Environmental Science and Policy 147 (2023) 215–227

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Engaging diverse experts in the global science-policy interface: Learning experiences from the process of the IPBES *Values Assessment*

Katri Mäkinen-Rostedt [a,*], Viola Hakkarainen [b,c], Max Eriksson [d], Riley Andrade [e,f], Andra Horcea-Milcu [g,h], Christopher B. Anderson [i,j], Carena J. van Riper [e], Christopher M. Raymond [b,c,k]

[a] Politics Unit, Faculty of Management and Business, Tampere University, Kanslerinrinne 1 (Pinni A), FI-33100 Tampere, Finland
[b] Helsinki Institute for Sustainability Science, University of Helsinki, Finland
[c] Ecosystems and Environment Research Program, Faculty of Biological and Environmental Sciences, University of Helsinki, Finland
[d] Brussels School of Governance, Brussels, Belgium
[e] Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, USA
[f] U.S. Fish and Wildlife Service, USA
[g] Kassel Institute for Sustainability, University of Kassel, Germany
[h] Faculty of Humanities and Cultural Studies, University of Kassel, Germany
[i] Centro Austral de Investigaciones Científicas, Consejo Nacional de Investigaciones Científicas y Técnicas, Ushuaia, Tierra del Fuego, Argentina
[j] Instituto de Ciencias Polares, Ambiente y Recursos Naturales, Universidad Nacional de Tierra del Fuego, Ushuaia, Tierra del Fuego, Argentina
[k] Department of Economics and Management, Faculty of Agriculture and Forestry, University of Helsinki, Finland

ARTICLE INFO

Keywords:
Learning
Reflexivity
IPBES
Interdisciplinarity
Transdisciplinarity

ABSTRACT

This longitudinal study explores evidence of learning and reflexivity among experts involved in the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) *Values Assessment* from 2018 to 2022. As part of an online survey administered at yearly intervals, experts self-reported their views on: i) the aims they attributed to the *Values Assessment*, ii) their epistemic worldviews, iii) the definition of the multiple values of nature, and iv) their personal learning experiences in the assessment process. The represented epistemic worldviews corresponded to Constructivist, Transformative, Pragmatist, and Post-positivist. Across the three surveys, 59% of the respondents shifted their epistemic worldviews. However, these same experts did not change their core perspectives regarding the motivation behind the *Values Assessment*. At the same time, experts holding a Post-positivist worldview came to express more engagement-inclined themes and openness to dialogue with diverse knowledge systems. While enhanced reflexivity stimulated overall learning, cutting across all learning dimensions, it was itself a multilayered learning outcome. This study illustrates how diverse experts critically reflected and changed their own underlying assumptions during the inter- and transdisciplinary process of the *Values Assessment*. It further reveals that learning experiences in the *Values Assessment* were embedded in epistemic worldviews and connected to cognitive, relational, and transformative dimensions of learning. Our findings have broader implications for the design of inclusive and reflexive learning processes in future work of organisations aiming to facilitate inter- and transdisciplinary practices at the science-policy interface.

1. Introduction

The Convention on Biological Diversity's (CBD) Kunming-Montreal Global Biodiversity Framework (CBD/COP15, 2022) sets targets for biodiversity conservation and restoration and calls for inclusive and participatory processes. This emphasizes the importance of shifting away from value monism towards recognizing diverse knowledge systems, values, and voices in environmental policy and decision-making. Values plurality, however, can lead to tensions about how to account for and manage value expressions underpinned by different knowledge systems at the science-policy interface (Raymond et al., 2022). Especially the inter- and transdisciplinary methods utilized in science-policy processes require researchers and experts involved to contemplate their own and others' social positions and epistemic beliefs

* Corresponding author.
E-mail address: katri.rostedt@tuni.fi (K. Mäkinen-Rostedt).

https://doi.org/10.1016/j.envsci.2023.06.010
Received 15 June 2022; Received in revised form 3 June 2023; Accepted 12 June 2023
Available online 30 June 2023

(Rosendahl et al., 2015) and to reflect on how to engage diverse actors towards a common understanding of the problem at hand, while also taking power dynamics into account (Hakkarainen et al., 2022). Indeed, despite its aim to weave together scientific, Indigenous, and local knowledge (ILK), even the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has been critiqued for not having adequate mechanisms in place to navigate the power relations and potential dissonance among participants with diverse epistemologies, given that the platform's current focus on consensus and standardisation may come at the expense of plurality (Díaz-Reviriego, 2019; Dunkley et al., 2018; Löfmarck and Lidskog, 2017; Turnhout et al., 2014).

In the IPBES *Methodological Assessment of the Diverse Values and Valuation of Nature* (hereafter, *Values Assessment,* 2018–2022), the recruitment process was guided by the principles of regional and gender equity and led to unprecedented representation from the social sciences, including the humanities and local knowledge systems, compared to previous assessments (Balvanera et al., 2022; Timpte et al., 2018; Vadrot et al., 2018). Our baseline study of the experts involved in the *Values Assessment*'s first author meeting revealed variation in their initial views, depending on their epistemic worldviews, on what constitutes valid knowledge and their definitions of the multiple values of nature (Hakkarainen et al., 2020). Previous studies have considered that represented epistemic views influence the effectiveness and inclusiveness of the IPBES assessment processes (Montana, 2021; Obermeister, 2017). However, to date no longitudinal studies have explored the development of experts' understandings while engaging this kind of plurality of views in knowledge assessments, or more generally how learning occurs during such inter- and transdisciplinary communities of practice. Much of the extant literature in environmental and natural resource governance focuses on what fosters learning and reflexive understanding, including diversity of values and belief systems (Diduck et al., 2012), power differentials, and institutional rules that affect diversity in participation or decision-making processes (Heikkila and Gerlak, 2018). Yet, this corpus lacks consistent empirical analysis of evidence for learning to guide real-world assessments (see Gerlak et al., 2019 for a review) and reflexive expert advice (Boström et al., 2017; Montana, 2021). Therefore, there is a conceptual and practical need for research on how learning happens, who learns, and what is learned (de Kraker, 2017; Gerlak et al., 2019; Suskevics et al., 2018), especially in the context of global science-policy interfaces (Borie et al., 2020; Gustafsson et al., 2020).

In the larger context of environmental governance, the assessment processes that construct knowledge for the use of decision-making create influential ontological meanings and social imaginaries for environmental problems (Beck et al., 2014; Beck and Mahony, 2018; Borie et al., 2021; Vardy et al., 2017). To support the IPBES process of self-critical reflexivity, it is crucial to know what kinds of views academic experts bring to collaborative settings and what learning impacts inter- and transdisciplinary processes have on the experts themselves. Such insights can inform how other similar organisations can design and support more reflexive practices for advancing just interdisciplinary and transdisciplinary advice and engagements in the management of diverse human-environment relationships (Berkes et al., 1998; Biggs et al., 2021).

In this study, we draw on cognitive, relational, and transformative learning dimensions to investigate how scholars with diverse epistemic worldviews (Creswell, 2014) understand and learn about plurality (of social contexts, knowledges, and values). Cognitive learning refers to gaining new or reorienting existing knowledge (Baird et al., 2014). Relational learning refers to awareness of others' thinking as a result of social interactions, combined with ability to cooperate and build trust (ibid.). Transformative learning refers to that which leads to substantial and long-lasting transformations in one's worldview (Mezirow, 2003, 2009). Reflexivity as a driver and outcome of different dimensions of learning refers to multiple degrees of operationalized awareness among experts: 'reflexivity' can be a social and political goal for transforming the current paradigms, while 'reflexiveness' concerns the cognitive awareness of and openness to plural views and knowledge (Stirling, 2006; see also Boström et al., 2017). In this study, we use the term of reflexivity to describe all degrees of reflexivity but underline the importance of multilayered reflexivity outcomes.

Overall, our aim is to evaluate evidence for reflexivity within cognitive, relational, and transformative dimensions of learning through longitudinal data of experts' self-perceptions during nearly four years of participation in the IPBES *Values Assessment*. We relate the learning dimensions to four categories of epistemic worldviews: Constructivist, Transformative, Pragmatist, and Post-positivist (Creswell, 2014). While not a formal IPBES activity, this is the first longitudinal study of experts' views parallel to an IPBES assessment process. We examine the shifts in experts' understandings over the assessment process, drawing on three survey periods timed to occur just prior to the annual author meetings in 2018, 2019, and 2021 (Appendix A: Supplementary Table 1). We first introduce our theoretical framework of reflexivity as a cross-cutting link within different learning dimensions. Then, we summarise the mixed methods that were adopted for this longitudinal research. Next, we present results on what has been learned, differentiating the changes in epistemic worldviews, in motivation-related goals for the IPBES process, and in understanding of the multiple values of nature. We also present results that show how experts have learned and developed their reflexivity, analyzed across epistemic worldviews. Finally, we interpret these findings in relation to their implications for IPBES and other science-policy initiatives seeking more reflexive and inclusive engagement of diverse actors with plural knowledge systems for environmental management and conservation decision-making.

1.1. Theoretical background

Research that has explored learning specifically at the environmental science-policy interface emphasises: i) the need to consider learning as an emergent property of a long-term process (Andrade et al., 2023; Sol et al., 2018); ii) the importance of weaving together instead of integrating multiple forms and systems of knowledge within a coherent process underpinned by trust and respect for different ways of understanding and validating knowledge (Hill et al., 2021; Raymond et al., 2010; Tengö et al., 2017); and iii) committing to researching solutions, empowering voices, navigating differences, and managing diverse power relations (Chambers et al., 2021). In line with the extant literature, we concentrate on the dimensions of learning as a: i) cognitive process; ii) deliberative interaction in collaborative or participatory settings; and iii) normative process that has a potential of permanently transforming values, opinions, and beliefs over time (Baird et al., 2014; Muro and Jeffrey, 2008). In this context, we define how these different dimensions of learning connect to and crosscut one another within reflexivity. Reflexivity is looked at both as a driver and a (desired) outcome of learning among experts.

1.1.1. Cognitive learning

Cognitive learning refers to learning about different beliefs, experiences, perceptions or contexts of the problems at hand which might result, for example, in the accumulation of knowledge or restructuring of existing knowledge. Cognitive learning can with time lead to fundamental changes in one's understanding (Baird et al., 2014). Cognitive learning in collaborative settings is stimulated by the plurality and diversity of the group's understandings and is positioned as one dimension of social learning (Reed, 2010). We build on previous research that has evaluated how multiple dimensions of social learning are reflected in deliberation among groups defined by their value profiles (Andrade et al., 2023). In this context, cognitive learning was least prominent, possibly owing to the similarities in experience and the geographic region of study participants.

1.1.2. Relational learning

Relational learning in collaborative settings is another dimension of social learning (e.g., Andrade et al., 2023; Baird et al., 2014) that can be defined as gaining a more holistic understanding of others' views from social interaction (Baird et al., 2014). In addition, new social relationships, collaborations, and experienced trust can catalyze the learning outcomes derived from relational processes. Although this type of learning is cognitively processed (e.g., participants may report beliefs about their awareness of shared - or unshared - values in a group, Andrade et al., 2023) it requires "reflection and reflexivity throughout the entire process, if only to monitor change and progress throughout" (Wals, 2007, 500).

1.1.3. Transformative learning

Transformative learning (Mezirow, 2003, 2009), through which double-loop learning (Argyris and Schön, 1997) can lead to profound and permanent transformations, has been connected to sustainability transitions and to the work of global science-policy interfaces such as IPBES (Borie et al., 2020). Argyris and Schön (1997) have made a distinction between single-loop learning (achieving an objective) and double-loop learning (questioning the objective). Double-loop learning, arguably transformative learning, takes place when people become aware, often in interaction with others, of their assimilated beliefs and values. In a similar vein to relational learning presented above, transformative learning requires critical reflection of one's own and other's assumptions and positions (Mezirow, 2003; Pallett and Chilvers, 2013). However, it is not clear in the literature yet if learning increases reflexivity or whether the changes in reflexivity precede learning - or both.

1.1.4. Reflexivity and learning

In the field of sustainability governance, the growing focus on learning and reflexivity underlines a turn of perspective in the construction of environmental knowledge and related institutional spaces for sustainability transformations (Beck et al., 2014; Boström et al., 2017; Voß et al., 2006). A definition of reflexivity entails querying one's position critically and examining one's embeddedness in power-laden collaborative settings (Stirling, 2006). Other conceptual definitions connect reflexivity as a stimulant for learning (Boström et al., 2018; Mezirow, 2009; Pallett and Chilvers, 2013). The practice-oriented literature, however, discusses reflexivity in the more socio-political meaning of actively embracing and operationalizing plurality (Horcea-Milcu et al., 2019; Popa, 2015). In the knowledge governance literature, reflexivity as a dimension of cognitive learning relates to being aware and open to multiple knowledges and views (Borie et al., 2020; Boström et al., 2018; Manganelli, 2020). The connections between the three dimensions of learning and three aspects of reflexivity are presented in Fig. 1.

Reflexivity, therefore, can refer to multiple levels of gained awareness; scholars have shown that critical awareness can be heightened within one setting while 'outside of the setting' the 'unreflexivity' prevails (Boström et al., 2017). Furthermore, 'reflexivity' as a social and political goal for the interventions of the current paradigms and institutions in power should be distinguished from 'reflexiveness', which refers to the cognitive change and not necessarily transformation (Stirling, 2006). This differentiation suggests that active reflexivity as a learning outcome is partly connected to specific social settings (Feindt and Weiland, 2018), such as the *Values Assessment* process. Reflexive capacity-building as an aim or driver of any kind of learning process is normative. The desired outcome is reassessment of one's tacit assumptions to create new kinds of understandings and practices to support inclusivity and sustainability transformations rather than just passive awareness (ibid.).

To sum up the connections between learning, plurality, and reflexivity, it has been noted that successful learning in collaborative teams requires administratively both organisational and individual capacity support (Boix Mansilla, 2006; Borie et al., 2020) and reflections on one's own and other's understandings (Stevenson and Dryzek, 2012). A continuous commitment to the creation of active spaces for reflexive learning processes, despite their heavy investments of time and process, is supporting operationalizing the plurality and disrupts power asymmetries by confronting those 'silent' patterns that reproduce inequalities

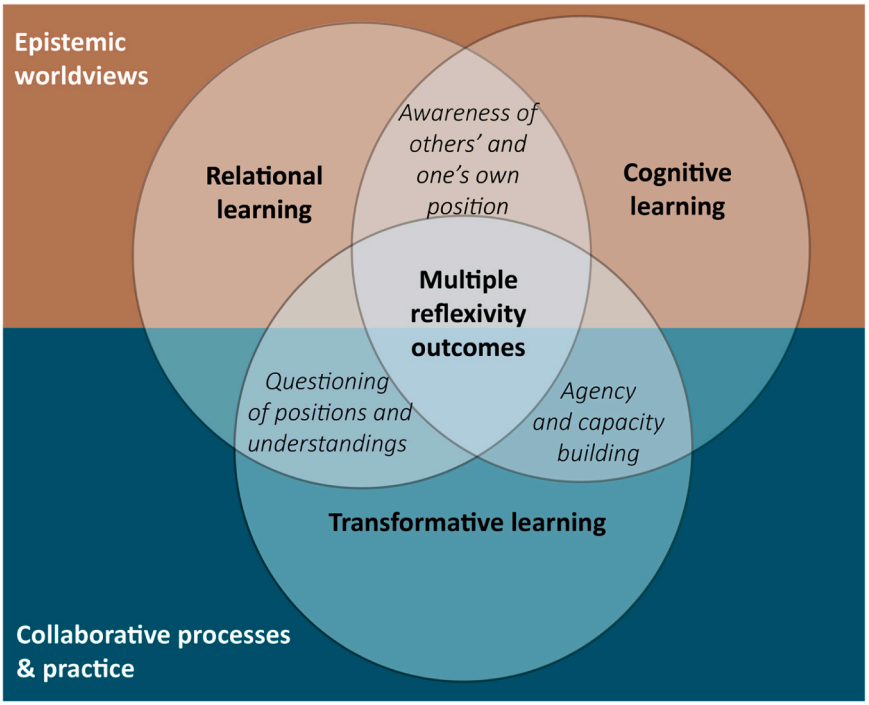

Fig. 1. Learning as a multi-level and interactive process with cognitive, relational and transformative dimensions that are linked to social contexts and individual experiences with collaborative practices. Overlapping portions of the Venn diagram illustrate the possibilities for learning outcomes at the intersections of the three learning dimensions. These outcomes result from reflexive self-consideration of epistemic worldviews and social contexts.

(Moreno-Cely et al., 2021; Plank et al., 2021; Wittmayer, 2021).

1.2. Synthesis: Towards a multi-level learning framework

The different dimensions of learning presented above are all seen as necessary components of inter- and transdisciplinary practices (Borie et al., 2020; Freeth and Caniglia, 2020; Manganelli, 2020). Diduck et al.'s (2019) framework demonstrates how multiple pathways of learning occur, nesting various resources, observations, and practices, and leading to multi-level learning outcomes such as relational changes (e.g., community building), normative changes (e.g., personal fulfillment), and cognitive or behavioral changes (e.g., validation, empowerment). Within the same social context, different dimensions of learning can stimulate changes in multi-level outcomes and the positions of stakeholder groups (van Riper et al., 2018). Importantly, Diduck et al.'s (2019) framework highlights the overlap between dimensions of learning, and for different dimensions of learning to inform one another, otherwise referred to as 'intermingled pathways of learning'. Fig. 1 presents three different dimensions of learning (i.e., cognitive, relational, transformative) and their intermingled pathways as drivers for, but at the same time supported by, three aspects of reflection (see 1.1.1.–1.1.4.).

Here, we draw upon Diduck et al.'s (2019) multi-level learning framework and our baseline study (Hakkarainen et al., 2020) to elucidate the multiple learning pathways by which experts holding different epistemic worldviews learn and generate reflexivity related to the shared socio-political context (in Fig. 1 presented as 'collaborative processes & practices'), to others and themselves. Besides the ability of being (passively) aware of diversity, experts need to be tolerant and able to actively advance collaboration in practice (Freeth and Vilsmaier, 2019; Sipos et al., 2008), including reflexive self-consideration of their epistemic worldviews and social contexts (Awareness of others' and one's own position', 'Questioning of positions and understandings' and 'Agency and capacity-building' in Fig. 1).

2. Material and methods

2.1. Sampling and survey techniques

At the time of the third survey in May 2020, the IPBES *Values Assessment* involved a total of 96 experts (Table 2). The sampling frame remained largely the same size over the four years.

Several days prior to each three author meetings, we sent 96 emails inviting all *Values Assessment* experts to complete an online survey. The first author meeting was held in November 2018; the second author meeting was held in October 2019; the third author meeting was held in April 2021. Personal emails were sent to invite all co-chairs, coordinating lead authors, lead authors, and fellows to participate. Surveys were conducted online through Qualtrics and took 15–30 min to complete. Each survey consisted of the following sections: i) expectations of the *Values Assessment*, ii) views on the multiple values of nature, iii) perspectives on knowledge and understanding of reality in science, and iv) background information. In the last survey, an additional section assessed personal learning experiences during the four-year assessment period (see Appendix B for surveys).

2.2. Analyses

We examined the evidence of learning, learning outcomes, and heightened reflexivity therein with respect to multiple concepts in the surveys. Those concepts are summarised in Table 1.

Descriptive statistics were used to evaluate the representativeness of the sample compared to the population of 96 experts involved in the *Values Assessment* (Table 2). The assessment's Technical Support Unit provided the anonymized aggregate population data. Repeat answers across the three datasets were identified using a personal ID, which

Table 1
Overview of the main concepts, their definitions, and how they were operationalised in the surveys.

Concept	Definition	Operationalisation of the concept in the surveys
Epistemic worldview	Epistemic worldviews are philosophical ideas about knowledge shaped by various external, epistemic and personal factors, that in case of researchers, shape how they practice research and use the knowledge created (Hakkarainen et al., 2020). To differentiate between expert's worldviews, we follow Creswell's (2014) classifications in which: -**Constructivist** utilizes social and historical approach that recognizes multiple meanings towards phenomena. They focus on understanding the interactions between humans and specific contexts. -**Transformative** worldview concentrates on topics such as empowerment, inequality, oppression, and suppression. They call attention to political, collaborative and practical views to research that affects change. -**Pragmatist** aligns towards real-world and practice-oriented problem solving. They embrace pluralistic approach to concepts and methods, concentrating on consequences of actions. -**Post-positivist** applies reductionist views on complex phenomena to test theories through careful observation and measurement. They have an assumption that objective reality exists.	The baseline study (Hakkarainen et al., 2020) related the expert's understandings of i) objectivity and ii) motivation to the characteristics of Creswell's (2014) four epistemic worldviews. **Understanding of objectivity** was utilized in this study as an indicator of whether experts see the world as objective or socially constructed. The question and exact statements that were used across the three surveys to differentiate between understandings on objectivity are listed in Table 3.
Motivation	Defined here in the meaning of the overall goals the experts bring into the assessment work. Motivation-related goals reveal expert's epistemological perspectives on how and why knowledge should be constructed and disseminated on the science-policy process (Eigenbrode et al., 2007; Hakkarainen et al., 2020).	In this study, **motivation** was studied investigating what experts consider as the purpose of the IPBES *Values assessment* (Section 3.3.1. and 3.3.2.). Two questions that were used to investigate motivation across the three surveys were: "Please describe what you see as the main purpose of the IPBES *Values Assessment*." "Please describe what you think is the most pressing issue that experts will address during the IPBES *Values Assessment*." In the last survey, experts were additionally asked to identify if their perceptions on the main purpose and most pressing issue had changed and what factors had caused the change. All questions on motivation as well as example quotes from responses are listed in the Appendix A: Supplementary Table 3.
Multiple values of nature	Approach to multiple values of nature recognizes and opens the space for different ways	Question across the three surveys: "How would you define 'the multiple values of

(*continued on next page*)

Table 1 (*continued*)

Concept	Definition	Operationalisation of the concept in the surveys
	that humans value nature (Pascual et al., 2022). Specific values can be, for example, instrumental ("nature's contributions to people"), intrinsic ("value of nature independently of people") or relational ("meaningfulness of people-nature relations") (ibid., 20). The underlying purpose of the approach is to include the plurality of these understandings into the design and implementation of policies.	nature'?" Question in surveys 2 and 3: "Has your definition of multiple values of nature changed during your involvement in the IPBES *Values Assessment*? If so, why?"

Table 2
Descriptive statistics, survey samples, and population.

Characteristics	Population (*Values Assessment*)	Survey 1 November 2018	Survey 2 October 2019	Survey 3 April 2021	Surveys 1–3
N (repeat respondents)	96 (-)	45 (-)	46 (21)	26 (22)	74 (43)
Response rate	-	47%	48%	27%	77%
Female, incl. cis and transgender	51%	47%	44%	52%	53%
Age (mean)	47	43	45	46	44
Origin: Global South	39%	29%	28%	32%	32%
Academic background					
Social sciences	54%	62%	59%	58%	68%
Natural sciences	54%	31%	28%	42%	31%
Humanities	10%	7%	10%	-	8%
Engineering	7%	-	-	-	-
Interdisciplinary/ Mixed	-	-	3%	-	3%
Role within IPBES					
Co-Chair	4%	-	3%	8%	5%
Coord. Lead Author	18%	12%	18%	16%	16%
Lead Author	51%	64%	59%	48%	64%
Fellow	16%	17%	21%	28%	16%
Review Editors	12%	-	-	-	-
Institutional affiliation					
Research institute	18%	41%	46%	48%	35%
University	69%	49%	49%	43%	56%
Other	7%	10%	6%	10%	9%

Note. Column totals may not equal 100% because decimal points are not presented.
Note. The total number of all responses received was 117, including repeat respondents.

allowed us to detect repeated observations from the same individuals.

First, all valid responses across the three datasets (n = 102) were clustered based on their responses to questions about objectivity in science (Table 3), rooted in Creswell's (2014) epistemic worldviews (Table 1). To avoid making a priori assumptions, clusters were identified using Ward's minimum variance method. Quantitative analysis was conducted in Stata version 15.

Second, we used qualitative thematic coding to organize experts' self-reported descriptions of taking part in the *Values Assessment* process to determine: i) how experts perceived the purpose of and most pressing issues (i.e., motivation) addressed in the assessment over time; ii) how definitions of the multiple values of nature changed over time; and iii) how learning experiences were viewed by experts at the end of the assessment process (survey questions used are detailed in Table 1). These reflections across the same thematic coding used in each of the three surveys enabled the research team to gauge variation and change that emerged from the experts' learning processes (Eriksson et al., 2019).

Third, the team characterized change from the four epistemic worldview clusters (Table 3) by analyzing differences in the qualitative coding within each cluster across the three datasets (i.e., over time). In addition, repeated observations of the same individuals (distinguishable by answering ID) enabled the team to characterize change in responses at the level of individual respondents across time. After each of the three datasets were assembled, three rounds of open, axial, and thematic coding ensued. Directed coding was applied to the second and third dataset (Hsieh and Shannon, 2005). We used NVivo 12 (first data set) and Atlas.ti (second and third data sets) to organise the codes. After the first, open round of coding, the codes of the second and third datasets were compared with the first dataset codes and reviewed. The codes and subcodes were cross-checked and validated by two to three individual members of our team (Appendix A: Supplementary Table 2).

3. Results

3.1. Respondent characteristics

Across the three surveys, 74 of the 96 experts involved in the *Values Assessment* participated in at least one of the three surveys. Among these, there were a total of 43 (37%) repeat respondents in surveys 2 and 3. The socio-demographics of this sample generally aligned with the broader population (Table 2). Approximately two-thirds of respondents were from the Global North (68%) and had a lead author role in the assessment (64%). Gender identity was balanced (53% female, including cis and transgender). The majority were academics, employed by a university (56%) and represented multiple disciplines, predominantly social sciences (68%).

Table 3
Average values of survey items (SD) on objectivity with clusters mapped to Creswell's (2014) epistemic worldviews' understanding on objectivity (Constructivism, Tranformativism, Pragmatism, Post-positivism).

To what extent (from 1 to 5) do you agree or disagree with the following statements?	Cluster: Constructivism	Cluster: Transformativism	Cluster: Pragmatism	Cluster: Post-positivism	All respondents
The natural world is external and objective	1.4 (0.66)	3.0 (0.95)	1.9 (0.66)	3.9 (0.76)	2.5
Researchers should formulate hypotheses and then test them	2.4 (0.73)	2.8 (0.83)	4.4 (0.50)	4.7 (0.49)	3.5
Researchers should use multiple methods to establish different types of data	4.9 (0.21)	4.3 (0.81)	4.9 (0.26)	4.6 (0.62)	4.6
Researchers should try to develop ideas through induction from data	4.1 (0.83)	3.4 (0.75)	3.8 (0.84)	4.6 (0.51)	3.8
n	22	34	28	18	102

3.2. Represented epistemic worldviews in the IPBES Values Assessment

The four clusters that emerged from responses on objectivity across the three surveys were related to Creswell's (2014) epistemic worldviews: Constructivist, Transformative, Pragmatist, and Post-positivist (Table 3). The representative quotes of each cluster can be found from Appendix A: Supplementary Table 3.

The largest cluster of the respondents across the three surveys was connected to Transformativists (n = 34, 33%), even though this worldview was absent from the baseline data (Hakkarainen et al., 2020). According to Creswell (2014), Transformativists stress inclusiveness, democracy, and the need for ease of interpretation across all kinds of audiences. In line with this, Transformativists considered measurements and methods to be as important as theoretical thinking and often connected these thoughts to practical governance. Although one question asked about objectivity (Table 3), it did not entirely capture the features of empowerment and collaboration posited by Creswell (2014). Rather, these features (i.e., empowerment, collaboration, political, change-orientation) emerged from the respondents' answers to questions about their motivation (Section 3.3.1.).

In accordance with Creswell (2014), the Constructivist cluster's (n = 22, 22%) responses highlighted the importance of multiple worldviews, inductive processes, and social constructions, while Pragmatists (n = 28, 27%) brought up the meaning of 'real world' problem-solving, practice-orientation, and pluralist approaches to concepts, methods, and contexts. The Post-positivist cluster's (n = 18, 18%) responses embraced validation of data and evidence, reliability of measurements, and avoiding biases. This group thought that the natural world was more objective than the other clusters (Table 3).

Regardless of worldview, all experts in our sample saw the importance of transformation and linking knowledge to action, but the methods to gain that change and the level of engagement it requires varied according to worldview. The Pragmatist cluster felt that change needed to be achieved with collaborative practices and problem-solving that would better connect scientific knowledge with the 'real world.' Post-positivists relied on better validated, more accurately measured, standardized, and 'holistic' scientific knowledge; in their opinion, decision makers work as information givers. Constructivists and Transformativists were often the most emancipatory; they thought that transformative change came from revealing and understanding power structures or policy contexts. Different from all other three clusters, Transformativists highlighted the joint responsibility of the researcher community to urge decision makers to consider "commitments to equity, justice, and democracy."

Observing the three survey periods, 59% of the respondents that answered multiple surveys shifted their worldview between the first and last measurement (n = 27). The largest proportion of those who changed (22%) went towards Post-positivism. Most changes were made away from the Pragmatist cluster (22%), while there was little movement away from the Constructivist cluster (3%). At the same time, the Constructivist cluster also grew the most across the measurement times, from 15% to 29%, respectively.

3.3. Identified changes across the four years of the IPBES Values Assessment

3.3.1. Themes of motivation across time

Respondents were asked in each survey what they considered to be the main purpose and pressing issue from the IPBES *Values Assessment* (Appendix A: Supplementary Table 2). The answers to these two

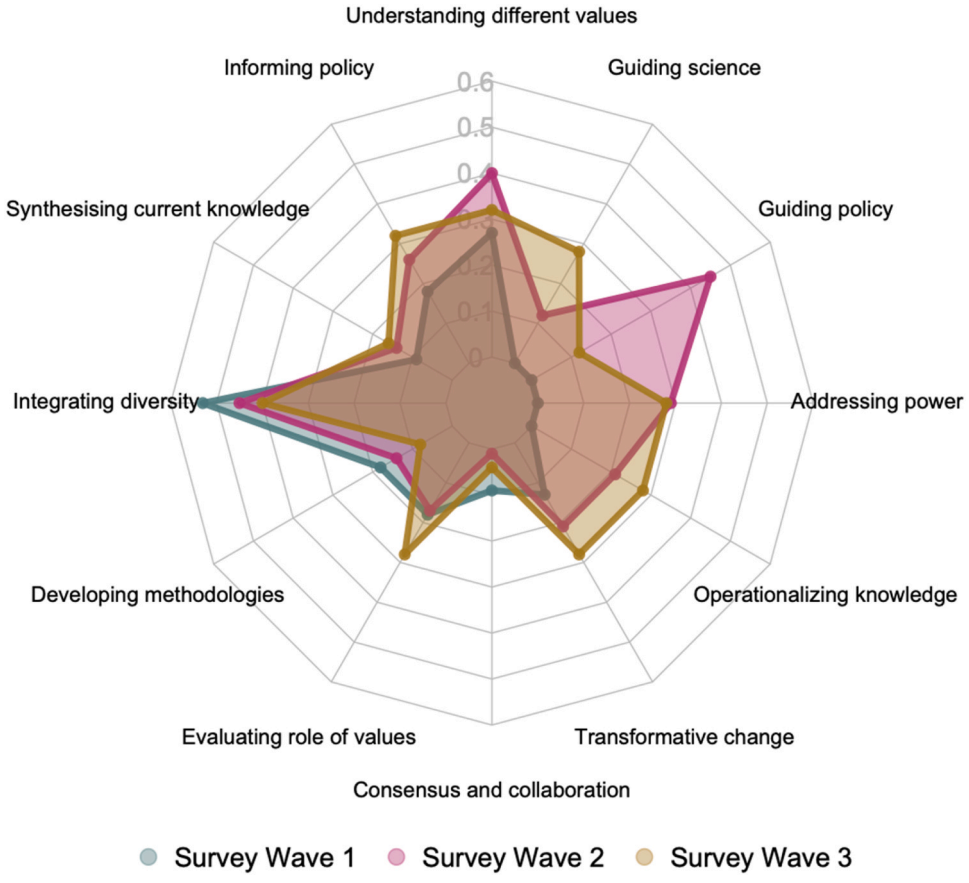

Fig. 2. Theme frequency for each survey period regarding respondent understanding of the IPBES *Values Assessment*'s purpose and its most pressing issue to address ('motivation').

questions reflected experts' overall motivation for participation (Table 1).

In all survey periods, the theme of *Integrating diversity of values* was the most prominent, with 53%, 45% and 40% of respondents answering the question in the surveys 1, 2, and 3 (Fig. 2), but its frequencies also declined the most over time (Fig. 3). *Transformative change*, in turn, emerged most across the three years (13%, 21%, and 28%) and it was linked to change- and future-oriented motivations tied to the goals of "better socio-environmental outcomes" and/or "more just and equitable and sustainable solutions." The theme of *Integrating diversity of values* referred to actively appreciating, integrating and/or incorporating diversity of values, perspectives and knowledges, and/or supporting and practicing inclusive decision-making. The word 'integrating' was not used by everyone, and some respondents also referred to creating awareness, including, or mainstreaming.

We also found that answers evolved from short responses in survey 1 to more detailed, complex, and sometimes critical descriptions of the relationship between experts and decisionmakers in surveys 2 and 3. Also, IPBES vocabulary (e.g., Nature's Contributions to People, NCP) was used more frequently in later surveys. The growing complexity and more nuanced tones were well expressed in two new themes from surveys 2 and 3: *Guide policy and decision-making* and *Guide science*. The theme of *Guide policy and Decision-making* was different from the *Inform policy* theme. This notion related to willingness to practice engagement and step out of the traditional roles of expert (i.e., knowledge creator) and decisionmaker (i.e., knowledge receiver). *Inform policy* was expressed in terms like communicating and evaluating. Informing was one-sided, whereas *Guiding decision-making* was more about mentoring decisionmakers, also taking note of their needs and creating knowledge together. While *Guide science* and *Guide policy and decision-making* were connected, the former was a self-reflection of the scientific community on their working methods; it stood for creating interdisciplinary frameworks and methodologies focused on finding answers to make the scientific community work in more plural ways. The differing gradients between the themes reveal the multiple ways experts are ready to open up their own space of epistemic authority, and to possibly step out to more active deliberation towards the decisionmakers (Boström et al., 2017). The ways that knowledge is disseminated has a meaning to the knowledge-action gap (Lemos and Morehouse, 2005).

3.3.2. *Understandings of the motivation in different epistemic worldviews across time*

Even if some individuals changed their epistemic worldview across time (Section 3.2.) or highlighted different themes over time (Fig. 2), their core understandings and definitions of motivation remained more or less unchanged (See Appendix A: Supplementary Table 3 for representative quotes). The individuals who identified generating evidence, measuring complexity, and creating standardised methodologies as the main purpose of the *Values Assessment*, or those who saw the main purpose as integrating plurality and making knowledge fit for different policy contexts, continued to do so across the measurement times even if they shifted their epistemic belief on objectivity (Table 1).

Constructivists most frequently identified the motivation of the *Values Assessment* to *Integrating diversity of values* (33%, 28%, and 22%). However, in this cluster, the frequency of *Addressing power* increased over time (Fig. 3). In survey 3, it was mentioned as often as *Integrating diversity of values*. Also, Pragmatists mentioned most often *Integrating diversity of values* across the study (29%, 27% and 23%). In survey 3, Pragmatists often mentioned *Transformative change* (14%) and *Evaluating the role of values in decision-making* (14%), too.

In general, Post-positivists' themes evolved to align more closely with the other cluster areas (Fig. 2). Post-positivists did not associate

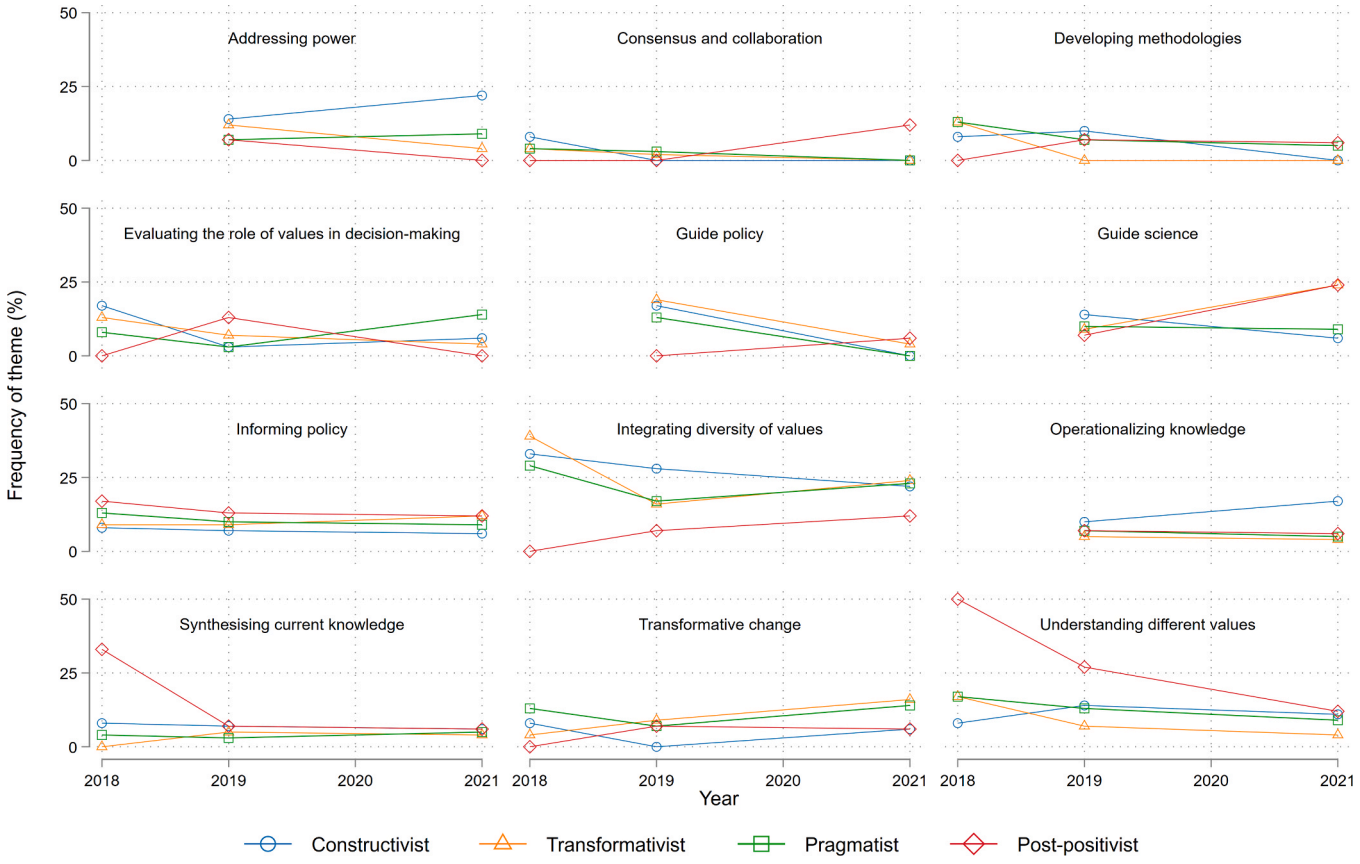

Fig. 3. Time series of the motivation's theme frequencies between survey 1 (2018), survey 2 (2019), and survey 3 (2021) for the four clusters delineating the various epistemic worldviews (Constructivism, Transformativism, Pragmatism, and Post-positivism).

themselves with the theme of *Integrating diversity of values* at the time of the first measurement, but its frequency increased over time (up to 12%) (Fig. 3). In contrast to the other worldviews, this group associated the least with *Addressing power imbalances*, but referred most often, especially at the time of the last measurement, to the *Guide science* theme (24%) (Fig. 3). Compared to other clusters, Transformativists embraced *Integrating diversity of values* as the most frequent motivation across time periods (39%, 16%, and 24%). In addition, this group referred to *Transformative change* (16%) and *Guide science* (24%) the most frequently compared to all clusters, especially in the last survey.

Post-positivist cluster were increasingly related to more active and process-oriented themes (Miller, 2013), such as *Informing policy* or *Guide science*, rather than passive or descriptive themes (Feola, 2015), such as *Understanding values* or *Synthesising values*. Other clusters' vocabulary stayed on the same level of 'activeness' across time (shift was from 71% to 75% to 73–78%), but Post-positivists shifted from 20% to 82%. On the individual level, representatives from all clusters identified with either active or passive themes and the mix of the two were less frequent. Independent from the worldview, this signals a constant diversity of experts' notions regarding the needed level of engagement with society (see also Hakkarainen et al., 2020). However, this result also indicates that experts holding a Post-positivist worldview came to adhere to more engagement inclined themes during the IPBES *Values Assessment*.

3.3.3. Understandings of the multiple values of nature in different epistemic worldviews across time

In each of the three surveys, respondents were asked to provide a definition of the multiple values of nature (Table 1) to clarify how they established and understood this concept before and after working with it during the *Values Assessment* process. We identified a general change in the definitions towards themes that emphasise more plural and relational values (Appendix A: Supplementary Table 4). While in the first survey the theme *All value types* was often expressed without a deeper explanation, in later surveys, the respondents reflected critically on the different values from the perspectives of positionalities, ways of knowing and context. A new theme that emerged over time was *Ethics* (and moral values) that was particularly expressed in survey 2. *Monetary values* were stated less often in the surveys 2 and 3 than in survey 1. *Instrumental*, *Intrinsic,* and *Relational values* remained as an often-used conceptual combination, especially among Post-positivists in survey 3 (Fig. 4).

Among the respondents who changed their views regarding the multiple values of nature (n = 30), the self-reported change related to definitions and understanding of multiple values of nature had moved towards more 'complex and deep' understandings, understanding interconnectedness of concepts, gaining more nuances in the definition, learning new concepts but also achieving more focused definitions. Some people who did not change their definitions (n = 30) expressed they already had a "plural valuation perspective".

Relational values was one of the most frequently mentioned themes in

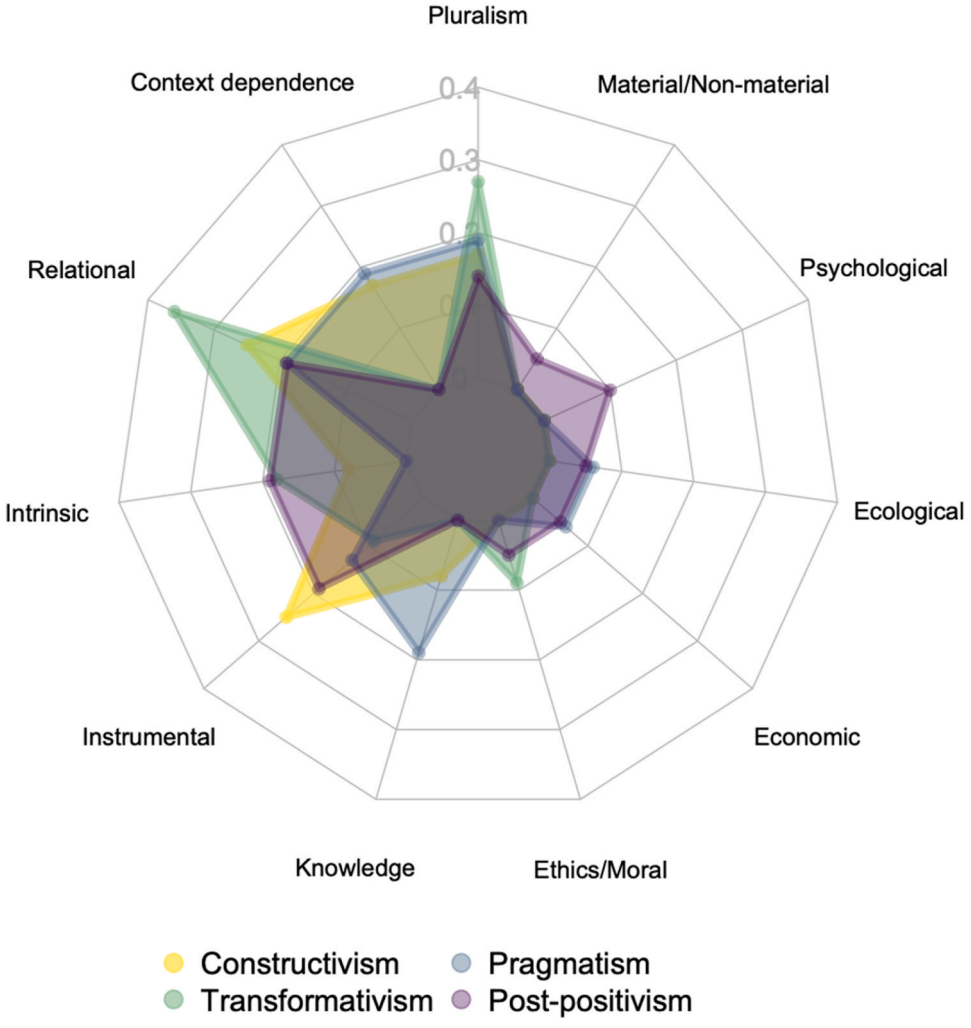

Fig. 4. Themes of multiple values of nature in survey 3, organized by epistemic worldviews.

all clusters, but was especially frequent in the Transformativist Cluster in survey 3 (Fig. 4). There was a tendency towards *Relational values*, especially in particular clusters. In survey 1, none of the Post-positivists mentioned *Relational values*, but in survey 3, *Relational values* was among this cluster's most mentioned themes (19%). The other two most mentioned themes were *Instrumental* and *Intrinsic*, of which the former was frequently mentioned by Post-positivists already during the first survey, but the latter only emerged later (Appendix A: Supplementary Table 4).

Transformativists emphasised Pluralism (*All value types*). Pluralism was also valued highly also by the other three clusters. Pragmatists' second most mentioned theme in survey 3 was *Context dependence and knowledge* (Fig. 4), while Constructivists and Transformativists both highlighted *Relational values* the most. Constructivist themes stayed mostly the same across the three years. However, in addition to the 'relational turn' expressed by the Post-positivists, Pragmatists also shifted from frequently mentioning *Instrumental values* in survey 1 to a more *Contextual understanding of values*: "Multiple values can include diverse values depending on cultures, social groups, knowledge systems, languages and territories" (example answer from survey 3).

3.4. How did different epistemic worldviews learn?

In the final survey, we asked about expert's subjective views on their learning experiences during their involvement in *Values Assessment*. Responses, along with the changes in epistemic worldviews and motivation (Section 3.3.2.) and understandings of multiple values of nature (Section 3.3.3.) across time, highlight the multiple, intermingled pathways of learning, underpinned by reflexivity, that occurred for experts (Fig. 1 and Appendix A: Supplementary Table 5). We identified three dimensions of learning that corresponded to cognitive, relational, and transformative.

Relational learning was linked to experts' increased understanding of one another, and it appeared in answers mostly as passive knowledge sharing. Constructivists and Transformativists especially appreciated the "interesting diversity of perspectives" that came from "different theoretical backgrounds and experiences." Likewise, experts hoped that sharing their own unique disciplinary and geographical perspectives would spark learning for other participants. Constructivists also embraced social, more informal IPBES activities as drivers for their learning.

Cognitive learning was stimulated by the group practices and experiences. This type of learning was mentioned most often by Pragmatists and Transformativists. Pragmatists underlined the meaning of the process and not the output itself, while Transformativists appreciated generation of shared understandings as drivers for their knowledge accumulation. Post-positivists, in turn, emphasized that they gained more holistic and accurate knowledge from other experts who were holding different views.

Transformative learning was brought up across all clusters, but in the context of the general need for change in the society, instead of them personally acting as transformative agents or of experiencing any deep, normative shifts in basic premises of thought (Hoggan, 2016). The current internal and external structures were seen to act as a barrier to transformative power. One Transformativist suggested challenging existing structures as a way to increase transformative learning across society, including assumptions of what 'nature is' and the connections between "plural values that people hold towards nature" and environmental conservation.

There was, across all clusters, an emergence of reflexivity as a cross-cutting theme related to organisation and context awareness and their own positions as part of a larger society. This was a prominent trend that increased across the multiple surveys. In particular, experts reflected on various organisational norms and structure of IPBES based on the goal of creating a shared consensus. Experts appreciated that a diversity of perspectives, based on multiple values of nature, reinforced their questioning of consensus seeking. Post-positivists mentioned consensus-based common goals, frameworks, and methodologies as important drivers for their learning more often than other clusters. Notably, even if shared understandings were seen as worth mentioning across clusters (Appendix A: Supplementary Table 5), consensus seeking as a normative IPBES goal was challenged by the experts as part of their learning process: "the difficulties of listening and exploring in a structure that was designed to deliver, not challenge, consensus" (example answer from survey 3).

Related to transformative learning underpinned by enhanced self-reflection, Constructivists and Transformativists often mentioned power and organizational contexts as an important theme as to their increased awareness on their positions: "How others work, think, about other institutions, about how academia is organised, power relations in academia …" (example answer from survey 3). In the Pragmatist Cluster, the experts considered that they learned most about the policy context. In contrast to Constructivists and Transformativists, Pragmatists did not reflect the issue of power relations too much but underlined the need for communication and shared practices between experts and decision makers.

4. Discussion

This study examined how experts' epistemic worldviews and understandings shifted during the four-year inter- and transdisciplinary process of the IPBES *Values Assessment*. Building on previously reported findings regarding their perspectives on objectivity and motivation (Hakkarainen et al., 2020), we elucidated further how experts' learning evolved during the assessment process. Our approach to learning, underpinned by reflexivity, was conceptualised by adapting Diduck et al.'s (2019) framework on multiple pathways to learning. While previous research notes that experts do not always have the necessary collaborative skills to engage with and learn from the plurality of views in science-policy settings (Cheruvelil et al., 2014; Freeth and Caniglia, 2020), we found evidence that the *Values Assessment* process supported three learning dimensions: cognitive, relational, and transformative. These emerged from various assessment-specific collaborative processes and practices, such as author meetings, team-building activities and ILK dialogue workshops (Appendix A: Supplementary Table 1). Learning was stimulated by reflection but resulted in multi-level reflexivity outcomes. The degree and limits of reflexivity were ingrained partly in epistemic worldviews: more reflexivity in the setting of IPBES science-policy interactions and organizational structures was not necessarily accompanied by heightened self-reflexivity in the sphere of scientific practices and vice versa. Rather this outcome partially depended on the expert's epistemic worldview. In the following discussion, we refer to three main findings.

Key finding 1: Collaborative assessment process, grounded in reflexivity, promoted various dimensions of learning. The nature of learning varied by epistemic worldview.

The three factors that were perceived as relevant drivers for expert's reflexive capacity were (Section 3.4): i) plurality of represented epistemic worldviews and values (Section 3.2), ii) plurality of represented case-specific contexts (Section 3.3.3), and iii) IPBES collaborative practices that provided spaces for interactions (including formal and informal practices, meetings, and resources). Multiple pathways of learning nested collaborative practices which entail various social, cognitive, and context-dependent activities (Diduck et al., 2019). Fig. 1 presents three main dimensions of learning - cognitive, relational, and transformative - grounded in epistemic worldviews, but through these common collaborative practices embedded in the organisational and social framework. For example, plurality and collaborative practices initiated relational learning among Constructivists, while among Post-positivists, the same experiences mostly provoked cognitive learning and knowledge accumulation.

What learning dimensions the pathways aligned with, and what were

the limitations of reflexivity as a driver for learning, were partly dependent on the expert's epistemic worldview. While Post-positivists developed especially their individual-level cognitive understanding within their discipline's positionality and mentioned consensus-based goals as important drivers for their learning, Constructivists and Transformativists reflected the most policy and organisational contexts outside of their own scientific spheres. Pragmatists reflected the relation between decisionmakers and experts. This highlights the need for science-policy interfaces, such as IPBES, to pay systematic attention to how learning materializes as an interactive, intertwined process (Manganelli, 2020; Suskevics et al., 2018) in which not just organisational frameworks and social interactions have an influence, but epistemic views. Therefore, the chosen collaboration practices should consider the differences and capacities across represented epistemic worldviews in addition to disciplines and career stage (Freeth and Caniglia, 2020; Freeth and Vilsmaier, 2019).

Key finding 2: Experts expanded their understanding of the positionality and diversity of knowledge. However, there was no clear evidence of experts' critical reflection on the power of their own agency.

The literature has highlighted the need of researchers to reflect the concept of 'strong objectivity' and the social positions of themselves and others involved in any inter-and transdisciplinary processes (Hakkarainen et al., 2022; Rosendahl et al., 2015). We advance this literature by demonstrating how different epistemic worldviews learned to reflect their social positions. Experts, independent of their epistemic worldview, have gained overall awareness of the diversity of positions, contexts, and implicit assumptions regarding various positions and the multiple values of nature. The target and limitations of reflexivity seem to differ, partly because of various epistemic worldviews. This finding on multi-level reflexivity and its various boundaries (Boström et al., 2017) is aligned with the growing body of literature that distinguishes reflexivity as: i) passively being aware and open to multiple knowledges and views (Borie et al., 2020; Boström et al., 2017; Manganelli, 2020); or ii) actively embracing or operationalizing plurality (Horcea-Milcu et al., 2019; Popa, 2015). Interestingly, whether the exact focus of reflection was passive openness, self-criticism, or action building in the larger society was dependent on the expert's epistemic worldview. Post-positivists progressed their critical reflexivity within their disciplines' domains, but others expanded their awareness on larger organisational or societal structures.

Being aware of and critically thinking about overall structures between science and decision-making challenged experts in all clusters to consider options for active engagement with society as part of their epistemic worldviews. For example, experts in certain clusters associated issues of power with *Integrating the diversity of values* (Section 3.3.2) while others reflected on lack of societal transformative change, or organisational factors that inhibit the uptake of scientific evidence in decision-making. This finding supports a growing body of literature problematising the business-as-usual tendency of many similar science-policy collaborative fora to seek to 'integrate' knowledge (Caniglia et al., 2021; Klenk and Meehan, 2015; Stepanova et al., 2020). Some authors claim that moving away from integration heavily depends on learning and define transdisciplinarity as a multidimensional "open-ended learning process without pre-determined outcomes" (Pohl et al., 2021, 18). Our results indicate that all identified three dimensions of learning were underpinned by overall reflexivity (see intersections in Fig. 1). Therefore, the importance of incorporating agile enough processes and practices in future science-policy endeavors, as a way to allow multiple dimensions of learning to occur, arises as a critical step towards the institutionalisation of reflexive processes (Borie et al., 2020; Montana, 2021).

To go beyond the limited function of facilitating integration and consensus, the role of researchers themselves needs to move towards more engaged interactions at the science-policy interface (Turnhout et al., 2020). This mirrors recent calls in the transformation literature for researchers to intentionally step into more reflexive roles, such as change agents, transition participants, and self-reflexive scientists (Bulten et al., 2021; Horlings et al., 2020). However, in our study, there was no clear evidence of experts' critical or normative reflection on the power of their own agency to affect change directly. This was somewhat unexpected as there was a good representation of transformative view in our sample. This might be related to navigating the general tension between scientific reliability and social legitimacy "that have to be pursued in parallel and traded off against each other" (Popa, 2015, 46). The tension is a common challenge for all epistemic worldviews and for processes aiming to increase reflexivity (Koetz et al., 2012).

Our results indicate that the *Values Assessment* process has led to greater acknowledgement of value pluralism, which is key to successful inter- and transdisciplinary collaborations (Cornell et al., 2013; Laursen et al., 2021). Further, the experts have been more familiarised with the complexity of values, both expanding understanding of plurality and building coherence among views. This outcome challenges the recent statements by Washington et al. (2022) that i) this assessment presents values as dichotomized between anthropocentric and ecocentric and ii) the process did not support reflexivity. Here, we provide evidence to the contrary and along with other accounts that underline avenues for reducing dichotomies (Horcea-Milcu et al., 2019; Kenter et al., 2019; Obermeister, 2017), we propose that more attention and time should be given to operationalizing a culture of epistemological plurality instead of homogeneity (Balvanera et al., 2017; Haider et al., 2018) and to building a stronger reflexive capacity to overcome an emphasis on consensus (Díaz-Reviriego, 2019).

Key finding 3: Epistemic worldviews can partly shift independent of epistemic beliefs on how knowledge should be translated and communicated to the larger society.

While this study supports the idea that disciplinary diversity alone is insufficient to guarantee epistemological plurality (Hakkarainen et al., 2020), it further delineates the complexity in epistemic worldviews and the epistemic beliefs therein. This is aligned with a previous study by Hoggan (2016) who identified different forms and their subcategories of transformative outcomes that present themselves as various multilayered changes in worldviews, behavior, consciousness, feelings or 'ways of being in the world.' Our study unveiled that a changed epistemic worldview did not necessarily mean altered core epistemic beliefs, but the worldview was "becoming more comprehensive or complex" due to reflection (Hoggan, 2016, 66).

In addition to actively reflecting different viewpoints throughout the IPBES process, experts across clusters were socialised by this organisation over time. That is, the individuals involved in this process were exposed to an increasingly transformation-oriented approach and its action-based vocabulary. Especially experts holding a Post-positivist worldview adhered to more process-oriented themes. Contradictorily, Post-positivists most often self-reflected that they did not transform their perceptions, but had merely gained new, more 'holistic' knowledge by listening to others.

Accordingly, we see that epistemic worldviews are not necessarily discipline-specific; rather, we recorded an additional layer of diversity in epistemic beliefs that focused on how to make knowledge policy-relevant and how to engage with a larger society. These epistemic beliefs, represented in the views on overall motivation, did not shift similarly and as often as epistemic beliefs concerning views on objectivity. Experts, namely fellows and more experienced lead authors through their mentoring relationship, are essential parts of the IPBES institutional competence-building process. Thus, their selection in the sense of what kind of knowledge, expertise, and notably engagement of their epistemological values and beliefs drive for becomes an essential question for the overall reflexive capacity of the science-policy platform itself (Borie et al., 2020; Gustafsson et al., 2019).

The requirement of greater inclusivity demands for reflexivity. However, our result on reflexivity's connection to epistemic worldviews suggest that a fuzzy call for 'more reflexivity' is not a road to more inclusivity or common understanding of the problem at hand (Boström

et al., 2017). This entails that careful consideration of what enhanced reflexivity means for various actors and how it could be facilitated in the given context is required throughout the process.

4.1. Limitations and future directions

Notwithstanding these new insights regarding how diverse experts learn in inter- and transdisciplinary settings, we cannot verify if the changes we have detected are long-lasting (i.e., beyond the 3.5 years of study). Our results align with previous empirical evidence on deliberation and social learning taking place in inter- and transdisciplinary settings, which has demonstrated that understandings and values might change relatively quickly and at least temporarily due to facilitated interactions (Eriksson et al., 2019; Raymond and Kenter, 2016). Nevertheless, how permanent and context-dependent these detected changes are needs to be re-evaluated in the future. As we were able to identify transformative features in all clusters, we should also pay attention to whether certain kinds of experts are drawn into IPBES processes. For example, Post-positivists are expected to emphasise a deductive approach over inductive; however, our results indicate that experts in all four clusters placed importance on induction from data (Table 3). At the same time, experts with Post-positivist worldviews also underscored induction the most. This might be due to IPBES attracting experts who are already more inclined to inter- and transdisciplinary or process-oriented approaches. We aim to use a control group consisting of experts outside the *Values Assessment* to further investigate whether the persons involved with IPBES were more inclined to transdisciplinary working methods than on average. Finally, we also recognise the general limitations that surveys and self-reports have as a method of measurement (i.e., vulnerability of different response biases like acquiescence biases or survey characteristics like wording).

5. Conclusion

Our study highlights the need to more transparently consider the latent and non-discipline specific understandings that guide experts in their positioning towards decision-making and society during global assessment processes. These results contribute to better comprehending how diverse epistemic worldviews interact with and within inter- and transdisciplinary processes in science-policy interfaces, generating multiple pathways of learning and levels of reflexivity. Equally important, we stress that more systematic study of learning processes would help advance recent pledges to open science-policy systems and Western-dominated science to multiple knowledge systems, inclusivity, and different ways of knowing. The reflective-capacity of the represented epistemic worldviews influences the ways knowledge is constructed and disseminated, having thus implications for overcoming the knowledge-action gap. IPBES, as a space for various dimensions of learning, should harvest lessons from systematic evaluations and develop cooperative practices explicitly to facilitate reflexivity. At the same time, keeping learning processes open at multiple levels ensures that the plurality of views is not forced into consensus.

Funding

K. Mäkinen-Rostedt was supported by the Tiina and Antti Herlin Foundation, the Maj and Tor Nessling Foundation, and the Finnish Cultural Foundation. R. Andrade and C. Raymond were supported by a three year project called ENVISION funded through the 2017–2018 Belmont Forum and BiodivERsA joint call for research proposals, under the BiodivScen ERA-Net COFUND programme, and with the support of the following national funders: Swedish Research Council for Sustainable Development (FORMAS, grant number 2018-02429), Federal Ministry of Education and Research, Germany, Netherlands Organisation for Scientific Research (NWO), National Science Foundation in the US (grant number 1854767), and the Ministerio de Ciencia e Innovación, Spain. C. Raymond was also supported by a three-year project called VIVA-PLAN, funded by the Swedish Research Council for Sustainable Development (FORMAS, grant number 2018-00175). A. Horcea-Milcu was supported by an IASS (Institute for Advanced Sustainability Studies) fellowship. V. Hakkarainen was funded by the RECOMS project within the European Union's Horizon 2020 Research and Innovation programme under the Marie Sklodowska-Curie grant agreement No 765389.

CRediT authorship contribution statement

Katri Mäkinen-Rostedt: Conceptualization, Data curation, Investigation, Visualization, Writing – original draft, Project administration. **Viola Hakkarainen**: Conceptualization, Visualization, Investigation, Writing – original draft. **Max Eriksson**: Conceptualization, Data curation, Formal analysis, Writing – original draft. **Riley Andrade**: Conceptualization, Visualization, Writing – original draft. **Andra Horcea-Milcu**: Conceptualization, Writing – original draft. **Christopher B. Anderson**: Conceptualization, Writing – original draft. **Carena J. van Riper**: Conceptualization, Writing – original draft. **Christopher M. Raymond**: Conceptualization, Writing – original draft, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The data that has been used is confidential.

Acknowledgements

We would like to warmly thank all IPBES *Values Assessment* experts, especially those who gave us their valuable time and contributed to the surveys. We would especially like to thank the Technical Support Unit on Values for their guidance on IPBES guidelines. This study does not constitute a formal IPBES product. We acknowledge that C.M.R., C.B.A and A.H.M. were involved in the IPBES *Values Assessment*.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2023.06.010.

References

Andrade, R., van Riper, C.J., Goodson, D.J., Johnson, D.N., Stewart, W., López-Rodríguez, M.D., Cebrián-Piqueras, M.A., Horcea-Milcu, A.-I., Lo, V., Raymond, C. M., 2023. Values shift in response to social learning through deliberation about protected areas. Glob. Environ. Change 78, 102630. https://doi.org/10.1016/j.gloenvcha.2022.102630.

Argyris, C., Schön, D.A., 1997. Organizational learning: A theory of action perspective. In: Revista Española de Investigaciones Sociológicas. 77/78. Monográfico sobre la Formación y las Organizaciones, pp. 345–348. https://doi.org/10.2307/40183951 (Jan. - Jun., 1997.

Baird, J., Plummer, R., Haug, C., Huitema, D., 2014. Learning effects of interactive decision-making processes for climate change adaptation. Glob. Environ. Change 27, 51–63. https://doi.org/10.1016/j.gloenvcha.2014.04.019.

Balvanera, P., Daw, T.M., Gardner, T., Martín-López, B., Norström, A.V., Ifejika Speranza, C., Spierenburg, M., Bennett, E.M., Farfan, M., Hamann, M., Kittinger, J. N., Luthe, T., Maass, M., Peterson, G.D., Pérez-Verdin, G., 2017. Key features for more successful place-based sustainability research on social-ecological systems: a Programme on Ecosystem Change and Society (PECS) perspective. Ecol. Soc. 22 (1), 14. https://doi.org/10.5751/ES-08826-220114.

Balvanera, P., Pascual, U., Christie, M., Baptiste, B., Lliso, B., Monroy, A.S., Guibrunet, L., Anderson, C.B., Athayde, S., Barton, D.N., Chaplin-Kramer, R., Jacobs, S., Kelemen, E., Kumar, R., Lazos, E., Martin, A., Mwampamba, T.H., Nakangu, B., O'Farrell, P., Raymond, C.M., Subramanian, S.M., Termansen, M., Van Noordwijk, M., Vatn, A., Contreras, V., González-Jiménez, D., 2022. Chapter 1: The

role of the values of nature and valuation for addressing the biodiversity crisis and navigating towards more just and sustainable futures. In: Balvanera, P., Pascual, U., Michael, C., Baptiste, B., González-Jiménez, D. (Eds.), Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6418971.

Beck, S., Mahony, M., 2018. The IPCC and the new map of science and politics. WIREs Clim. Change 9, 6e547. https://doi.org/10.1002/wcc.547.

Beck, S., Borie, M., Chilvers, J., Esguerra, A., Heubach, K., Hulme, M., Lidskog, R., Lövbrand, E., Marquard, E., Miller, C., Nadim, T., Neßhöver, C., Settele, J., Turnhout, E., Vasileiadou, E., Görg, C., 2014. Towards a reflexive turn in the governance of global environmental expertise the cases of the IPCC and the IPBES. Gaia 23 (2), 80–87. https://doi.org/10.14512/gaia.23.2.4.

Berkes, F., Folke, C., Colding, J., 1998. Linking social and ecological systems. Management Practices and Social Mechanisms for Building Resilience. University Press, Cambridge.

Biggs, R., Clements, H.S., de Vos, A., Folke, C., Manyani, A., Maciejewski, K., Martín-López, B., Preiser, R., Selomane, O., Schlüter, M., 2021. What are social- ecological systems and social- ecological systems research? In: Biggs, R., de Vos, A., Preiser, R., Celments, H., Maciejewski, K., Schlüter, M. (Eds.), The Routledge Handbook of Research Methods for Social-Ecological Systems, first ed. Routledge, London, pp. 3–26. https://doi.org/10.4324/9781003021339.

Boix Mansilla, V., 2006. Assessing expert interdisciplinary work at the frontier: an empirical exploration, 1 April Res. Eval. 15, 17–29. https://doi.org/10.3152/147154406781776075.

Borie, M., Mahony, M., Obermeister, N., Hulme, M., 2021. Knowing like a global expert organization: Comparative insights from the IPCC and IPBES. Glob. Environ. Change 68, 102261. https://doi.org/10.1016/j.gloenvcha.2021.102261.

Borie, M., Gustafsson, K.M., Obermeister, N., Turnhout, E., Bridgewater, P., 2020. Institutionalizing reflexivity? Transformative learning and the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). Environ. Sci. Policy 110, 71–76. https://doi.org/10.1016/j.envsci.2020.05.005.

Boström, M., Lidskog, R., Uggla, Y., 2017. A reflexive look at reflexivity in environmental sociology. Environ. Sociol. 3 (1), 6–16. https://doi.org/10.1080/23251042.2016.1237336.

Boström, M., Andersson, E., Berg, M., Gustafsson, K., Gustavsson, E., Hysing, E., Lidskog, R., Löfmarck, E., Ojala, M., Olsson, J., Singleton, B.E., Svenberg, S., Uggla, Y., Öhman, J., 2018. Conditions for transformative learning for sustainable development: A theoretical review and approach. Sustainability 10, 4479. https://doi.org/10.3390/su10124479.

Bulten, E., Hessels, L.K., Hordijk, M., Segrave, A.J., 2021. Conflicting roles of researchers in sustainability transitions: balancing action and reflection. Sustain. Sci. 16, 1269–1283. https://doi.org/10.1007/s11625-021-00938-7.

Caniglia, G., Luederitz, C., Wirth, T., von, Fazey, I., Martín-López, B., Hondrila, K., König, A., Wehrden, H., von, Schäpke, N.A., Laubichler, M.D., Lang, D.J., 2021. A pluralistic and integrated approach to action-oriented knowledge for sustainability. Nat. Sustain. 4, 93–100. https://doi.org/10.1038/s41893-020-00616-z.

Chambers, J.M., Wyborn, C., Ryan, M.E., Reid, R.S., Riechers, M., Serban, A., Bennett, N. J., Cvitanovic, C., Fernández-Giménez, M.E., Galvin, K.A., Goldstein, B.E., Klenk, N. L., Tengö, M., Brennan, R., Cockburn, J.J., Hill, R., Munera, C., Nel, J.L., Österblum, H., Bednarek, A.T., Bennett, E.M., Brandeis, A., Charli-Joseph, L., Chatterton, P., Curran, K., Dumrongrojwatthana, P., Durán, T.P., Fada, S.J., Gerber, J.-D., Green, J.M.H., Guerrero, A.M., Haller, T., Horcea-Milcu, A.-I., Leimona, B., Montana, J., Rondeau, R., Spierenburg, M., Steyaert, P., Zaehringer, J. G., Gruby, R., Hutton, J., Pickering, T., 2021. Six modes of co-production for sustainability. Nat. Sustain. 4, 983–996. https://doi.org/10.1038/s41893-021-00755-x.

Cheruvelil, K.S., Soranno, P.A., Weathers, K.C., Hanson, P.C., Goring, S.J., Filstrup, C.T., Read, E.K., 2014. Creating and maintaining high-performance collaborative research teams: the importance of diversity and interpersonal skills. Front. Ecol. Environ. 12 (1), 31–38. https://doi.org/10.1890/130001.

, 2022Conference of the Parties to the Convention on Biological Diversity(CBD/COP15), 2022. Final Decision of the Fifteenth Meeting: CBD/COP15/L.25.Montreal, Canada, 7-19 December. https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf (accessed 25 March 2022).

Cornell, S., Berkhout, F., Tuinstra, W., Tàbara, J.D., Jäger, J., Chabay, I., de Wit, B., Langlais, R., Mills, D., Moll, P., Otto, I.M., Petersen, A., Pohl, C., van Kerkhoff, L., 2013. Opening up knowledge systems for better responses to global environmental change. Environ. Sci. Policy 28, 60–70. https://doi.org/10.1016/j.envsci.2012.11.008.

Creswell, J.W., 2014. Research Design Qualitative, Quantitative and Mixed Methods Approaches, fourth ed. Sage Publications (In).

Díaz-Reviriego, et al., 2019. Participation and inclusiveness in the intergovernmental science–policy platform on biodiversity and ecosystem services. Nat. Sustain. 457–464. https://doi.org/10.1038/s41893-019-0290-6.

Diduck, A.P., Sinclair, A.J., Hostetler, G., Fitzpatrick, P., 2012. Transformative learning theory, public involvement, and natural resource and environmental management. J. Environ. Plan. Manag. 55 (10), 1311–1330.

Diduck, A.P., Raymond, C.M., Rodela, R., Moquin, R., Boerchers, M., 2019. Pathways of learning about biodiversity and sustainability in private urban gardens. J. Environ. Plan. Manag. 63 (6), 1056–1976 https://doi.org/10.1080/09640568.2019.1633288.

Dunkley, R., Baker, S., Constant, N., Sanderson-Bellamy, A., 2018. Enabling the IPBES conceptual framework to work across knowledge boundaries. Int. Environ. Agreem. 18, 779–799. https://doi.org/10.1007/s10784-018-9415-z.

Eigenbrode, S.D., O'Rourke, M., Wulfhorst, J.D., Althoff, D.M., Goldberg, C.S., Merrill, K., Morse, W., Nielsen-Pincus, M., Stephens, J., Winowiecki, L., 2007. Employing philosophical dialogue in collaborative science. BioScience 57 (1), 55–64. https://doi.org/10.1641/B570109.

Eriksson, M., van Riper, C.J., Leitschuh, B., Bentley Brymer, A., Rawluk, A., Raymond, C. M., Kenter, J.O., 2019. Social learning as a link between the individual and the collective: evaluating deliberation on social values. Sustain. Sci. 14, 1323–1332. https://doi.org/10.1007/s11625-019-00725-5.

Feindt, P.H., Weiland, S., 2018. Reflexive governance: exploring the concept and assessing its critical potential for sustainable development. Introduction to the Special issue. 20:6, 661–674. https://doi.org/10.1080/1523908X.2018.1532562.

Feola, G., 2015. Societal transformation in response to global environmental change: a review of emerging concepts. Ambio 44, 376–390. https://doi.org/10.1007/s13280-014-0582-z.

Freeth, R., Vilsmaier, U., 2019. Researching collaborative interdisciplinary teams. Pract. Princ. Navig. Res. Position. Sci. Technol. Stud. 33 (3), 57–72. https://doi.org/10.23987/sts.73060.

Freeth, R., Caniglia, G., 2020. Learning to collaborate while collaborating: advancing interdisciplinary sustainability research. Sustain. Sci. 15, 247–261. https://doi.org/10.1007/s11625-019-00701-z.

Gerlak, A.K., Heikkila, T., Smolinski, S.L., Armitage, D., Huitema, D., Moore, B., 2019. It's time to learn about learning: where should the environmental and natural resource governance field go next? Soc. Nat. Resour. 32 (9), 1056–1064. https://doi.org/10.1080/08941920.2019.1597235.

Gustafsson, K.M., Díaz-Reviriego, I., Turnhout, E., 2020. Building capacity for the science-policy interface on biodiversity and ecosystem services: activities, fellows, outcomes, and neglected capacity building needs. Earth Syst. Gov. 4, 100050 https://doi.org/10.1016/j.esg.2020.100050.

Gustafsson, K.M., Berg, M., Lidskog, R., Löfmarck, E., 2019. Intersectional boundary work in socializing new experts. The case of IPBES. Ecosyst. People 15 (1), 181–191. https://doi.org/10.1080/26395916.2019.1628105.

Haider, L.J., Hentati-Sundberg, J., Giusti, M., Goodness, J., Hamann, M., Masterson, V. A., Meacham, M., Merrie, A., Ospina, D., Schill, C., Sinare, H., 2018. The undisciplinary journey: early-career perspectives in sustainability science. Sustain. Sci. 13, 191–204. https://doi.org/10.1007/s11625-017-0445-1.

Hakkarainen, V., Anderson, C.B., Eriksson, M., van Riper, C.J., Horcea-Milcu, A., Raymond, C.M., 2020. Grounding IPBES experts' views on the multiple values of nature in epistemology, knowledge and collaborative science. Environ. Sci. Policy 105, 11–18. https://doi.org/10.1016/j.envsci.2019.12.003.

Hakkarainen, V., Mäkinen-Rostedt, K., Horcea-Milcu, A., D'Amato, D., Jämsä, J., Soini, K., 2022. Transdisciplinary research in natural resources management: Towards an integrative and transformative use of co-concepts. Sustain. Dev. 30 (2), 309–325. https://doi.org/10.1002/sd.2276.

Heikkila, T., Gerlak, A.K., 2018. Working on learning: how the institutional rules of environmental governance matter. J. Environ. Plan. Manag. 62 (1), 106–123. https://doi.org/10.1080/09640568.2018.1473244.

Hill, R., Díaz, S., Pascual, U., Stenseke, M., Molnár, Z., Van Velden, J., 2021. Nature's contributions to people: Weaving plural perspectives. One Earth 4 (7), 910–915. https://doi.org/10.1016/j.oneear.2021.06.009.

Hoggan, C.D., 2016. A typology of transformation: reviewing the transformative learning literature. Stud. Educ. Adults 48 (1), 65–82. https://doi.org/10.1080/02660830.2016.1155849.

Horcea-Milcu, A.I., Abson, D.J., Apetrei, C.I., Duse, I.A., Freeth, R., Riechers, M., Lam, D. P.M., Dorninger, C., Lang, D.J., 2019. Values in transformational sustainability science: four perspectives for change. Sustain. Sci. 14, 1425–1437. https://doi.org/10.1007/s11625-019-00656-1.

Horlings, L.G., Nieto-Romero, M., Pisters, S., Soini, K., 2020. Operationalising transformative sustainability science through place-based research: the role of researchers. Sustain. Sci. 15, 467–484. https://doi.org/10.1007/s11625-019-00757-x.

Hsieh, H.-F., Shannon, S.E., 2005. Three approaches to qualitative content analysis. Qual. Health Res. 15 (9), 1277–1288. https://doi.org/10.1177/1049732305276687.

Kenter, J.O., Raymond, C.M., van Riper, C.J., Azzopardi, E., Brear, M.R., Calcagni, F., Christie, I., Christie, M., Fordham, A., Gould, R.K., Ives, C.I., Hejnowicz, A.P., Gunton, R., Horcea-Milcu, A.-I., Kendal, D., Kronenberg, J., Massenberg, J.R., O'Connor, S., Ravenscroft, N., Rawluk, A., Raymond, I.J., Rodríguez-Morales, J., Thankappan, S., 2019. Loving the mess: navigating diversity and conflict in social values for sustainability. Sustain. Sci. 14, 1439–1461. https://doi.org/10.1007/s11625-019-00726-4.

Klenk, N., Meehan, K., 2015. Climate change and transdisciplinary science: problematizing the integration imperative. Environ. Sci. Policy 54, 160–167. https://doi.org/10.1016/j.envsci.2015.05.017.

Koetz, T., Farrell, K.N., Bridgewater, P., 2012. Building better science-policy interfaces for international environmental governance: assessing potential within the Intergovernmental Platform for Biodiversity and Ecosystem Services. Int. Environ. Agreem.: Polit. Law Econ. 12, 1–21. https://doi.org/10.1007/s10784-011-9152-z.

de Kraker, J., 2017. Social learning for resilience in social–ecological systems. Curr. Opin. Environ. Sustain. 28, 100–107. https://doi.org/10.1016/j.cosust.2017.09.002.

Laursen, B.K., Gonnerman, C., Crowley, S.J., 2021. Improving philosophical dialogue interventions to better solve problematic value pluralism in collaborative environmental science. Stud. Hist. Philos. Sci. 87, 54–71. https://doi.org/10.1016/j.shpsa.2021.02.004.

Lemos, M.C., Morehouse, B.J., 2005. The co-production of science and policy in integrated climate assessments. Glob. Environ. Change 15 (1), 57–68. https://doi.org/10.1016/j.gloenvcha.2004.09.004.

Löfmarck, E., Lidskog, R., 2017. Bumping against the boundary: IPBES and the knowledge divide. Environ. Sci. Policy 69, 22–28. https://doi.org/10.1016/j.envsci.2016.12.008.

Manganelli, A., 2020. Realising local food policies: a comparison between Toronto and the Brussels-Capital Region's stories through the lenses of reflexivity and co-learning. J. Environ. Policy Plan. 22 (3), 366–380. https://doi.org/10.1080/1523908X.2020.1740657.

Mezirow, J., 2003. Transformative learning as discourse. J. Transform. Educ. 1 (1), 58–63. https://doi.org/10.1177/1541344603252172.

Mezirow, J., 2009. An overview on transformative learning. In: Illeris, K. (Ed.), Contemporary Theories of Learning: Learning Theorists in their Own Words, Vol. 2009. Routledge, London, New York, pp. 90–105.

Miller, T.R., 2013. Constructing sustainability science: emerging perspectives and research trajectories. Sustain. Sci. 8, 279–293. https://doi.org/10.1007/s11625-012-0180-6.

Montana, J., 2021. From inclusion to epistemic belonging in international environmental expertise: learning from the institutionalisation of scenarios and models in IPBES. Environ. Sociol. 7 (4), 305–315. https://doi.org/10.1080/23251042.2021.1958532.

Moreno-Cely, A., Cuajera-Nahui, D., Escobar-Vasquez, C.G., Vanwing, T., Tapia-Ponce, N., 2021. Breaking monologues in collaborative research: bridging knowledge systems through a listening-based dialogue of wisdom approach. Sustain. Sci. 16, 919–931. https://doi.org/10.1007/s11625-021-00937-8.

Muro, M., Jeffrey, P., 2008. A critical review of the theory and application of social learning in participatory natural resource management processes. J. Environ. Plan. Manag. 51 (3), 325–344. https://doi.org/10.1080/09640560801977190.

Obermeister, N., 2017. From dichotomy to duality: addressing interdisciplinary epistemological barriers to inclusive knowledge governance in global environmental assessments. Environ. Sci. Policy 68, 80–86. https://doi.org/10.1016/j.envsci.2016.11.010.

Pallett, H., Chilvers, J., 2013. A decade of learning about publics, participation, and climate change: Institutionalising Reflexivity. Environ. Plan. A: Econ. Space 45 (5), 1162–1183. https://doi.org/10.1068/a45252.

Pascual, U., Balvanera, P., Christie, M., Baptiste, B., González-Jiménez, D., Anderson, C. B., Athayde, S., Barton, D.N., Chaplin-Kramer, R., Jacobs, S., Kelemen, E., Kumar, R., Lazos, E., Martin, A., Mwampamba, T.H., Nakangu, B., O'Farrell, P., Raymond, C.M., Subramanian, S.M., Termansen, M., Van Noordwijk, M., Vatn, A. (Eds.), 2022. Summary for Policymakers of the Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES Secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6522392.

Plank, C., Haas, W., Schreuer, A., Irshaid, J., Barben, D., Görg, C., 2021. Climate policy integration viewed through the stakeholders' eyes: A co-production of knowledge in social-ecological transformation research. Environ. Policy Gov. 31 (4), 387–399. https://doi.org/10.1002/eet.1938.

Pohl, C., Thompson Klein, J., Hoffmann, S., Mitchell, C., Fam, D., 2021. Conceptualising transdisciplinary integration as a multidimensional interactive process. Environ. Sci. Policy 118, 18–26. https://doi.org/10.1016/j.envsci.2020.12.005.

Popa, F., Guillermin, M., Dedeurwaerdere, T., 2015. A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. Futures 65, 45–56. https://doi.org/10.1016/j.futures.2014.02.002.

Raymond, C.M., Kenter, J.O., 2016. Transcendental values and the valuation and management of ecosystem services (Part B). Ecosyst. Serv. 21, 241–257. https://doi.org/10.1016/j.ecoser.2016.07.018.

Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M., Evely, A.C., 2010. Integrating local and scientific knowledge for environmental management. J. Environ. Manag. 91 (8), 1766–1777. https://doi.org/10.1016/j.jenvman.2010.03.023.

Raymond, C.M., Cebrián-Piqueras, M.A., Andersson, E., Andrade, R., Arroyo Schnell, A., Battioni Romanelli, B., Filyushkina, A., Goodson, D.J., Horcea-Milcu, A., Johnson, D. N., Keller, R., Kuiper, J.J., Lo, V., López-Rodríguez, M.D., March, H., Metzger, M., Oteros-Rozas, E., Salcido, E., Sellberg, M., Stewart, W., Ruiz-Mallén, I., Plieninger, T., van Riper, C.J., Verburg, P.H., Wiedermann, M.M., 2022. Inclusive conservation and the post-2020 global biodiversity framework: Tensions and prospects. One Earth 5 (3), 252–264. https://doi.org/10.1016/j.oneear.2022.02.008.

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., Stringer, L.C., 2010. What is social learning? Ecol. Soc. 15, 4. https://doi.org/10.5751/ES-03564-1504r01.

Rosendahl, J., Zanella, M.A., Rist, S., 2015. Scientist's situated knowledge: Strong objectivity in transdisciplinarity. Futures 65, 17–27. https://doi.org/10.1016/j.futures.2014.10.011.

Sipos, Y., Battisti, B., Grimm, K., 2008. Achieving transformative sustainability learning: engaging head, hands and heart. Int. J. Sustain. High. Educ. 9 (1), 68–86. https://doi.org/10.1108/14676370810842193.

Sol, J., van der Wal, M.M., Jelle Beers, P., Wals, A.E.J., 2018. Reframing the future: the role of reflexivity in governance networks in sustainability transitions. Environ. Educ. Res. 24 (9), 1383–1405. https://doi.org/10.1080/13504622.2017.1402171.

Stepanova, O., Polk, M., Saldert, H., 2020. Understanding mechanisms of conflict resolution beyond collaboration: an interdisciplinary typology of knowledge types and their integration in practice. Sustain. Sci. 15, 263–279. https://doi.org/10.1007/s11625-019-00690-z.

Stevenson, H., Dryzek, J.S., 2012. The discursive democratization of global climate governance. Environ. Polit. 21 (2), 189–210. https://doi.org/10.1080/09644016.2012.651898.

Stirling, A., 2006. Precaution, foresight and sustainability: reflection and reflexivity in the governance of science and technology. In: Voß, J.-P., Bauknecht, D., Kemp, R. (Eds.), Reflexive Governance for Sustainable Development. Edward Elgar, Cheltenham, pp. 225–272. https://doi.org/10.4337/9781847200266.00020.

Suskevics, M., Hahn, T., Rodela, R., Macura, B., Pahl-Wostl, C., 2018. Learning for social-ecological change: a qualitative review of outcomes across empirical literature in natural resource management. J. Environ. Plan. Manag. 61 (7), 1085–1112. https://doi.org/10.1080/09640568.2017.1339594.

Tengö, M., Hill, R., Malmer, P., Raymond, C.M., Spierenburg, M., Danielsen, F., Elmqvist, T., Folke, C., 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. Curr. Opin. Environ. Sustain. 26–27, 17–25. https://doi.org/10.1016/j.cosust.2016.12.005.

Timpte, M., Montana, J., Reuter, K., Borie, M., Apkes, J., 2018. Engaging diverse experts in a global environmental assessment: participation in the first work programme of IPBES and opportunities for improvement. Innov.: Eur. J. Soc. Sci. Res. S15–S37. https://doi.org/10.1080/13511610.2017.1383149.

Turnhout, E., Neves, K., de Lijster, E., 2014. 'Measurementality' in biodiversity governance: knowledge, transparency, and the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). Environ. Plan. A: Econ. Space 46 (3), 581–597. https://doi.org/10.1068/a4629.

Turnhout, E., Metze, T., Wyborn, C., Klenk, N., Louder, E., 2020. The politics of co-production: participation, power, and transformation. Curr. Opin. Environ. Sustain. 42, 15–21. https://doi.org/10.1016/j.cosust.2019.11.009.

van Riper, C.J., Thiel, A., Penker, M., Braito, M., Landon, A.C., Thomsen, J.M., Tucker, C. M., 2018. Incorporating multilevel values into the social-ecological systems framework. Ecol. Soc. 23, 25. https://doi.org/10.5751/ES-10047-230325.

Vadrot, A.B.M., Rankovic, A., Lapeyre, R., Aubert, P.-M., Laurans, Y., 2018. Why are social sciences and humanities needed in the works of IPBES? A systematic review of the literature. Innov.: Eur. J. Soc. Sci. Res. 31 (sup1), S78–S100. https://doi.org/10.1080/13511610.2018.1443799.

Vardy, M., Oppenheimer, M., Dubash, N.K., O'Reilly, J., Jamieson, D., 2017. The Intergovernmental Panel on Climate Change: Challenges and Opportunities. Annu. Rev. Environ. Resour. 42, 55–75. https://doi.org/10.1146/annurev-environ-102016-061053.

Voß, J., Bauknecht, D., Kemp, R. (Eds.), 2006. Reflexive Governance for Sustainable Development. Elgar. https://doi.org/10.4337/9781847200266.

Wals, A.E.J. (Ed.), 2007. Social Learning towards a Sustainable World. Wageningen Academic Publishers, The Netherlands.

Washington, H., Piccolo, J., Gomez-Baggethun, E., Kopnina, H., Alberro, H., 2022. The trouble with anthropocentric hubris, with examples from conservation. Conservation 1, 285–298. https://doi.org/10.3390/conservation1040022.

Wittmayer, J.M., Loorbach, D., Bogner, K., Hölscher, K., Hendlin, Y., Lavanga, M., Vasquez, A., von Wirth, T., d Wal, M., 2021. Transformative research: knowledge and action for just sustainability transitions. DIT Working paper for positioning transformative research. Rotterdam, Design Impact Transition Platform. Erasmus University of Rotterdam. https://doi.org/10.13140/RG.2.2.28485.99047.