

Exploring Barriers and Opportunities in Adopting Crowdsourcing Based New Product Development in Manufacturing SMEs

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Abstract: Crowdsourcing is an innovative business practice of obtaining needed services, ideas, or content or even funds by soliciting contributions from a large group of people (the ‘Crowd’). The potential benefits of utilizing crowdsourcing in product design are well-documented, but little research exists on what are the barriers and opportunities in adopting crowdsourcing in new product development (NPD) of manufacturing SMEs. In order to answer the above questions, a Proof of Market study is carried out on crowdsourcing-based product design under an Innovate UK funded Smart project, which aims at identifying the needs, challenges and future development opportunities associated with adopting crowdsourcing strategies for NPD. The research findings from this study are reported here and can be used to guide future development of crowdsourcing-based collaborative design methods and tools and provide some practical references for industry to adopt this new and emerging collaborative design method in their business.

Keywords: new product development, open design innovation, collaborative design, crowdsourcing, manufacturing, SMEs

1 Introduction

Crowdsourcing^[1] is often associated with a special form of ‘Open Innovation’^[2–3]. It is an ICT-enabled innovation tool that may be social media-based^[4–5], web-based^[6] or a combination of both^[7]. By taking advantage of the connectivity enabled by the Internet, use of social media, smart devices and apps by consumers worldwide, crowdsourcing and its associated online platforms and tools offer the opportunity to businesses to ‘open’ their innovation processes and connect with a widely distributed and diverse network of both experts and nonexperts (e.g., consumers) in order to outsource innovative ideas and solutions in the Industry 4.0 era^[8]. In contrast to the traditional paradigm where organisations typically source ideas and solutions through their internal staff or external partners and suppliers, crowdsourcing enables organisations to maximise their capabilities and innovation opportunities by adopting a co-creative approach. Nowadays, several organizations such as P&G, Fiat, Amazon, Dell, Starbucks, Boeing, amongst others, have developed ongoing crowdsourcing communities that collect ideas for new products and services from the crowd^[9–10]. Others such as Philips and Siemens crowdsource product

ideas from commissioning established crowdsourcing platforms and tools^[11]. The most popular crowdsourcing approach is through the advertisement of open calls to the ‘crowd’ to participate in challenges and/or competitions relating to set problems and invite their contribution of ideas, solutions and/or suggestions. The contributions are screened, evaluated and individuals are rewarded based on the success of their solutions.

In general, companies can benefit from using crowdsourcing tools and the access to specialised resources available to them, amongst others, a) by the novelty, speed and cost effectiveness of the solutions generated, b) from their ability to dynamically scale up (or down) around internal processes, and c) by retaining direct contact with their customers and better geographical coverage in the ever changing markets^[11–14]. For SMEs in particular, crowdsourcing can enable the scaling-up of design and manufacturing operations past a handful of employees^[15], introduce a step change in new product development (NPD) process and technology^[16] and ultimately improve design performance and quality. Whilst there is a growing body of research on crowdsourcing, crowdsourcing-based product design and development is still at an early stage with relatively few studies^[10, 17–19] dealing specifically aspects of the NPD process. Likewise, little is known with regards to the levels of the adoption of crowdsourcing from manufacturing SMEs and what are the key challenges and/or opportunities from businesses of this type. For

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example, following an email-based ‘Expression of Interest’ survey among design-related and manufacturing SMEs in the North East of England, we sought to find out about their current familiarity and adoption of crowdsourcing tools. Over 100 SMEs expressed their interest in the use of this type of innovation approach, however they all wanted to learn more about crowdsourcing as they have not yet applied it in their business practice. Our initial findings set our first research question: ‘What are the needs and challenges that stop SMEs from adopting crowdsourcing approaches in their innovation practices?’

Moreover, it can be argued that the booming of internet and mobile phone users (which according to Daze info report(<http://dazeinfo.com/2015/05/27/internet-mobile-phone-users-worldwide-2000-2015-report/>) in 2015 was found to be over 50% of the world’s population) suggests that a good number of specialised experts and consumers are currently untapped by organisations and could be potentially linked to various crowdsourcing platforms to help product design and development. Under current harsh economic and competitive conditions, businesses need to respond to these trends and harness the full potential of digital platforms in order to outsource expertise and co-create with consumers. Therefore, a second research question concerned by this study is: ‘How can we improve the current situation and encourage design and manufacturing SMEs to gain benefits from adopting crowdsourcing into their business practices?’

This paper presents some preliminary findings based on a study to investigate the use of a crowdsourcing platform for accomplishing traditional forms of design and new product development activities by manufacturing SMEs. Here, we specifically draw on findings from a proof of market study concerned with exploring the current adoption needs and challenges of SMEs and the requirements for a potential platform to successfully meet them. Around the two aforementioned research questions, our study sets to identify:

- (1) Current crowdsourcing platforms, tools and their applications;
- (2) Key business models for crowdsourcing;
- (3) Key barriers in adopting current tools in SME practice;
- (4) Needs and challenges for crowdsourcing NPD by SMEs;
- (5) Potential markets for new tools;
- (6) Research and development opportunities.

Our research contributions are two-fold: first, we set out to better explicate crowdsourcing application scenarios and the needs and challenges for NPD in SMEs. Second, we aim to identify the key requirements for developing future crowdsourcing-based product design and development platforms based on a NPD activity-based process model.

The paper is organised as follows. Firstly, we discuss our research methods and activities relating to a proof of market study which this paper is based on. Secondly, we

introduce the context of NPD and SMEs and argue that it is an important neglected area for research. This is followed by a brief overview of existing crowdsourcing platforms and tools and later we explore which NPD tasks are currently supported by these platforms. We then discuss our findings around challenges and barriers in crowdsourcing adoption by SMEs in parallel with relevant studies in the area. Further, we present open source software as a potential technology towards the development of a draft crowdsourcing platform which we are currently trialling in industry. We conclude our study by providing some key insights and guidelines for meeting the market needs.

2 Research Methods and Activities

The study takes a qualitative, interpretive approach, using literature review, review of existing crowdsourcing platforms and applications, online survey, focus group study, and several semi-structured interviews with industry experts as primary methods of data collection. Data was analysed based on a grounded theory approach in order to extract emerging themes and insights which we discuss in relation to adoption challenges and suggested directions for crowdsourcing NPD in SMEs.

Initially, we conducted desk-based research and looked at both literature and online resources to find relevant publications around Open Innovation (OI) and crowdsourcing. We regarded crowdsourcing as one of the available OI tools and our goal was to identify and examine current crowdsourcing platforms’ tools, features and functions. In particular, DIENER and PILLER’s extensive survey^[20] on the market for open innovation from a global perspective, served as a starting point for our UK-focused study. In addition, we conducted an extensive online search for existing crowdsourcing platforms and case studies from companies. Websites such as crowdsourcing.org and boardofinnovation.com served as key resources for identifying relevant material, surveying digital crowdsourcing platforms as well as more general open innovation platforms/services. As a starting point, we explored nine OI/Crowdsourcing categories organised by the Board of Innovation website (<http://www.boardofinnovation.com/list-open-innovation-crowdsourcing-examples/>):

- Research & Development
- Marketing
- Design & Ideation
- Collective Intelligence & Prediction
- HR & Freelancers
- Branding
- Corporate Tools
- Creative Co-creation

The criteria used for reviewing each platform were primarily based on their level of relevance to our study and/or their novelty to their approach. For example, we specifically looked for platforms that, first, supported any

type of design activities, and second, product design or new product development (NPD) in particular. We also found a number of platforms whose function targeted different audiences (e.g., public, science and technology sector) that offered novel functions and tools which the study considered their potential adaptability into a NPD crowdsourcing platform.

Furthermore, in order to identify key barriers in adopting crowdsourcing from SMEs, we conducted an online survey with the support of RTC North/Design Network North (DNN)'s network of regional SMEs. The survey was sent to over 100 companies and asked the respondents about their experience (if any) in crowdsourcing activities.

Following our initial insights, we approached and interviewed a number of industry experts, innovators and design directors from large corporations such as Unilever, Philips, P&G, Northumbrian Water, North-East (UK) regional innovation coordinators and the Packaging Society of the UK. We conducted semi-structured interviews to find out about their views, experience and future potential for crowdsourcing. For this reason, we devised a pilot questionnaire whose use was two-fold; first, the questionnaire was sent to each participant prior to the interview in order to familiarise them with the study and key topics in question. Second, it provided a flexible structure and assisted the research team while conducting the interviews. We asked our participants to name digital platforms they have used in the past, being using at the time, or have heard about in their business environment. Some interviews took place at Northumbria University business meeting grounds, while others required the research team to visit the participants' industry offices and/or to organise teleconferences via both Skype and telephone. Moreover, we engaged in informal discussions with Maker Spaces, manufacturers and researchers during an RCA's sponsored event in Manchester which focused on future scenarios in distributed and smart manufacturing (<http://futuremakespaces.rca.ac.uk/25k-research-call-digital-networks-tools-or-cultures/>).

Finally, we ran a focus group study with regional SMEs at a DNN's business and innovation support event called 'The Power of the Crowd'. 23 members of SMEs with varied roles attended the event and were introduced to the concept of OI and crowdsourcing through presentations from industry and university-led examples of crowdsourcing projects and businesses. This was followed by a group-based workshop to identify current key barriers and needs relating to applying crowdsourcing into business practice. We focused on four key business challenges which were devised by the research team as a result of both our review of existing platforms and interviews with industry experts:

- Define the need/want
- Find the right experts
- Filter responses
- Manage terms of engagement

We discuss these in more detail in the following sections.

3 Context: New Product Development and SMEs

NPD is a vital aspect to every organisation as providing tangible and/or intangible goods and services to their 'customers' are critical to the survival, resilience and/or growth of these (and other) organisations^[21]. New products and/or services add to organisations' economic viability as well as differentiates them from competition through attractive and pleasant products that people are more likely to choose to buy. The most important aspects to the success of any NPD include: a) the in-house organisational efforts to constantly search for applications of own expertise and resources into developing a new product, and b) the ability to search and utilise external sources of expertise to identify opportunities and/or solve problems which are difficult for the organisations to provide themselves.

Successfully managing the internal organisational environment goes hand in hand with finding appropriate ways for coordinating diverse functional expertise and creates shared meanings across boundaries^[22]. The capacity to innovate is co-dependent with the organisational structure which supports the day to day internal communication and knowledge sharing^[23]. Hence, organisations need to establish appropriate patterns of social processes that can enable the integration of people and the mobilisation of critical knowledge across boundaries to deal with novel challenges such as innovation^[21, 24-27]. However, the ability to develop in-house innovations increases when organisations are able to also learn from innovation practices of other individuals and organisations^[28]. Therefore, it is argued that a key organisational capability requires nurturing strong external relationships such as those with customers, suppliers, partners and other institutes (e.g., universities)^[29-30]. Doing so, organisations can overcome their lack of in-house expertise by expanding their search for new ideas, inspiration and key knowledge sourcing through external networks, collaboration and strong partnerships^[31-32]. This reality is particularly important for SMEs who are typically characterised, amongst others, by informal and ad-hoc processes, obscure innovation practices, interpersonal relationships, risk aversion and resource limitations^[21].

Open Innovation, crowdsourcing systems and practices seek to enable organisations to better meet both the aforementioned internal and external challenges by tapping on the opportunities offered by advancements in digital and Web 2.0 technologies. For instance, crowdsourcing systems can help organisations to improve internal communication amongst diverse functional departments, enable bottom-up sources of innovation from in-house staff and bring into attention the often 'unsung creative heroes'^[21]. On the other hand, crowdsourcing can enable organisations to crowd-source NPD tasks, as opposed to the traditional

outsourcing paradigm, essentially helping them overcome limitations in their own resources and capabilities by operating globally and with a very large pool of participants. Put it differently, crowdsourcing-based innovation is based on openness, peering, sharing and acting globally. Therefore, we argue that crowdsourcing NPD in manufacturing SMEs is an important area for research that is less developed compared to other industries and organisations.

4 Brief Overview of Crowdsourcing Platforms, Types and Models

Crowdsourcing is based on the simple idea that anyone can potentially contribute a valuable solution or suggestion to a problem. HOWE^[1], who allegedly first coined the term in his *Wired* magazine, defined crowdsourcing as “the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call.” In this section we discuss key, albeit general, characteristics of crowdsourcing platforms, types and models. It is important to point out that the following discussion does not aim to provide an exhaustive review of crowdsourcing platforms, types and models as these have been systematically reviewed elsewhere^[33–35] and from different viewpoints (e.g., components and functions of crowdsourcing systems^[36], human resource perspective^[37] and strategic outsourcing^[38]).

Generally speaking, applications of crowdsourcing (See for example, <http://www.crowdsourcing.org/>) are being developed rapidly and cover a wide range of services, such as crowdfunding, content translation, education and decision making. Within manufacturing and NPD, crowdsourcing can be applied for ideas generation, problem-solving, design, collaborative work, testing and prototyping as well as for expert support^[8,13]. Regardless the specific focus of crowdsourcing applications, there are some common features and functionalities that can be said to be associated to crowdsourcing and which we discuss hereafter.

Taxonomies of crowdsourcing platforms: several classifications and typologies, have been proposed by researchers with regards to crowdsourcing platforms and their associated business models. For example, SAXTON, et al^[39], classified nine crowdsourcing business models: intermediary, citizen media production, collaborative software development, digital goods sales, product design, peer-to-peer social financing, consumer report, knowledge base building, and collaborative science project model. In Ref. [40] an integrated typology consisting of five platform types is proposed: crowdcasting, crowdcollaboration, crowdcontent, crowdfunding, and crowdopinion. Following our review of crowdsourcing platforms, we propose that crowdsourcing platforms can be generally categorised in two key types as follows.

(1) Corporate Innovation Tools: a digital crowdsourcing platform is licensed to a corporation and is hosted and run by their internal IT department.

(2) Intermediary platform: hosted and owned by a service provider company (broker), offering fee-based crowdsourcing services to clients (businesses/solution seekers).

Corporate platform types can be run by organisations both internally and externally whilst intermediary-types are typically externally-based. The former types seek to better utilise ideas and problem solving skills from within the organisation (e.g., existing members across different departments) while the latter usually from large, undefined, heterogeneous external actors (individuals, organisations)^[8].

From our review of intermediary crowdsourcing platforms, we found that they generally support their clients in four key business challenges either through consultancy-based services or a range of digital tools.

(1) Framing a problem/need/want; often an expert supplier understands the nature of a problem better than the buyer so it is hard for the ‘non-expert’ buyer to define the need. Hence, clients can receive support from a platform’s experts (brokers) to clearly define what the actual need or problem that they would like the ‘crowd’ to help them resolve. This is a crucial activity as it significantly impacts the ability of a business to receive appropriate and relevant solutions from the ‘crowd’. It is a complex and challenging task which platforms can offer their expertise to work with the customer (either through consultancy services such as workshops/brainstorming sessions, or by offering standardised templates) to set the focus of the ‘brief’, often by separating them between Want Vs Need. Ultimately, the formulated brief drives the ‘call’, i.e., a Challenge, Contest, Idea Sharing, or Solution based on the needs of the project.

(2) Sourcing expert(s); once a need is identified, it can still be difficult for a solution seeker to get in contact with the right solution providers. Hence, formulated briefs become calls to experts. Platforms can scan and help customers to find the most appropriate partners/solvers sourced from a network of experts, owned by either the platform or the customer. Platforms are often equipped with a bespoke in-house search engine. In an open-based platform, the call is published either through a) a dedicated online portal (customizable to fit the company’s specifications), b) as an Open Call within a web-based platform (i.e., Buy/Sell services type), or c) an internal innovation portal where in-house employees and other stakeholders are invited to join the community.

(3) Filtering responses; once a need or request for proposals has gone out to the community of experts, it can be difficult for buyers to evaluate responses from different providers. This is especially true if the need is not clearly defined or if the buyer is not expert in the product/service they are buying. Intermediaries help solution seekers with expert knowledge and/or proprietary systems to filter out

solutions who do not work whilst helping with selecting those with the greatest potential.

(4) Terms of engagement; even once a company understands the need and know who they want to talk to, engaging with external partners can still be problematic. Some of the issues that might come up include confidentiality, intellectual property, licensing, managing different business cultures and power imbalances (e.g., between SMEs and large organisations), expectations, payments and rewards. Platforms can offer proprietary systems, billing and pricing systems, facilitate interactions between peers ensure intellectual property and commercial interests are protected. As we will discuss in the following sections, this area creates the most common barrier preventing a company, especially an SME, from employing a crowdsourcing strategy in NPD.

Platform technology and tools — The underlying technologies which these platforms are built are typically SaaS based, although they can operate both as Web-based and as standalone software packages. Briefly, corporate platform owners have the ability to customise systems to meet their business needs such as defining the focus, access, design and communication of the content. Some software-based platforms provide automatically generated outputs such as analytical reports, visual content analysis and storytelling of the interactive content. On the other hand, intermediaries offer premium services such as advanced search engines/directories of experts, technologies, companies/partners; social media listening; expert community membership; expert and identity verification; IP protection agreements; access to content databases (e.g., research reports such as market trends).

Crowd engagement and tools—Crowdsourcing not only actively involves a diverse crowd of users (e.g., consumers, suppliers, experts) but actively controls the online community through sophisticated management schemes involving compensation, copyright protection, and the like while social media sites place emphasis on the social aspect of community^[39]. Crowdsourcing initiatives typically take the form of a challenge or contest and can have an open or private format. Likewise, there are several different rewarding systems in place for attracting and engaging the ‘crowd’. As we argue later in the paper, this area of enquiry (crowd engagement) has attracted most of the scholarly research around crowdsourcing. Briefly, rewarding and recognition systems are the most typical approach to attract participation to challenges, contests and research in both public and private crowdsourcing platforms. Rewards span from cash prizes to various other incentives such as earning badges, levels of achievement, points awarded, with leader boards and dashboards displaying user statistics based on participation and contribution. For example, challenges and contests often aim at attracting individuals interested to participate by offering a financial reward only to those individuals who produce a satisfying solution related to the call (contest winners) (platform example: 99designs-[https://](https://99designs.co.uk)

99designs.co.uk). On the other hand, a challenge or contest can be also run on a co-creative, community basis^[8]; community members are individuals with specific skills, expertise, or common interests, essentially forming a network of experts who gather around a particular organisation and contribute in solving problems set by the organisation. Participation in such crowdsourcing communities can be both open to everyone (harnessing collective intelligence, such as OpenIDEO-<https://openideo.com/> and/or restricted to selected individuals who possess the necessary qualifications such as in the platform: amazon mechanical turk-<https://www.mturk.com/mturk/welcome>). In the latter case, every recruited expert receives a minimum financial reward, though it varies according to task difficulty and personal achievements (number of contributing solutions/ideas). Moreover, members of the ‘crowd’ can construct their personal profiles where they advertise information about themselves and their expertise, while keeping a record of their activities, contributions and rewards. Members’ roles span from solution seekers, problem solvers, researchers, facilitators, and/or idea evaluators. They are provided with tools such as custom surveys, idea generation tools (e.g., brainstorming, mind mapping, card sorting), ideas and research sharing (e.g., visual media galleries), and direct communication with other members.

Process—The crowdsourcing process generally follows these steps:

(1) The organisation/solution seeker defines the problem through a form of brief and sets the parameters for the challenge.

(2) The challenge is advertised over the Internet via the organisation’s or intermediary’s platform, or in some instances over the organisation’s website (Portal).

(3) The ‘crowd’ individually or co-creatively submit solutions in response either through the platform’s submission forms or simple email (e.g., in the Portal case). In intermediary platforms, the crowd is selected from their existing network of experts.

(4) The organisation (with the help of the intermediary experts when relevant) filters/validates the responses and chooses most satisfactory solutions. In open challenges, the crowd may also review and rate responses.

(5) Winning respondents receive relevant rewards.

Fig. 1 demonstrates key features of popular existing platforms and Fig. 2 provides a brief overview of the tools offered by existing crowdsourcing platforms to both organisations and the community (crowd) and how these relate to each other.

5 Current Crowdsourcing Services Against NPD Process

We wanted to find out to what extent current crowdsourcing platforms generally support NPD tasks. As NPD processes differ from one organisation to another^[21], we

looked at the UK Design Council’s Double Diamond design process model^[41] (see Fig. 3) as a framework for thinking^[42].

	Create/develop							Outcomes			Community			Technology			
	Idea sharing	Challenges	Contests	Online	SaaS	Portal	Buy/sell services	Analytical reports	Data visualisation	Visual storytelling	Access to experts	Open reg. users	Co-creation groups	X-search engines	Media integration	Configurable	Evaluation
Inductsoftware	•	•			•			•	•		•	•					•
Innocentive	•	•									•	•					
Ideaconnection	•	•	•	•							•	•					
Cmnty		•	•		•			•	•	•		•		•	•		
Mindjet	•				•			•	•		•	•		•	•		
Cognistreamer	•			•	•			•	•		•	•					•
Lumenogic	•			•				•				•					
Topcoder	•	•	•	•								•	•				
Imaginatik	•				•			•	•		•	•		•	•		
Chaordix	•	•	•	•	•				•		•	•	•	•	•		
Startupcrowdfunding	•			•								•			•		•
Kapipal	•			•			•					•					
Yet2	•	•		•		•					•	•					
Communispace		•		•		•					•	•					
Trendwatching				•				•	•		•	•					
Ixc-uk	•	•				•											
Blurgroup				•			•					•					
Ninesigma		•	•	•		•					•	•		•			
Ideaken		•	•	•	•						•	•					
Innovation-community		•	•	•		•						•					•
Presans		•	•					•						•			
Innoget		•		•	•	•	•				•	•				•	
Ideabounty crowdspring 99designs	•	•		•			•					•					
Eyeka	•	•	•	•								•	•				
Venturespirit	•	•	•		•							•		•	•		
Zazzle				•			•					•	•				
Quircky	•			•							•	•	•				•
Jovoto	•	•	•	•								•	•				

Fig. 1. Key features of existing platforms

According to this model, the process starts with the Discover phase, which includes activities such as gathering inspiration and insights, identifying user needs and exploring initial ideas. Traditional design methods used in this stage include R&D activities such as market and technology research, user research, managing information and design research groups. At the second phase organisations need to ‘Define’ what matters most and where their efforts and resources should be focused. The goal is to develop a design brief that clearly communicates

the requirements for the new development across the organisation. Key activities in this phase include project development, project management and project sign off. During the ‘Develop’ phase, solutions are created, prototyped, tested and iterated. This process of trial and error helps designers to improve and refine their ideas. Key design methods in this phrase include brainstorming, prototyping, multi-disciplinary working, visual management, development methods and testing. Finally, during the ‘Deliver’ phase, the newly developed product(s)

or service(s) are finalised, put into production and launched to the market. Key activities here include final testing, approval, production and product launch, targets, evaluation and customer feedback loops.

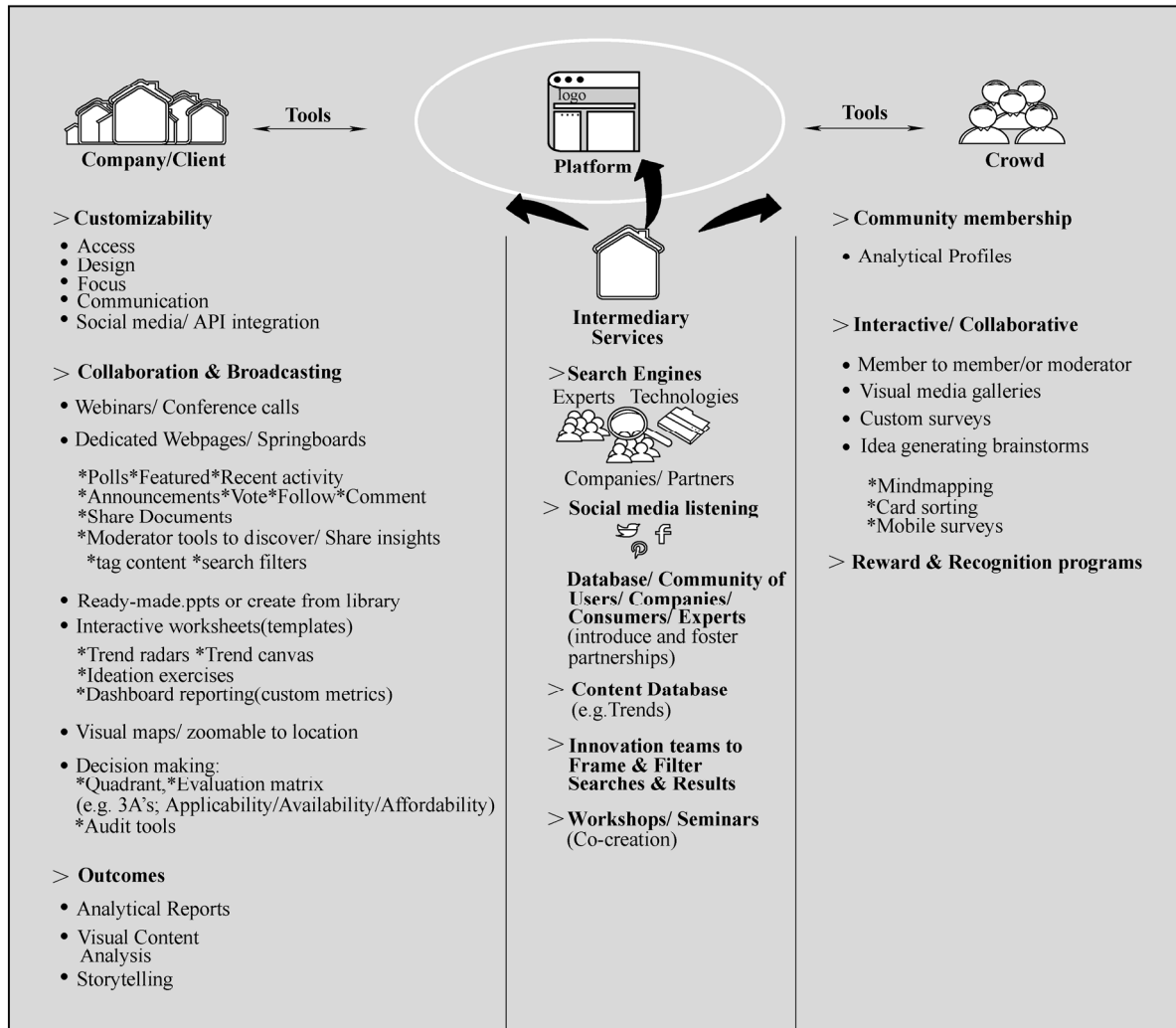


Fig. 2. Key functions and tools between platforms, businesses and the community

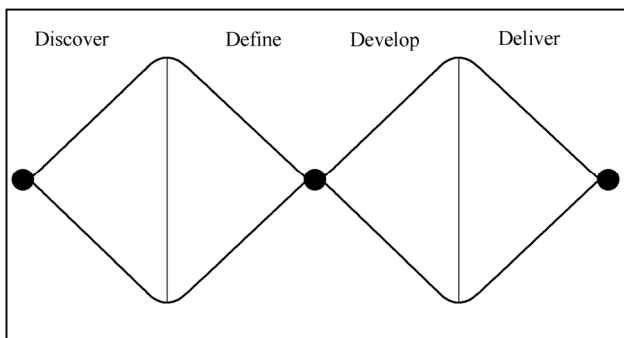


Fig. 3. Double diamond design process model

For the above typical New Product Development (NPD) activities, current platforms provide different levels of support. We further simplified the double diamond process model into three periods of activities based on the innovation journey^[43], termed ‘Initiation’, ‘Development’ and ‘Implementation’. We then explored which typical NPD activities across the three periods were supported by intermediary platforms in relation to the identified

(discussed earlier) four business challenges they typically assist their clients. Fig. 4 shows the availability of existing crowdsourcing services for NPD activities. As it can be seen, some activities are fully supported, some partially and others are not currently supported at all. Therefore, in line with CHANG, et al’s highlights^[14] of gaps in existing crowdsourcing schemes, we propose that there is a lack of an integral platform to support NPD activities across its whole design spectrum.

6 Challenges and Barriers for Adopting Crowdsourcing in SMEs

Benefits associated with crowdsourcing in organisations are well documented by several studies in both academia and industry grounds^[26,37]. Some notable efforts have also been done in relation to identifying the key challenges and barriers associated with OI and crowdsourcing adoption by organisations^[15]. Even so, the majority of those have focused on case examples of popular existing platforms

across different industries and from large organisations. While there are a number of studies that have specifically looked at the manufacturing industry^[33], NPD^[44], and SMEs^[15], there still exists a notable gap of scholarly work

that deals with all three areas in an integrated way. In this section, we bring at the forefront key insights from our study's collected data analysis and posit them along with key findings and arguments found within current literature.

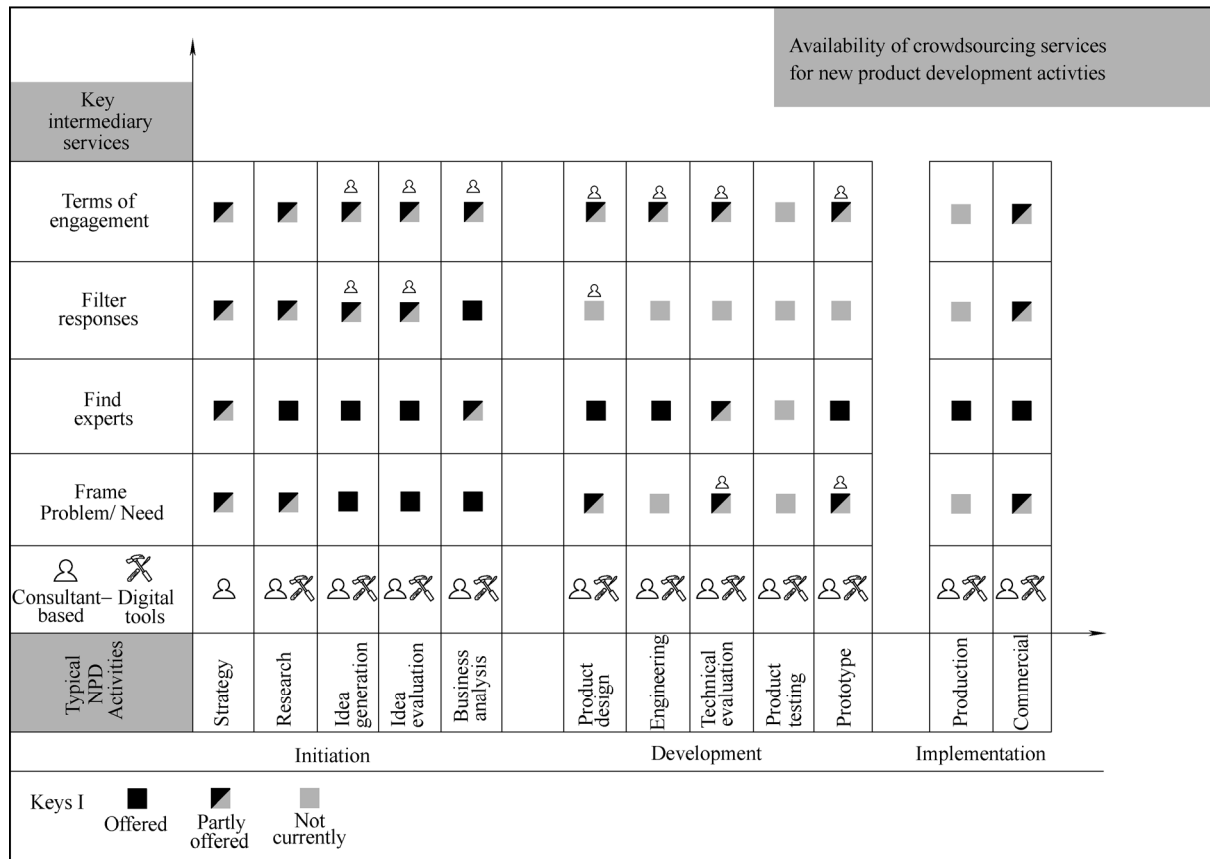


Fig. 4. Availability of crowdsourcing services against typical NPD activities

6.1 Unawareness of tools/models

Interestingly, whilst the benefits from using OI and crowdsourcing were acknowledged by a big portion of SMEs, nonetheless they had not yet adopted it in their practice. The low adoption levels of SMEs was also pointed out by PILZ, et al^[45] who also noted that the reasons behind this reality are not well-known. One recurring theme emerging through our interview with SMEs regarded their low level of awareness of existing platforms and tools.

More precisely, our research confirmed that the majority of both small and large organisations are aware of the concept of open innovation (OI), yet only large organizations, such as Unilever, P&G and Philips were found to already been practicing OI and crowdsourcing with both licensed or in-house developed platforms and systems. In contrast, SMEs noted that they lack detailed knowledge of which platforms are suitable for their business and tasks or what tools are available and how to use them. Past research has highlighted a number of issues that can be related around this including; the tendency of only few executives to actually understanding the potential of accessing workforces from virtual communities^[11] or having the vision and willingness to pursue it^[15], the lack of effective crowdsourcing support for product innovation and

the design of crowdsourcing tasks^[17], lack of practical guides for companies to help them decide what task to crowdsource^[13] or perhaps more importantly why to crowdsource a particular task^[35], not knowing how to effectively attract and manage an online community^[11] and how to facilitate interactions^[18].

The problem of unawareness was illustrated during our interview with an industry expert [RS, ex. P&G]; the respondent was part of the industry board of the Royal Society of Chemistry (RSC) who wanted to help small businesses, members of the RSC, to better engage with problem solving through OI. The board noticed that SMEs were not aware of existing platforms and services and their first reaction was to think about ‘building their own platform’ (an idea, he argued, was the wrong way to go about it), rather than finding and licensing services from established providers. On this particular topic, DJELASSI, et al^[13], postulated that the adoption of crowdsourcing should not be taken light-hearted by business owners as a simple marketing tool because OI is a rather complex endeavour which affects every part of the organisation. RS further noted that SMEs generally lack awareness even of existing platforms where challenges are advertised and which SMEs could be tapping into as problem solvers:

“...the sort of hurdle you have to overcome as an SME to act as a provider of the challenge is a bit different from the “let me keep my eyes open for opportunities to solve other people’s problems” [...] the other one is “I need somebody continuously searching the web for challenges on platforms such as xxxx, xxxxx or xxxx [existing platforms] [...] It requires a strategy for engagement which most small companies do not have.” RS, P&G

RS argued that there exists a fundamental flaw currently as there is not enough awareness and knowledge in the North East region of the UK around these things. Moreover, he suggested that the region needs to enhance its networking problem-solving capabilities, as very often small businesses are not aware of other companies who may operate nearby and who can solve a particular problem in need. As we have mentioned earlier, this capacity to network and identify new partnerships and expertise is vital to SMEs innovation potential and survival, irrespective of the benefits of adopting crowdsourcing. RS further postulated that raising awareness of the value of crowdsourcing services would be very valuable across different sectors and industry clusters, such as the automotive industry, the IT sector (e.g., Dynamo North East) and the public sector. This would essentially offer regional clusters with the tools and platforms to bring together a wide pool of participants, communities and experts over different sectors and enable them to connect and solve problems in more efficient and effective ways. In the same line of thought, PILZ, et al^[45], suggested that a possible useful direction for SMEs would be to use crowdsourcing as an open paradigm to their current business model with the aim of creating partnerships with other SMEs, large organisations, and/or online communities in an institutionalized way, therefore evolving from competition to cooperation and co-creation.

The reality of ‘want to engage but not knowing how’ was also evident in both our discussions with members of the Maker Spaces during our visit to the Future Makespaces in Redistributing Manufacturing event in Manchester, as well as during our focus group study with regional SMEs at (Design Network North) DNN’s workshop day. Maker spaces, such as Fab Labs, represent another area of great potential for crowdsourcing services in the not-for-profit and public sector. They are a growing phenomenon influenced by contemporary social changes and emerging technological and digital advances towards small-scale manufacture, supported by design and information tools. As they are primarily grassroots movements rather than government initiatives, they are driven by an ethos of being part in a community of likeminded people:

“Makespaces encourage innovation, new value systems and propositions, and provide potential for new ways of working.... By their nature they are local; they are small-scale; and their economics and manufacturing differ

greatly from traditional manufacturing industries.” (http://futuremakespaces.rca.ac.uk/makespaces-and-redistributed-manufacture/)

Members of maker spaces noted that they generally see the emerging importance of digital tools and platforms such as crowdsourcing, yet nobody had been practising it – everyone is waiting for it to happen but it is just not there yet. They further argued that as maker spaces evolve and grow, such tools will be critical to their performance.

6.2 Need to change internal culture (‘the way we do things around here’)

The integration of OI and crowdsourcing practices and digital tools for outsourcing external input in NPD, ultimately requires organisations to change from their traditional and established ways of doing things. This topic has been most extensively covered by existing research and it is among the most important barriers for crowdsourcing adoption by SMEs. For instance, VERZIIL, et al^[11], argued that before implementing an appropriate crowdsourcing platform, companies are required to accept and adapt to a new reality and ways of working which is very different from the traditional paradigm. Indeed, it is argued that opening up the innovation process to the crowd, SMEs are faced with a number of risks, amongst others, from exposing their innovation strategy to threats around intellectual property rights, the added burden of managing human resources and controlling the quality of an unknown number of solutions provided by the ‘crowd’^[33,46].

From our interviews with key members from large corporations such as P&G, Unilever, and Northumbria Water we learned that OI was integrated strategically in their organisations as a means to digitize their R&D activities. It followed their realisation that future organic growth was linked with tapping into the confluence between the physical and digital worlds. This meant that they needed to start exploring opportunities by taking other people’s ideas, adding value based on their companies’ strategic needs and turning them to their portfolio of activities. What was described as “a complete change of philosophy” by RS (P&G), these corporations realised that no matter how bright their internal staff were, others would likely exist outside their organisational grounds:

“We need people to recognise that problems don’t just need to be solved within a supply chain, or within a customer base...they can be solved on the boundaries...it’s a bit of a cultural shift.” RS, P&G

Nowadays, both P&G and Unilever operate dedicated teams of experts to drive OI in their companies by “looking out of the box”, identifying opportunities and external experts and building strong deep rooted partnerships they could not achieve by traditional means. Finding strategic partners and driving OI through deep knowledge

partnerships, sharing scientific and technological knowledge and therefore enabling a co-creation process for innovation, was described as the most successful approach for Unilever. A similar example was discussed in the study^[44] around Adidas' efforts in establishing formal structures for accepting and supporting crowdsourcing innovation as a permanent part of NPD, a practice which was thought to offer the best chances for long-term success and scalability.

However, this endeavour can be a significant barrier to SMEs' effort to integrate OI and crowdsourcing. As we noted earlier, nurturing good links with external sources of knowledge and learning are particularly critical and relevant to SMEs because it helps them compensate for the lack of in-house resources. Yet, fear of change is a well-documented reality for many traditional organisations who are used to closed innovation processes and are often driven by the attitude of 'not invented here' hence not valuing external input (see e.g. ^[11]). An example of closed innovation process can be seen in the Kellogg's example found in^[18], an organisation who had never previously used crowdsourcing, felt reluctant to open its innovation process to the 'crowd' as it required a change and rethink of its marketing strategy which was unwilling to do. This notion is particularly evident in SMEs for another reason; innovation activities there are far more challenging, in the sense that SMEs potential risk failures have far greater existential consequences, compared to large organisations whose abundance of resources may tolerate failure with less damaging effects. One particular risk for example regards the inherited costs associated with adopting a crowdsourcing approach in NPD. For instance, crowdsourcing initiatives need to be well considered and designed (e.g., defining problem, filtering responses) before being executed because otherwise the costs of doing this may be greater than directly hiring experts the traditional way^[19,47]. More importantly, SMEs lack the necessary resources (such as staff, finances and time) to pursue an activity such as an open-based crowdsourcing task that does not relate to core business activities^[45]. In most of examples of successful adoption of OI and crowdsourcing systems by large organisations, the activities are driven by dedicated teams whose time and skills are allocated specifically for this activity. For instance, Dell's IdeaStorm platform^[9] is managed by a senior-level idea review team whose role is to review and validate thousand of ideas generated from the crowd and disseminate them to the right departments to implement. It is sensible to suggest that SMEs generally lack this capacity and therefore cannot be expected to adopt a similar approach. As we point out later, there are two key strategies that can 'bridge' this gap in the SME context; a) the adoption of intermediary crowdsourcing systems where innovation brokers support SMEs with managing the complexity, and b) a progressive approach of implementing crowdsourcing components in nonthreatening areas to the business in order to gradually

learn and familiarise with the process.

6.3 Trust & confidentiality issues

As mentioned earlier, OI and crowdsourcing platforms rely on the involvement of an external community of users/experts. Usually, these community experts are new and unknown to the client. On the other hand, SMEs traditionally rely on personal contacts and relationships to acquire expert knowledge and feedback — a practice through which companies build trust. In the traditional paradigm, outsourcing from external experts' ideas and solutions is done according to a contract. Typical crowdsourcing approaches such as in open calls, the participation of the 'crowd' takes place on a voluntary basis or motivated by more diverse incentives as opposed to pure financial ones ^[35]. Hence, the challenging task of finding and engaging with the right anonymous people to help with an innovation challenge appeared in both our discussions with industry experts and during our focus group study. Trust between both solutions seekers, problem solvers as well as brokers (intermediary types) are particularly important for the adoption or not of crowdsourcing by an organisations^[8,33] and SMEs in particular ^[15]. Relationships are fundamental to the success of partnerships and therefore, it is crucial for both parties to have clear roles and a mutual understanding of the value created and positive future gains from their collaboration^[8].

Building trust is a difficult endeavour and requires a constant dialogue to take place between the different parties; on this subject, industry expert RS (P&G) brought up the sensitivity of partnerships between large and small organisations. According to this expert, a common challenge in project partnerships between large and small organizations relates to the different structures and decision-making processes they possess; for instance, by their nature, small organisations with their informal and flexible structures enable them to reach quick decisions (less bureaucracy, key people involved directly) and expect the same from others. Meanwhile, large organisations are not quick decision makers and quite often decision makers are quite different from the people involved in the potential project partnership. Therefore, it is very important to solve such issues by developing a mutual understanding early in the process:

"...to have the dialogue which is a legitimate shared [commercial] risk and shared reward dialogue which makes small companies happy dealing with large companies and also ensures that there is a momentum for the activity which is understandable for both sides."

According to the same expert, a crowdsourcing approach can be the starting point of such an important dialogue, regardless of company size. Ultimately, OI and crowdsourcing services act as a curator of information. In order to make it easier for businesses to find relevant

information, experts are needed to curate it. Evaluating experts and solution responses is a key challenge for digital platforms as they lack the personal peer-to-peer interaction traditionally used by organisations to help ensure expert credibility. As mentioned earlier, intermediaries through innovation brokers^[46] can have such a gatekeeping, facilitating role to support SMEs with key crowdsourcing challenges, such as defining problems, finding appropriate experts, filtering multiple responses, and managing terms of engagement across different stages of the NPD process. Moreover, companies who want to employ a crowdsourcing service to solve e.g. a technical problem, may not want to do it under their brand name, in order to not be exposed to competitors or customers, or protect their own community of experts. VERZIIL, et al^[11], noted that one way of protecting potential valuable information is to limit the published information to only specific parts of the overall problem (e.g., develop a fuel cell) and not to reveal the actual product where it is needed (the car design in their example). The difficulty of managing and negotiating aspects such as data ownership, has led companies like Philips to stop licencing established OI services and develop their own internally, in order to ensure consumer confidence. Like with any traditional project partnership between a company and external actors, managing and reaching mutual agreements with regards to legal and possible intellectual property rights is a fundamental aspect for the success of the partnership (and long-term co-creation relationship) in an OI and crowdsourcing service. It is, however, an area that many companies such as SMEs struggle to deal with in their day-to-day business. Digital crowdsourcing platforms often keep relatively simple mechanisms to enable prospective experts to join their community requiring only that they accept general terms and conditions, and rarely that they sign a formal contract as is typical within traditional forms of collaboration such R&D networks and alliances. When crowdsourcing NPD tasks, this is not a sufficient commitment level to enable trust and confidence in the process. As we argue in the next section, developing effective crowdsourcing systems need to take into consideration the idiosyncratic characteristics of the contexts to which they are called to support.

6.4 No appropriate platforms to support activities across a whole design spectrum

Today, several OI and crowdsourcing platforms exist that offer distinct services and software solutions, however, our study has found that there is no single platform capable of delivering a set of support tools for the whole NPD process. As a result, design activities can be currently crowdsourced separately within several unconnected platforms, which may give rise to project management issues, design skill/knowledge disruptions, design/data consistency issues.

As mentioned earlier, the New Product Development process entails a number of different tasks across different

stages. This means that different tasks require different expertise and, therefore, the level of expertise of the community significantly differs among different services in need. VERZIIL, et al^[11], postulated that an effective crowdsourcing platform for manufacturing businesses needs to offer information sharing tools that are not too complex and/or costly. The authors further noted that in manufacturing contexts in particular, single file sharing systems can be very beneficial for eliminating the often incompatibility between design files (CAD) produced in different software programs. Others^[10,44], have stressed the importance of having the right tools to help businesses to define tasks, complexity and nature of the task as these factors have an immediate effect upon how community engages as well as the quality of their responses. Moreover^[35, 44] suggested that factors, such as usability, user interface, UX, procedure of idea formulation, features for collaboration etc. affect the performance of platforms, whilst EVANS, et al^[33], noted that platforms need to offer tools that facilitate the complex process of filtering and validating responses and their quality. From our review of crowdsourcing platforms, we found that these currently seem to offer access to a specialist ‘crowd’ for only some NPD services, such as technology or market research or ideation and concept generation. The implication here is that existing platforms are unable to connect manufacturing SMEs with a relevant and appropriate community to help them with their needs. In their attempt to integrate OI strategies within their companies, SMEs are potentially faced with the struggle of not knowing how to answer key questions such as “who is an external actor that can contribute to my innovation challenge and how do I find them?”

Furthermore, many OI software providers fail to offer flexible systems that are finely tuned with the particular context characteristics of the organisations. For instance, CHANG, et al^[17], argued that platforms are generally designed in a fixed manner which can result to being neglected from prospective clients due to not meeting their specific needs. This reality was evident in our interview with a Northumbrian Water’s key member of staff, who suggested that the solutions offered by various established OI software providers who approached the company, were not appropriate to meet their needs as they could not be implemented within their existing IT department:

“...what we found is there’s a whole spectrum of these products ranging from the cheap and cheerful to the horrendously expensive and some of the salesmen were more interested telling you about their products than listening what your problems are.”

The case of Northumbrian Water, although it regards a large company, it can be argued that closely resembles the challenges we discussed earlier with regards the idiosyncrasies of the SME context and the importance for

platforms to effectively take into consideration specific organisational contexts' characteristics. Northumbrian Water has only recently begun examining potential OI processes as part of their corporate strategy. In their journey to find appropriate solutions, they do not want to invest significant financial resources in a new system that has not been proved to be effective and efficient with their existing processes. Instead, the company wants to slowly implement some core features and components to try along with their existing communication systems, prior to deciding to make the final decision and integrate them across the organisation. A similar example was given from a Maker Space member who argued that the success of their networking-platform was because it was built by the community members for the community, that is, it has grown within instead of the traditional way of "here's a platform to work".

According to Ref. [48], designing an effective crowdsourcing platform, requires three key aspects to be considered first:

(1) About the crowd: Who forms it, what it has to do, and what it gets in return?

(2) About the initiator: Who it is, and what it gets in return for the work of the crowd?

(3) About the process: The type of process it is, the type of call used, and the medium used?

In line with this mode of thinking, we propose that one potentially appropriate approach to designing effective crowdsourcing platforms is through a module-based design. That is, the platform and its associated tools is progressively built according to specific tasks and needs, moving gradually with the development of more complex components on demand and in parallel with the training and familiarisation of the organisations with the crowdsourcing process. This way, the crowdsourcing platform may enable organisations such as SMEs to fully exploit the benefit of digital technologies with as little disruption to the ongoing business as possible.

7 Technological Enablers for Developing Crowdsourcing Platforms

Following our conceptual idea of a modular-based design of a crowdsource system, we tested the feasibility of using open source software to build a crowdsourcing Web application. We built on the Drupal (<https://www.drupal.org/>) software framework and developed a web-based digital platform for testing in order to ascertain the quality and flexibility of framework tools.

Web 2.0 technologies and HTML 5.0 are well known technological enablers for developing interactive Web applications. While for mobile devices, social media platforms and apps are widely accessed to most people. For example, British consumers are some of the most "digitally savvy" in the world and the majority of the UK population now own smartphones. They are able to participate via various platforms. Businesses in the UK need to respond to

these trends, harnessing the full potential of digital platforms in order to outsource information and design from British consumers.

We set out to explore free to use, adaptable tools that could be implemented to deliver crowd-sourcing functionality. We installed OpenideaL (<https://www.drupal.org/project/idea>), i.e., a Drupal distribution that provides 'out of the box' free to use idea management tools. Drupal is a popular open source software framework used to deliver a wide range of large scale, web based applications in the public and private sector. Drupal is a popular framework for the development of complex web applications as it lends itself well to iterative development (enabling on-going development from a core set of features based on user needs), it offers a high level of interoperability with other web based systems and there are more than 30 000 contributed modules freely available which can be 'plugged in' to deliver additional functionality.

We registered the domain name crowd.org.uk and installed the OpenideaL distribution. With minimal configuration it provides for some basic crowdsourcing features, such as: idea creation, idea presentation + comments, categories and tags, popular ideas, social engagement, member profiles, project pages, trends & analytics reports. The distribution has been built with some specific use cases in mind (providing an 'out of the box' tool for organisations to build a community around their product or service). Although the code is open source and completely configurable, building a more complex web application 'on top of this distribution may create more problems than it solves. What is demonstrated by OpenideaL is the potential to use the Drupal framework to develop effective crowdsourcing and community web applications. By way of an example, Drupal software powers www.innocentive.com, one of the more popular online innovation platforms. Benefits of Drupal Software in Implementation of Crowdsourcing Application include;

It supports rapid prototyping and innovation. There are more than 30 000 contributed modules in the Drupal ecosystem which can support the rapid rollout, testing and iteration of new features.

Drupal Commerce can add highly configurable commerce capabilities.

(1) It has a dedicated security team and is used to power high profile websites and applications including examples, such as whitehouse.org, harvard.edu, teslamotors.com, oxfam.org and drupal.org itself where millions of developers collaborate on the Drupal project.

(2) It is scalable and extensible, lending itself to iterative development of new functionality in response to user needs and it is scalable, handling some of the world's busiest web sites.

(3) It is interoperable—it is straightforward to build API's to interface with other information and communications systems.

(4) More importantly, it is open source, meaning that the core code and contributed modules are free to use and adapt. These freely available adaptable tools represent many tens of thousands of hours of developer time as well as ideas that continuously improve the software's features. Put it differently, the Drupal product is itself a result of crowdsourcing of both ideas and code development.

The above discussed crowdsourcing platform is currently under trial with regional SMEs. We intend to report our findings in future papers.

8 Conclusions

The crowdsourcing market is large and growing rapidly. Current low uptake by manufacturing SMEs could be overcome by the adoption of the right platforms with tailored key functions, tools and features for NPD tasks. Doing so, crowdsourcing has significant potential to deliver value and growth within the SMEs innovation practices.

However, to achieve this, there are several challenges and barriers that need to be addressed before this trend becomes mainstream. In this study, we found four critical crowdsourcing barriers; (1) lack of awareness of crowdsourcing systems and applications, (2) fear of changing established business models, (3) trust and confidentiality issues in the open and digital environment, and (4) lack of appropriate and flexible platforms that meet the contextual, relational and situational needs of SMEs.

Despite of these barriers, we also suggested there are a number of strategies that can help alleviate these. For example, there exists a niche opportunity for a platform that specifically targets pre-existing cluster organisations and networks who use public and private funds to support SME growth. Creating digital tools specifically designed to multiply their impact could give access to a ready-made marketplace with an identified need and a network of subscribers who already have established relationships of trust with the network or cluster as an information or relationship broker, thus overcoming many of the barriers to SME engagement. Below we offer a number of key practical guidelines for the development of crowdsourcing systems for NPD to meet the market needs. Based on the mapping of the current crowdsourcing services against the NPD process, there is a need for an integral crowdsourcing platform to systematically support NPD activities. To achieve this, an effective crowdsourcing system should be as follows.

(1) User-centred (focused on the user's needs)- knowing where the user (SME) is in their NPD journey across the four key business challenges (framing a problem, sourcing experts, filtering responses, managing terms of engagement) and support them at each stage.

(2) Based on Interoperability, i.e., able to integrate with digital tools already being used, e.g., chat software, social media, etc, and make use of APIs to integrate with existing organisational IT systems.

(3) Cloud based, white label system that can support iterative development in response to data about usage along with some core features, such as ID verification, contracting/IP protection, etc.

(4) Iterative and modular-based design gets the best results because its built-in flexibility allows it to respond to user needs, trends, social, economic and technological changes.

(5) Digital tools to make crowd work more efficient (and measurable) and facilitate leadership to support culture change.

(6) Opportunities for commercial/social exploitation of a successful platform; subscriptions, brokerage fees, trading platform, opportunities to exploit aggregated data.

(7) Expand on the social media aspect. This is about several different things from making it easy for challenges to be shared across platforms, file sharing systems, and tools that can help collate and filter responses from social media.

(8) Digital tools for crowdsourcing are still a relatively immature market. In other more mature digital markets the marginal cost of engagement has tended towards zero with companies (such as Google) leveraging their access to aggregated data. This could be an interesting model to explore in this field, e.g., offering a platform for free in order to create value from mining of aggregated data.

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Biographical notes

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