that is intended to access creative thinking and elicit difficult-to-articulate elements of the design space. This approach functions as a kind of ’transinstrumentality’, defined by Dalsgaard (2017) as when ‘designers start working with well-known instruments without knowing exactly where they are going and what they want to achieve, and yet as the interaction between designer, instrument and situation unfolds, they end up producing something meaningful, which advances the design process.’ In this context, the design tool enables the design outcome. The physical tools we use in design can therefore be influential, even critical, to successful design outcomes. As such, improving designer understanding of, and access to tools is valuable to design practice, and a number of reviews have been conducted to this end, as below.

2.2 Previous work

A handful of reviews on different types of design tools have been conducted over the past decade. In general, these have reviewed limited samples of tools and are often specific to a certain type of tool. For example, Tidball et al. (2010) reviewed nine libraries of design methods including online compilations (i.e. Usability Net) as well as ‘toolkits’ comprising a set of methods (i.e. IDEO Human-Centered Design Toolkit). In doing so, they highlight a number of challenges emerging from their review with regard to the dissemination of tools, including the diversity of perspectives held by professionals in the multidisciplinary field of Human-Computer Interaction (HCI) and ‘the lack of a common language’ (this posed a challenge for our review as well, as discussed later under ‘Method’). Tidball and colleagues reviewed only one specific type of tool: methods collections.

In a similar vein, Wölfel and Merritt (2013) surveyed a sample of 18 design method card decks identifying five dimensions and three archetypes of existing tools. Their review was specific to the method card format (card decks of design methods) and covered only a representative sample of these. Most recently, Ho (2017) reviewed ideation tools for use during game jams (hackathons for digital gaming) including ten ‘idea generation toolkits’. While the tools reviewed were largely for broader use, the review itself was limited to a game design context.

To our knowledge, there have been no reviews to date attempting to map the landscape of ideation tools broadly and comprehensively, i.e. going beyond one type of design (e.g. game design) and beyond one type of tool (e.g. methods collections). Moreover, there is gap in knowledge of ideation tools for newer technologies such as Mixed Reality and the Internet of Things (IoT). De Roeck, Stappers and Standaerdt (2014) identify this gap and highlighted how the shifting boundary of industrial design necessitates new ideation and conceptualisation tools that allow for interaction with both the digital and physical elements of a product or service.

In light of the many benefits of design tools--from creativity support, to externalisation, to thinking through design--a comprehensive review and consolidation of available tools stands to provide value to practitioners and researchers alike in a number of ways. Specifically, it would: scaffold the analysis of existing tools, provide a basis for the selection and use of tools for different contexts, and help accelerate the development of new tools in a world of constant digital transformation. Our process in attempting to fill this gap is described below.

3 Research questions

Our goal for this review was to map the breadth and rigour of available analogue ideation tools that can be used for the collaborative design of technologies (we justify this scope below). Broadly, our research questions were:

- What analogue ideation tools are available to designers?
- How might available tools be pragmatically distinguished and classified?
- To what extent are available tools empirically evaluated, and/or theoretically grounded?

3.1 What we mean by 'ideation'

Jonson (2005) describes ideation as 'a matter of generating, developing and communicating ideas, where 'idea' is understood as a basic element of thought that can be either visual, concrete or abstract.' Our review is aligned to this broad definition as it includes both exploratory divergent and convergent processes that occur in the early stages of a design process. It is during this 'fuzzy front-end' of design, which includes 'pre-design' and 'generative' phases (Sanders & Stappers, 2014) that designers use tools 'to create future

products and services…to understand the design situation and the problem at hand, and to explore and experiment with potential solutions.' (Dalsgaard, 2017). It is this multifaceted stage of design that we refer to as ideation.

3.2 What we mean by 'design tools'

At a broad level, we define a design tool as 'something that provides materials with which a designer interacts to create a situation that 'talks back to the designer' (Schoen, 1983).' (Yamamoto & Nakakoji 2005). More specifically, we refer to *analogue* tools (excluding digital tools such as technical toolkits or graphics software). Moreover, we specify *tailored* analogue tools, or those which have been designed specifically to support some aspect of design ideation, thus, excluding general-purpose tools such as pen and paper.

Furthermore, although we acknowledge that methods and techniques can function as 'tools' and are sometimes referred to as such, we limit our review to tools in the form of *physical artefacts*. For instance, while a common design method such as 'building a persona' is not included in our review, a pre-designed template intended to help designers collaboratively work with personas, or a boxed toolkit including representative personas within a particular domain *would* be included.

Finally, our approach favours generalisability. As such, bespoke tools created for specific projects, but which apply only to those projects, are not included since other designers cannot make use of them.

What we mean by 'analogue'

Design tools can, of course, be digital as well as non-digital, or a hybrid of both. While there is significant existing and ongoing research into the area of *digital* creativity support tools (see Frich, Biskjaer, & Dalsgaard, 2018 for a review), for this review, we target non-digital tools. In other words, we include only tools for which a computing device and internet connection are not required. It's worth noting that many of the tools surveyed have digital versions (e.g. an app version or printable PDF) but, critically, their use during ideation is not contingent on digital technology.

Our decision to focus on physical tools is two-fold. First, analogue tools deserve attention in their own right as they have distinctive affordances. In fact, there is evidence that analogue tools continue to be central to the early stages of the design process (Borum, Petersson, & Frimodt-Møller, 2014) in particular when collaboration is involved (Inie, & Dalsgaard, 2017). This is probably because externalising and organising insights and concepts within a group is still more fluid, flexible, and tangible with analogue tools. Furthermore, Kwiatkowska et al. (2015) found that using generative techniques with analogue tools can help technically-oriented teams generate ideas that are less technologically-driven. Finally, as designers who work with diverse communities, we value that analogue tools can be made available to design teams anywhere on the planet, at low cost, including for co-design with users in the field and in remote communities.

3.3 What we mean by 'design'

Because 'design' is such a loosely bounded term (and is used within areas as diverse as business innovation, architecture and jewellery), we focus our review specifically on tools for the design of technologies or digital artefacts and services (e.g. interactive systems, digital art, connected products, web and mobile technology, etc.). We felt this scope was sufficiently broad as to be useful to a large audience, but not so vague as to evade a clear boundary. As such, an ideation tool tailored exclusively to furniture design or architecture would not be included. However, many of the tools we include are general enough to be used across many, if not all, design contexts (i.e. general creativity tools). Therefore, this review will serve designers in general, but especially digital designers.

4 Method

With the aim of attempting an exhaustive list of available tools, we undertook a multi-step review process which included a three-step literature review and a web search. The goal of the web search was to identify tools provided by commercial, non-profit and government sources, rather than reviewing only those from academic contexts. Those tools with research evidence are differentiated from those without in the resulting table. Our process is visualised in Figure 1.

4.1 Challenging terms

One critical problem confronting a review of analogue ideation tools for digital design is the lack of consistent terminology. The terms ‘design toolkit’, ‘design tool’ and ‘artefact’ are used in many different ways. For example, pilot searches on the ACM digital library (ACM DL) for ‘toolkit’ yielded mostly work on ‘technical toolkits’ designed to facilitate programming and the building of software. Because we seek, not only ‘toolkits’ but ‘tools’ more generally, a search for ‘design’ and ‘tool’ would seem appropriate, but these two terms are so broad in their interpretation, that such a search yields nearly 50,000 results. Adding ‘interaction’ to the query only reduces the results to 14,000 while excluding tools useful for, but not specific to, ‘interaction design’.

This difficulty with searching for tools is complicated by a lack of consensus around terminology for digital design itself and design as a process. In fact, the ideation tools with which we, as researcher/practitioners, were already aware, use varied terms such as ‘digital’, ‘multimedia’, ‘user research’, ‘user experience’, ‘HCI’, ‘ideation’, ‘brainstorming’, ‘fuzzy front-end’, ‘design thinking’, ‘design process’, ‘participatory’, ‘co-design’, ‘social innovation’ and ‘creativity’ among others, and with little, if any, overlap.

Owing to the difficulties surrounding indiscriminate terminology, our approach to conducting the literature review was to run a number of fairly specific queries on two large databases and then expand on these via backward and forward reference searching of the relevant results (as recommended by Webster & Watson, 2002). We combined this with a web search in order to capture non-academic tools (our process is documented in detail below).

[Figure 1 here]

4.2 Inclusion/exclusion criteria

The following guided our inclusion and exclusion of tools from the review.

Inclusions

- Self-proclaimed ‘toolkits’, cards and other analogue tools intended for use during the early stages of the design process. This includes tools for creativity, provocation,

planning, co-design or design thinking, but excludes technical tools for programming, engineering or development of high-fidelity prototypes.

- Tools available to the public and in English

Exclusions

- Technical tools and 'HCI toolkits' for programming or development.
- Digital tools and resources, including databases or websites.
- Education toolkits primarily designed for teaching.
- Tools specific to non-digital design, such as those exclusive to industrial design or architecture (except where there is overlap, e.g. Internet of Things).
- Standard documents (e.g. articles or reports that describe a process but do not include templates, cards or other manipulable artefacts for appropriation during the design process).

4.3 Literature search

In order to cover both the computing and design literatures, we conducted searches in both the ACM Digital Library—'the most comprehensive database of computing and information technology literature' (Frisk, Biskjaer & Dalsgaard, 2018)—and the Design and Applied Arts Index (DAAI) (Peer reviewed collection, results in English since 2000) on the terms 'design AND toolkit', 'design AND cards', 'creativity support tool' and 'ideation'. The results in table 1 were accurate as of the 27 August 2018.

[Table 1 here]

A filtering of the 3,322 total results based on a title/abstract review yielded 221 articles. Of these, a full-text review lead to the exclusion of all but 32 articles. A large number of tools were excluded because they were either: 1) digital rather than analogue, 2) not available for others to use, or 3) methods/techniques rather than physical artefacts. Finally, reference and citation lists were searched (citation chaining) yielding 3 additional articles for a total of 35. These 35 articles describe 21 tools, as some tools are described by more than one article. For example, five of the articles included describe the PLEX tool (Lucero & Arrasvuori, 2010; Arrasvuori et al. 2011; Lucero & Arrasvuori, 2013; Van Dooren et al. 2014; Mekky & Lucero, 2016).

4.4 Web search for practice-based tools

The web search was conducted via the Google search engine. Search terms required greater specificity than those used for the literature search, since Google applies no disciplinary filter (eg. a search of 'ideation' effective within the focus of the ACM DL was too broad to uncover design tools on the World Wide Web). As such, after pilot searching, we identified 'design toolkit', and 'design ideation cards' as the most productive search terms and our review of the results included follow-on searches into libraries and lists of other tools for better coverage (i.e. 'Deckaholic', and a number of blog 'top tools' lists.) Review of Google search results continued until three straight pages yielded zero relevant results and resulted in 55 tools total.

4.5 Taxonomy

In search of a framework with which to organise the resulting 76 tools, we reviewed a number of theoretical models of ideation, creativity, and design artefacts including Dalsgaard (2017), Biskjaer, Dalsgaard & Halskov (2017 & 2010), Sanders and Stappers (2014b), Hernandez et al. (2010), Cross (1997), Rosemann and Gero (1993) and Gero (1994). During the review process it became clear that, while existing frameworks provide insight into the process of creativity itself, for example by breaking the process into components (eg. analogy, combination, etc.), these components of creativity do not manifest exclusively in practice, and therefore, tools designed to guide or trigger creativity generally do not discretely align to individual components. Instead, design tools generally have the potential to support *all* of the components of these models and therefore, as categories, they provide little to distinguish the tools.

As such, we turned directly to the data to identify (via constant comparison analysis) a set of approaches to ideation support consistent across the tool list. The first author conducted a sequence of open, axial and selective coding (Strauss & Corbin, 1990) to arrive at a set of tool type categories which was subsequently reviewed and iterated by the other authors. Each tool 'type' (as in the results table) reflects one of seven content-based approaches that tools take to support ideation. Specifically, we found that tools could be described as being of one or more of the following types:

1. **Methods** – Many tools are essentially collections of design methods or creativity strategies (i.e. a methods card deck).

2. **Prompts** – Many tools include provocative questions, triggers or abstract visuals to prompt divergent thinking.
3. **Components** – A number of tools include placeholders (cards, tiles or pawns) to represent different *components* within a system or of a problem (i.e. users, stakeholders, government, technologies, etc.) allowing these to be externalised, reorganised and kept salient during collaboration.
4. **Concepts** – Some tools present chunks of expert knowledge in a manageable manipulable form (e.g. short descriptions of psychological theory on individual cards). This makes the knowledge easier to learn, share and represent externally.
5. **Stories** – A few tools incorporate narratives as part of their approach. For example, a story to illustrate the use of a strategy or as a prompt.
6. **Embodiment** – One tool surveyed incorporates analogue simulation of embodied experience. This was the *Cambridge Inclusive Design Toolkit* which contains both glasses and gloves to allow designers to directly experience reduced visual and manual ability.
7. **Construction** – One tool surveyed (*LEGO Serious Play*) comprises construction pieces for co-creation of physical 3D artefacts.

The types above represent various approaches understood in terms of content and neither is exclusive of the others. In theory, a tool could include methods, concepts, and stories, as well as components for embodiment and construction, but in practice most tools identified with just one or two types.

In addition to the above types, the tools reviewed are classified according to ten pragmatic descriptors. Firstly, we split the tools into two groups based on *specificity* (either 'generic' or 'specialised'). We classified as generic those tools that were broadly applicable to many, if not all, types of design work (i.e. tools for ideation, creativity or design broadly). These will be of interest to most designers. In contrast, *specialist* tools are domain- or context- specific (e.g. technology for health), or they are focused on a particular aspect of design (e.g. 'inclusive design', or 'sound design in games') or a specific technology (e.g. IoT, or VR). We found that separating the tools into these 'generic' and 'specialised' categories facilitates search and selection.

Then, we describe each by: *title*, *author*, *industry of origin* (whether a tool was created within an academic, commercial, or other context), *focus area* (the type of design, objective or activity the tool is intended to support), *format* (a tool's physical manifestation, for example, a card deck or poster includes detail on the type of imagery used) and *availability* with regard to cost (whether the tool is available for free, at a cost, or both, as in when both a free and print version are available). The final two categories are *research* and *case studies*. We believe it is ideal to evaluate tools within a rigorous context in order to give sufficient evidence for their efficacy and to improve them iteratively. It stands to reason that practitioners can have more confidence in a tool that has published research behind it, and this is therefore a helpful selection criterion. However, in reality, the vast majority of tools in use do not have peer-reviewed research associated with them. As such, we added a 'case study' descriptor, in order to provide scope for referencing more informal practitioner-shared experiences using the tool. We believe these can also be valuable to designers looking for guidance on how to use the tool in practice and for the dissemination of lessons learned.

In total, the ten descriptors included for each tool are:

1. **Specificity** (generic or specialised)
2. **Title**
3. **Author** (creator or source of the tool)
4. **Focus area** (e.g. service design, inclusive design, gamification, etc.)
5. **Format** (e.g. cards, gameboard, template, poster, etc.)
6. **Industry of origin** (education, government, commercial, or non-profit)
7. **Type** (methods, prompts, components, concepts, stories, embodiment, or construction)
8. **Availability** (free, paid or both options)
9. **Research evidence** (any published research on the tool)
10. **Case studies** (any public case studies available)

[Tables 2 and 3 here]

5 Results

5.1 Examples of results

Due to its size, the complete results list of 76 tools with all descriptors is available as a supplementary file. Twenty tools are presented in Tables 2 and 3 below to provide a representative sample of results.

Specifically, Table 2 contains ten examples of 'generic' tools whereas Table 3 presents ten 'specialised' tools. As mentioned previously, generic those tools are broadly applicable across design work and will be of interest to most designers while specialist tools are specific to a single domain, technology, context or aspect of design (e.g. design for health, IoT design, inclusive design, sound design in games). We found that separating the tools into these categories facilitates search and selection.

5.2 Companion web resource

Owing to the limitations of a static data table, we created an additional web resource to accompany this review. All 76 tools included in our results table (as well as any additional tools found by the authors post-submission) have been included in the Ideation Tools website (http://ideationtools.blogspot.com) which is searchable by category or keyword. The design community is invited to submit new tools to the site to further increase the comprehensiveness of the resource.

5.3 Summary of results

Overall, among all 76 tools, the best represented focus areas are creativity & innovation (15), game design/gamification (9) service design (7), human-centred design (6) and social innovation (5). Among just the 37 specialised tools, diversity is impressive with tools targeting areas as varied as content strategy, circular design, tangibles, design for wellbeing, and generative art. Among specialised tools, game design/gamification (8), ethics & values (4) and inclusive design (4) are served by the largest number of tools.

For a coherent overview of all results, it is helpful to categorise tools by format. The majority of tools consist of cards and templates (as well as kits which comprise the two), while a number of more unique formats are also represented (such as wearables and construction materials). Each of these categories is described in more detail below.

5.3.1 Cards

Cards (in the form of card decks and card games) overwhelmingly dominate our results. Of the 76 tools reviewed, 55 were (or included) card decks. While this, to some degree, may reflect search terms, the increasing popularity of card-based tools is apparent in their impressive growth over the past decade. For example, the MethodKit company released its first card deck in 2012 and now offers 33 different decks on design topics as varied as app development, gender equality and public health. IDEO (the first to widely popularise the method deck format) released their *Methods Cards* in 2003 and have since released two new decks, one for social innovation and *Nature Cards* featuring design strategies from the natural world. Further evidence for the persistent popularity of card-based tools can be found in the many decks that have been successfully crowdfunded. For example, *Triggers,* which is described on its website as a 'powerful ideation tool for any creative project' received nearly €20,000 (five times the amount requested) via Kickstarter. Both the *Game of Creativity (*a card game for idea generation), and *Generonimos* (a deck for generative art) were also crowdfunded successfully.

The popularity of cards can possibly be explained by the many affordances reported. Users describe them as valuable for sparking creativity, externalizing tacit concepts, constructing and organizing ideas, and working both playfully and collaboratively (Logler, Friedman, Yoo, 2018*;* Buur & Soendergaard 2000*).* Additionally, Kwiatkowska (2014) notes that cards help to set rules for collaborative activities and act as boundary objects, as well as helping designers focus on ideation rather than production.

Indeed, our review revealed an impressive diversity of uses of the card format, with regard to both content and approach. Cards may be distributed in print (i.e. *Mental Notes*) or digitally, for example as a printable PDF (i.e. *PLEX Cards*) and usually consist of sets of *prompts* (provocations/inspiration), *concepts* (discrete bits of knowledge), *components* (placeholders for people and elements in a system) or *methods* (including techniques or strategies). They are offered stand alone or included as a part of larger toolkits.

Diverse examples of *prompt* decks include the *Design Fiction Product Design Work kit* by the Near Future Laboratory, *Human-centered Design Prompts for Emerging Technologies* by IDEO & Google, and Atlassian's *Constraints Deck*. *Oblique Strategies*, the classic 1975

deck created by artist/musician duo Peter Schmidt and Brian Eno is a combination of the *prompts* and *methods* types. Like many other decks, each card has just one idea on it: in this case, either a prompt ('Is there something missing?') or a creativity strategy ('Use an unacceptable colour') both of which are intended to provoke creative thinking.

Among typical *methods* tools, 'method' can range from well-established professional methods (i.e. IDEO *Methods Cards*) to informal micro-strategies for approaching a problem (*Oblique Strategies*). Other decks of this type include the commercially available *75 tools for Creative Thinking* and the research-based *Design with Intent Toolkit*.

[Figure 2 here]

5.3.2 Templates and Toolkits

Beyond card decks, 15 of the remaining tools comprise templates (15) (including worksheets, canvases, or other structured documents designed to scaffold creativity or design processes), or self-described toolkits/kits (22) which generally contain templates and/or card decks, guides or other tools. Some of these use the term 'toolkit' (i.e. *Collective Action Toolkit* and *Platform Design Toolkit*) while others use the simpler term 'kit' (e.g. *Service Design Kit* and *UX Design Kit.)*

Dan Lockton (2017) describes design toolkits as 'a collection of 'ways of doing things' during the design process in the context concerned, such as templates for particular methods, suggested activities and examples of implementing particular principles in practice.' Indeed, a more specific definition is not possible as we found that the term 'toolkit' is used very loosely within the design industry and can refer to any of the following: a) a collection of physical artefacts (i.e. *IoT Toolkit*), b) a combination of physical and digital tools (i.e. the *Inclusive Design Toolkit*), or any of the following which were excluded from our review: c) components to simplify software development, d) a book providing guidance on a process, or e) a collection of web resources.

Our review included a toolkit to the extent that it constituted some form of tangible analogue artefact intended for physical interaction as part of ideation. Therefore, websites and books referred to as 'toolkits' were not included.

5.3.3 Games

A number of card decks are games intended to be played according to a set of rules. For example, the *Game Changer Game*, *Future Deck* and *Grow-a-Game*, all belong to this ideation card game genre. Three tools, however, (the *CoCo Toolkit, IMPACT: A foresight Game* and *the IoT service kit)* leverage the table game format, complete with tokens, game boards and other objects of play.

[Figure 3 here]

5.3.4 Posters

Three examples of posters exist, and in both cases, are part of a larger set of related tools. The *Brains Behavior and Design Toolkit* includes the *Concept Ecosystem Poster* which serves to visualise a complex process, while *Innovation Tools* contains two posters, one for scaffolding collaborative work and another for simple inspiration.

[Figure 4 here]

5.3.5 Wearables for embodied experience

Only one example of a tool for embodiment emerged, namely, the University of Cambridge's *Inclusive Design Toolkit*. In addition to digital tools (such as an 'Exclusion calculator' which estimates the number of people unable to use a product or service because of the demands it places on capabilities) and analogue tools (i.e. reduced ability personas) this toolkit includes a set of wearables for first-person simulated experience. These include reduced visibility glasses and reduced mobility gloves with which designers can directly experience a product as one of the many users with arthritis or other ability impairments. The *Inclusive Design Toolkit* is the only analogue tool we encountered that takes advantage of wearable artefacts and embodied interaction.

[Figure 5 here]

5.3.6 Construction materials

While co-design through making has been popularised by researcher-practitioners such as Liz Sanders and Pieter Stappers (2014a, 2014b), these methodologies usually employ general-purpose craft materials (such as blank stickers and clay) rather than purpose-built tools. However, the *LEGO Serious Play* Kit is an exception. While LEGO is generally considered a generic construction tool (and is indeed used in its generic form for co-design), *LEGO Serious Play* offers a combination of prescribed methodology and a custom kit of blocks designed specifically for creativity and innovation in professional contexts.

[Figure 6 here]

5.4 Notable exclusions

There were a number of tools excluded from our survey that nonetheless serve to inform the space of ideation tools in a few important ways. As such, we describe these below.

5.4.1 Tools for collaboration with diverse participants

While tools exist to help designers understand disability-related issues, there are very few tools designed to facilitate the inclusion of diverse participants into the *design process* (such as those with accessibility requirements). For example, Noel (2015) describes the development of tools for interviewing people with communication disabilities and Regal et al. (2016) describe *TalkingCards*, a mobile connected card-based system to allow for brainstorming with blind and visually impaired users. Although the digital format of these tools placed them outside our review, we choose to draw attention to them as they help break down barriers to user participation and underscore an important gap in the existing tool space.

5.4.2 DIY Tools

A number of articles in the literature provide detailed instructions on how to make a particular type of project-specific tool. Examples include ‘body cards’ (Tholander, 2014) which are intended to bridge ethnographic research to design ideation, ‘video cards’ (Buur & Soendergaard, 2000) which turn user video recordings into a tangible resource for ideation, and ‘inspiration cards’ which externalise domain features and technology capabilities for ideation (Halskov & Dalsgaard, 2006). Although we only included complete artefacts made

publicly available, we felt it worth mentioning this category of tools as they support the kind of customisation often required in practice.

5.4.3 Tools as values (decolonizing ideation)

During our exploration, we came across the *Social Design Toolkit*, (Lamadrid, 2018), a social critique and toolkit for Latin American community leaders working with social designers from Industrialised countries. The toolkit highlights issues of 'ideation hegemony' and the typical lack of power balance and reciprocity in social innovation initiatives carried out in the 'developing world'. It provides guidance to community leaders on balancing power dynamics by offering social designers insight into their own cultural assumptions around collective problem-solving, and exposing an over-focus on consumer products. Although it was excluded from our analysis for being a digital resource, it provides a potent reminder of the cultural biases and value assumptions inevitably embedded into tools and toolkits. We elaborate on this theme in the discussion.

6 Discussion

We have described some of the benefits of analogue ideation tools and explored the landscape of existing tools in terms of type, format and focus area. In this section we look at some of the gaps and opportunities for future work.

6.1 Research without tools and tools without research

Of the 76 tools reviewed, fewer than a third (21) were associated with published research. In addition, a significant proportion of the 221 research-based tools examined in the second round of reviewing had to be excluded on the grounds that the tools described were not made publicly available. We believe it is unfortunate that a significant quantity of research is done on bespoke tools that are not made available in some form to the community (e.g. as a document, or instructions for making). Thus, designers are left with research on the effectiveness of tools they cannot use. Besides being a missed opportunity for dissemination of evidence-based practice, it also poses a problem for replicability of research.

Therefore, we found that the landscape of design tools is disproportionately characterised by a combination of: (a) research on tools that are not made available, and (b) available tools for

which there is no research. There are a number of notable exceptions (listed in the results table), providing excellent examples of how the two can be joined towards evidence-based practice, and we hope more future work will follow their lead. To assist in this, we provide a summary of the various research methods used for evaluating those tools that do have evidence behind them.

6.1.1 Methods for tool evaluation

Of the 21 tools described in the literature, only 14 of these are associated with published evaluations: *AT-ONE Service Innovation Tools*, *LEGO Serious Play*, *Design with Intent*, *Developmentally Situated Design Cards*, *Envisioning Cards*, *Exertion Cards*, *Generonimos*, *Grow-a-Game*, *Inclusive Design Toolkit*, *Mixed Reality Game Cards*, *PLEX Cards*, *Sound Design in Games*, *Tangible Interaction Framework Cards*, and *Tiles IoT Toolkit*). The remaining 7 describe theoretical foundations and/or rigorous development processes, but not empirical evaluations of tool efficacy.

The most common methods used for tool evaluation involve observation of the tool in use (e.g. within a collaborative workshop environment) and participant interviews and/or open- and closed-ended questionnaires. For example, Clatworthy (2011) describes the development of a card-based toolkit evaluated within workshops via a combination of interviews, discussion sessions, questionnaires and observation. Exceptions include evaluations for *Grow-a-game* and the *Envisioning Cards* which instead provide descriptive analysis of case studies of use, in which the authors draw out evidence of tool efficacy through observation (Belman et al. 2011; Friedman & Hendry, 2012). Just one tool, the *Inclusive Design Toolkit*, was evaluated via a pre-and post- condition in which designers were observed using a technology without the toolkit, and then with it (Cardoso & Clarkson, 2012). In all cases, evaluation results are positive with analysis of observed use and questionnaire results providing some evidence for tool acceptability and perceived value.

While results for existing work show promise, there are some limitations worth acknowledging. Most existing evaluations of tools are descriptive (often relying on observation by the tool creators themselves), conducted ‘in the lab’ (rather than in field settings), and lack a control for comparison. As Clatworthy (2011) admits, ‘It is difficult to distinguish between the role of the cards themselves and the role of collaborative workshops

in these positive team building results' and 'it is difficult to know if a potential solution is inhibited without using controlled testing procedures.' While controlled procedures will admittedly often be prohibitively impractical in real project contexts, future work comparing the use of different tools, comparing groups (or output) with and without tools (for example, via creativity measures) or assessing tools within real-world settings all present potential opportunities for future research.

6.2 Gaps and opportunities

6.2.1 3D objects and Embodiment

Cards as a tool format possess many benefits which might explain their popularity, however, the preponderance of cards could also be a result of fixation on the format–that is, familiarity with the card approach leads to repetition of its use. Now, more than ever, with the availability of 3D printers, opportunities are wide open for other types of analogue tangible tools to be created and shared. The use of reusable stickers, magnetic pieces, sculpting material, children's toys, and methods like bodystorming can provide inspiration. There is an exciting opportunity for designers to innovate new 3D printable toolkits (see the *IoT Toolkit* for a unique example), 3D printed wearables as well as tools to augment physical movement, environment, and experience. It could be that some of these alternatives will share many of the advantages of cards but with their own unique affordances to add value.

6.2.2 Inclusivity

Inclusivity (designing in ways that are accessible to users with disabilities) emerges as a gap area for tools but inspiration can be found in the few tools that do exist. Beyond the *Cambridge Inclusive Design kit* which helps designers empathise with users through simulation, the other tools mentioned in the 'notable exceptions' section take a participatory approach by opening the door for users *themselves* to play an active role in design. Similarly, Morrison et al. (2017) use a technique for tactile ideation for imagining Artificial Intelligence (AI) futures with people with visual disabilities. With the percentage of users with a disability growing, inclusive tools can help involve a greater diversity of users as co-designers and encourage the development of more inclusive technology.

6.2.3 Cultural-tailoring

In her book *Decolonizing methodologies*, Linda Tawai Smith (1999) reveals the ways in which research methods themselves have perpetuated colonialism. Lamadrid's *Social Design Toolkit* provides a manifestation of this point specific to collaborative design methods. Work in HCI within diverse cultures (e.g. Winschiers-Theophilus, 2010 and Chen & Wang 2012) has demonstrated how design research methods of Western origin can fail to function appropriately within other cultural contexts. This work highlights that even tools produced within not-for-profit and academic settings carry values and culturally-specific attributes in their approaches, format, and imagery. The result is that tools can be tailored to a particular culture without designers or users of the tool being aware of it.

For example, the *Design for Happiness Deck* is a set of cards including positive emotions, goals and virtues designed within a Western European business context. The cards include the desire for 'superiority' and 'material gain' as personally significant life goals and include Christian representations of spiritual experience. They also illustrate 'satisfaction' as wine appreciation. These examples demonstrate how tools, even via simple line-drawn images, can embed socially and culturally specific connotations.

Indeed, the significant difficulty in creating imagery for tools that is abstract enough to be useful to a wide audience, and yet specific enough to communicate clearly has been documented by tool creators (Lucero & Arrasvuori, 2013). It is probably for this reason that tools intended to function within highly diverse contexts (eg. IDEO's *Design Kit – Travel Pack*) rely on colour and typography alone. It is also for this reason that we include 'imagery' as a descriptor in our results, so that designers can easily identify tools that are text-only or that employ more abstract or symbolic imagery, and so researchers can familiarise themselves with the variety of graphical approaches employed.

Proponents of value sensitive design (Friedman, 1996; Friedman & Brainbridge 2004) would argue (and we would agree) that there is no way to have a design (or therefore a tool) that is values-free. Therefore, the point is to acknowledge and understand the values and assumptions embedded in our tools to the best of our ability, and ensure they are appropriate for our context. We could ask ourselves, what are the philosophies behind the tools we create or use? Are they relevant to the group for which we are using them or do they inappropriately

impose social practices or reinforce inequalities? Value sensitive design provides a starting point for unearthing buried assumptions, as does testing tools with a diverse population. (See *Envisioning Cards*, *Liberatory Design Cards* and *Another Lens* for some tools that can help in the bias exposure process).

While one approach is to make broadly applicable tools, another is to make tools more consciously culturally-tailored. For example, it will arguably be most effective for spirituality to be represented by a cross in one context and animal imagery in another – the critical point is awareness so that tools are genuinely context-appropriate and avoid perpetuating cultural hegemony or distorting research outcomes. This may require involving the audience in tool creation/customisation.

Some other promising approaches include: 1. more room for customisation to allow communities to easily tailor tools themselves, and 2. more efforts for mainstream Western tool development to be informed by tools and perspectives from other cultural groups. In general, making tools more customisable would allow their uptake within varied contexts even within the same culture or community. We believe that making an effort to expose our biases has other benefits too; it can help us productively disrupt fixed mindsets leading to greater opportunities for innovation.

7 Limitations and Further Research

Despite our efforts to make this review as exhaustive as possible, the inconsistent language and multi-disciplinarity of the space means that tools will inevitably have been overlooked. We hope to mitigate this by providing the companion website which can function as a living resource in which new tools can continually be added.

There is a growing number of valuable and research-based digital tools (e.g. online 'ideators' and crowd ideation tools) as well as hybrid tools (i.e. *TalkingCards*) which hold great potential for ideation. Therefore, future studies focusing on digital and hybrid tools would be of great benefit.

Finally, a systematic study into how and why designers do or do not use tools in practice would yield valuable insights for tool designers on how to develop future tools of practical

value. Existing research suggests that advantages to do with the affordances of tangibility play a strong role in uptake, and evidence from the papers in this review echo Freach's points cited earlier. For example, Clatworthy (2011) credits the *AT-ONE* card-based tool with allowing for a holistic understanding by providing a re-configurable visual overview of a problem space. While it is possible for digital tools to provide this, working with components is particularly intuitive with physical tools, and the relative lightweight, low-cost quality of cards welcomes experimentation in ways more high-tech alternatives may not. Clatworthy implicates analogue affordances specifically when citing the unexpected finding that 'the physical form of the cards, together with physical position and movement' aided cognitive processes. And goes on to say that 'It became clear that holding, moving and grouping the cards all supported the cognitive processes involved in the task.'

These advantages might be usefully understood as methods for breaking down the barriers of cross-functional collaboration described by Molin-Juustila's (2006): personality barriers, different cultural thought worlds, language barriers, organisational responsibilities and physical barriers. Still, research on tools has generally been conducted in lab settings in which tools are introduced into a design activity by researchers (i.e. designers didn't select the tools independently). Research is still lacking on what tools are adopted independently and why.

8 Conclusion

Effective ideation in the early stages of the design phase is critical to the success of any design project. In this review, we have attempted to facilitate the advancement of design research and practice by presenting the landscape of existing ideation tools in a structured and accessible way. We have reviewed both the academic literature and industry websites and identified 76 tools, including tools for general ideation and for specific design contexts. We also provide a taxonomy of descriptors to help in the organisation, understanding and selection of these tools.

Our review revealed that tools can be described as being of one or more types: methods, prompts, components, concepts, stories, embodiment or construction. Interestingly, all of the tools uncovered by our review are suitable, if not specifically designed for collaboration, making them all of potential value for co-design and participatory processes.

This might be because analogue tools have the most to contribute within collaborative contexts as the research reviewed provides evidence that tools benefit collaboration by providing: a shared language, a shared goal/context, moveable parts, reification of abstract concepts, and the possibility for collaborative experimentation with symbolic futures.

Finally, we have indicated areas where further tool development and/or research would benefit the community, highlighting cultural-tailoring, inclusivity, embodiment and more evaluation on tool efficacy as areas of great opportunity for future endeavour.

We hope the review of analogue ideation tools provided herein will help design research and practice benefit from a wide variety of carefully crafted, research-based and practice-informed tools.

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Notes

The full list of tools and review data are included in the supplementary file.

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