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ABSTRACT

Participatory scenario planning (PSP) is widely used by researchers and practitioners working towards social-ecological resilience with the expectation that it can encourage learning. However, thus far there is a lack of theoretically informed analysis regarding how PSP may support learning in this context. In this paper we present a novel conceptual framework, based on the Zone of Proximal Development, which highlights how learning can arise through interactions between people with different fields of expertise, and add the concepts of 'boundary objects,' and 'scaffolding.' We applied this framework to an empirical study of learning in PSP processes that focus on social-ecological resilience. We found that PSP purposively brings different participants into dialogue with each other, and through the process of developing and analysing narratives of possible futures, encourages their exposure to different knowledges. If carefully designed and facilitated, PSP can also stimulate structured, creative thinking about possible futures. This can be usefully understood as enabling participants to 'enter' their Zone of Proximal Development and to explore ideas and ways of thinking in which they would not normally engage. This highlights the importance of studying interactions between different participants in PSP, and of actively facilitating the process of imagining and exploring scenarios.

KEYWORDS: Participatory scenario planning; learning; zone of proximal development; boundary objects

1. Introduction

Futures tools are often used by researchers, policymakers, and practitioners to help address the complex, uncertain and destructive challenges that characterise social-ecological systems. Participatory Scenario Planning (PSP), especially, has been widely used as a tool to help tackle these challenges, commonly motivated by an assumption that it can help people learn about and identify responses to them (Oteros-Rozas et al., 2015). Indeed, one of the founders of scenario planning, Wack (1985), explains that it can help people to structure future possibilities into coherent narratives. In this way, he explains, scenario planning enables groups of people who are working towards a common goal to articulate and reflect upon their assumptions about the world, consider alternative perspectives, and thus learn through developing a broader understanding of whatever system they are operating within. Similarly, two other influential scenario planning scholars, Schoemaker (1993) and Van der Heijden (1996), both argue that it can help people to develop an expanded understanding of the world by structuring highly uncertain futures into sets of manageable narratives.

More recently, Ramirez and Wilkinson (2016; p.5) build on this earlier work to describe how scenario planning can enable learning through 'reframing' (a process of exploring alternative future contexts, which leads to an exchange of different perspectives, and thus the creation of new knowledge and shared perspectives, as well as consideration of different options for action) 'reperception' (identification of new courses of action to be taken for achieving change). In this way, scenario planning can help groups and individuals to develop a more holistic understanding of the system in which they are working, and then to identify ways to approach a specific situation. Similarly, Ehresmann, Tuomi, Miller, Bejean, and Vanbremeersch (2018) describe PSP as a 'Collective Intelligence Knowledge Creation' process that enables participants to understand and appreciate how the way they imagine the future influences their perceptions of and actions in the present. This can thus encourage people to ask new questions and 'think outside the box.'

This scholarship creates expectations that scenario planning can be useful for learning and provides some insights into how this learning can occur. However, there has thus far been limited theoretically informed explanation of how participatory scenario planning (PSP) enables such learning, especially as used in the context of tackling complex challenges in social-ecological systems. Developing such an understanding could help futurists, researchers and practitioners to assess how it should be used and what benefits it may be expected to have when applied in different contexts. In this paper, we have two aims: Firstly, we review theoretical literature on learning to build a conceptual framework that can help futurists and other researchers and practitioners of PSP to study, understand and evaluate learning in PSP processes. We base this on a specific pedagogical theory - Vygotsky's (1978) Zone of Proximal Development (ZPD) – then build on it using other influential concepts related to learning, namely 'boundary objects,' (S. L. Star & Griesemer, 1989) and 'scaffolding,' (Wood, Bruner, & Ross, 1976). Secondly, we apply this framework to a study of learning in PSP processes that focus on addressing complex challenges in social-ecological systems. The study comprised i) an analysis of 30 cases of PSP described in the academic literature, ii) interviews with 16 practitioners of PSP, and iii) two empirical case studies of PSP processes. We do this to identify the processes through which PSP can support learning, and to assess the usefulness of

our conceptual framework. We begin with the review of theoretical literature on learning, below.

2. Using Pedagogical theories to build a conceptual framework for explaining learning in PSP

2.1 Literature Review of Pedagogical theories that can explain learning in PSP

Defining Learning. To begin, it is important to clarify what we mean by learning. There are many ways in which learning scholars have defined learning, but they are often linked by the theme of change (cognitively or physically) on the part of the learner, as a result of interpreting experience (Illeris, 2009; Jarvis, Holford, & Griffin, 2003; Parker, 2005). In this paper, we therefore consider learning to be a change in a person's cognitive or physical capacity that results from that person interpreting their experiences of external stimuli. For example, not just learning new facts and information, but identifying new priorities and solutions to problems, understanding alternative perspectives, reframing specific issues, and developing a more holistic understanding of possible future conditions. We focus on cognitive traditions of learning theory because of their emphasis on cognitive processing of experience as the driver of learning. In particular, we look at the Zone of Proximal Development, proposed by Vygotsky (1978).

The Zone of Proximal Development. In this influential learning theory, Vygotsky distinguishes between a person's current development (their independent capacity for learning), and their proximal development (the potential learning capacity they have when assisted by others). Vygotsky thus assumes that an individual's capacity for learning increases when they receive assistance from others. When such assistance is provided, he refers to this as 'entering' the ZPD. In a more recent description of the ZPD, Wals and Dillon (2013) explain the ZPD as the potential learning that can occur through interactions with other people, their work and their thoughts and ideas. They indicate that such interactions can help people understand things they would have been unable to without being encouraged or challenged by one another.

However, as Chaiklin (2003) warns, Vygotsky specifically states that learning occurs through interactions between learners and people who are more capable in a given field, or who have a more advanced level of cognitive development. In PSP, the participants and facilitators may have similar levels of cognitive development. However, it may create opportunities for participants to encounter others who are more capable in different fields or contexts to their own. For example, a smallholder farmer may have more expertise about localised rainfall patterns in a village than a climate scientist. Conversely, the climate scientist may have more expertise in global atmospheric processes than a smallholder farmer. If both apply their knowledge to exploring scenarios about the possible effects of changing rainfall patterns, they could each benefit from interactions with the other in learning about certain aspects of the problem. The Zone of Proximal Development thus provides a useful theoretical basis for explaining how learning occurs in PSP – indicating that it occurs through interactions

between people with different expertise. However, it is not sufficient for understanding the specific attributes of PSP that enable such interactions, or indeed why these interactions help participants to 'enter' their ZPDs.

Boundary Objects. One useful way to explain how PSP enables interactions and why these interactions encourage learning is through using the concept of 'boundary objects.' These were first conceptualised by S. L. Star and Griesemer (1989) as material or abstract objects that occupy several interacting, intellectual worlds and remain relevant and outwardly acceptable to all of them. They explain that boundary objects can facilitate effective communication between diverse actors, which helps them to cooperate despite their disciplinary and other differences. White et al. (2010) reason that this can enable negotiation and exchange of knowledge between different groups. As Susan Leigh Star (2010) clarifies, a 'boundary' in this context is not the physical edge of something. Instead, she states that it is a physical or conceptual space that is shared by actors from different social worlds. Star also emphasises that an 'object' is not necessarily a material thing but can be a concept that people work towards and with.

The inclusion of different knowledges in PSP means the scenarios that are imagined can become spaces that are shared by participants from different social worlds. They can thus encourage interactions between people with diverse knowledge through creating opportunity for interaction on a shared concern. Scenarios are also conceptual objects that participants work towards and with, which can encourage them to share their knowledge and thus learn from one another. We therefore follow Chaudhury, Vervoort, Kristjanson, Ericksen, and Ainslie (2012) in proposing that the process of imagining plausible futures in PSP fits particularly well with the concept of a boundary object. Viewing PSP processes as boundary objects thus helps to understand how PSP can encourage interactions between participants with different knowledge. This builds on the idea of the ZPD, in that these interactions between different participants encourage them to enter their ZPD, and thus to learn. This is illustrated in Figure 2, below.

Scaffolding. When Vygotsky (1978) proposed the ZPD, he argued that learners require assistance, not just interaction, for them to enter the ZPD and for learning to occur. Hence, we also draw on the related pedagogical concept of 'scaffolding,' Wood et al. (1976). Wood et al. describe this as someone with more expertise than the learner gradually introducing them to and helping them complete tasks that they would not have been able to complete alone. A more recent description of scaffolding is provided by Van der Pol, Volman, and Beishuizen (2010), who argue that scaffolding involves: contingency (tailoring support provided to a learner's existing ability), fading (decreasing the level of assistance as the learner becomes more proficient), and transferring the responsibility for learning from the expert to the non-expert.

Van der Pol et al. (2010) critique Wood's view of scaffolding because it assumes that what is learned is predefined by the expert. Instead, they argue that learners should be viewed as active participants, rather than recipients of knowledge, and scaffolding should be viewed as an interactive process, in which learners and experts create new knowledge together. This reflects an argument made by other learning scholars, Fernández, Wegerif, Mercer, and Rojas-Drummond (2001), who contend that scaffolding can and does occur in peer-to-peer interactions as well as interactions with experts. Specifically, they indicate that peer-to-peer

scaffolding occurs when people engage in what they call ‘exploratory talk.’ They describe this as a process of people engaging critically and constructively with others’ ideas by proposing new ideas, and then giving and receiving critical but constructive feedback to and from others. This enables learners to develop new understandings and drive the learning process forward.

The concepts of both expert-learner and peer-to-peer scaffolding are valuable for understanding learning in PSP since they highlight the role of facilitation in PSP. Typically, PSP processes are designed and led by one or more facilitators. However, the role of facilitators is something that appears to have received scant attention in PSP literature. Facilitators may have an important role in enabling or constraining learning in PSP processes since they arguably provide scaffolding that helps participants engage in, as well as learn through, PSP. This can influence how participants interact with each other, as well as the extent to which these interactions result in learning. Peer-to-peer scaffolding may also occur between different participants in PSP when they interact in a way that encourages exploratory talk. This could also help to explain why such interactions can encourage learning. This is illustrated in Figure 3, below.

It is important to recognise that scenarios may be imagined for different purposes, ranging from identifying what is probable by projecting trends in the past and present, through exploring what is possible through constructive narratives of the future, to creating the future by expanding what people consider possible (Tuomi, 2019). PSP processes can thus include different methods, as well as different approaches to facilitation, depending on their purpose. The ‘Futures Literacy Framework’ outlined by Miller (2018) lays out five stages of learning with regards to anticipating the future, which represents a scaffolding process, in that participants start with one stage and then become more proficient as they progress through the different stages. In the early stages participants develop experience and awareness of how their perceptions of the future influence how they think and act in the present, then in the latter stages participants reassess their perceptions of the past and present, as well as their aspirations for the future, and ultimately, through collaboration with others, choose why and how to anticipate the future. The methods and facilitation style of individual PSP processes will depend on the stage of the learning that participants are intended to reach through the process, and the stage they are at already.

2.2. A conceptual framework for understanding learning in PSP

The conceptual framework is presented in three parts, reflecting the three learning theories (the Zone of Proximal Development, boundary objects and scaffolding) reviewed above. Firstly, we argue that PSP can support learning by creating opportunities for interactions between people from different social and disciplinary backgrounds, and with different kinds of knowledge and experience. This is illustrated in Figure 1, below.

(Figure 1 here)

Secondly, PSP can act as a boundary object that can facilitate exchange of knowledge, ideas and experience between different people. By doing this, PSP can help those who participate in it to enter their ZPDs and thus to learn. This is shown in Figure 2, below.

(Figure 2 here)

Thirdly, the above theories also suggest that facilitation plays a key role in enabling and supporting learning. This is shown in Figure 3, below.

(Figure 3 here)

To further our understanding of how learning can occur in PSP, we conducted an empirical study to understand whether and how the above characteristics of PSP can encourage learning. Specifically, we explored real-world examples of PSP with a particular focus on the interactions between participants, the processes that encouraged and hindered these interactions, and the roles played by facilitators. We focused on PSP processes that aimed to tackle complex challenges in socio-ecological systems, as this has become a popular application of PSP (I. Brown, Martin-Ortega, Waylen, & Blackstock, 2016; Johnson et al., 2012; Oteros-Rozas et al., 2015; Varum & Melo, 2010). As with the wider literature on PSP, enthusiasm for PSP in this context often seems linked to implicit or explicit expectations that PSP can support learning, specifically through the incorporation of knowledges of different stakeholders in deliberations on how to tackle these problems. However, none of these reviews or case descriptions have employed a theoretically informed explanation of how learning occurs, particularly how PSP can encourage interactions, why these interactions can promote learning and what role facilitation can play in this. We explored these issues through the methodology described in Section 3, below.

3. Methods

To apply the conceptual framework in Section 2 to real-world applications of PSP we conducted an empirical study into how learning occurs in PSP. We used a qualitative mixed method approach as this is appropriate to explore a hitherto poorly-understood topic (Creswell, 2003). This involved three different sources of data, gathered over 16 months between August 2015 and December 2016. These were: i) a review of 30 PSP cases described in the academic literature, ii) interviews with 16 practitioners of PSP, and iii) two empirical case studies of PSP processes. These are described in more detail below. In accordance with our use of the ZPD as the basis for the conceptual framework, we focused specifically on exploring the interactions between different participants in PSP processes, the exchange of knowledge between them, and the learning (if any) that resulted from this.

This research was conducted with ethical clearance from the Research Ethics Committee at the School of Agriculture, Policy and Development, University of Reading. Participants in the practitioner interviews and case studies were thus provided with, and asked to sign an information sheet, clearly explaining the purpose, intent and process of the research, as well as their right to request that any of their responses be excluded from recording and analysis, and to withdraw from the research at any point. We ensured the confidentiality of participants' responses by attributing quotes to pseudonyms, rather than participants' real names, and replacing the names of the two case study workshops with pseudonyms. Data was stored and managed in accordance with the University of Reading's Data Protection Policy and the UK Data Protection Act.

3.1. Review of cases of PSP described in the academic literature

PSP is frequently used by sustainability researchers as part of wider research projects that aim to inform responses to challenges in social-ecological systems. There is, therefore, a substantial body of peer-reviewed, academic literature reporting on individual cases of PSP being used. However, cross-cutting analyses of these cases are rare. We therefore interrogated and analysed 30 such cases to develop an understanding of how learning was discussed and theorised (if at all), as well as how learning may have occurred in them. As Haddaway, Woodcock, Macura, and Collins (2015) suggest, we ensured that the selection of cases was rigorous by selecting literature from multiple databases, selecting literature based on a consistent set of criteria, and critically appraising the literature before selection. The literature was identified using the databases: 'Web of Science', 'Google Scholar' and the University of Reading's online literature catalogue. In line with our focus on PSP in social-ecological contexts as a case study, we searched for: 'scenario planning social-ecological systems,' 'scenario planning sustainable development,' and 'scenario planning environmental management'. We then selected individual pieces of literature by studying the titles of papers that were found through these searches. We selected titles that matched the search terms exactly, and also those that used words and phrases related to the search terms. For example, a title such as 'identifying strategies for poverty reduction under climate change using future scenarios,' would be included. Finally, we narrowed the sample down from 53 cases to a set of 30 information-rich cases that provided enough information for a justifiable analysis of learning and other benefits that occurred in these examples.

However, although this provided a set of detailed cases for analysis, we acknowledge that the sample is biased towards well-reported and information-rich analyses of PSP processes. Equally, our sample focuses solely and deliberately on academic literature, as we did not seek to conduct a thorough analysis of grey, and other forms of literature in this research. We also recognise that the papers that described these cases were written by academics, many of whom had been directly involved in the cases they reported on, thereby introducing a second source of bias. It was therefore important to triangulate this with other sources of data.

3.2. Practitioner Interviews

As stated by Yeo et al. (2016), in-depth interviews can be a powerful way of exploring detailed interactions with people. In-depth, interviews were therefore conducted with 16 practitioners of PSP (researchers and professional facilitators) globally to explore how interactions between participants in PSP processes may have resulted in learning. These practitioners included 14 researchers from: ecology and ecosystem services (n=5), geography (n=2), sustainable energy (n=1), interdisciplinary studies (n=1), sustainable development (n=1), food systems (n=3), climate change adaptation (n=1). The remaining two practitioners were both professional facilitators. Nine practitioners were from the cases in the academic literature that were reviewed as part of this research, one was from a case that was excluded from the review for lack of detailed information about learning (to investigate if the detail was understood by those involved, but excluded from published material), three were prominent figures in PSP discourse, and three were from the case studies detailed below.

Most of the interviews took place by Skype or telephone. However, four of the interviews took place face-to-face, as the practitioners were available locally and suggested we meet in person. All of the interviewed practitioners interviewed appeared happy to talk, were open to being questioned, and provided detailed and eloquent responses. The practitioner interviews were

semi-structured and used mainly open-ended questions to achieve both breadth of coverage and depth of information regarding the key topics of interest in the research (Yeo et al., 2016). These questions focused on practitioners' experiences of PSP, including why they thought it was beneficial, or not, in the contexts in which it was used, as well as specifically exploring cases in which they thought learning had occurred and how they explained this. The full topic guide can be found in Appendix A. Pseudonyms were given to each of the interviewed practitioners and used in the analysis below to protect the identity of individual informants.

3.3. Case Studies of specific PSP processes

The review of cases of PSP in the academic literature and the practitioner interviews provided useful information, but they still relied on post-rationalised accounts of PSP processes by the people who facilitated or had been directly involved in them. For the purposes of triangulation, it was also important to elicit the experiences of participants and to observe, first-hand, the interactions that took place in specific PSP processes, how these interactions were encouraged, and how assistance provided by facilitators, and between participants, enabled learning to occur.

We collected observations from two case studies. These were selected based on the criteria that they: 1) developed alternative narratives of plausible future events, conditions and trajectories; 2) were participatory and included a range of different participants; 3) encouraged knowledge exchange between different participants; and 4) focused on tackling global challenges. Of the processes that met these criteria, we selected the two that were easiest to access, because of existing contacts held by the research team. Both processes were part of wider research projects. The first was part of the 'Food Security Futures' (FSF) project, which explored threats and opportunities for achieving food security under climate change in Tanzania. The second was part of 'Positive Futures for Southern Africa' (PFSA), an initiative that aimed to develop hopeful and innovative, but also realistic, ways of thinking about future relationships between human and environmental systems.

We chose two case studies for comparison, but as Lewis (2003) observes, some degree of difference between cases is always inevitable and may be illuminating. The two case studies used different approaches but followed essentially the same logic for developing scenarios – using present signals, trends and drivers to develop storylines of alternative futures. Both processes were participatory to the extent that they included participants (purposively selected) with a range of different worldviews, social-economic backgrounds, and disciplinary perspectives, and they actively encouraged them to share knowledge through imagining and exploring scenarios together. Table 1, below, provides an overview of both case study workshops, whilst Tables 2 and 3 provide detailed descriptions of the structure and activities undertaken in each one. The case studies have been anonymised to protect the identity of the participants, facilitators and organisations involved. Pseudonyms were given to each of the workshop participants and facilitators, and used in the below analysis to protect their identities.

(Table 1 here)

(Table 2 here)

(Table 3 here)

Our research into the case studies involved three aspects: i) administering a pre-workshop questionnaire by email to the participants of each PSP workshop; ii) observation of the

workshops; and iii) semi-structured interviews with the workshop participants and facilitators. The pre-workshop questionnaires consisted of five open-ended questions, concerning: participants' occupations, motivations for attending the workshop, and the benefits they expected it to have, and were administered the week before each workshop occurred. The observations involved: meetings with the workshop facilitators before, during and after the workshops to explore their preparations and expectations, watching, listening and speaking to participants and facilitators during the workshops themselves, and asking participants and facilitators to reflect on their experiences during breaks and meal times. Detailed written notes were made throughout these observations using an observation guide (see Appendix C), based on the conceptual framework outlined in Section 2, which included the extent and type of interactions that occurred during the workshops, the role that developing and analysing the scenarios played in encouraging and shaping interactions between the participants, and how participants were encouraged to engage effectively in PSP through assistance from facilitators.

The interviews with participants (n=13 from each case study) from the case studies focused firstly on ascertaining whether learning, taken as a change in understanding as a result of some external stimuli, had occurred through the workshops. Participants were asked directly if their understanding of the subject of each workshop had changed through the PSP process. Furthermore, most participants alluded to learning, unprompted, when asked about other aspects of the workshops, including what they found most interesting and challenging, and about their interactions with others. The second focus was to explore the interactions between different participants, the role (if any) that these interactions played in enabling learning, and the specific activities that stimulated these interactions. We thus asked participants about which aspects of the workshops, and which specific activities, they attributed learning to.

4. Results

4.1. Learning through interactions

Our research confirmed that learning is commonly reported as a benefit of PSP. Indeed, 23 of the 30 reviewed cases in the academic literature reported learning as a benefit (Poskitt, 2017). This supports previous assumptions that PSP can result in learning. A total of 14 of these cases alluded to interactions between diverse participants contributing to learning, particularly interactions that involved 'discussion,' 'deliberation,' 'dialogue,' and 'knowledge exchange' as highlighted in bold in Table 4. In each of these 14 cases, the authors subsequently reported that learning occurred. We thus infer from this that learning is linked to interactions that involved 'discussion,' 'deliberation,' 'dialogue,' and 'knowledge exchange' between different participants. Although there are nuanced differences between the terms 'discussion,' 'deliberation,' 'dialogue,' and 'knowledge exchange,' this study focused more on exploring the attributes of PSP that can encourage these kinds of interactions, rather than defining the differences between them. We therefore refer to these kinds of interactions as 'discussions between different participants.'

(Table 4 here)

The attribution of learning to interactions was also a recurrent theme in the practitioner interviews, in which respondents referred to learning occurring through interactions between indigenous and scientific communities, local and national level stakeholders, smallholder and commercial farmers, and many more. This was summed up eloquently by two practitioners, Gavin and Gordon, with substantial experience of using PSP in high-profile global processes:

> *"The learning potential lies in interactions across disciplines, where people's assumptions are questioned in a respectful way… This leads to learning about different drivers and learning about different people's visions and desires for the future." (Gordon, 2016)*

> *"It is the interactions between stakeholders that are brought together. They are brought together with people they don't normally interact with, across those different scales or across sectors, or areas of government, or industry." (Gavin, 2016)*

This evidence shows that practitioners, and the authors of papers reporting on specific PSP processes regarded that learning occurs through interactions between different participants in PSP. This theme was also evident in the interviews with participants in the case studies, especially from the PFSA workshop, in which all 13 of the interviewees indicated they had learned through interactions with other participants. For example, one participant, Geoffrey gave a detailed example of how discussions with another participant about the role that artificial intelligence (AI) could play in creating just and sustainable futures, led to him learning about a specific topic:

> *"I sat in that group with a totally different understanding of what artificial intelligence meant. [To me it meant] we're going to be taken over by aliens, but through Penelope's explanations, I thought 'oh, this is what it actually means, okay!' It's not necessarily just a computer; it's also the digital learning and all these different dynamics." (Geoffrey, 2016)*

In the interviews with participants from the FSF workshop, 6 of the 13 interviewees stated that interactions with other participants had resulted in them learning. The lower number of responses reflecting this may be because many of the interviewees in this case study found it difficult to articulate how they had learned in English. One participant, Sally, an academic researcher, described how she had learned from interacting with participants who had different expertise:

> *"I met with people's different expertise, nutrition specialists, policy makers, one person from the pressure group, from NGOs. Those participants shared their skills, their knowledge, their experience accordingly." (Sally, 2016)*

Our data thus demonstrates that learning in PSP does indeed occur through interactions between different people, and infers that discussions between participants are aspects of these interactions that encourage learning. However, this could arguably be said of any participatory

or educational process that brings different people into discussion. We therefore move on to explore any specific attributes of PSP processes that encourage discussions between participants and any specific attributes of these discussions that promote learning.

4.2. Providing a point of focus for discussions between participants

As shown in Table 5, 21 of the 30 reviewed papers mentioned specific aspects or activities that encouraged learning in PSP by acting as a point of focus for discussions between different participants. These aspects or activities are highlighted in bold in Table 5, below.

(Table 5 here)

The evidence in the table above indicates that discussing different aspects of social-ecological systems through developing structured narratives of the future provides a point of focus for discussions between different participants. In one typical case, extracted from Table 5, Van Berkel, Carvalho-Ribeiro, Verburg, and Lovett (2011) state that *'The scenarios acted as prompts in the workshop discussions,' (p.135)*. In their paper, the authors explain that deliberating on the effects of specific future trajectories in participants' local area stimulated discussion about local development issues. They report that this led to a *'richer understanding of rural development issues,' (p.136)* including the interests of different stakeholders. It thus appears that developing and exploring specific narratives of the future prompted discussion between the participants, which led to learning.

This was also reflected, strongly, in the practitioner interviews. We asked 10 of the 16 respondents about what specific aspects of PSP they thought enabled learning. All 10 of them indicated that the narratives of the future provided a point of focus for discussions about SEPs. This was encapsulated by one practitioner, Belinda, who had a wealth of experience conducting PSPs in global projects. She stated:

> *"Everyone has expectations, aspirations and anxieties with regards to the future, which they are forced to make explicit when they imagine scenarios." (Belinda, 2016)*

Another practitioner, Rick, provided more detail regarding how he thought learning had resulted from a specific PSP process in which he was involved. He explained that the PSP process encouraged learning:

> *"through focusing people's minds on what they think are the most important developments and trends… People know it, but people don't necessarily have a chance to focus on it and pull it together." (Rick, 2016)*

This shows that the participants learned, specifically, through focused discussions on potential future developments, which encouraged them to reflect on their existing assumptions.

In the FSF case study too, the process of exploring specific narratives of the future acted as a focal point for discussions. Of the ten interviewees who stated they had learned from the

workshop, eight of them described how this learning had been stimulated by the process of exploring structured narratives of the future together with others. For example, one interviewee, Alan, who indicated that he had learned about different aspects of food and nutrition security, explained that thinking about future narratives in a step-by-step way had helped him to learn:

> *"The methodology of using scenarios, and the planning by using the backcasting, that was the most interesting part because really it was new to me… It facilitates somebody to go step-by-step… It is difficult to miss something, to overlook something." (Alan, 2016)*

The above evidence thus indicates that PSP can engage participants in processes of exploring narratives of the future together in a structured and focused way. This is a specific aspect of PSP that encourages discussions between participants, and specifically acts as a focal point for these discussions, which encourages them to share and reflect upon their existing knowledge and assumptions about the future. However, as discussed in the next section, it is not just structure and focus, but also the opportunity to be creative in exploring narratives of the future that stimulates learning.

4.3. Creativity and learning in PSP

In the PFSA case study there was also evidence that exploring structured narratives of the future resulted in learning through promoting discussion between different participants. However, this went further than just structure to emphasise the importance of creativity. In our interviews with the workshop participants, 9 of the 13 interviewees attributed learning in PSP to structured thinking *combined* with creative thinking. For example, one participant, Penelope, stated fluently:

> *"I think imagining different futures, or different realities, is really powerful, because you're starting from a place of possibilities. When you are thinking of different futures like that, when you're doing scenarios, you're provided an opportunity to be creative… scenario planning provides an opportunity to be strategic, to be creative, and to start from a place of possibilities." (Penelope, 2016)*

Similarly, another participant, Gareth emphasised creative thinking, but within a structure provided by PSP:

> *"It helped people to 'think outside of their boxes,' but within some particular parameters." (Gareth, 2016)*

In other words, the PSP process in the PFSA workshop provided some structure to focus the participants' thinking about the future but gave freedom within this structure to explore possibilities they would not normally think about.

In the PFSA workshop, this 'focused, creative thinking' appeared to be especially encouraged by two specific activities: 'Futures Wheels' (Bengston, 2016) and connecting small-scale initiatives in the future. As explained in Table 3, above, the PFSA workshop began with creating 'Futures Wheels,' whereby participants imagined the impacts of small-scale initiatives if they were mainstream ways of doing things. This activity provided the initial

stimulus for participants to think creatively. For example, one group of participants imagined a future in which the division between rural and urban spaces became increasingly blurred. In another group, the participants imagined how the effects of gene technology on human health could lead to much longer human life. The ideas and creative thinking generated in the Futures Wheels were subsequently expanded on and developed in the later activities. The subsequent activity of exploring the effects these small-scale initiatives could have on each other also helped participants to think creatively. For example, one discussion group connected an initiative involving artificial intelligence (AI) with another promoting more equitable and inclusive access in urban spaces. This led to them imagining 'fluid infrastructure,' in which urban infrastructure could physically change shape to meet different purposes and, thus, encourage more equitable and sustainable use of space.

These observations were reinforced by the responses given by participants in the interviews. For example, Penelope spoke about how imagining the future using the 'Futures Wheels' had provided a stimulus for focused, creative thinking:

> "It gave people a structure to push beyond where their thinking would normally take them… we did, in some ways, get beyond the standard ways of thinking about how things will evolve. It was a genuine shift in my understanding of what is possible." *(Penelope, 2016)*

This provides a clear example of how focused, creative thinking in PSP resulted in a strong learning experience for this participant.

The observations of the FSF case study also showed that creativity combined with structure helped to encourage learning. During the workshop, we observed that the activity of thinking about how to overcome specific future challenges that were presented in the scenarios encouraged this structured creative thinking. A key objective of the FSF workshop was to explore plausible future conditions and identify challenges and opportunities for food security in Tanzania. We observed that this aspect of the workshop prompted participants to think creatively together about challenges and opportunities for FNS, as well as responses to them. For example, one discussion group came up with the idea of a 'taskforce' to help foster cooperation across different sectors dealing with food and nutrition issues.

This observation was encapsulated by two interviewees, Sally and Fiona, who described how encountering a challenging lack of communication in their scenario had prompted them to think creatively about how to overcome it.

> *"We were in a scenario whereby there was no cooperation, so we had to design a committee, which would be responsible to create that cooperation… There are challenges, but with ideas given by others then you get through." (Fiona, 2016)*

> *"We said we need the task force to include different people with different backgrounds, from different sectors, because the issue of food security and nutrition is a cross-cutting issue." (Sally, 2016)*

The above evidence shows that PSP can stimulate learning through: 1) bringing different participants into discussion, thus exposing them to new or unfamiliar perspectives and approaches, 2) the development and exploration of future narratives providing a point of

focus and a structure to aid these discussions, and 3) providing opportunities through structured activities to think creatively about new ideas and solutions, but in a focused way. However, although these characteristics may be present in many PSP processes, as we explain below, the way in which PSP processes are designed and delivered by facilitators can also enable or constrain learning.

4.4. Facilitation as a constraint and enabler of learning in PSP

In the reviewed cases of PSP in the academic literature, although the authors of the 30 analysed cases typically paid scant attention to the role of facilitation in PSP, five of them did emphasise the importance of carefully designing PSP workshops to provide a structure for participants' discussions and thinking. For example, Plieninger et al. (2013) state that: *'the workshops were pre-structured regarding their form and central aims, but remained completely open for the participants regarding content,' (p.44).* Hence, the facilitators appear to have provided a structure to support participants' discussions by providing a template for them to fill in.

This overall lack of attention given to facilitation and design in these papers is especially surprising when compared to the practitioner interviews. In these, 13 of the 16 interviewed practitioners acknowledged the importance of facilitation for helping participants engage in PSP processes. One practitioner, Vera, who was interviewed as part of these interviews, and was a highly experienced professional facilitator of PSP and other futures-thinking methods, emphasised that facilitation is a key condition for learning in PSP. She acknowledged that participants can find it difficult to think about the future, in the way that PSP proposes, which means facilitators need to help ease them into it:

> *"The challenge is to get people to engage with these scenarios… The important thing is to get participants to at least entertain the idea [of thinking about possible futures] and play with it. The role of the facilitator must be to pick up on what incremental changes people are willing to consider in the future and build on those." (Vera, 2016)*

Arguably, since the interviewed practitioners all had experience of facilitating PSP processes, they might have emphasised their own roles in enabling learning. However, the importance of facilitation was also strongly evident in the two case studies. In PFSA, we observed that the role of the facilitators in designing and facilitating the workshop encouraged participants to engage in the structured creative thinking, described in Sections 4.2 and 4.3, which stimulated their learning. The facilitators designed the workshop to include specific activities, including the Futures Wheels mentioned in Section 4.3, that provided a structure within which participants could think 'outside the box' with regards to innovative solutions to the challenge of thinking about just and sustainable futures. Furthermore, the lead facilitator, Anne, took time to explain and demonstrate each activity to ensure that the participants understood them and how each activity fed into the process and eventual goals of the workshop. For instance, she demonstrated the Futures Wheels activity, described in Table 5, using an example of how the primary, secondary and tertiary impacts of a specific small-scale initiative could develop in the future.

Anne then moved between the discussion groups to provide clarification and advice on the activities. This allowed the four supporting facilitators to concentrate solely on encouraging and guiding discussions between the participants. They did this by asking questions and prompting participants to discuss specific points. For example, one facilitator, Pamela, asked participants to think about where people would live, and how, in the world described by her group's scenario. This helped the participants to imagine future conditions in greater detail. Another facilitator, Danielle, encouraged participants in her discussion group to consider the divide between rural and urban spaces, and how it might change in their scenario. This was appreciated by participants in the interviews. For example, one informant, Miriam highlighted how the facilitator in her group had prompted discussions by asking questions about how the small-scale initiatives could develop:

> *"She was just bringing questions in, like: 'okay what's next, and what's next, and what's next?' 'What are the limits of this?' 'Do you think this is bad?'" (Miriam, 2016)*

Anne's explanations and the supporting facilitators' prompting questions therefore seem to have encouraged participants to engage in structured, creative thinking that helped them to learn.

In the FSF case study, by contrast, the participants' ability to engage in the workshop was limited by the fact that the facilitators were fewer in number, had less time, and limited resources. The lead facilitator, Mike, was an expert in PSP, having facilitated many PSP processes, as well as publishing academic papers on PSP, and had been recruited to lead the FSF workshop. However, he had to play multiple roles, including explaining the activities, moving between the groups to provide clarification, and prompting discussion in one specific group. At the end of the workshop, he reflected that this had limited his ability to ensure all the participants were engaging with the activities. This was especially problematic since one of the two sub-facilitators lacked previous experience in facilitating PSP and would thus have benefited from more support. This was picked up on by one of the interviewed participants, who stated:

> *"I think facilitator matters. I know the other facilitator (Mike), he is very much experienced, so he knows how to 'pick' things from out of people, but in this group, you could see, he is not much experienced of scenario-creating things." (Keith, 2016)*

This shows that the constrained facilitation in FSF limited the potential opportunities for structured, creative thinking, and thus for learning. Hence, although PSP can be a useful tool for learning, through creating a focal point for discussions between different participants, and encouraging structured creativity, it requires skilled and well-resourced facilitation to fully realise this potential.

5. Discussion & Conclusion

In this paper we aimed to: 1) present a conceptual framework that could help to understand, study and evaluate learning in PSP processes; and 2) use an empirical study of PSP processes (specifically focused on tackling complex problems in social-ecological systems), to test this framework and identify the processes by which PSP can support learning. In this paper, we have laid out the conceptual framework, and presented empirical evidence regarding the processes through which learning occurs in PSP. We now draw these two strands together to assess how useful our conceptual framework is for explaining learning in PSP, and what implications this has for PSP researchers and practitioners. We begin by looking at the connections between the evidence presented in Section 4, and the learning theories introduced in Section 3.

The evidence from our study of PSP processes connects closely to our conceptual framework. It shows that PSP encourages people to learn through fostering interactions between people who have different expertise and ways of understanding. Specifically, these interactions can encourage discussions between different participants, which promotes learning. This fits well with the elaboration of Vygotsky's ZPD (Vygotsky, 1978), which posits that learning is encouraged by interactions between people with different kinds of expertise. This also reflects commonly held arguments that bringing different stakeholders into dialogue through PSP can encourage them to engage with each other's knowledge, which can thus foster learning (Johnson et al., 2012; Oteros-Rozas et al., 2015). This evidence indicates that the ZPD is a useful basis for understanding learning in PSP processes, and research that aims to assess and understand learning-related outcomes of PSP should therefore focus on studying interactions between different participants.

However, the idea that learning can be encouraged through creating opportunities for interactions between diverse participants does not apply exclusively to PSP. Indeed, it is widely believed by researchers and practitioners of participatory methods that such approaches can, generally, create conducive conditions for learning to occur (Mark S Reed, 2008; Stringer et al., 2006). In this paper, we thus identified specific aspects of PSP that can encourage learning. We found that through exploring narratives of the future in a structured and focused way, PSP processes can provide a focal point and structure for discussions between different participants. This encourages them to make explicit their knowledge, assumptions, anxieties and aspirations about the future, as well as to reflect critically on them and those of other people. Our research also highlights how this can be especially effective when PSP processes are designed to include specific, structured activities, such as 'Futures Wheels' and testing proposed responses to future challenges. These activities not only create a focal point but provide opportunities for participants to think creatively about ideas and solutions they would not normally think about, within a structured set of parameters. This encourages participants to enter their ZPDs, and therefore to learn.

PSP processes thus fit well with the concept of 'boundary objects,' as outlined in our conceptual framework (S. L. Star & Griesemer, 1989). The process of creating and exploring scenarios can become a boundary object through providing a focal point and structure for discussions between different participants. This corresponds with previous work on PSP by Chaudhury et al. (2012) who state that PSP is useful as a boundary object. However, Chaudhury et al. specifically consider the outputs of PSP (scenarios themselves) as boundary

objects that can be used to negotiate the exchange of knowledge between different stakeholders after the scenarios have been developed. In this paper, we argue that the *process* of creating, imagining and exploring scenarios can also act as a boundary object. This reflects findings by Bowman (2016) which indicate that the process of creating and exploring scenarios is more meaningful as a boundary object, than the scenario narratives themselves. Our findings also emphasise the importance of carefully designing PSP processes to include specific, structured activities that can stimulate structured creative thinking. Conceptualising PSP as a type of boundary object therefore helps to explain how it can enable interactions and encourage learning through creating opportunities for discussions on a shared concern.

Our findings resemble the arguments put forward by the influential scenario planning scholars we referred to at the start of this paper. The arguments put forward by Wack (1985), Schoemaker (1993) and Van der Heijden (1996) that scenario planning can provide a structure that helps people to understand complex and uncertain problems, are reflected in our finding that PSP supports learning through creating a focal point, which enables people to imagine uncertain futures in a structured way. Equally, the argument of Ramirez and Wilkinson (2016), that scenario planning can lead to an exchange of knowledge and development of new understandings and courses of action, is reflected in our findings that PSP processes can act as boundary objects that encourage interactions between different people, and stimulate the exchange of different knowledge. Our research adds to this knowledge by providing a conceptual framework, based on an established pedagogical theory, that helps to explain how learning occurs in PSP, and connects this with empirical evidence of how PSP processes can support learning.

However, although PSP processes can themselves be powerful tools for learning, as explained in Section 4.4, we also found that they may be enhanced or constrained by the ways in which they are facilitated. As shown in the PFSA case study, skilled and well-resourced facilitation can help participants to engage in PSP processes and to achieve the sort of structured creative thinking described in this paper. This speaks to the concept of 'scaffolding' (Wood et al., 1976) described in our conceptual framework and shows how such support can provide the assistance Vygotsky claims is necessary for people to enter and subsequently extend their ZPDs. The design and explanation of specific activities to assist participants to engage in PSP processes also reflects the specific stages of scaffolding (contingency, fading, and transfer of responsibility), as outlined by Van der Pol et al. (2010). Equally, the prompting questions observed in our two case studies encourage the 'exploratory talk,' (proposing new ideas and then receiving critical and constructive feedback from others) described by Fernández et al. (2001). In contrast, the FSF case study showed that facilitation can constrain learning if the facilitators are under-prepared and under-resourced, thus limiting the support they can provide for participants.

It is also important to consider that the different case studies had different aims and scope, and could thus be described as aiming for different stages of learning. The PFSA workshop aimed to broadly explore how positive futures might look, and how they may be reached, thus expanding participants' perceptions of what is possible and their capacity for 'creating' the future (Tuomi, 2019). This required methods and facilitation that pushed participants to be creative, to ask new questions and to think 'outside the box' (Ehresmann et al., 2018), as per

the more advanced levels of Miller's (2018) framework. In contrast the FSF workshop had a more specific focus and aimed to inform decision-making on a specific policy. There was therefore less emphasis on creativity, and more on encouraging participants to use anticipation to think about how imagining the future could influence their decisions and actions in the present, as per the early stages of Miller's (2018) framework.

We conclude that our conceptual framework based on the ZPD is a useful way of studying learning in PSP. This highlights the importance for futurists, as well as other researchers and practitioners of PSP, of studying interactions between different participants in PSP. Our research also emphasises the importance, not just of creating opportunities for interactions, but of actively enabling the process of imagining and exploring scenarios, since this is what pushes people, through discussion, to engage critically and constructively with their own and others' assumptions about the future. It is therefore vitally important to consider the specific activities that are included in the design of PSP processes, as well as the role of facilitation to help PSP participants engage in this process. This paper is the first of our knowledge to highlight the importance of learning as an outcome of PSP and to offer a theoretical framework that helps to understand this. We acknowledge there is scope for further refinement of theory about how and why PSP can support learning, especially regarding the role of facilitation in supporting and promoting learning through interactions in PSP. We note this as an area for further research.

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Figures and tables

Figure 1: Explanation of how PSP enables learning through interactions with others, using the Zone of Proximal Development. *Publish in colour*

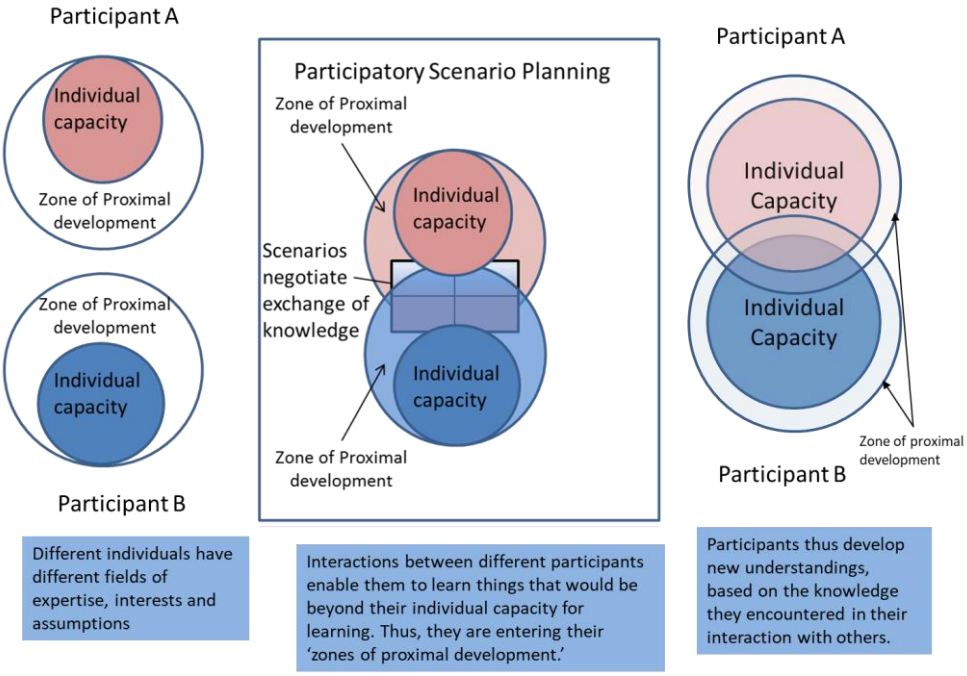


Figure 2: The process of creating scenarios in PSP can be viewed as a boundary object, by including the knowledges of participants from different social worlds. *Publish in colour*

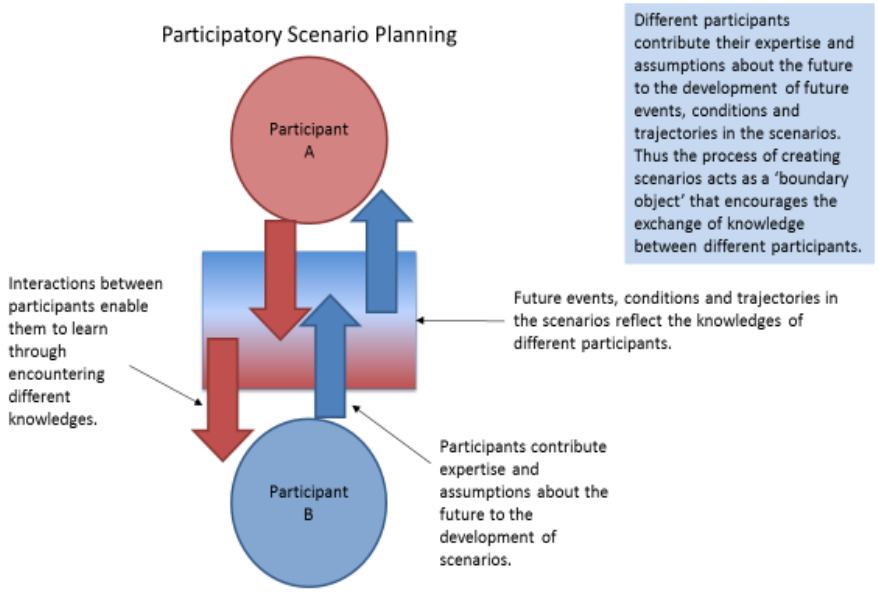
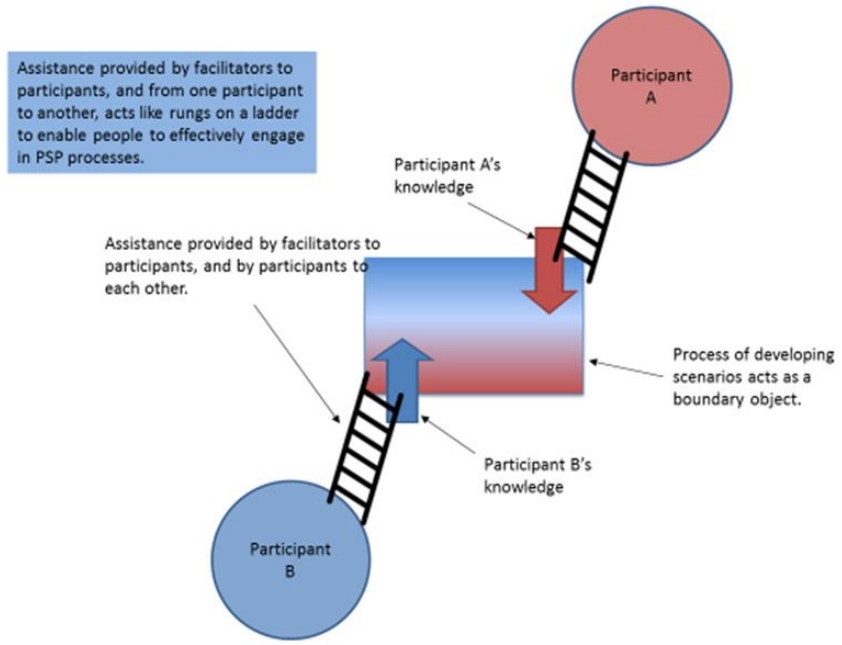


Figure 3: Assistance provided by facilitators to participants, and through interactions between participants, helps participants to engage effectively in PSP. *Publish in colour*



959 **Table 1 Overview of the case studies**

	Case Study 1 – Food Security Futures (FSF)	**Case Study 2 – Positive Futures for Southern Africa (PFSA)**
Topic and scale of Focus	Specific focus on food and nutrition security for urban dwellers in Tanzania.	Broad focus on exploring possible just and sustainable future conditions for the Southern African region.
Location and length of the PSP process	Took place in a seminar room at the University of Dar es Salaam over 1.5 days.	Took place in a conference suite at a hotel in Cape Town over 3.5 days.
Aims of the PSP process	Aimed to use downscaled versions of pre-developed 'East Africa scenarios' (Vervoort et al. 2013) to inform the Tanzanian government's food and nutrition policy for their new 'Five-Year Development Plan.'	Aimed at exploring how positive futures might look, and how they may be reached, in order to guide the sorts of small-scale initiatives that the specific development organisation who funded the project should be directing funding towards.
Funding and organisation	Modest funding from a research institution. Seemingly haphazard organisation of the process.	Generous funding from a development organisation. Organised strategically, well in advance.
Approach to PSP	Exploratory approach to assess the implications of plausible futures on food and nutrition security in Tanzania.	Normative approach to explore what participants' preferred futures would look like and how they might be realised.
Specific activities used in the PSP process	Developing a scenarios matrix of downscaled versions of pre-developed regional scenarios. Used 'visioning,' 'backcasting' and testing potential strategies under different scenarios.	Used the 'Manoa method' to create original scenarios based on 'weak signals' of the future in the present. Included use of 'Futures Wheels' and '3 Horizons.'
Participants	20 participants from a mixture of government institutions, NGOs, education, academia, and the private sector, all of whom were Tanzanian and worked and lived in Dar es Salaam	23 participants, including a mixture of academics, practitioners and Artists from several countries across Southern Africa.
Facilitators	3 academics with a range of facilitation experience, led by a PSP expert with experience facilitating PSP processes.	4 academics with a range of facilitation experience, led by one experienced professional facilitator.

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962 **Table 2 – Structure of the Food Security Futures case study PSP workshop**

Activities (Food Security Futures)	Description
Introduction	Presentation of workshop objectives and process. Participants split into 3 groups. Each group explored one of 3 themes: 1) issues directly affecting food security, 2) capacity-building for food security, and 3) cross-cutting themes.
'Visioning'	Participants constructed a 'vision' of an ideal future in which specific objectives from a new government food security policy were realised. Each participant noted ideas for how this vision would look, and then presented their ideas to their group. The groups then discussed these ideas and combined them into a collective vision.
'Backcasting'	Participants considered what steps would need to be taken to achieve the visions they created in the previous step. They constructed a timeline of these steps, working backwards from the visions to the present day.
Imagining scenarios for Tanzania	Participants imagined scenarios for Tanzania, based on scenarios for the East Africa region scenario, which had been previously developed by another researcher programme. Each group imagined what events, conditions and trajectories would be like in Tanzania in one of the pre-built scenarios for East Africa.
Identifying challenges and solutions	Each group considered the timeline of steps developed in the 'backcasting' stage and imagined how they could successfully implement them in the scenario they had developed for Tanzania. This included identifying challenges and exploring solutions to them. Each group then developed a set of recommendations that could help decision-makers to achieve food security objectives in different scenarios in Tanzania.

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964 **Table 3 - Structure of the Positive Futures for Southern Africa case study PSP workshop**

Activities (Positive Futures for Southern Africa)	Description
Introduction	Introduction of the topic and objectives for the workshop. Explanation of the workshop process and the activities involved. Participants were split into 4 groups and given 3 diverse, small scale initiatives that promote sustainability and social justice in Southern Africa and globally.
'Futures Wheels' (Bengston, 2016)	Each group imagined what these small-scale initiatives would look like if they were or mainstream ways of doing things in the future, including their primary, secondary and tertiary impacts. Participants noted their ideas and then presented them on paper as a series of concentric circles, the inner circle representing primary impacts, the second representing secondary impacts, the outermost representing tertiary impacts.
Connecting the small-scale initiatives	Each group explored how the small-scale initiatives would affect each other if they were mainstream ways of doing things in the future. Participants plotted these connections on a table and with lines drawn between the initiatives to represent connections between them.
Imagining scenarios	Each group imagined and explored a scenario based upon the Futures Wheels and the connections between the small-scale initiatives. This included exploring the events, conditions, and narratives that would exist in their scenario. Each group presented their scenarios in the form of a headline statement, three imaginary statistics and an artistic expression that represented their scenario.
'3 Horizons' (Sharpe, Hodgson, Leicester, Lyon, & Fazey, 2016)	Each group imagined three trajectories, or 'horizons' for how the future could develop in their scenario. 'Horizon 1' represented the dominant way things are in the present, 'Horizon 2' represented the way things will be during the transition from Horizon 1 to Horizon 3 and 'Horizon 3' represented the way things would be the future in the group's scenario. The groups each identified ways to encourage a transition from Horizon 1 to Horizon 3, and then presented this to the other groups.
Plenary discussion	After each group had presented their scenario, the participants and facilitators reconvened in plenary to discuss commonalities between the scenarios, insights for how a 'positive' future might look in southern Africa and what steps could be taken to achieve this.

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966 **Table 4 – Evidence from the review of 30 cases of PSP described in the academic literature**
967 **that learning occurred through interactions between different participants (this is our**
968 **synthesis of evidence in the sources, not verbatim excerpts except where quotation marks**
969 **are used).**

Case of PSP	Evidence of interactions
E. L. Bohensky, Reyers, and Van Jaarsveld (2006) - ecosystem services in South Africa	Creating links between different aspects of the scenarios encouraged **discussion** between participants at different spatial levels.
Brand, Seidl, Le, Brandle, and Scholz (2013) - ecosystem services in the Swiss Alps.	**Discussions** around consistency and surprise in potential futures occurred between participants from different disciplines and spatial levels.
Fisher et al. (2011); and Swetnam et al. (2011) - ecosystem services in Tanzania.	'Diverse' participants **collectively deliberated** on the development of trends and drivers in alternative futures.
Malinga, Gordon, Lindborg, and Jewitt (2013) - ecosystem service assessment in South Africa.	**Interactive** workshops were held with stakeholders from different spatial levels.
Mistry et al. (2014) - ecosystem management in Guyana.	PSP created a **'platform for dialogue'** (p.131) between participants with different worldviews.
Palacios-Agundez, Casado-Arzuaga, Madariaga, and Onaindia (2013) - ecosystem management in Spain.	PSP encouraged **interactions** between participants with local, and specialised scientific knowledge.
Plieninger et al. (2013) - managing ecosystem services provided by cultural landscapes in Germany.	PSP encouraged **discussion** between scientists and local actors.
Ravera, Hubacek, Reed, and Tarrason (2011); and M. S. Reed et al. (2013) - environmental management and adaptation in UK uplands.	**Interactions** occurred between participants with different knowledges.
Shaw et al. (2009) - adaptive action for climate change.	Inclusion of participants from different stakeholder groups expanded the amount of local-level information that was included and facilitated **knowledge exchange**.
Van Berkel et al. (2011) - rural development in Portugal.	Carefully selected stakeholders from different professional roles **deliberated** on challenges and opportunities for the future.
Vermeulen et al. (2013); and Vervoort et al. (2013) - climate change and food security in East Africa.	**Different stakeholders** explored uncertainties and considered how to overcome potential future challenges.
Schulz, Ioris, Martin-Ortega, and Glenk (2015) - Payments for Ecosystem Services in Brazil.	Carefully selected participants, with different worldviews, **deliberated** on future threats and how they may be overcome.

K. Brown et al. (2001) - marine protected area (MPA) management in Tobago.	Different stakeholders **deliberated** on trade-offs in the future.
Wollenberg, Edmunds, and Buck (2000) - use scenario planning in adaptive co-management of community forests.	PSP encouraged **knowledge exchange** between different stakeholders.

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971 **Table 5 - Evidence from the review of 30 cases of PSP described in the academic**
972 **literature that PSP supported learning by creating a point of focus for discussions**
973 **between different participants (this is our synthesis of evidence in the sources, not**
974 **verbatim excerpts except where quotation marks are used).**

Case of PSP	**Evidence of PSP creating a point of focus for discussions**
Rivard and Reay (2012) - exploring the future of Malawi's energy sector.	Discussions encouraged by **exploring 'structural uncertainties.'**
E. L. Bohensky et al. (2006) - ecosystem services in South Africa.	Discussions prompted by **creating links between different components of the scenarios**.
Brand et al. (2013) - understanding ecosystem services in the Swiss Alps.	Discussions arose from **exploring issues of consistency and surprise** in potential future states.
Fisher et al. (2011); and Swetnam et al. (2011) - ecosystem service analysis in Tanzania.	Collectively thinking about the **development of trends and drivers** in alternative futures encouraged discussions.
Mistry et al. (2014) - ecosystem management in Guyana.	**Creating a 'platform for dialogue'** stimulated discussions between participants from different perspectives.
Palacios-Agundez et al. (2013) - ecosystem management in Spain.	Discussions arose from **exploring plausible futures** and **thinking about how to avoid challenges**.
Plieninger et al. (2013) – managing ecosystem services provided by cultural landscapes in Germany.	Discussion occurred through **participants being provided with a structure**, with which to **explore future possibilities and responses to challenges**.
Henly-Shepard, Gray, and Cox (2015) - improving adaptive capacity to hazards in Hawaii.	Discussions prompted by **considering responses to challenges**.
Pearson, Park, Harman, and Heyenga (2010) - sustainability planning in Australia.	Discussions triggered through **developing and testing responses to problems**.
Ravera, Hubacek, et al. (2011); and Ravera, Tarrason, and Simelton (2011) - climate change adaptation in Nicaragua.	Discussions encouraged by **considering adaptation options** in different scenarios.
Tschakert et al. (2014) - climate change adaptation in Ghana and Tanzania.	Discussions arose from **combining experiences of everyday life with climate projections and anticipatory views** of the future.

Wesche and Armitage (2014) - understand environmental change in northern Canada.	Structured discussions occurred regarding the **implications of different drivers, on livelihoods, in alternative scenarios**.
Sheppard et al. (2011) - climate change action and awareness.	**Visual methods** helped stimulate discussions by making potential climate impacts seem real.
Van Berkel et al. (2011) - rural development in Portugal.	**Scenarios 'prompted' discussions** about rural development issues.
Vermeulen et al. (2013); and Vervoort et al. (2013) climate change and food security in East Africa.	Discussions encouraged by **exploring how to overcome potential future challenges**.
E. B. Bohensky, Butler, and Mitchell (2009) - ecotourism in Papua New Guinea.	**Considering what would influence the outcomes of 'guiding questions'** stimulated discussions between participants.
Schulz et al. (2015) - Payments for Ecosystem Services in Brazil.	Discussions arose through **deliberating on challenges and responses** to them.
K. Brown et al. (2001) - marine protected area management in Tobago.	Discussions stimulated by **deliberating on trade-offs of different options** in the future.
Palomo, Martin-Lopez, Lopez-Santiago, and Montes (2011) - protected area management in Spain.	Discussions encouraged through **exploring trade-offs between different options**.
Jessel and Jacobs (2005) - planning for the European Water Framework Directive	**Considering the effects of different policy options in different scenarios** encouraged discussions between participants.

Appendix A – Interview guide for practitioner interviews

Discussion topics

1. Experiences of using scenario planning.
2. Disciplinary background
3. The approach taken to using scenario planning.
4. Motivations/rationales for using scenario planning. The intended benefits of using scenario planning for the management of wicked problems.
    a. The theory underlying these intentions and rationales.
    b. The objectives for using scenario planning.
5. The reported outcomes of using scenario planning for the management of wicked problems.
    a. The learning outcomes of scenario planning processes.
    b. The relationship (if any) between the learning outcomes and the management of wicked problems in practice?
6. The evidence they used to justify the reported outcomes of SPPs.
7. The challenges they experienced in using scenario planning.
8. Discussion on the results of my case review, including the specific projects they were involved with, where appropriate.

Questions to discuss

Informal, factual, ice-breakers

1. Approximately how many scenario planning processes have you been involved in?
    a. What role(s) did you take in each of them?
2. Can you tell me any interesting anecdotes? For example, are there any particular scenario narratives, or scenario planning processes that have really stuck in your mind?
3. Tell me a bit about your disciplinary background. How did you end up practicing scenario planning?
4. Did you receive any formal or informal training in how to facilitate scenario planning processes?

a. Could you describe what this entailed?
b. How did this inform the way you facilitated scenario planning?

Lead into more granular questions on the core research

5. How do think your disciplinary background has influenced your role in facilitating scenario planning?
6. Can you describe your rationale for using scenario planning?
    a. What were your expectations regarding the benefits scenario planning could achieve?
    b. Why was scenario planning selected over other methods?
    c. How did you come to form these expectations? Where did you get the idea that scenario planning might be beneficial?
7. Thinking specifically about the processes you have been involved in, what would you say were the benefits achieved by using scenario planning?
    a. To what extent did scenario planning processes influence participants' understandings of the wicked problem(s) being addressed? If so, how?
    b. Was there any variation between different participants in terms of the outcomes scenario planning had for them?
        i. Could you describe this variation?
        ii. Why do you think this was?
    c. How would you describe the roles played by different participants in the scenario planning process?
        i. Could you describe the relationships that developed between different participants over the course of the process?
        ii. What do you think influenced the development of these relationships?
    d. What tangible impacts have scenario planning processes achieved in practice?
        i. What were the mechanisms by which these impacts resulted from the scenario planning process?

ii. What was the relationship between the tangible impacts and the internal dynamics of the scenario planning process itself?

8. Can you justify these claims?
    a. What concrete evidence do you have for these outcomes?
    b. What methods and criteria have you used to assess the outcomes of scenario planning processes?
9. Could you tell me about any challenges you have faced in the use of scenario planning?
    a. Why do you think these challenges came about?
    b. How do you think these challenges could have been avoided, and could be avoided in the future?

Appendix B – Interview guide used in the case studies

1. Icebreaker – questions to ask me? Did my presence as an observer affect their experience of the workshop? If so, how?
2. Participant's expectations of the workshop.
    a. A little bit about participant's background and reasons for attending the workshop.
    b. What they expected the benefits of the workshop to be.
3. Participants' experiences of the workshop
    a. How well participants understood the objectives of the workshop.
    b. How easily participants were able to carry out the tasks set for them by the facilitators
    c. What participants found interesting, challenging, easy, difficult about the process?
    d. What participants thought about the location and layout of the workshop space? – How comfortable did they feel, how did the space affect their participation?
    e. What participants felt they, and others contributed to discussions in the workshop and to what conditions, events and trajectories were eventually included in the storylines.
    f. Participants' interactions with other participants. – Who they spoke with most, the extent to which they felt included in group discussions, who they thought was most vocal and who was more of an active listener, what they thought about the characteristics of their group (argumentative, cooperative, friendly, relaxed, hostile, imaginative, pragmatic, analytical).
    g. Participants interactions with facilitators – how they helped participants carry out the tasks to engage with the process, how well the time was managed, how well they managed the group discussions and the interactions between different participants.
    h. Observations as prompts – "I noticed you seemed to be having an interesting discussion with *x*, could you tell me some more about that?"
4. What participant's think were the benefits of imagining future conditions of human-environmental systems.
    a. What do they think were the benefits of imagining alternative futures of social-ecological conditions?
    b. Has the way they imagine alternative futures of social-ecological systems changed? If so, how? – What topics, problems, opportunities, relationships has the workshop flagged up for them?
    c. What aspects of the workshop encouraged learning to occur? – What sorts of processes do they feel help them to learn?

d. What participants felt were the most important outcomes for them – what they learnt, how they think the workshop will affect them in their everyday activities, any opportunities for new actions, roles and relationships to help encourage more sustainable and socially equitable future conditions in social-ecological systems.
e. Anything they thought could have been better about the process. – What else would they have liked to learn about? What else do they think it would have been important for others to learn about? What would have helped further encourage learning?
f. Would they take part in a participatory scenario planning exercise again in future? What are their reasons for this?

Appendix C – Observation Guide used for observations during the case studies

In this research, I assume that learning in PSP occurs through interactions between people from different fields. Specifically, I assume that scenarios act as boundary objects, in that deliberating over their creation, and then using them to analyse aspects of the future stimulates the exchange of knowledge across different perspectives. I also suggest that participants are enabled to engage in the process of developing and analysing scenarios through assistance from facilitators of PSP processes.

To test these assumptions and understand the process of learning in PSP, it is important to understand the extent and nature of interactions that occur during the process, the role that developing and analysing the scenarios plays in encouraging them, and how facilitators enable people to effectively engage in PSP. These aspects may be indicated by interactions leading to changes in understanding, the extent and nature of interactions across different fields being stimulated by development and discussion of scenarios, and the ways in which facilitation enables this process to occur.

Observation of the Seeds GA workshop in Stellenbosch will therefore involve looking at:

- Facilitation: how facilitators prepare themselves for the workshop – their aims, expectations, understanding of the topic (the Anthropocene), awareness of the different types/levels of assistance different participants might need; the materials they prepare to help facilitate the workshop; the ways they introduce scenario planning to participants and then help them to carry out specific tasks - including tailoring them to participants' existing abilities, decreasing the level of assistance as participants becomes more competent, and transferring the responsibility for carrying out tasks to participants; the way the workshop is structured, including the method used for scenario planning, time management, and the way the workshop space is laid out; and how quickly participants are able to confidently carry out the tasks necessary for scenario planning.
- Interactions between people and how they may be stimulated by thinking about scenarios: who speaks to whom at different points in the workshop, and in the informal spaces outside it; what is the content of different discussions – what knowledge is exchanged during discussions, is it related to the tasks being undertaken or is it irrelevant; the content of the scenarios and how this relates to the perspectives of different participants; at what points do discussions appear most lively – when does most conversation occur, when do people seem most stimulated based on their level of contribution, body language, facial expressions, vocal expressions, and actions.

As well as exploring *how* learning may occur in PSP, observations in the workshop will also be used to help understand *what* is learned by whom and under what *conditions* learning occurs. In this research, I assume that learning ranges from identification of boundaries with different perspectives, through communication across boundaries, to expansion of understanding about wicked problems and transformation of roles and actions to confront them. I also suggest that learning is shaped by the extent to which participants find information to be credible, salient and legitimate, which is itself influenced by the social context that learning occurs in, including the roles and relationships between different participants, and between participants and facilitators.

Observation will thus include looking at:

- Present and historical context: the present and historical condition of social and ecological systems in southern Africa – challenges faced and how they came about, positive aspects and how they came about, historical and current relationships between different groups of people.
- Facilitation: social groups that facilitators are a part of; institutions they are associated with; their prior knowledge of participants – the groups they belong to, the relationships between them; how they introduce, explain and help participants to engage with scenario planning – and how they tailor these aspects to the needs of different people; how they manage discussions, conflicts, power imbalances, domination, subordination, different abilities, sensitive issues; who they interact with, and how, in informal spaces outside the workshop.
- Interactions between participants: who participants are – the social groups they belong to, the relationships between them, their interests in attending the workshop, their roles in society, their prior experience of workshop settings; who contributes most and least frequently in group discussions; who is heeded and who overruled; who appears to take interest in the contributions of which others, indicated by eye contact, vocal encouragement, non-verbal signals, distractions, interruptions; content of discussions – what is discussed and what ignored, what seems relevant and irrelevant, what people agree and disagree on; how different people speak – tone, pitch, speed, clarity, body language, volume, length of speech; who interacts in informal spaces outside the workshop – what is the nature and content of these conversations; how people position

themselves, physically, around other people – body language, distance, peripheral or central, who groups together.

In practice, the approach to observing these aspects of the Seeds GA workshop began with communicating with the workshop organisers, via email and Skype. This will continue through face-to-face meetings in the period building up to the workshop, throughout the workshop itself and after it has finished. During these meetings I have been, and will continue to ask questions and make notes about their preparations for the workshops, their plans for how it will be organised, what the aims and objectives will be, how the scenarios will be created and used, and who the participants will be. I will also spend time, during and after the workshop, discussing the ways they facilitated the workshop and their rationale for the decisions and actions they made.

Prior to the workshop, I will also familiarise myself with the context in which it takes place. This involves using the list of attendees to find out about each participant, their background and their role in society. Equally, it will involve developing a working understanding of current, and historical, social and environmental conditions, challenges and opportunities in southern Africa. Importantly, I will also need to become familiar with the 'seeds,' or initiatives that represent socially and ecologically just and sustainable conditions in the Anthropocene, since they will make up the foundations of the scenarios.

In the workshop itself, I will introduce myself, my research, and my intention to observe the workshop to participants at the start. I will also ask them to fill in my information and consent sheet, to ensure they are aware of the purpose of my research and consent to it. Thereafter, I will move around the workshop space, watching, listening and making notes on the structure, facilitation and interactions that occur in the workshop. Since I am interested in who learns what from whom, I am reluctant for learning to be influenced by my own contributions. For this reason, I will not be directly participating in the workshop myself. It will also be important for me to move around and observe discussions in different groups. Participating in the process would limit me to staying in just one group for the duration.

Considering that the expected number of participants is 33, and these will be divided into multiple groups, it will be impossible to observe every single participant and every single group at all times. Equally, since the interactions that occur in any group will be of equal interest, it would be inappropriate to prioritise one over another. In order to concentrate on each group to a similar extent, I will aim to observe each group evenly during each stage of the workshop. This will involve consulting the workshop programme and dividing up the time for each section between the different groups. In the follow-up interviews, I will also ensure I speak to people from all of the different groups to explore the interactions and learning that went on in them.

I will position myself such that I can hear participants' discussions as they occur, but avoid becoming obtrusive (for example, distracting participants, diverting participants' attention away from the workshop tasks). If it does not interrupt the flow of conversation, or concentration on a particular task, I may ask participants to tell me a little about what they are discussing, at what stage they are at in the process, and what they are finding easy/hard, interesting/boring etc. I will also aim to speak to as many people as possible during breaks, mealtimes, and informal settings outside the workshop space.