Pilot Experiments on a Designed Crowdsourcing Decision Tool

Nguyen Hoang Thuan, Pedro Antunes, David Johnstone
School of Information Management
Victoria University of Wellington
Wellington, New Zealand
Thuan.Nguyen@vuw.ac.nz, Pedro.Antunes@vuw.ac.nz, David.Johnstone@vuw.ac.nz

***Abstract*—Crowdsourcing is a new business strategy that can collaborate a large number of human workforce. The strategy is operationalised through an appropriately established crowdsourcing process. A few computer-supported systems have developed to assist several aspects of the crowdsourcing process. However, these systems mainly focus on a particular aspect rather than the whole integrated process. Furthermore, there is a shortage in empirical evidence on how the developed systems support the establishment of crowdsourcing processes. This paper presents our initial experimental evidences on using a designed decision tool in supporting the integrated crowdsourcing process. The experiments show that the designed tool is likely to improve participants' performance on designing crowdsourcing processes, but not in making the decision to crowdsource. Based on the experiment results, the paper suggests several lessons and recommendations for future research.**

Keywords—business process crowdsourcing; crowdsourcing; computer supported system; experiment

I. Introduction

Crowdsourcing is a sourcing strategy in which organisations send tasks to a large group of individuals through an open call [1]. With its ability to collaborate large number of human workforce for task accomplishment, crowdsourcing requires newer form of computer-supported design and thus has attracted large attention from the Computer Supported Cooperative Work in Design (CSCWD) community. CSCWD researchers have explored applications of crowdsourcing, i.e. on collaborative design and collaborative service monitoring [2, 3], and several aspects of crowdsourcing processes.

The success of crowdsourcing strategies largely depends on how to properly establish crowdsourcing processes [4]. Although prior research proposed some simplified process descriptions, recent literature has consistently emphasised that crowdsourcing processes are complex activities [5]. A crowdsourcing process encompasses all tasks needed to operationalise the crowdsourcing strategy. Thus, it involves not only several stages of the workflow, but also structures and entities for the workflow enactment. The complexity increases with process integration. Given that in crowdsourcing some activities may be performed externally while others may be performed internally, the crowdsourcing process needs to integrate them into a seamless workflow, being "able to seamlessly bring together the crowd, individual actors, and the machine" [5].

Addressing the complexity, some computer-supported systems have been developed to facilitate the crowdsourcing process [6, 7]. However, these systems mainly focus on a particular aspect of the process such as task recommendation [6], rather than the whole integrated crowdsourcing workflow. Furthermore, there is a shortage in empirical evidence on how the designed systems supporting the crowdsourcing process establishment. Therefore, we developed a foundation and designed a decision tool supporting the crowdsourcing process establishment [8, 9]. The aim of this paper is to fulfil the gap and bringing forward these studies by presenting our preliminary experimental evidence on using the tool. More precisely, the experiments test two hypotheses on using the tool for supporting the decision to crowdsource and the crowdsourcing process design. The results show that using the tool can support decision makers in the crowdsourcing process design, but not the decision to crowdsource. Accordingly, we contribute empirical insights on using decision support systems in supporting crowdsourcing processes. As a result, we provide lessons learnt from the experiments, which can benefit other empirical research and system design in the crowdsourcing topic.

In the next section, we summarise related work. Then, we present a brief description of a designed tool supporting the establishment of crowdsourcing processes. Section 4 details the experiments, which are designed to evaluate the usage of the tool. We then present the experimental results and discuss some lessons learnt from the experiments. We finish the paper with a conclusion and discussion about future research.

II. Related Work

Researchers have been started to investigate how to support organisations in their crowdsourcing process establishment. The supporting goal is within the typical domain of Decision Support Systems (DSSs) [10]. From the DSS perspective, two streams of research supporting crowdsourcing processes can be identified. The first stream identifies and conceptualises challenges that should be focused in the crowdsourcing process [7, 11]. It analyses the crowdsourcing process and highlights what organisations need to deal with in their process establishment. Consequently, the main contribution of this stream includes the identification of decision issues, which are the targets for DSS development.

The second stream develops foundations and designs systems in order to address the identified decision issues.

Thuan, N., Antunes, P., & Johnstone, D. (2016). Pilot Experiments on a Designed Crowdsourcing Decision Tool. Paper presented at the 20th IEEE International Conference on Computer Supported Cooperative Work in Design (CSCWD), Nanchang, China.

Different from the first stream that are more conceptual, this stream allocates within the operational level and targets on computer-based development. For instance, Yuen et al. [6] and Geiger [12] constructed foundations for a recommendation system matching individuals in the crowd with several types of crowdsourcing tasks. Recently, Prokesch and Wohlenberg [13] proposed a supporting system processing outcomes from the crowd. Common to the existing systems is their focus on a specific workflow of crowdsourcing processes, like task assignment [12] and results aggregation [13]. Furthermore, the assessment of the existing DSSs mainly demonstrates the system logic and applicability rather than evaluates their utility in supporting decision makers in crowdsourcing processes. This issue has been highlighted in the literature, e.g. in the case of crowdsourcing recommendation systems that "one of the most fundamental issues for future research [...] is the empirical evaluation of its general utility to the crowdsourcing process" [7]. Consequently, there is a need for empirical research on how DSSs can support decision makers in the establishment of the crowdsourcing process.

III. A Designed Crowdsourcing Tool

In this section we summarise the functionality of a tool that was developed to help making informed decisions in the crowdsourcing process establishment. We start the section by discussing an ontology founding the tool development. The tool functionality is then described. The interested reader is referred to [8] for a detailed description of the ontology and to [9] for the tool implementation.

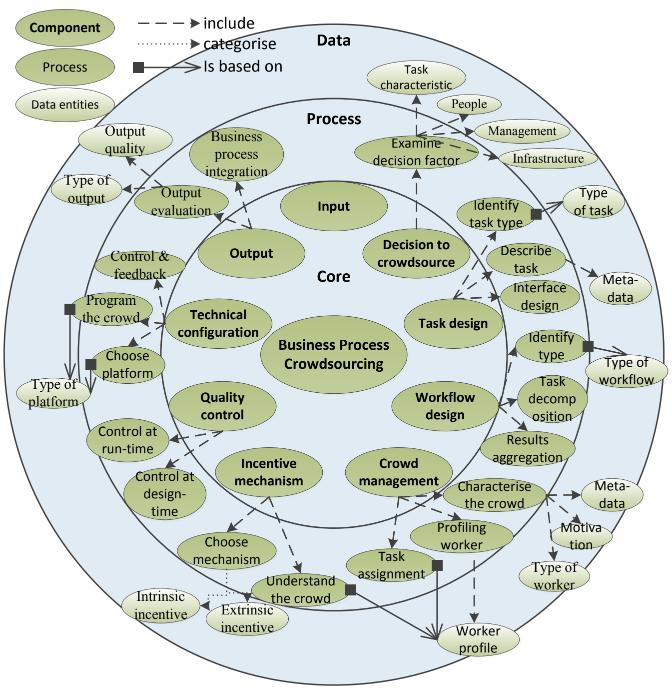

Fig 1. The three main layers of the BPC ontology [8]

An ontology of business process crowdsourcing (BPC) was constructed to provide a foundation for the decision tool [8]. More precisely, the ontology formulates main concepts and semantic relationships in the domain. Given the complexity of the domain, more than 100 concepts and many relationships were identified. To conceptualise these ontological elements, we structured them into a layer framework. This framework classifies the concepts into four layers: components, processes, data entities, and data attributes, which are linked by semantic relationships. The ontology provides an overview about the domain, and at the same time operationalises knowledge presentation necessary to further translate the conceptualisation into DSS implementation. Due to the limited space of the current paper, Fig 1 presents the three innermost layers of the ontology, while the full presentation of the ontology can be referred to [8].

Based on the ontology, we developed a decision tool assisting managers and process designers to establish their crowdsourcing process. The tool was designed as a web application, using Php and MySQL. Concerning two main types of decision makers in crowdsourcing projects, i.e. project managers and process designers, the tool consists of two main functions: tool 1 supports making the decision to crowdsource; and tool 2 supports the process design. More precisely, the former formulates a list of decision factors and provides advice on whether to crowdsource or not. The latter presents the main components in a crowdsourcing process, i.e. task design, workflow design, crowd management, incentive mechanism, quality control, technical configuration and output (the most inner layer of Fig 1). Within each component, the tool suggests activities that should be operated; information facilitating the operation; and what-if advices according to the input information. The two tools are presented in Fig 2 and Fig 3.

As seen via Fig 2 and Fig 3, the tools were designed with a consistent user-interface, organised in three areas. The right-hand side provides an overview about the decision to crowdsource and process design. It also has a section for what-if advices. The left-hand side is dedicated to the user inputs. It is divided into two areas presenting the pre-defined issues (or decision factors) and questions. In the issue area, the tool allows users navigating through a tree structure to choose a decision factor in tool 1 or a design issue in tool 2. It further provides the explanation on the chosen factor/issue. In the other area, the tool presents a pre-defined question and parameters according to the chosen factor/issue, as well as the explanation of the question and parameters. When the user answers the question, the tool provides appropriate advices based on the business rules captured by the ontology.

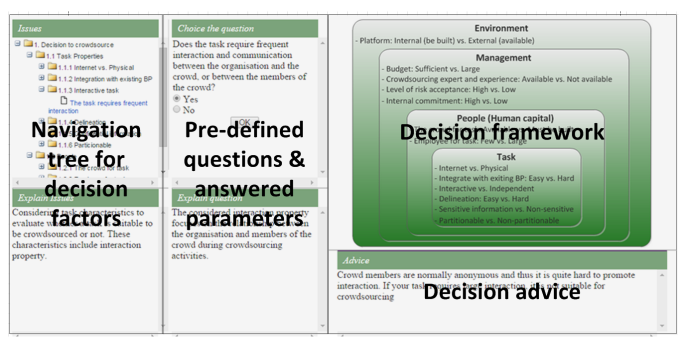

Fig 2. GUI of the tool 1: decision to crowdsource

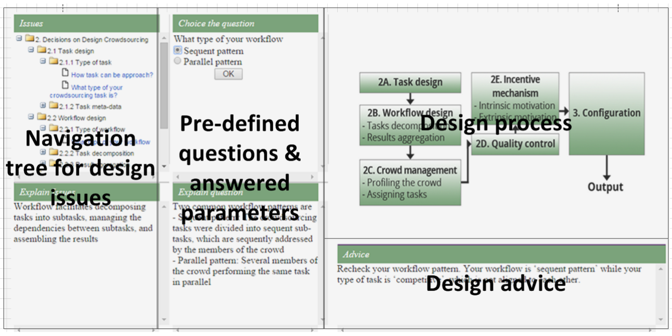

Fig 3. GUI of the tool 2: crowdsourcing process design

IV. PILOT EXPERIMENTS

Pilot experiments were arranged to evaluate the tool, which is the focus of the current paper. The aim of the experiments is twofold. From an experimental point of view, the pilot experiments seek to test the research materials and provide preliminary data about the tool usability [14]. From a system design point of view, they determine whether the tool meets its performance requirements and thus help to identify possible improvement of the tool. In both perspectives, we experimentally test how well the decision tool help decision makers/ process designers. More precisely, we ask how much difference (if there is any) on the performance between participants using the tool and others who do not use the tool.

Naturally, our experiment utilises a simple comparative model to compare the two conditions: use or not use the tool [15]. The group of participants using the tool is the treatment group, while the other is the control group. Intuitively, the tool is considered to be useful if the treatment group outperforms the other group. Given that, the experiments have a single independent variable with two levels of decision support: the usage and absence of the tool. The performance of participants on crowdsourcing process decisions is the dependent variable, which is measured by their answers on the two pre-defined exercises. The two exercises were designed according to the decision to crowdsource (tool 1) and the process design (tool 2). Given the above discussion, the hypotheses for the experiments are:

H1a: The usage of tool 1 will result in better performance for making the decision to crowdsource.

H1b: The usage of tool 2 will result in better performance for designing crowdsourcing processes.

A. Experimental Design and Participants

To test the hypotheses, we could design the experiments in the way that the treatment group uses tool 1 and then tool 2, while the control group does not use both of them. However, such experimental design may not allow us to measure the performance of the two tools separately as the participants already have experience of using tool 1 when they come to tool 2 (what we call learning effect). Considering the issue, the experimental design twisted the group role regarding the two tools, which is presented in Table I.

TABLE I. EXPERIMENTAL DESIGN

	Exercise 1: decision to crowdsource	**Exercise 2: crowdsourcing process design**
Group 1 (26 participants)	Treatment group (without the tool 1)	*Control group* (using the tool 2)
Group 2 (20 participants)	*Control group* (using the tool 1)	Treatment group (without the tool 2)

We invited 49 students to participate in the experiments. They are second and third-year IT students in the Can Tho University of Technology (CTUET) – Vietnam. IT students are considered to be appropriate to test computer-based tools [14], and our convenient sampling approach leads to the choice of recruiting participants in CTUET. These participants were randomly assigned to group 1 and group 2. Incentives for involved participation were $10, paid as mobile phone re-charge gift cards. In the experiments, we note that three participants did not use the tool to address the exercise while they were asked to do so. Thus, we removed their answers from the final dataset. As a result, the experimental dataset consists of 46 participants in the two groups: 26 participants in group 1 and 20 participants in group 2.

B. Procedure and Materials

Starting the experiments, the participants joined a 30-minutes tutorial to help them become familiar with the crowdsourcing concept. They were then located at two computer labs according to group 1 and 2. Each participant was seated at a PC and was instructed to do exercise 1 (30 minutes) and then exercise 2 (30 minutes). The same exercises were delivered to both groups. The only difference between the two groups is that the treatment participants were referred to the tool 1/tool 2 for addressing the exercises. Participants in both groups were prompted to write out answers and handed their answers to the researchers by the end of each exercise.

The two exercises are related to decisions in crowdsourcing processes. More precisely, exercise 1 consists of four different scenarios focusing on the decision to crowdsource. These scenarios describe situations where crowdsourcing may be possible and each scenario has the main question that is "should the task [in the scenario] be crowdsourced?". To be diverse, each scenario highlights different factors that influences the decision to crowdsource, i.e. human resource to perform task; where task can be performed through the internet; does tasks include confidential information; and project budget. These factors are typical factors influencing the decision to crowdsource [16, 17]. Exercise 2 addresses issues related to the design of crowdsourcing processes. It consists of two scenarios, which are based on two actual crowdsourcing projects. Each scenario has two questions, asking about different aspects that need to be concerned in the crowdsourcing process: task division, task description, incentive mechanism, and quality control. These concerns were adapted from Kittur et al. [18]. Intuitively, each exercise consists of four yes/no and multiple-choice questions. Answering these questions, the participants can also choose 'No Idea' if they cannot make decisions. By the end of each exercise, the answers were collected by the researchers. Fig 4 and Fig 5 present two pictures of the experiments.

Fig 4. Group 1 in the experiment

Fig 5. Group 2 in the experiment

C. Measurement

We used solution score to measure the participant performance. In particular, we developed standard answers for each question based on the work of Afuah and Tucci [17] and Kittur et al. [18]. Using the standard answers, the score was calculated as the following formulation: A corrected answer is scored 1; 'No Idea' is scored 0.5; a wrong answer is scored 0. With the formulation, the participants' score on each exercise was calculated. Given that each exercise consists of four questions, the score scale is ranging from 0 to 4.

V. Results

Overall, 46 students participated and provided valid answers in the experiments, 25 of whom are female and 21 are male. Their answer scores were calculated. Table II presents the frequency of scores of the two groups in exercise 1 and 2. In both exercises, the lowest score is two and the mode is three. In exercise 1, only very few participants answer correctly all the question, whereas it is quite popular in exercise 2.

TABLE II. Score frequency in the two exercises

Score	Exercise 1		Exercise 2 (Twist the group role)	
	Group 1 - without the tool	***Group 2 - using the tool***	***Group 1 - using the tool***	***Group 2 - without the tool***
2	2	8	3	3
2.5	3	2	0	2
3	18	10	12	7
3.5	0	0	0	1
4	3	0	11	7

We further analyse the data to test the hypotheses. As the solution scores are discontinuous and ordinal measures, we expect that the data may not be normally distributed, which is confirmed by the Shapiro-Wilk tests. Thus, Mann-Whitney U tests are appropriate to test the different performance between control and treatment groups in each exercise. Table III and Table IV present the descriptive data and the p-values of the Mann-Whitney U tests.

TABLE III. Descriptive data and p-value: exercise 1

Exercise 1 (scale 0-4)	**p-value**	**Without the tool 1 (Group 1)**			**Using the tool 1 (Group 2)**		
		N	***Mean***	***Std.***	***N***	***Mean***	***Std.***
Solution score	0.08	26	2.98	.48	20	2.55	.48

TABLE IV. Descriptive data and p-value: exercise 2

Exercise 2 (scale 0-4)	**p-value**	**Without the tool 2 (Group 2)**			**Using the tool 2 (Group 1)**		
		N	***Mean***	***Std.***	***N***	***Mean***	***Std.***
Solution score	.51	20	3.18	.73	26	3.31	.68

Regarding the hypotheses testing, Table III and Table IV show mixed results. While the direction of measures in exercise 2 (Table IV) is consistent with the hypothesis, the direction of measures in exercise 1 is not (Table III). More precisely, the group using the tool 2 has a higher score compared to the other group, while it is the group using the tool 1 has a lower score. Regarding to p-values, the results do not provide significant support for hypothesis H1b (0.51) and for a reversed direction of hypothesis H1a (0.08) at the significant level of 5%. Although the hypotheses are not significantly supported, the mean differences indicate two important points. Regarding to the hypothesis H1b, the difference is likely enough to warrant further study in using the tool 2 to support decisions related to the crowdsourcing process design. In other words, the tool likely shows its usefulness in designing the crowdsourcing process. Regarding to the hypothesis H1a, treatment participants are less performance than the control participants (mean of 2.55 versus 2.98). This would be unexpected results from the experimental perspective but would be understandable from a design perspective where design is an iterative process. More precisely, the experiments are a part of the first iteration of designing and testing the tool, and the tool design in this early iteration may not fully satisfy the design requirements.

VI. Lessons Learnt

From the experiments, there are a few lessons we can learn and should be applied to the next round of design and experiments. These lessons were grouped according to the experimental point of view and system design point of view.

A. Lessons for Experiments

As mentioned in the experimental design, the exercises were intentionally constructed with diverse scenarios, adapted from [17, 18]. The purpose is to test the tool in diverse and complex decisions of crowdsourcing processes. However, it seems that the level of complexity still needs to be increased.

This can be seen via the lowest score in both exercises is two, which is quite high in a 0-to-4 range. When we check the dataset in detail, some questions in the exercises were answered correctly by almost all participants. Consequently, these questions may not be complex enough to discriminate results, a similar issue described in [14]. As a result, future experiments should add more information into the scenarios to diverse their contexts.

In Table III and Table IV, we note that participants in group 1 always outperforms participants in group 2, which suggests that group 1 may have stronger background on crowdsourcing than the other group. This contributes to illustrate our point for twisting the control and treatment groups in the two exercises of the experiments, which helps reduce bias related to the group background. Additionally, the bias should also be limited in the future experiments by increasing the number of participants and recruiting participants with diverse backgrounds, e.g. management students.

While the above points are related to the experimental design, we take here another note for executing the experiments. More precisely, we observed that some participants in the control group did not use the tool but randomly answered the questions. This led us to an elimination of these answers in the final dataset. To reduce this issue, the future experiments should ask participants to save their interaction with the tool. The interaction increases the possibility that the participants will use the tool. Furthermore, the researchers will have an additional measure, i.e. interaction data, to remove invalid answers in their analysis.

B. *Lessons for Tool Design*

From a design perspective, design process consists of multiple iterations of two main activities: build and evaluation [19, 20]. The build activity constructs and refines the systems for specific purposes. The evaluation assesses how well the constructed systems meet the objectives, and consequently provides feedbacks for the next design iteration. In this perspective, the current experiments are an evaluation activity in the first iteration of the tool design process. Thus, they should assess both the usability of the tool and its unintended effects that indicate further improvement of the tool [20, 21]. For this purpose, we also observed how the participants interact with the tool during the experiments. This observation combining with the participants' feedbacks provides us some notes for the tool design, summarising in the following three points.

First, the tree structure in the tools provides an effective way to navigate around decision factors/design issues. Participants used the structure to choose the factors/issues that are most related to their context, similar to what managers and process designers actually do in practice. As a side effect of too fast navigation, participants faced a challenge. We observed that some of them answered the exercise based only on an advice for one certain issue, rather than for the whole project. This can make the answer incorrect due to the incomplete context awareness, especially in exercise 1 where the decision to crowdsource should be made based on the evaluation of all related factors. We believe that the incomplete context awareness is one of the reasons for the unexpected results in H1a testing results. To overcome this issue, we suggest the tools should keep the navigation tree structure and should provide an additional function for final integrated project's advice.

Second, we note an important role of the ontology backing the tool. The tool applicability, i.e. tool 2 applicability, has been assessed via the mean improvement in Table IV. During the experiments, we observed that the participants were assisted with provided alternative parameters, options, and what-if advices. This assistance is enable though the usage of the BPC ontology that backs the tool and provides a means for effectively structuring the domain knowledge [22]. As a result, we suggest that the usage of ontologies is appropriate for the DSS design, similar to Miah et al. [22] regarding an ontology backing an expert system supporting rural business operators, and Amailef and Lu [23] regarding an ontology founding a decision support system on emergency response.

Third, as the experiments also serve to explore possible improvement for the tool design [20, 21], we asked participants and received some feedbacks for improving the tool. For instance, the tool as a webpage application loaded a few times for presenting questions, question definition and advices, which was complained by some participants about long waiting time. The loading time became longer when more participants assess to the website at the same time. Consequently, the next design should be modified for providing the information instantly, and thus interactive programming languages like JavaScript should be used. Besides, other minor improvements are also suggested, e.g. removing the model/process diagrams in the tools; and providing more space for issue, question, and advice. Basically, the users want a simpler user interface where the issue and advice functions should receive the focus.

Based on these lessons, we have updated the tools. For further interaction with the updated tool, the interested readers are invited to visit https://crowdsourcing.sim.vuw.ac.nz (username: F97; password: F97). We note that as the current participants are Vietnamese students, some parts of the tool are still in Vietnamese and will be translated into English in the next experiments.

VII. CONCLUSION

Crowdsourcing provides a new way for collaborative work, establishing through a crowdsourcing process. To support the crowdsourcing process establishment, our previous work conceptualised foundations and designed a decision tool assisting the decision to crowdsource and crowdsourcing process design. In this paper, we presented our empirical effort to evaluate the tool. More precisely, we conducted the pilot experiments examining how much the tool helps making informed decisions for the application domain. Two hypotheses (H1a and H1b) were tested on using the tool to support the decision to crowdsource and the process design. The results showed that the tool can improve participants' performance on the crowdsourcing process design, but not in the decision to crowdsource. Lessons related to the experiments and tool design were discussed.

Providing empirical evidence, the paper moves forward our previous work [8, 9, 24] and extends previous theoretical findings on crowdsourcing decision support systems. More precisely, we have shown that the DSSs can improve the user performance on designing crowdsourcing processes. From a research perspective, the mean improvement in hypothesis H1b suggests a promising research direction of building decision support systems for crowdsourcing. This is aligned to the recent works by [6, 12] aiming to assist decision makers in several crowdsourcing activities.

From a system design perspective, we note the important role of sound knowledge bases founding the DSS development. However, we highlight the challenges of movement from the theoretical knowledge bases into operationalised and validated implementation, as seen via the unexpected results in H1a. Consequently, we suggest that this movement should be further researched, e.g. theoretical foundation on supporting crowdsourcing like [7] should be empirically implemented and validated. In this manner, the aforementioned summarised lessons may be useful in future empirical studies.

In future work, we will re-design the tool based on the lesson learnt and conduct experiments to further test it. A part of the re-design has been done and the updated tool was launched in https://crowdsourcing.sim.vuw.ac.nz. Considering the limitation of using students as proxies for business decision makers [14], another way to empirical test the tool is to evolve experienced crowdsourcing managers and process designers in using the tool. This can be processed by conducting some focus groups in order to discuss the functionalities of the tool and its possible improvements. In a more general manner, we highlight a missing empirical evidence on using decision systems for supporting crowdsourcing processes. Thus, we call for further empirical research in this area.

REFERENCES

[1] Howe, J.: 'Crowdsourcing: A Definition', 2006, http://crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html, accessed October 2015

[2] Oliveira, L.F., Schneider, D., Moreira de Souza, J., and Rodrigues, S.A.: 'Leveraging the crowd collaboration to monitor the waiting time of day-to-day services', Computer Supported Cooperative Work in Design (CSCWD), 2015 IEEE 19th International Conference on, 2015, pp. 109-114

[3] Wu, H., Corney, J., and Grant, M.: 'An evaluation methodology for crowdsourced design', Advanced Engineering Informatics, 2015, 29, (4), pp. 775–786

[4] Geiger, D., Seedorf, S., Schulze, T., Nickerson, R.C., and Schader, M.: 'Managing the crowd: towards a taxonomy of crowdsourcing processes', Proceedings of the Seventeenth Americas Conference on Information Systems, 2011

[5] Tranquillini, S., Daniel, F., Kucherbaev, P., and Casati, F.: 'Modeling, Enacting, and Integrating Custom Crowdsourcing Processes', ACM Transactions on the Web (TWEB), 2015, 9, (2)

[6] Yuen, M.-C., King, I., and Leung, K.-S.: 'Taskrec: A task recommendation framework in crowdsourcing systems', Neural Processing Letters, 2015, 41, (2), pp. 223-238

[7] Geiger, D., and Schader, M.: 'Personalized task recommendation in crowdsourcing information systems—Current state of the art', Decision Support Systems, 2014, 65, pp. 3–16

[8] Thuan, N.H., Antunes, P., Johnstone, D., and Ha, X.S.: 'Building an Enterprise Ontology of Business Process Crowdsourcing: A Design Science Approach', PACIS 2015 Proceedings. AISeL, 2015, Paper 112

[9] Thuan, N.H., Antunes, P., Johnstone, D., and Nguyen, H.A.D.: 'Establishing a Decision Tool for Business Process Crowdsourcing', in Dang, T.K., Wagner, R., Neuhold, E., Takizawa, M., Küng, J., and Thoai, N. (Eds.): 'FDSE 2015. LNCS' (Springer International Publishing, 2015), pp. 85-97

[10] Arnott, D., and Pervan, G.: 'A critical analysis of decision support systems research revisited: the rise of design science', Journal of Information Technology, 2014, 29, (4), pp. 269-293

[11] Demartini, G.: 'Hybrid human–machine information systems: Challenges and opportunities', Computer Networks, 2015

[12] Geiger, D.: 'Personalized Task Recommendation in Crowdsourcing Systems' (Springer International Publishing, 2016. 2016)

[13] Prokesch, T., and Wohlenberg, H.: 'Results From A Group Wisdom Supporting System', Proceedings of the European Conference on Information Systems (ECIS) 2014, 2014, pp. Paper 7

[14] Dennis, A.R., and Valacich, J.S.: 'Conducting experimental research in information systems', Communications of the association for information systems, 2001, 7, (1)

[15] Montgomery, C.D.: 'Design and Analysis of Experiments' (John Willey & Sons, Inc, 2012, 8 edn. 2012)

[16] Thuan, N.H., Antunes, P., and Johnstone, D.: 'Factors Influencing the Decision to Crowdsource: a Systematic Literature Review', Information Systems Frontiers, 2015, Online first, pp. 1-22

[17] Afuah, A., and Tucci, C.L.: 'Crowdsourcing as a solution to distant search', Academy of Management Review, 2012, 37, (3), pp. 355-375

[18] Kittur, A., Nickerson, J., Bernstein, M., Gerber, E., Shaw, A., Zimmerman, J., Lease, M., and Horton, J.: 'The Future of Crowd Work', Proceedings of the 2013 Conference on Computer Supported Cooperative Work, 2013

[19] Hevner, A., March, S.T., Park, J., and Ram, S.: 'Design science in information systems research', MIS Quarterly, 2004, 28, (1), pp. 75-105

[20] Sonnenberg, C., and vom Brocke, J.: 'Evaluation Patterns for Design Science Research Artefacts', in Helfert, M., and Donnellan, B. (Eds.): 'Practical Aspects of Design Science' (Springer Berlin Heidelberg, 2012), pp. 71-83

[21] Mettler, T., Eurich, M., and Winter, R.: 'On the use of experiments in design science research: a proposition of an evaluation framework', Communications of the Association for Information Systems, 2014, 34, (1), pp. 223-240

[22] Miah, S., Kerr, D., and von Hellens, L.: 'A collective artefact design of decision support systems: design science research perspective', Information Technology & People, 2014, 27, (3), pp. 259-279

[23] Amailef, K., and Lu, J.: 'Ontology-supported case-based reasoning approach for intelligent m-Government emergency response services', Decision Support Systems, 2013, 55, (1), pp. 79-97

[24] Thuan, N.H., Antunes, P., and Johnstone, D.: 'Toward a Nexus Model Supporting the Establishment of Business Process Crowdsourcing', in Dang, T.K., Wagner, R., Neuhold, E., Takizawa, M., Küng, J., and Thoai, N. (Eds.): 'FDSE 2014. LNCS' (Springer, Heidelberg, 2014), pp. 136–150