Relationship Between Knowledge Creation and Open Innovation Applied Through Public Open Innovation Platforms

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Abstract: Public online open innovation (OI) platforms, widely used across countries, allow communities to participate in OI processes by sharing innovative ideas about specific problems. Knowledge creation and OI are related. To implement an innovative solution, new knowledge must be created. Previous studies have discussed knowledge creation and OI in the context of organisational teams in business, but knowledge creation by communities in the context of public OI platforms has received little attention. The socialisation, externalisation, combination and internalisation (SECI) model is a well-known model that embodies the knowledge-creation process. The OI process involves determining community needs, identifying themes, identifying a community problem, posting that problem on a platform, sharing innovative ideas for solutions, selecting the best solutions and implementing and diffusing the solution to the community. This study applied a multi-case approach to investigate how knowledge was created by communities through an OI process based on the SECI model. Data were collected by conducting in-depth interviews with leaders of two different OI platforms in two countries. Deductive analysis was utilised to clarify the OI process used by each platform and the relationship between the processes and the SECI model. The findings revealed that the OI process applied by public OI platforms follows the SECI structure. This means that innovative solutions created by communities represent tacit knowledge, which is turned into explicit knowledge and then becomes tacit knowledge again. The developed conceptual framework can facilitate the application of OI through the knowledge creation model and enhance understanding of community knowledge creation.

Keywords: Open innovation process, Public open innovation platform, Knowledge creation, SECI model, Public sector

1. Introduction

Developing innovation capability is now increasingly seen as essential for any organisation. Although innovation has been an important trend for many years, organisational practices that encourage innovation have changed continually. Building multidisciplinary teams has become a common practice, as has acquiring ideas from outside organisations—a trend that is commonly called open innovation (OI).

Innovation is increasingly related to knowledge development. New ideas represent new knowledge, and knowledge is needed to convert ideas into practice. In any innovation process, organisations must develop or capture knowledge about their stakeholders and their needs. They must then develop ways to satisfy those needs using experts' knowledge and ideas. However, innovation has gone beyond organisations' innovation of their products and services and has been extended to innovation in a wider community context via services provided by governments or community developments, such as smart cities. Industry and governments use a wide variety of processes to foster innovation, but a distinction may be made between closed innovation and OI. The relationship between knowledge creation and innovation was clarified by Nonaka et al. (1996) knowledge creation cycle.

Initially, most organisations supported closed innovation, meaning that ideas were generated by employees inside an organisation's boundaries (Herzog, 2011; Bae and Chang, 2012). In closed innovation, needs are often collected from selected customers chosen by the organisation and innovative ideas are generated by internal organisational staff. In contrast, innovative ideas in OI can come from both inside and outside an organisation (Herzog, 2011), involving customers, university researchers or suppliers (West and Bogers, 2014). While closed innovation is a well-known concept in the literature, OI was first introduced by (Chesbrough, 2003) and has since become the focus of attention for many studies.

Recently, the concept of innovation has been widely applied in the public sector (Harris and Albury, 2009; Torfing, 2016; Sørensen and Torfing, 2017). According to Bommert (2010); (Kankanhalli et al., 2017), public sectors should open their closed innovation due to the policy challenges they face. Moreover, approaches that invite community participation in decision-making processes, which were previously handled completely by

governments, should be covered more extensively in the literature (Bekkers et al., 2013; Kankanhalli et al., 2017), since communities are an important part of OI processes.

Understanding knowledge that comes *from* customers rather than merely gathered *about* customers, as is often the case in closed innovation, is important in OI, which invites customers to provide knowledge about their current and future needs. Understanding customers' needs is often a key indicator of successful product innovation. Instead of starting with idea generation as the initial phase of innovation, organisations should first gather knowledge from customers to understand their patterns of needs and wants (Katemukda and Sudasna-na-Ayudthya, 2015). Thus, OI and knowledge creation theory are related. This research applied the SECI model as a well-known knowledge creation model. The study explored how these concepts are related to each other in the context of public online OI platforms, then considered how knowledge is converted into ideas and, subsequently, solutions that satisfy needs in terms of knowledge development as posited by (Nonaka et al., 1996). The study focused on public OI platforms used by communities to post innovative ideas to develop ways to identify stakeholders' needs and satisfy them. The research examined whether there is a connection between the knowledge creation model (specifically, the SECI model) and the OI process used for public OI platforms.

The main research questions were as follows:

- What OI processes were followed by the Australian and the United Arab Emirates (UAE) OI platforms?
- Does the knowledge created by communities through the OI process using public OI platforms follow the common SECI knowledge creation model? If yes, how does it proceed?

The next section discusses our previous work, which revised the traditional OI process to be appropriate for use by public OI platforms. The following section discusses public OI platforms and provides a background to knowledge creation and OI. The subsequent sections demonstrate the research methodology, analysis and findings; discuss the findings; and present the conclusions.

2. OI Process

According to Salerno et al. (2015) who mentioned many studies that addressed the innovation process, a closed innovation process involves idea generation, idea selection, idea implementation and idea diffusion. Closed innovation starts with an idea (as is often the case with start-up organisations) and shows how this idea will satisfy needs. In the OI literature, the OI process starts by generating ideas from external sources, such as citizens, customers or researchers (West and Bogers, 2014).

Table 1 summarises the most common innovation processes, open or closed, with or without the use of online platforms. The focus of many papers is on finding solutions—the stage at which ideas are initially generated. Figure 1 describes how prior studies have addressed the OI processes used by OI platforms in both the private and public sectors.

Table 1: Common Processes Used for Open and Closed Innovation Processes

Reference	Innovation process	Focus
(Salerno et al., 2015)	Previous innovation models followed a linear innovation process: 1) idea generation, 2) idea selection, 3) idea implementation and 4) idea diffusion.	Closed innovation Private organisations New product development
(Gerke et al., 2017; Bergendahl and Magnusson, 2015; Roberts, 2007; Dougherty, 1992)	Phases of the innovation process: 1) idea selection; 2) invention phase, including the implementation process; and 3) exploitation phase, including the product/service launch.	Closed innovation Private organisations
(Hansen and Birkinshaw, 2007)	Innovation process as an innovation value chain: 1) idea generation, 2) idea conversation and 3) idea diffusion.	Closed innovation Value chain

| Reference	Innovation process	Focus
(Yang et al., 2009)	Steps in the OI process using online contests: 1) Posting: when the innovation seekers post a description of the project that they want people to give innovative ideas or solutions for. 2) Bidding: when the users submit their ideas. 3) Feedback: when the innovation seekers give feedback to the platform users. 4) Awarding: when awards are provided for the selected best-posted ideas. 5) Extending: an optional stage for the innovation seekers if they want to extend the project post for additional time. 6) Evaluating: another optional stage where the innovation seekers can leave feedback on all of the users' ideas.	OI Online contest
(West and Bogers, 2014)	According to an analysis of many articles about OI, the process can follow these stages: 1) obtaining innovation from external sources; 2) integration of innovations; 3) commercialising of innovations; and 4) interaction mechanisms, which may occur at any phase of the innovation process.	OI Private organisations
(Durst and Ståhle, 2013)	Open innovation phases are as follows: 1) searching for innovations, 2) selecting the most appropriate innovation, and 3) implementing the chosen innovation.	OI
(Milutinović et al., 2018)	Process in online OI platforms: 1) collecting new or existing innovative solutions; 2) choosing the best solutions by experts or the community and 3) implementation and launching the selected solution, either product or service.	Online OI platforms
(Adamczyk et al., 2012; Bullinger et al., 2010)	1) generation of innovative ideas through the platform; 2) selection of the more appropriate ideas by evaluators who are experts in the field; and 3) application of the selected idea, including launching the innovative idea into the market.	OI Innovation contests
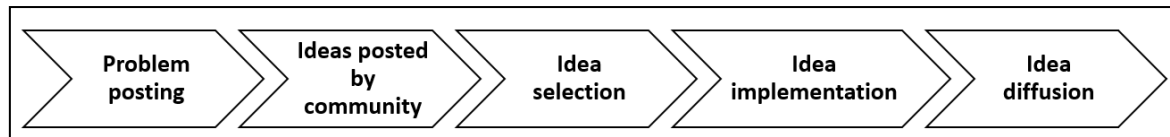
Figure 1: Traditional OI Process Through Public Online OI Platforms

The OI process shown in Figure 1, from our previous 2021 study, was revised to the one shown in Figure 2. The previous study proved that there was a missing step in the OI process for public online OI platforms (Figure 1)—how the problem was determined. It is found three methods used by one OI platform (platform A in the previous study) to capture community needs: community interviews, workshops (including consultations) and recent research on problems. The other platform used different methods, such as suggestion boxes, social media and the monitoring of country vision indicators. The revised process was divided into two parts—problem determination and the selection of an innovative solution. The main contribution of this study was to prove the viability of the existing procedure for capturing community needs, identifying themes and specifying problems through an OI process. Capturing needs can be divided into two parts: first, *what* is needed, such as improved transportation or educational services; and second, *how* solutions and services can be provided to meet the identified needs.
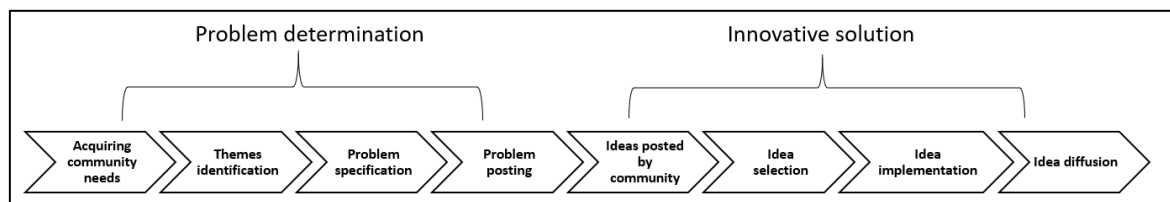

Figure 2: Revised Innovation Process Through Public Online OI Platforms (Previous Work)

3. Public Online OI Platforms

OI can be applied to either the private or public sector, though the implementation can be different in each sector. Application of OI in the private sector often focuses on particular products. For example, LEGO is a toys brand who faced a decreased in revenues, then, the company launched a philosophy said "people don't have to work for us to work with us" by establishing a LEGO Ideas where customers can share and votes for ideas. This was a turning point for the company which becomes "a global leader in toy innovation" (Markowitz, 2018). Therefore, The application of OI in the private sector leads to various benefits, such as high revenues and competitive advantage (Bommert, 2010). On the other hand, the public sector is usually aware of the delivery of innovative public services, specifically if the external sources of ideas are citizens (Bommert, 2010). Both public and private sectors benefit from including external ideas in their innovation processes. One general example here is the development of smart cities such as initiative of Melbourne as Smart City in Australia (Melbourne, n.d.).

Zhang et al. (2017) identified the factors that drive the implementation of OI in the public sector, namely 'support of top managers', 'the access and competence of IT personnel', 'the regional economic' and 'social environment'. According to Curtain (2003), several point important in OI, ,such involvement itself has options. For example, is citizen input only needed in defining needs or do citizens also get involved in generating ideas. Many smart city projects for example define needs in general terms and then issue challenges to the community to provide solutions. Some include citizens in the decision-making process in the context of government services like education or health. For example, citizens can play the teacher role to explain specific problems and their solutions in more detail. Citizens can also take the discovery role. Therefore, citizens can define the hidden principles for specific problems (Curtain, 2003).

Figure 3 presents a process that we have identified for applying OI using online platforms. This process is supported by governments to find innovative solutions for community problems, for example, in health or education. First, the platform posts a specific problem to be solved by the community. Next, the community shares its innovative solution through the platform. Afterward, the proposed solutions are analysed by an evaluation team to select the best solution that can be implemented for the problem.

The first external source of innovation that can play an essential role in the OI process is the customer. The inclusion of the customer has long been considered a valuable component in the innovation process. However, such inclusion was limited to getting the customer's requirements for product development; their participation

was not included throughout the innovation process. Katemukda and Sudasna-na-Ayudthya (2015) argued that customer involvement in the first phase of the innovation process (idea generation) is missing. Organizations focus on knowledge about customers, not from customers (Katemukda and Sudasna-na-Ayudthya, 2015). For example, they consider the customers' age and gender but not their needs. Although Katemukda and Sudasna-na-Ayudthya (2015) did not explicitly mention the concept of OI, their analysis led to companies acquiring more knowledge from customers as it is an important component of the innovation process, which in turn led us to the concept of OI. Moreover, Piller et al. (2011) stated that in the context of OI, 'customers become active participants in an innovation process of a firm and take part in the development of new products or services. Previous studies have shown that the integration of customers and suppliers can generate great ideas that can be considered in the innovation process (Lau et al., 2010). Overall, the involvement of customers' ideas throughout the innovation process can be a valuable external source.

Nowadays, the community also plays an essential role as an external source of knowledge for innovation (Lee et al., 2012). Seltzer and Mahmoudi (2013) indicated that the participation of citizens in the innovation process needs to be well managed and organised, as this involvement can contain several ideas. Most researchers linked the studies of community participation as an external source of knowledge with innovation in the public sector. This involvement is usually implemented through online platforms (Mergel, 2018). A community can assist governments in creating more innovative services faster (Lee et al., 2012). Many governments have recognised the importance of citizen participation and have therefore adjusted their strategy to include citizens as a valuable source of ideas (Lee et al., 2012). Previous studies have emphasised the customer as an external source of ideas specifically in the context of product innovation.
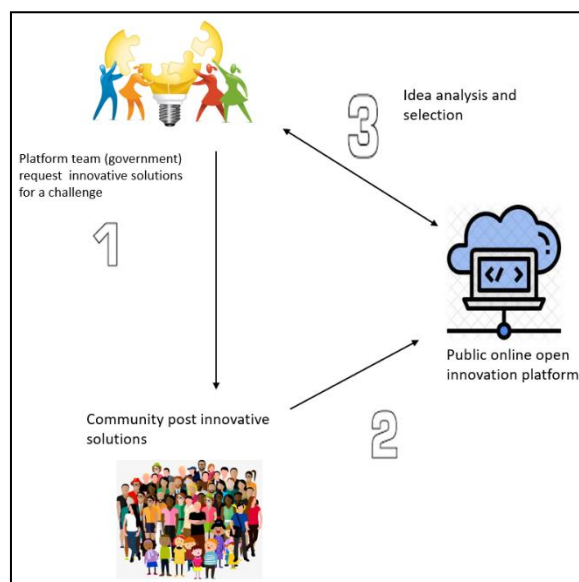

Figure 3: How Public Online OI Works

4. Knowledge Creation and OI

Knowledge management (KM) is 'the process of using meticulous steps to acquire, design, manage and share knowledge within an organization to achieve better performance such as reduced costly rework, faster work and use of best practices' (Abubakar et al., 2019). Knowledge creation is an important activity in the KM field. In the late 70s and 80s, knowledge creation in companies largely referred to the development of new products, but in the 90s, the knowledge creation theory emerged (Konno and Schillaci, 2021). Nonaka and Takeuchi (1995) stated that knowledge is initially created by individuals and then by groups of people. There are many definitions of KM. However, knowledge is created throughout the process of acquiring, transferring or sharing proposed solutions. According to Alavi and Leidner (2001); (Mardani et al., 2018), KM commonly focuses on five processes: 'acquisition, identification, development, diffusion, usage and repository of knowledge'. Other factors, such as knowledge implementation, creation and exploration, have also been studied widely in the literature. Mardani et al. (2018) concluded that knowledge creation and acquisition are the processes involved in knowledge production, involving the 'integration of knowledge, including knowledge storage and knowledge distribution' and the 'application of knowledge, including protection and use of knowledge'.

Nonaka studied knowledge creation from the 90s onwards, particularly examining the generation of knowledge by people in organisations. Nonaka (1994) stated that the creation of knowledge is not a sequential process; it is an ongoing spiral process. However, some studies have suggested a sequential process of knowledge creation involving creation, retrieval, transfer and application (Alavi and Leidner, 2001).

Nonaka and Konno (1998) divided knowledge into two types: tacit and explicit. Tacit knowledge resides in people's minds, experiences and actions. It is not visible; thus, it is hard to capture. Conversely, explicit knowledge is represented by numbers or words and can be captured in books, documents and models; therefore, it is effortless to acquire and easier to share between individuals and apply.

Knowledge creation has been embodied in many models, one of the most common and well known of which is Nonaka's SECI model. Nonaka and Takeuchi (1995) based the SECI model on the transformation between tacit and explicit knowledge. As shown in Figure 4, the model has four components relating to socialisation, externalisation, combination and internalisation:

Socialisation

This is the first component of the model. It appears in an organisation when tacit knowledge is shared through observations, brainstorming, talking, actions and employees' cooperation, but only at the individual level.(Eseryel, 2014).

Externalisation

Tacit knowledge is made explicit when it is demonstrated through group discussions, open dialogues, and the use of documents, images and models. It is expanded through groups at the individual level (Chatterjee et al., 2018).

Combination

This includes gathering, combining, systemising, categorising and editing existing explicit knowledge, besides diffusing it, to form new explicit knowledge (Eseryel, 2014; Nonaka and Toyama, 2015).

Internalisation

Internalisation means that previous explicit knowledge is put into practice. Simulations and experiments are used to convert explicit knowledge back into tacit knowledge (Kahrens and Früauff, 2018).
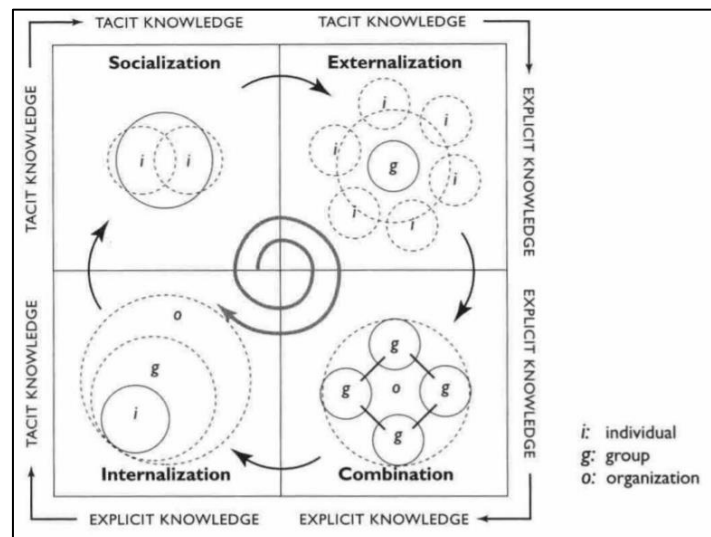

Figure 4: SECI Model (Nonaka and Konno, 1998)

Generally, there is a relationship between knowledge creation and innovation since knowledge creation is a source of innovation continuity, increasing competitive advantage (Nonaka and Takeuchi, 1995). Grimsdottir and Edvardsson (2018) stated that 'knowledge creation can be seen as the starting point of both KM and innovation'. Specifically, radical innovation is preceded by the process of knowledge creation (Forés and Camisón, 2016; Alshanty et al., 2019). Teixeira et al. (2019) indicated that knowledge is 'recognized as an arrangement of processes that facilitates innovation'. Also, Oliva and Kotabe (2019) indicated that an organisation's innovation is affected by individuals' interactions throughout the KM process. Andreeva and

Kianto (2011); (Lai et al., 2014) studied many companies in different countries and found a positive relationship between knowledge creation and innovation performance. Therefore, there is no doubt about the link between KM in general and knowledge creation and innovation in particular.

Regarding OI and the knowledge creation process, many studies have mentioned them together. Eseryel (2014) stated, 'The core of open innovation is knowledge creation' (Eseryel, 2014). Eseryel (2014) studied how open-source software development teams, such as OI teams, created knowledge by using technology. In this context, the author adapted the SECI model to the OI setting. Another study by Du Chatenier et al. (2009) investigated how knowledge was generated collaboratively by an OI team. The authors developed a conceptual framework based on 1) knowledge sharing, 2) interpretation, 3) negotiation and 4) combination. In a different context, Grimsdottir and Edvardsson (2018) studied two different small–medium companies, each with different products and each with its own OI knowledge creation model. They found that one company sought customers' knowledge in the early stages of OI, whereas the other company only engaged its customers at the end of the process.

Therefore, the OI process depends on the nature of the organisation and the source of the created knowledge. In this research, the community was the source of outside knowledge and the focus was on innovation and knowledge creation using public online OI platforms managed or monitored by governments. Based on the previous discussion, a conceptual framework was developed (see Figure 5).
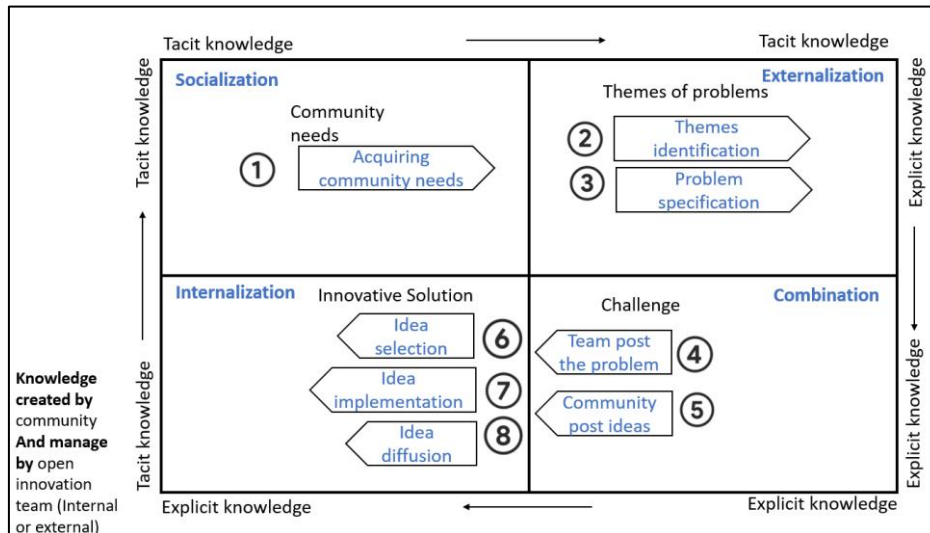

Figure 5: Conceptual Framework of Relationship of Knowledge Creation Model (SECI) and OI Process Applied Through Public OI Platforms

5. Methodology

Given its use of the 'how' question, this study constituted exploratory research, meaning that it investigated a particular part of a field to understand what was happening (Robson, 1993). Specifically, this study explored, from the perspective of the SECI model, the way communities create knowledge through OI processes using public OI platforms. To acquire deep knowledge and explore more than one culture using the same platform, we applied a multi case study design (Battistella et al., 2017) because it was the most appropriate method for answering the research question. We chose the qualitative multi case approach due to the need to examine the knowledge creation cycles followed by communities and managed by OI teams and compare them to the SECI model.

5.1 Case Selection

To obtain in-depth knowledge about the research question, we explored two platforms from different countries. Both of the studied organisations run OI platforms to allow their communities to solve problems by sharing innovative solutions. The two platforms function as follows:

- The platform raises a challenge faced by the community, such as a congested highway in the city.
- The platform asks the community for ideas for innovative solutions.
- The competition is closed and the ideas are evaluated.

- Candidates who provide innovative solutions are invited to presentations.
- Finally, winners are announced.

The two cases were limited to OI platforms established for the community and run by governments, not private organisations. An OI team for each platform managed the challenge, and a judging panel evaluated the ideas and selected the ideal solution.

The first case was an OI platform located in Australia, while the second was located in UAE. Despite the very different cultures, the two platforms worked similarly, as mentioned earlier. Innovative solutions were generated by communities. The Australian platform launched its first challenge in 2018 and has since presented one challenge annually on a different theme (e.g. for this year, the challenge was the city's recovery after the COVID-19 pandemic). The UAE platform covers many aspects of innovation, such as innovative educational tools and launches annual challenges, with themes relating to social issues in the UAE, such as the environment and climate change.

5.2 Data Collection

In-depth interviews were conducted with the leaders of the two OI platforms. Each interview lasted for one hour and all interviews were conducted online. To ensure the accuracy of the information, the Emirati interviews were recorded, transcribed and translated from Arabic into English. The interviews were conducted in 2020. The team leader for the UAE platform worked directly with decision-makers in the country to investigate community needs, using discovery methods such as suggestion boxes in government ministries. The leader also managed workshops that took place in an innovation laboratory (hereafter, 'lab') to identify challenge themes. The Australian leader managed all stages of the OI process across all challenge stages.

5.3 Data Coding

A deductive analytical approach was used to code the data. According to (Pandey, 2019), 'deductive content analysis is an analytical method that aims to test existing categories, concepts, models, theories or hypotheses in a new context'. Moreover, deductive content analysis is used when the analysis is based on previous knowledge, which in this case refers to the knowledge creation SECI model. According to Elo and Kyngäs (2008), the stages of deductive content analysis were as follows: (1) selecting the unit of analysis, (2) making sense of the data as a whole, (3) developing structured analysis matrices, (4) coding data according to categories, (5) testing hypotheses and comparing them with earlier studies and (6) developing a model, conceptual system, conceptual map, or categories.

After the interviews, the audio recordings were transcribed, and a deductive content analysis matrix was used to analyse the transcripts. As shown in Figure 3, based on the relationship between OI process and knowledge creation, a deductive content analysis matrix was developed (see Figure 5). As mentioned previously, the recommended phases of deductive content analysis were followed to analyse the transcripts (Elo and Kyngäs, 2008). The first and second stages were the preparation phases, while the following phase was the organising phase. The final stage was the reporting phase.

5.3.1 Preparation Phase

- Selecting the unit of analysis

The unit of analysis could be a word, one or more sentences or even a page (Polit and Beck, 2004; Elo and Kyngäs, 2008), based on the research question and what we needed from the data. In this work, the unit of analysis was examined to explain processes and approaches, with the aim of showing the relationship between knowledge creation and OI in communities.

- Making sense of the data

This meant reading the data, becoming familiar with them (Burnard, 1991) and generally making sense of them. Thus, the data were read many times to enable the researcher to thoroughly understand the transcripts. This is an important step before coding data using either an inductive or deductive approach (Polit and Beck, 2004).

5.3.2 Organising Phase

- Developing the analysis matrix and coding data according to categories

An analysis matrix can be structured or unstructured (Kyngäs et al., 2019). In this study, a structured matrix was chosen because of the nature of the analysis, which was based on the SECI model and the OI process, as shown

in Figure 5. Table 2 describes the structured analysis matrix based on this model. The columns represent the OI process: acquisition of community needs, theme identification, problem specification, posting the problem on the platform, community posting of ideas, and idea selection, implementation and diffusion. The rows represent the phases of the SECI model relating to the life cycle of knowledge creation: socialisation, externalisation, combination and internalisation. The coding process was carried out using NVivo 12 software. The structured analysis matrix and interview transcripts were entered into the software for analysis. The checkpoints represent where the codes (units of analysis) from the transcripts were placed during the coding process.

Table 2: Deductive Analysis Matrix

Open innovation process / SECI Model	Acquiring community needs	Themes identification	Problem specification	Team post the problem	Community post ideas	Idea selection	Idea implementation	Idea diffusion
Socialization	✓							
Externalization		✓	✓					
Combination				✓	✓			
Internalization						✓	✓	✓

5.3.3 Reporting Phase

- Case 1: Australian platform

Figure 6 provides a description of OI process map and answers the research question regarding the OI process applied by the Australian platform based on the general OI process shown in Figure 2. The process map in Figure 6 presents the first step of the OI process. The process started by capturing community needs through engagement with the community using surveys or applying research. Then, the OI competition team specified a list of themes. Thereafter, one problem was identified after conducting a series of workshops involving experts and the OI competition team. The specified problem was then posted on the platform as a challenge to the community, with a predetermined deadline. Meanwhile, sessions were held between the theme experts and participants to answer questions regarding the challenge. Moreover, a week called 'knowledge week' was used to allow theme experts to assist participants in incorporating their ideas and solutions. After the challenge closed, a list of participants' ideas and solutions was sent to the OI competition team. The evaluation process then started with the assessment panel reviewing the list to score and discuss the ideas for solutions. A showcase event was held to present the solutions of each of the top candidates for four minutes. Finally, the judging panel specified the winners and awarded prizes.
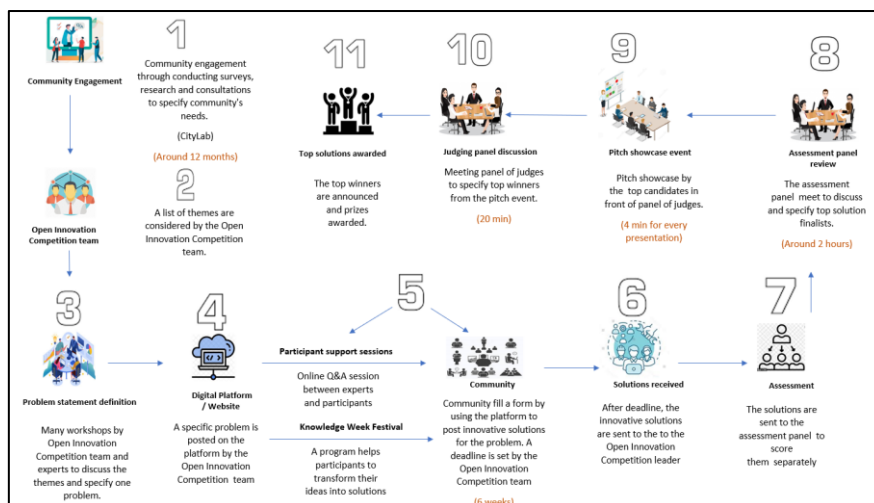

Figure 6: Process map of the Open Innovation Process in the Australian Platform

- Case 2: UAE platform

The OI process for the UAE platform (Figure 7) followed similar management to that of the Australian platform. In general, the operating of the challenges was the same; the challenge was posted and the community was asked to post ideas for solutions. Initially, the platform was based on an innovation lab, which was a series of workshops to discuss community needs and problems. As the platform leader stated, '*With this lab, we know why we want to engage with ideas from outside the institution, as we have groups in society who are benefitting from or affected by services in a particular sector*'. The government innovation lab was based on all government departments related to the community, such as the Ministry of Health. Any community needs or problems could be discussed in the innovation lab.

Generally, there is no specific way to acquire community needs or problems. One method, as shown in Figure 7, is the use of country vision indicators, such as the best education system. Suggestion boxes in ministries were checked in the innovation lab. Then, a problem statement was formed and posted to the community. The subsequent steps for selecting and evaluating the solutions were the same as those for the Australian platform.
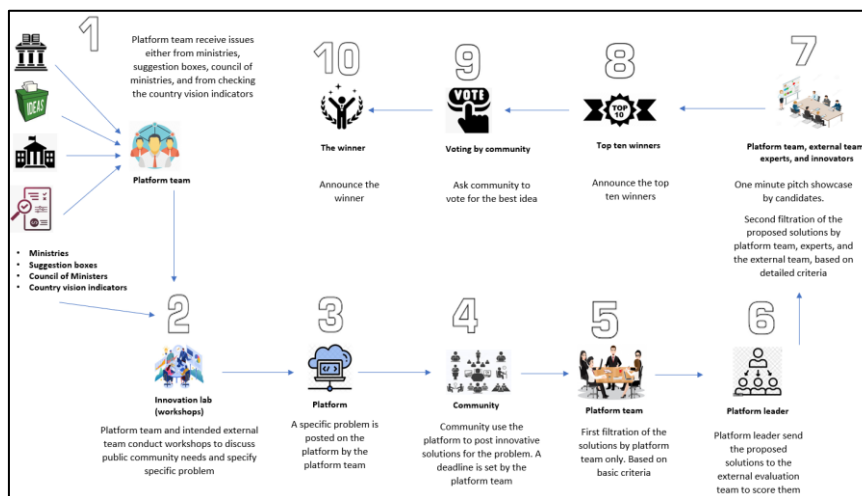

Figure 7: Process map of the Open Innovation Process in the UAE Platform

6. How Knowledge was Created During the OI Processes Applied by the Public OI Platforms (Based on the SECI Model)

The process map in Figures 6 and 7 shows the OI process approved in the previous study (Figure 2). To answer the second research question regarding the relationship between the knowledge created by the community and managed by the OI team and the SECI model, Figure 8 demonstrates the relationship.

Socialisation

Initially, the knowledge in the OI process was tacit, existing only in people's minds; for example, someone in the community had an idea for a solution to a specific social problem they faced. Community members might discuss ideas with their partners, consider the problem and solution, discuss a specific public service, suggest a solution for the problem or recommend another country's solution for adoption in their local community. These people may or may not have had experience with that solution. The OI team would then communicate with the community to identify their needs regarding specific social issues, such as the transportation system. Thus, the team socialised and interacted with the community. They might observe, interview, conduct research and/or conduct surveys with the community. Therefore, communication with the target community opened space for developing more themes on community needs. This interaction could be done in real life by interviewing people on TV channels or through social media exchanges. The suggestion boxes in the ministries were also checked, as for the UAE platform. Community knowledge was still tacit at this stage.

Externalisation

After socialising to determine the community's' knowledge, the OI team conducted workshops (the innovation lab of the UAE platform) to start transforming the extracted tacit knowledge into initial explicit knowledge.

External experts from the public sector, such as the Ministry of Education, joined the innovation lab. They studied the quality and effectiveness of new knowledge. As Chatterjee et al. (2018) stated, knowledge at this

stage 'becomes the basis of new knowledge'. This meant that community needs (community tacit knowledge) became explicit to the OI team, forming the basis of the innovative community solution.

Finally, another stage of the OI process (problem identification) occurred when the team specified one problem to be posted on the platform as a challenge and the identified problem was posted. Thus, external community knowledge became explicit.

Combination

The knowledge gathered from a community must be externalised to determine *what* must be provided to satisfy the needs and then combined with existing resources to determine *how* to provide it. As shown in Figure 8, the communities generated solutions for the challenge posted by the OI team, which meant that ideas for solutions were based on community needs. This meant that the community's previous knowledge (needs and ideas for solutions) was combined with solutions posted on the platform to form new knowledge. The evaluation and selection process was then conducted by the evaluation team and, sometimes, the OI team. The evaluation teams differed for each platform. For example, for the Australian platform, the evaluation team members were external individuals, chosen according to the challenge theme, such as university professors, international partners and Australian government partners: '*It's a team of our partners that gives prizes. So, there are usually … five or six on the final judging panel.*'

For the UAE platform, when the OI leader was asked about the formation of the evaluation team, he replied, '*I have been a member of it from the time the initiative was launched*'. There were criteria for evaluating each challenge. As the UAE platform leader explained:

> *There are approximately seven criteria, such as the feasibility of the idea and whether it is considered new, can work in a specific time and have an impact. The standards were studied with international organisations that had experience and selected the criteria.*

Internalisation

The idea selection process involved the two components of the model relating to combination and internalisation when the community's knowledge was put into practice. First, the selected ideas were presented to the judging panel. Second, by announcing the winner, the judging panel moved the process to the implementation phase. The judging panel tried to gain further understanding of the solution to the challenge by asking questions and holding discussions with the candidates. Explicit knowledge was embodied here by implementing and diffusing the solution back to the community. This knowledge was created by community stakeholders who evaluated how solutions would resolve the problems identified during externalisation. This included feedback from judges on the solution, especially when there were gaps in meeting the challenge. This knowledge was often tacit and could result in another cycle of improvement to the solution. In design thinking, such solutions are often presented as prototypes that are continually being improved.

Continuous improvement is part of the SECI model, with the cycle of socialisation, externalisation, combination and internalisation continually repeated as improved solutions are developed based on previous results.
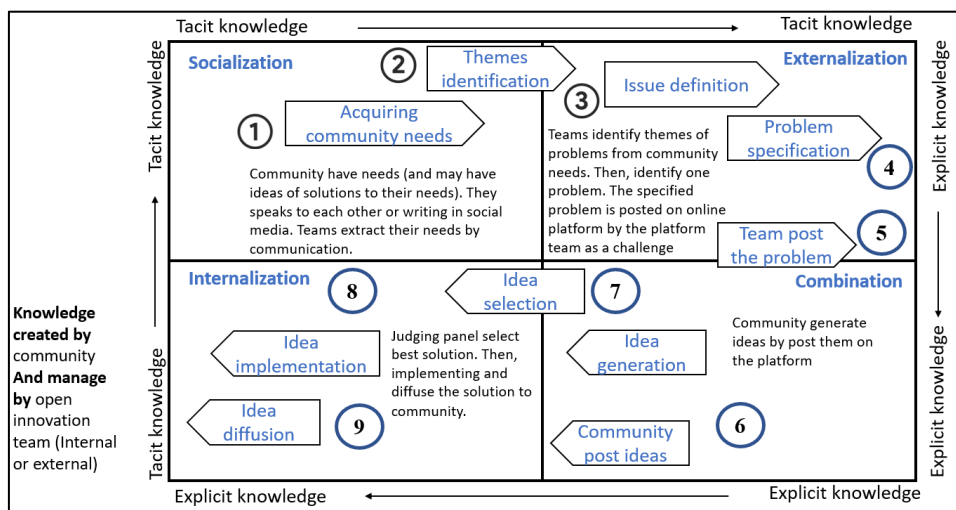

Figure 8: Revised Relationship Between SECI Model and OI Process Applied Through Public OI Platforms

7.   Conclusion and Future Work

The main achievements of this research and its contributions included confirming the innovation process used by two OI platforms in two different countries (Australia and the UAE). The results support our previous work, which discussed the OI process applied by public online OI platforms. The earlier findings indicated that the five platforms (three platforms are not explained in this paper) followed the previously approved OI process (Figure 2). Second, it confirmed knowledge creation by the community during the OI process. The literature showed that there is a relationship between knowledge creation and closed innovation but also between OI and knowledge creation, as discussed previously. However, this paper argues that the OI process used by communities on public OI platforms follows the well-known SECI knowledge creation model developed by (Nonaka and Konno, 1998). After interviewing the platform leaders, the interviews were analysed using a deductive analysis matrix, as shown in Table 2.

The results support the claims made in the literature that the OI process can follow the SECI model. Based on the analysed data, the key findings in Figure 8 demonstrate that the first and second phases of the OI process (acquiring community needs and identifying themes for problems) gather tacit community knowledge. Regarding the first component of the SECI model, the platforms' OI teams extracted this tacit knowledge from the community using many approaches, such as interviews, suggestion boxes, research and surveys. Then, tacit knowledge was converted into explicit knowledge by sorting it into themes and identifying the most important problem to be posted on the platform (externalisation). This explicit knowledge was converted into further new explicit knowledge by the community when they posted their innovative ideas for solutions to the target problem (combination). The idea selection process started with the judging panel analysing and selecting the best ideas. The selection process could flow between the combination and internalisation components of the SECI model at this stage. Finally, the announcement of the winner for the best innovative solution to be implemented and diffused to the community represented internalisation.

This study provides a framework that public OI platform management teams and decision-makers can follow to operate public OI platforms. Future research can examine ways of extracting tacit knowledge from communities and converting it into explicit knowledge for implementation as innovative solution for communities. Future work could also expand the data collection phase to include other public online OI platforms and interview other teams in other countries.

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