# Group modelling as discourse

## games, play, ontologies and the emergence of shared understandings

Max Willis[1][0000−0001−9718−4966], Greta Adamo[2,3][0000−0001−8108−2383], and Giancarlo Guizzardi[3][0000−0002−3452−553X]

[1] Universitat Politècnica de València, Spain
Corresponding author: maxwillismax@gmail.com
[2] Free University of Bozen-Bolzano, Italy
GretaAdamo@unibz.eu
[3] Semantics, Cybersecurity & Services, University of Twente, The Netherlands
g.guizzardi@utwente.nl

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GretaAdamo@unibz.eu
[3] Semantics, Cybersecurity & Services, University of Twente, The Netherlands
g.guizzardi@utwente.nl

**Abstract.** Participatory practices rely on group discussions to elicit information and shared understandings about systems under consideration, often employing representations such as conceptual models to help make sense of complexity. However the semantics of such models are often unclear, and a lack of participation in their creation can negatively impact their sense-making potentials. Ontologies can aid in multi-stakeholder engagements through semantic alignment, yet these can be difficult to learn and apply, adding more complexity to participation activities. This paper attends to these challenges by incorporating aspects of game and play to mediate expertise discourses through shared, cooperative, and playful experiences. It presents an exploratory case study of game-based group modelling using ontology-based models, reporting on two purpose-built group modelling games and their deployment in a conference workshop. The analysis of workshop outcomes examines in-game modelling, individual models, and corresponding model pairs, using qualitative discourse analysis techniques. Supplementary pre- and post-experience questionnaires and ethnographic observations elaborate the advantage of combining modelling, ontologies and games to foster and visualise shared understandings. This research sets a baseline for the study and development of participatory, ontology-based group modelling, and the examination of conceptual models as texts in multi-modal discourse analysis.

**Keywords:** Participatory sense-making · Ontologies · Game and play · Group modelling · Multi-modal discourse analysis.

## 1 Introduction

Participatory and collaborative practices are pillars of open and democratic science, and policy-making [62], especially in complex and critical sectors, such as social-environmental sustainability [43] and risk assessment [4]. Indeed participation is a prerequisite to ensure local, global, and equitable inclusion in knowledge co-production, the transdisciplinary engagement that concerns delicate and sometimes life-threatening matters [4, 48, 61]. Sense-making and the formation of shared understandings among interested parties are at the center of co-production strategies [6, 45], thus the development of adequate research tools for such interactions, their facilitation, data collection and evaluation are critical for successful implementation [65]. A large body of literature is dedicated to participatory knowledge representation, for instance in conceptual modelling (e.g. Enterprise and Business Process Modelling [19, 28, 53]), ontology engineering [15, 34, 47], with an even larger corpus in environmental and social-ecological systems sciences (e.g. [6, 65]). However, there is a prevailing lack of information on how the practices described deal with the mediation of pluralistic discourses and dialogues during co-design and associated group activities, which are often configured as challenging social spaces [36], particularly in transdisciplinary settings where redress of existing power imbalances is required for the inclusion of all participants' voices [61].

The study presented in this paper emerges from the recognition of ontologies and ontology-based formalisations as compelling tools for the explicit definition of shared meanings, for communication, and consensus-building [25, 44, 64]. As practices of formal disambiguation and conceptual alignment, ontologies would seem well-disposed to the tasks of co-design for knowledge representation. Nevertheless, ontologies can pose limitations in participatory contexts, including (*a*) a steep, time consuming, and often discouraging learning curve for beginners and (*b*) the potential imposition of top-down views driven by knowledge engineers with stakeholders in tow as information providers. Those claims are supported by relevant literature, e.g. [15, 26, 37, 47], and the authors' personal experiences. Additionally, (*c*) the current lack of in-depth human-centric research on *how* ontologies encourage consensus and foster shared understandings can bring further uncertainty to the use of ontologies in group activities.

This research addresses these limitations by integrating ontologies with aspects of game, play, and group modelling to structure unambiguous communication in *participatory sense-making* [14], and by paying close attention to the discourse, dialogue, and intersubjective engagements that are central to collaborative enterprise [68]. We present two purpose-built group modelling games, (i) *Type Token*, a game grounded on the top-level ontology *Unified Foundational Ontology* (UFO) [27] that aims at making ontological notions accessible for beginners, and (ii) *Risk Response*, an adversarial discourse game on risk and human responses, both of which revolve around the creation of ontology-based conceptual models through rule-based interactions. The co-design of these game artefacts was initiated by the first authors, and we report here on their gameplay during a conference workshop, as an exploratory case study. An evaluation is presented via *multi-modal discourse analyses* [51] that examines group models, pre- and post-experience questionnaires, photographs of gameplay, group debriefs and observations of participant interactions. The main contributions of this research are ($C1$) the introduction of gameful experiences to guide partcipatory sense-making using ontologies and ($C2$) a new perspective on analysis of ontology-based group modelling as discourse, which allows to trace uptake of ontological notions in emergent shared understandings.

The article is structured as follows: Section 2 introduces background knowledge, Section 3 explains the research design, Section 4 and 5 outline results and offer critical reflections. While Section 6 discuss the efficacy and utility of the research, Section 7 provides contextualised related works, finally Section 8 concludes the paper.

## 2 Background Notions

Participatory sense-making [14] is the shared construction, appreciation, and modification of meanings through social situations that involve discussion and embodied interpersonal experiences [20]. Design for participatory sense-making involves the development of artefacts, such as narrative texts, models, and games, to reinforce intersubjective engagement and drive pluralistic discourse [68]. So-called gameful interactions [57] can be particularly useful for participatory sense-making [69], and games have long been used to facilitate group activities, from sustainable development research [17] to Requirements Engineering [13]. The utility of games in participatory practices leverages the social contract that agreeing to play a game entails, as participants signal their availability and interest to engage in cooperative behavior [57]. Game mechanisms of rule-based interaction, turn taking and role-play can drive intersubjective engagement, re-frame power imbalances in communication and incite inclusive participation [68], which are especially important in outlining socio-technical systems which have existential impact on people's lives, for example AI-driven information applications used to inform sustainable development policy [49].

Participatory processes and sense-making are grounded in *discourse*, the use of spoken and written language in a social context, and *dialogue*, the sequentially evolving communication between and among actors [8]. Dialogue is necessary in the development of intersubjectivity [23], the connection between participant identities in interaction, and the maintenance of dialogue is an act of social coordination [54]. *Discourse analysis* (DA) offers a range of insights into the communication acts and development of mutual grounds [51] at the heart of participatory sense-making. DA brings to light *dialogic syntax*, the analysis of linguistic structures such as resonance, the iterative re-elaboration of speech partners' utterances [16], and *discursive psychology*, [67], naturalistic text interactions and texts' relations to participant actions and goals. Critical Discourse Analysis [63] further examines the structures of power and control conveyed by the rules and norms of verbal communication, attention to which aids in balancing expert and non-expert voices [56, 61]. Over many decades of practice in cognitive linguistics, social psychology and Human-computer Interaction (HCI), *multi-modal discourse analysis* [12, 39] has expanded the definition of discourse, and what constitutes text beyond spoken and written language, to include any symbolic representation or embodied communication that contributes to the sense-making of a subject, as well as their *intertextual* relations, i.e. similar or differentiated semantic properties [51]. Although related to multi-modal interaction analysis in HCI [60], and Conversation Analysis [58], multi-modal discourse analysis refers specifically to techniques for examination and evaluation of the discursive properties of textual artefacts which are extended to include game-play interactions, embodied communications and co-created models in addition to written and spoken language.

A type of participatory sense-making involves a family of practices we refer to as *group modelling*,[4] which belong to a range of disciplines, from computer science and information systems (see e.g. [28, 53]) to sustainability sciences and policy-making [6, 61, 65], and development research [17]. In group modelling, knowledge is elicited through multi-party discussions that strive for mutual learning and problem solving, subsequently modelled using a variety of analog and computational tools [65]. It exploits well-known social science and HCI approaches to engage stakeholders, gather information, and collectively design artefacts. *Facilitation*, a central aspect of group modelling, can involve the use of diagrams, pictures, the ever-popular sticky notes, digital interfaces, and games [65], yet all facilitation is not created equal. Its democratic and inclusive enactment requires expertise, experience and tacit knowledge derived from trial and error, and the mediation of the chosen modelling activity, which can include *qualitative* (e.g. causal loops diagrams and simple conceptual models), *semi-quantitative* (e.g. fuzzy cognitive maps), and/or *quantitative* representations (e.g. agent-based modelling) [65]. Frequently outcomes from guided group tasks are modelled by an expert modeller, such as in companion modelling [17], bringing into question the level of actual stakeholder participation in the modelling life-cycle [33].

## 3 Research Design

The **goal** of this exploratory case study is to evaluate gameful approaches for group modelling, and examine the structuring of unambiguous communication through the introduction of ontological notions. It follows Constructive Design Research protocols [35] and builds on previous research experiences, literature reviews, community discussions, and evolving design intuitions to create artefacts, enact interventions with them, and interrogate the outcomes for insights. This Section describes the research context and artefacts (Section 3.1), data collection, and evaluation approaches (Section 3.2).

### 3.1 In-the-Wild Deployment and Research Artefacts

The artefacts and activities of this study emerged from several preliminary investigations by the authors of ontology-based interaction design [69] and and use

[4] For a terminological discussion on participatory, collaborative and group model building see [66].

of participant-authored models as interaction analysis tools [72]. These informed the design of the two group modelling games described in the following, and their in-the-wild deployment at the *1st Playing with Meanings* (PwM) workshop, part of the *Joint Ontology Workshops* (JOWO 2024) held at the *14th International Conference on Formal Ontology in Information Systems* (FOIS2024) conference conference held in Enschede, Netherlands.

The workshop setting was predominantly interactive and took place in two sessions facilitated by two authors. In the first session, participants played the foundational ontology *Type Token*, and in the second, the adversarial discourse and group modelling *Risk Response*. Figure 1 depicts the two games in action. Conference attendees could join one, or both sessions, and were asked to sign an informed consent document which acknowledged that records of their participation would be included in the study. Preflight and post-experience questionnaires were provided, with a followup questionnaire after three months. Consent form and questionnaires can be found in the additional materials: `https://drive.google.com/drive/folders/1C76kH9o1_7HUs6rAFHNM82yhjjZkTLC6`.

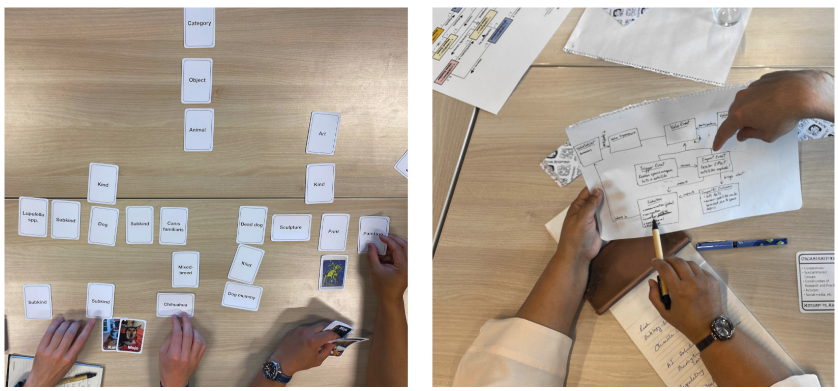

**Fig. 1:** *Type Token* (left) and *Risk Response* (right) group models.

*Type Token.* This session was initiated with a presentation of the project and a primer on participatory sense-making, and continued with gameplay of *Type Token*, which introduces salient UFO concepts [27]. UFO comprises a theory of types, with finer-grained ontological distinctions among types of types. For example, it distinguishes between: *kinds* (types that capture essential properties shared by their instances and that provide a uniform principle of identity for these instances, e.g. Bird); *subkinds* (static specializations of kinds; e.g. Waterfowl); *roles* (dynamic and relational specifications of kinds, e.g. Laying Hen); *phases* (dynamic but non-relational specializations of kinds, e.g. Chick); *categories* (union types that classify instances of multiple kinds, e.g. Raptor for the union of Hawk and Falcon); *collectives* (types whose instances are mereologically complex entities composed of multiple members, e.g. a Flock of birds). The game's objective is to introduce players to aforementioned UFO distinctions by modelling taxonomic structures with printed cards; an initial card starts the model, and in successive turns, players must add ontologically coherent phrases, vertically or horizontally building on card sequences, i.e. *threads*, that have previously been played. Special cards allow players to overcome of impasse, when no card in play can be added to the model, in which case a player can trade their cards with new ones from the deck, take cards from another player, or clean up the model and start anew. A detailed description of the game, its cards, rules and gameplay is available in [70]. The gameplay session lasted approximately 60 minutes, and wrapped up with a short debrief.

*Risk Response.* In the second session, participants played *Risk Response*, the adversarial discourse game that has its origins in an ontological unpacking of the Intergovernmental Panel on Climate Change (IPCC) definitions of climate change risks [1], extended with concepts from United Nations Disaster Risk Reduction (UNDRR) risk profiles and with cybersecurity and socio-technical systems concepts. Game time was also approximately 60 minutes. The goal of *Risk Response* is to stimulate discussion and group modelling, and unfolds as players form two teams: Team Risk must propose a risk, and Team Humanity must devise a plausible response. A discussion phase using a Futures Cone diagram (see additional materials, adapted from [22]), then ensues to decide a winner. Is Team Risk's proposal overwhelming, or will Team Humanity's response overcome? In Level I conversational play, risks and responses are discussed and debated vocally. In Level II group modelling play, teams create conceptual models to describe and argue for their proposals. As each team describes their Risk or Response, they draw a model following a reference model, for which blank A3 paper and several colors of marker are provided. The game is described in detail in [71].

Group modelling task employed reference models to guide and ground the model created by group's participants: the first round of gameplay followed the largely UFO-based *social-ecological systems (SESs) integrated model* [2, 3], that represents components such as *governance*, *natural*, *human-made resource*, *plan*, and *ecosystem service*, and their relations. The model and several of its patterns were made available as A2 and A3 printouts, as was the Futures Cone diagram. For the second round, the *Common Ontology of Value and Risk* (COVER) [52] served as reference model, with accompanying printed A3 model patterns extracted from that ontology. COVER is a UFO extension that deals with elements of risk and value, for example *vulnerability*, *object at risk*, *value object*, and *threat event*. White A3 paper and four colors of sharpie markers were provided for the group modelling. This session also concluded with a debrief, and participants were directed towards the post-experience questionnaire.

### 3.2 Data Collection Methods and Evaluation Strategy

A variety of data was collected before, during, and after the workshop for analysis. The modalities, i.e. types of data analysed, are listed in Table 1 and include:

a pre-flight questionnaire (**PreQ**), the *Type Token* and *Risk Response* collaborative models (**TT, RR**), post-experience (directly following) and post-post-experience (after three months) questionnaires (**PostQs**), photographic evidence (**Photo**), and supplemental group debrief feedbacks and ethnographic observations (**EObs**).

**Table 1:** Multi-modal discourse analysis dimensions.

| | **Modality** | | | | | |
|---|---|---|---|---|---|---|
| | | Coll. modelling | | | | |
| **Meta-function** | **PreQ** | **TT** | **RR** | **PostQs** | **EObs** | **Photo** |
| Ideation [idea] | + | + | + | + | - | + |
| Interpersonal [interp] | - | + | + | + | + | + |
| Compositional [comp] | - | + | + | - | + | + |

*Multi-modal discourse analysis* [12] was chosen as the evaluation method for its utility in elucidating intersubjective engagement in participant-authored texts and game-based interactions [68], and allowance for coincident examination of graphical and textual aspects of conceptual models created during gameplay. In discourse analysis, data is annotated using [codes] that correspond to particular linguistic forms and useage; coded words, phrases and passages are scrutinized within and between modalities, i.e. intertextual analysis. Through this process complementary intersemiotic relations, the ways that different modes of expression complement each other in their production and conveyance of meanings [51] are identified, such as markers of participants' intersubjective engagement [23], and the articulation of similar, or differentiated meanings, i.e. signs of common ground [20]. We follow a revised framework for Halliday's *Systemic Functional Linguistics* [29], after [51], to isolate three textual meta-functions: ideation [idea] (what is represented in a text/image), interpersonal [interp] (use of semantics in action and social contexts), and compositional [comp] (structure of visual and textual elements). Table 1 summarises (i) the **modalities** and (ii) the discourse **meta-functions** under analysis, wherein the symbols + and - specify the presence/absence of the meta-function within each modality. Additional codes used in the analysis, which can be found at "workshop_data_and_analysis" are as follows:

- syntactic resonances [res], or dialogic resonances, mark the repetition, use and reuse of language to introduce and maintain conversation topics [16]; these are signs of emergent intersubjectivity, i.e. participants' engagement with one another's perspectives [46].
- intersubjective repair [rep], or repair-after-next-turn, is the use of language structures, also by third-parties, to redress misunderstandings and breakdowns of intersubjectivity [23, 54] in sequential communication.
- Repair can demarcate disagreement [disag] being handled in consensus, or in an agonistic sense (see [68]), absorbed in pluralistic discourse; it denotes the overlapping of individual understandings, or dynamic understanding [41].

– EMBODIMENT [EMB] is a reference to physical, gestural and bodily objects that form part of a discourse [67], including interactional displays and the use of space and material artefacts, positioning, gaze, laughter, and non-verbal language; these provide reinforcement cues towards agreement/disagreement.
– SEQUENTIAL ELABORATION [SEQ] is the turn-based unfolding of discourse, wherein meanings evolve and are elaborated from what is expressed before, and after a participant's communicative action; indicates emergence of shared understandings, i.e. ideational, and at times compositional, cohesion [51].

## 4 Results

This section reports on participant demographics and the multi-modal discourse analysis of the group models (spreadsheet available in the additional materials, see the README for assistance in navigating the files). A total of twenty-five (25) participants joined the workshop, fifteen (15) of whom completed the questionnaires. The majority claimed Millennial age, with 3 Gen. Z, and one Gen. X, with 8 males and 6 females and one who "prefer not to say" their gender. Only 3 respondents declared to have middling to no expertise with ontologies, most considering themselves to be advanced or near to, 5 stated having none or beginner level experience with conceptual modelling, and the rest claiming between intermediate and expert experience. While most of the surveyed subjects had never played research games, all regularly engage in gaming, many quite frequently, predominantly role-playing games, board- and card games, with between 3 and 5 players.

### 4.1 *Type Token* Group Models

This session was attended by 17 participants arranged in 3 groups, *A* (4 players), *B* (8 players), and *C* (5 players). We examined models that were on the tables at the final stage of the session. *Group A* created a model using 24 cards that had two main threads, the [IDEA] elaborating a UFO *Category* of *Object* and a third thread of artefacts with associated tokens, e.g. *Dog mummy*. They used 5 UFO types and 11 specialised classes. *Group B* constructed a model using 37 cards, with four main threads [COMP], two of which were modelled in multiple directions, two branching clusters with numerous instances, two outliers, and several clusters of instances around a class. *Group C* used 11 cards to create a model with two ontological interpretations of *Dog* [IDEA]: as an actual animal instantiating UFO *Subkind*, with two instances, and as an artefact, i.e. a *Dog-Sculpture* with multiple instances. A transversal row of cards ([COMP]), extended the *Sculpture* card, with *Print*, *Photograph*, and *Painting*, signaling that these are types that are siblings of the type *Sculpture* as common specialisations of the same super-type.

Ontological assumptions across the group models were for the most part coherent, showing development of shared understandings via sequential elaboration

[SEQ], even if the ontological structures were not always correct. For example, *Group B* modelled correctly that *Dog* and *Cat* are both *Subkind* of an *Animal* class, but also that *Species* is a *Kind* belonging to the *Animal* class, and it subsumes *Lupullella sp.*, *Canis familiaris*, as well as *Cat* [IDEA]. *Groups A* and *C* both sequentially elaborated [SEQ] a secondary thread of artefact classes, e.g. *Print*, *Image*, *Photo* and *Box*, many with associated tokens, that diverged from their main game model. These threads were not elaborated with UFO meta-type cards, yet were correctly populated with subkinds and instances. Both groups accepted this transversal modelling practice, and in concerted efforts of repair [REP], players further elaborated them during subsequent turns [SEQ]. In *Group C* the artefact classes appeared in a horizontal row within the main model, while in *Group A* an *Object* card placed above eventually brought their secondary thread into alignment with the main model [REP]. At one point in *Group C*, a *Photograph* class card had been added, with a instance photo of a mixed breed dog, either as meta-play or as another compound class *DogPhotograph*. This was removed from the model [DISAG], and became the source of extended debate. *Group B*'s model also included meta-level play as a token of *Sleeping cat* is placed below the class *Image*, yet this gameplay was agreed by the group.

When the *Type Token* B deck was introduced, *Groups A* and *B* immediately added it to their gameplay, while *Group C* ignored it and continued on their initial model. At several points, when it appeared this group was having difficulty, the facilitators suggested they should feel free to start again, to which several group members replied [Oh No! We are having fun!] and one explained that argumentation and disagreements is something that all of them, and indeed most of the community present at the conference, enthusiastically engages in [DISAG]. See Table 2 for more details.

### 4.2 *Risk Response* Group Models

Seventeen (17) participants played *Risk Response*, forming three groups, *A* (5 players), *B* (7 players), and *C* (5 players) each of them divided into *Team Risk* and *Team Humanity*. The groups were instructed to create models during the gameplay following, in the first round, the SESs integrated model, and in the second, COVER. Instructions on how to model were left purposefully vague, viz. to model their risks and responses using elements from the reference model, which resulted in a diversity of group modelling practices. Table 2 provides precise account of the elements captured in the group models [IDEA].

In the first round, both *Group A*' teams produced models *à la* UML mimicking the SESs integrated model [COMP]. Team Risk built their first model using 5 elements, correctly connected by 5 relations from the SES reference model, while proposing 6 new entities, e.g. *farmer* and *food production*. Team Humanity used 4 elements and 1 type of relation repeated three times from the reference model [RES], plus 5 new elements. *Group A* did not model in the second round using COVER, yet engaged in a personal discussion on the risks and possible response to the impending loss of indigenous languages [IDEA]. *Group B*'s Team Risk, in their first modelling session, used 3 elements and 2 relations from the

**Table 2:** Group modelling results breakdown.

| | **Type Token** | | |
|---|---|---|---|
| | *Group A* | *Group B* | *Group C* |
| #of players | 4 | 8 | 5 |
| #of cards | 24 (tot.), 1 in play, one uncertain | 37 | 11 |
| Type of cards | 6 instances (+ 1 in play)<br>5 UFO entities (+ 1 uncertain)<br>11 specialised cards | 14 instances<br>7 UFO entities<br>17 specialised cards | 5 instances<br>1 UFO entities<br>7 specialised cards |
| #of thread [COMP] | 3 | 4 | 3 |
| Type of INTERP | REP | REP | REP,DISAG |
| Meta-play | + | - | +/- |
| | **Risk Response** | | |
| # of players | 5 | 7 | 5 |
| *Ref. model* | | *SES integrated model* | |
| ***Team Risk:*** | | | |
| Ref. model element | actor,activity,plan,<br>social actor,resource | natural resource,actor<br>human-made resource | natural resource,government<br>organisation,actor<br>human-made resource |
| Ref. model relation | performed by,affects,<br>is_a<br>recognized by,relevant for | affects,is_a | is_a |
| New element | protect habitat,habitat<br>habitat loss,State of the Netherlands<br>farmer,food production | habitat,reservoir<br>lakes,water scarcity | farmers,income, population,crops<br>food insecurity,rain/water<br>feed people,drought,flood<br>short bouts of heavy rain,impact<br>reduced crop production |
| New relation | - | - | - |
| ***Team Humanity:*** | | | |
| Ref. model element | human-made resource,activity<br>organisation, natural resource | - | governance |
| Ref. model relation | recognizes (3) | is_a | - |
| New model element | empty building,urban farming<br>intention to preserve<br>company,natural habitat | FOIS,servers,robots (defend)<br>Internet of Things,GIS<br>Earth Observation,byproduct<br>integrating ontologies<br>creating a super-AI<br>dune technology,material science<br>destroy fashion industry<br>destroy capitalism | regulate the prices,technology<br>external trade partners<br>economy,replace crops<br>investments in new markets |
| New model relation | has,uses,exploits | defend,located in<br>utilizes,enables | - |
| *Ref. model* | | *COVER* | |
| ***Team Risk:*** | | | |
| Ref. model element | - | (risk)event,risk enabler<br>vulnerability,loss situation<br>object at risk | value subject,value experience<br>value event,value enabler<br>trigger event,impact event<br>intention,impactful outcome |
| Ref. model relation | - | is_a | participates in (2),causes(2)<br>impacts (2),inheres in, is_a |
| New model element | - | mad hacking skills<br>passwords are not quantum safe<br>password secure software<br>2.53 cracking password software released | humans,Russian space weapon hits a sat.<br>Kessler Effect! satellites explode!<br>communication (global),navigation<br>weather satellites<br>space travel,espionage<br>GPS fails<br>No new sat. launched due to space debris |
| New model relation | - | | brings about |
| ***Team Humanity:*** | | | |
| Ref. model element | - | risk event | - |
| Ref. model relation | - | - | - |
| New model element | - | systems isolation<br>massive hacking systems! | mitigation,space clean<br>solutions to current problems<br>future tech,old tech,EWS<br>Engage SM to employ spy |
| New model relation | - | - | - |

SESs reference model, and invented 4 new elements. Team Humanity's response model used none of the reference model's elements, and invented numerous entities, e.g. *servers* and *byproduct*, using lines in place of *is_a* relations. While the compositional structure of both teams diverge from the reference framework

[COMP], Team Risk produced an organised representation, instead Team Humanity's model is rather disorganised; the dissonance continues in the second round models using COVER, which offer few discernible resonances [RES].

*Group C*, in their SESs integrated model, produced a schematic textual description of risk and response scenarios [COMP], naming 4 elements from the reference model and exclusively using *is_ a* relations. The response description used entirely invented classes and no relations. In their COVER models, *Group C* risk model directly reflected the COVER pattern [COMP], with main elements named and labelled with proper relations. *Group C*'s response model elaborated mitigation solutions from an explicit futures perspective, differentiating between *old tech* and *future tech*, with examples of yet-to-be discovered technologies [IDEA]. This explicit notion of potential future technologies shows the intertextual relations with the Futures Cone [22].

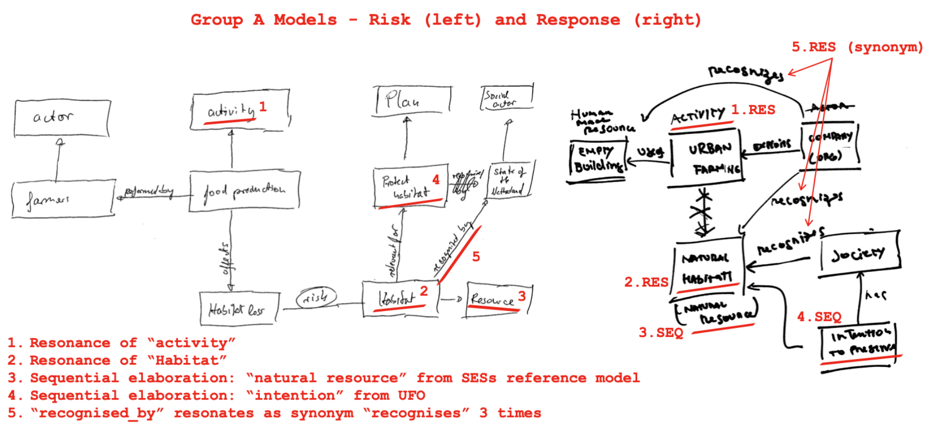


**Fig. 2:** Intertextual relations of Group A *Risk Response* models.

An examination of the models as discourse uncovers intertextual semiotic traces between them, and in the following we focus on specific instances which demonstrate the percolation of concepts from the reference ontologies in particapants' sense-making. For example, in *Group A*'s *Risk Response* models (see Figure 2) multiple resonances can be identified as parts of the risk model are mimicked in the response model [RES], directly, as with the entities *activity* and *habitat*, and as synonyms, in the reuse of the *recognized by* relation from the risk model, as *recognizes* in the response. These resonances reflect the game's framing of the textual exchange, wherein the second team was prompted for a response. Examples of sequential elaboration [SEQ], however, depict the mediation effect of the ontology and emergent shared understandings, such as where Team Humanity further specifies *habitat* with its superclass *natural resource* following the reference SESs integrated model, renaming it accordingly *natural habitat*, and their elaboration of the concept *protect habitat* as *intention to preserve*, drawing from the UFO assumptions [27] found in the SES model, i.e. *social actor* is a *actor*, and has *intentions.* In another profound intertextual relation from the second round, the COVER-inspired risk model of *Group B* depicts several empty boxes connected with unlabelled relations, all correctly placed as in COVER. Similarly, *Group C* modelled several blank COVER entities, correctly labelled, but unpopulated. The compositional structure ([COMP]) of both models and their ontological commitments ([IDEA]) are expressed by mimicking the structure of the ontology, even if the understanding of each element is not articulated.

## 5 Critical reflections and limitations

The following offers some critical reflections on (i) *the utility of our gameful approach*, and (ii) *the analysis of group models as discourse* and their potential to guide, and study, emergent shared understandings using ontologies.

*The gameful approach.* As evidenced by the group model analysis, participants in groups took quickly to the *Type Token* and the reference ontology concepts, although further intertextual analysis referencing participant responses to the questionnaires offer additional perspectives. Respondents commonly stated they "*learned how to play only after we played some.*" suggesting the games were not immediately understandable. Yet across the modalities and groups, players exhibited a grasp of meta-level understandings, e.g. one player reflected on internalising the difference between Type and Token but that they did not "[...] *think about the answer during the game, because the difference was already apparent in the sense that Tokens had pictures on the cards and Types had just the names.*" Several participants explicitly referenced ontology-driven discourse in feedback, e.g. "*The presence of images on cards was debated during our session, 'à la Duchamp': discussing if the card per se was representing e.g. a puppydog, or a photo of a puppydog, or a physical support reproducing a photo of a puppydog...*", and most engaged in participatory sense-making with the ontologies, at least for the duration of gameplay. For some this engagement extended beyond, with one suggesting after three months that playing *Type Token* had some influence on their thinking during study or working practice, and "*that the opinion or perceptions of type token can differ and it is important to discuss it.*" Many players reported learning, e.g. about UFO subkind, and discussing the ontological topics of Sortals, Rigidity, and Phase, and while several agreed that *Type Token* helped to understand foundational ontologies, some were less convinced that it provided better understanding of UFO. Of 10 participants who answered the question "When there was misunderstanding or a dispute in the game, how was this resolved?," all chose the answer "*Together we as players decided what was correct/acceptable*," although three also selected the answer about having searched online, three said that a more expert player explained, and one stated that their group moved on without proper resolution. All 6 participants who responded to a multiple choice question about their participation during gameplay felt that their voices and perspectives were valued during discussions. Overall the analysis supports the notion that gameful approaches have the potentials to assist in introducing complex ontological structures, concepts and relations, while mediating pluralist discourse in participatory settings.

*Group modelling as discourse.* Examination of the group models provides evidence of the uptake of ontological concepts, and conceptual alignment within and between groups, yet also reveals some challenges. For example the models from *Risk Response* varied widely, even though a majority of players reported having some experience with conceptual modelling; the models were for the most part coherent, but not always ontologically correct. Although they were quite agile at creating elements and drawing relations, many were less able to label those relations, hence stricter rules and clearer instructions on what, and how to model, may be necessary. The *Risk Response* models contain many instances of participants' sharing understandings with, and without agreement. Sequential elaborations of concepts between the group models provide some sense that consensus was reached, even if group understanding did not always comply with the ontologies. However the various parallel occurrences of both agreement and disagreement in, and between group models, and during modelling activities, suggest that ontologies not only facilitate consensus, but also flexibly accommodating for a plurality of understandings. Yet, there remains a challenging negotiation between the need to ease people into ontologies, and the structured representation of their thinking as group models, while ensuring that abstract notions are correctly understood and interpreted.

*Limitations.* The main limitations of this study regard facilitation, target audience, and participation itself. In retrospect two facilitators were insufficient to engage participants, record, and report; at least a third facilitator would be required to take photos and observation notes. In addition, participants were rather few in number, and all had pre-existing interest in ontologies, which likely influenced their positive engagement. A more comprehensive study involving a more diverse group of expert and non-expert members, from different communities would be needed to claim the games' utility for ontology learning. Finally, engagement with the questionnaires was patchy, and future facilitation should leverage the situation's momentary social contract to prompt attendees into completing the surveys *during* the workshop.

## 6 Efficacy and utility of the research

Games and playful experiences are acknowledged tools for managing group interactions and structuring discourse in knowledge co-production. Their potential for guiding social learning has been leveraged for decades to gather knowledge and inform stakeholders in systems analysis, management and design [32]. Simulation games play an important role in the elaboration of socio-ecological systems concepts [10], working with people at the community level both to understand local and traditional perspectives, and to guide understandings of sustainability, conservation and risk outcomes [55]. In information sciences, such as in Requirements Engineering, games offer tools to negotiate expertise discourses [56], wherein informal, playful situations bring together various expert, and non-expert, opinions, perspectives and tacit knowledge to build a more complete understanding of a system under consideration [13]. However the empirical study of such games is complicated by the multilayered overlapping of experience, information, social interaction and learning which combine in games (see [42]). While acknowledging that proving the efficacy of game and play approaches is a valid and interesting area of study, this study makes no claims as to the superiority of game and play techniques over other stakeholder engagement or learning strategies, and eschew analysis of the learning potentials of our games. Rather we deploy games for their collaborative, discursive functions, the shared social experience and connection between players [57] that games provide, and examine aspects of participatory sense-making from within game-based experiences. The particular focus of this research is on the uptake and mediating influence of ontologies, communicated and shared through collaborative creation of conceptual models, which is supported by the discourse analysis. The rule-based interactions of the proposed two games provide a lattice upon which discussions can build, and the onus is more on the procedures of group modelling [65] in navigating a plurality of perspectives that arise in multi-stakeholder engagements. Participant feedback does suggest that less expert participants, and less vocal participants, are afforded opportunity to add to discussions during gameplay, and as in Type Token, actually engage in modelling practices which are often dominated by more experienced modellers [33].

In social-ecological systems, risk, and sustainability research, the inclusion of pluralistic perspectives from e.g. academia, business, government, civil society and local communities, provides a richer description of the components of a system and how they interact [48]. Equally useful for enterprise modelling [28, 53], the game-based participatory process can integrate the management perspectives of how an organisation *should be structured* with those of line managers, employees and even customers on how it functions *in practice*. In software engineering, the use of multi-stakeholder game and play interactions is well established (see e.g. [9]) and extends to the design of how future information systems *can be* configured, for example in AGILE development [50] and requirements elicitation [40], looking beyond which components and processes are necessary, to address understandability, accessibility and the user experience of proposed systems. Throughout these practices is infused an attention to mediating discourses among experts and non-scientific stakeholders, wherein the use and co-creation of conceptual models becomes a form of communication [21] to co-produce knowledge, outlining, examining and defining systems that accommodate a plurality of needs and intentions.

## 7 Related works

Despite the proliferation of participatory modelling techniques in fields such as environmental science [66], we were unable to retrieve empirical studies combining ontologies, group modelling, game and play. Practices such as risk and vulnerability assessment [4] strongly focus on developing models with stakeholders, but seemingly without formal semantics. Literature on disaster risk games abounds, typically reporting on simulations and role-play for multi-party information sharing [55], yet few concrete ontology games exist, notable experiments being *Play-a-LOD* (`www.pldn.nl/wiki/Play-a-LOD`), a game to learn Linked Data triples and rules, and one for mapping of greenhouse data using the Semantic Sensor Network Ontology (SOSA/SSN) [11].

The combination of games and group modelling is a recurrent theme in information sciences literature, as Bakhanova et. al [5] report on potential uses of games for participatory modelling, yet beyond seminal investigations of role-play and model sketching with stakeholders by Bousquet et al. [7], and the use of a game for knowledge elicitation in *Companion Modelling* [17], in-game modelling has few precedents. The crossover of models, games and simulations has been widely examined, for example games for business process modelling [38], service design [30] enterprise modelling (see [31]) and agent based modelling [59]. However few examples of games can be found which facilitate collaborative creation of models as a game mechanic, and the bulk of this research is on modelling game mechanics, interactions or genres, and applying specific models to create games, often in educational contexts. A promising team-based game does exist for ontology and modelling discussions on cultural heritage information using the CIDOC Conceptual Reference Model [26]. This has evolved into a digital edition, however that appears not to enact group modelling, but single-player learning. Unfortunately, the evaluation of the aforementioned games, is limited to either domain-specific functionalities, or reporting on post-experience questionnaires, and lacks at the moment concrete evidence of learning outcomes. In sum, the cross-chatter between ontology, risk, and modelling communities on the need for new forms of engagement and learning has not (yet) translated into a substantial body of research.

Though it does not specifically concern game-based or group modelling, one notable related work approaches modelling and discourse analysis by examining ontology, argumentation and agency [24].However in our study we do not employ video or audio surveillance necessary to record players' in-game argumentative or rhetorical strategies, to preserve the intended relaxed play experience, and attenuate ethical challenges regarding personal data protection [18].

## 8 Concluding remarks

This paper presents an empirical research that combines game, play and ontology-based group modelling. An exploratory study evaluates two group modelling games, *Type Token* based on a foundational ontology and *Risk Response* that can deploy various frameworks for risk and response discussions. Multi-modal discourse analysis is applied to a collection of models and texts generated before, during and after the workshop, and provides evidence of (i) the utility of the gameful approach to foster intersubjective engagement and pluralistic discourse using ontology-based formulations, and (ii) the uptake of ontological notions from reference models and their structuring of participatory sense-making. Future works on the gameful approach to ontology-based participatory sensemaking include a multi-player game for another top-level ontology to play with relations, and an update to *Risk Response* that adds compound risks and their analysis.

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