

# Pedagogical Challenges in Social Physics Authoring

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**Abstract.** Authoring interactive narrative content for AI engines can be a difficult task, and as our work on collaborative social-physics based projects like *VESPACE* and *Vox Populi: The Ustradian Games* has revealed, there exist numerous key difficulties in training content authors. Despite the prevalence of these setbacks over years of training new authors, no comprehensive survey, analysis, or codification of pedagogical challenges has heretofore been completed. In order to formalize this knowledge, we have conducted an analysis of experiential results from previous workshops and collaborations as well as from written participant feedback and reflections. Our primary research objective has been to analyze these pedagogical challenges and their origins, including conflicting paradigms, unfamiliarity with computer science concepts, difficulty visualizing and managing authored content, and unresponsive feedback loops. Lastly, we introduce a design and prototype of a tutorial game which will train users in the authoring of content for the Ensemble social physics engine. The game’s design is a response to the challenges revealed in our analysis and will be one of open-ended freedom of play, leveraging the playful experimentation of the engine and guiding players to an intuitive understanding of the engine’s underlying mechanisms as they create and explore.

**Keywords:** emergent narrative · authoring tools · pedagogy

## 1 Introduction

Emergent narratives are narrative structures which are not predefined but rather generated by users through interactions and choices [2] [13]. These narratives have exponentially larger spaces of possible playthroughs as compared to more traditional narrative experiences, including modern video games using branching narrative logic [26]. Social physics engines like *Comme il Faut (CiF)* [20] and its spiritual successor *Ensemble* [27] offer one approach to the creation of emergent narratives by leveraging concepts relevant to the broader domain of social physics, including network theory and predicate logic. Social physics games can take the form of social puzzles [17], where players must try to anticipate the potential social effects of their actions [18], considering, for example, the range

of likely emotional responses by non-player characters [12]. Social physics systems in the CiF family have been implemented in mods to AAA games such as *Skyrim* and *Conan Exiles*, with user studies suggesting that players prefer and gravitate toward NPCs guided by such engines [11] [10] [23].

Unlike pre-written narratives, however, the authoring of content for the CiF and Ensemble engines requires the composition of predicate logic defining the logical structures and rules of the interactive world, including the realm of possible truths and states—known as a schema—as well as the individual rules which govern social behaviors and the range of actions that players and NPCs can take. Previous research has identified general challenges in the field of interactive digital narrative storytelling [14], surveyed issues presented by existing interactive narrative authoring tools [9], and examined pain points in interactive narrative authoring caused by authors’ lack of knowledge of underlying computational models [31]. However, the existing research has not yet examined the unique challenges of authoring for systems like Ensemble, wherein content is authored solely as first-order predicate logic rules rather than narrative fragments.

The authoring process may differ greatly depending on the goals of the authors. For example, in early applications of the CiF and Ensemble engines, content authors generally took an informal approach; for example, the authors of the game *Prom Week*—consisting primarily of computer scientists—strove to approximate the sociological and psychological situations portrayed by films in the “teen movies” genre [28], using examples from films of the genre for reference [19]. Subsequent projects like *VESPACE* and *Vox Populi: The Ustridian Games*, however, have required more stringent authoring processes. Both of these projects, being multidisciplinary collaborations between researchers in artificial intelligence, the humanities, and social sciences, required the training of researchers from outside the field of computer science in social physics authoring. In this paper, we will introduce these two projects and outline the various difficulties in author training which they have revealed, as well as the numerous methods which we will employ in our tutorial game in order to address and circumvent them.

Based on experience and feedback from *VESPACE* and *Vox Populi*, several pedagogical issues appear to occur with some regularity in collaborative social physics authoring efforts, and our hope is that documenting these challenges will aid future teachers and authors in their authoring endeavors. In order to address these difficulties head on, the training hurdles enumerated in our analysis have inspired our current tutorial game project, which seeks to guide users in effective social physics authoring by leveraging the unique pedagogical opportunities afforded by open-ended gameplay; much of our tutorial game design has come directly from written responses that *VESPACE* workshop participants took part in and which we will draw from in this paper.

To address the challenges identified in our analysis, we have designed and prototyped a tutorial game to train users by reinforcing learning through exploration, so that learners can immediately experience the expressiveness of the Ensemble engine through real-time feedback, all while being guided by various

challenges and motivational goals. In the game, players will guide a household of pets through social interactions, exploring the narrative and social effects of authorial choices as they complete challenges and unlock new authoring capabilities. The term “*SimCity* effect” has been used to describe video games possessing this ability to develop player understanding of internal structures and mechanisms through gameplay [35] [34] [21]. We have sought to design our tutorial game with the *SimCity* effect in mind, utilizing open-ended gameplay and exploration, along with motivating techniques such as skill trees, in order to instill a familiarity with the functionality and potentiality of the Ensemble engine.

## 2 Authoring Projects

In this paper, we focus on the authoring challenges of two major collaborative efforts, the *VESPACE* and *Vox Populi: The Ustradian Games* projects; we chose these two projects based on their complexity and the fact that both projects were interdisciplinary in nature, consisting of collaboration between computer science and artificial intelligence researchers on one hand and humanities and social science scholars on the other. In contrast with other social physics-based interactive narrative games, the authoring for these projects was largely performed by participants with no previous training in social physics or computer science. The *VESPACE* project included an authoring collaboration with French literary historians, which was conducted through numerous authoring workshops that ran in parallel with the development of a collaborative web-based authoring tool. The *Vox Populi: The Ustradian Games* project saw collaboration with education and assessment specialists in order to develop a game which challenges users to think critically as they explore an unfamiliar culture.

### 2.1 Authoring *VESPACE*

The *VESPACE* project, a multidisciplinary collaboration between various universities in the United States and France, has sought to create a virtual reality experience reconstructing the physical and social spaces of eighteenth-century Parisian theatre [7]. The first phase of the project involved the virtual construction of the physical interior of the Saint-Germain Fair theatre based on visual depictions and historical data, leading to the production of a VR experience allowing participants to explore this reconstructed space. Subsequently, the project has focused on the construction of an interactive social game taking place within the virtual environment. Over the course of a year and through a series of workshops, we endeavored to train participating literary historians in the authoring of social physics content, with the ultimate goal of these researchers mining historical texts for social rules capable of producing social experiences which are faithful to period sources. The final game will provide players with an immersive learning environment, allowing users to explore not only the class and gender dynamics of the social mores of eighteenth-century France but also the complexities of historical interpretation [24].

Authoring for the *VESPACE* project has required the construction of a large corpus of rules and a schema tailored to the social norms of 18th century France; importantly, this content must be written by literary historians, with citations supporting each authoring decision. Before the authoring process could begin, we needed to conduct significant training workshops for prospective authors, as well as to develop a new authoring tool facilitating collaborative authoring. We first conducted a series of short workshops as we iterated through the development sprints of the tool, ultimately working up to the deployment of the tool and its use in a week-long remote workshop [6]. The first round of *VESPACE* author training included four half-day workshops, attended by a group of six and guided by three of the participants. Two of the three workshop leaders were computer science researchers, while the other leader was a professor of literary history who had undergone some one-on-one training in social physics concepts and terminologies. The other three participants were graduate students in literary history. These short workshops held a three-fold value: as training sessions for authors, as a means of identifying significant pedagogical challenges in the use of Ensemble, and as beta-testing scenarios for the authoring tool.

The second round of *VESPACE* author training consisted of one week of day-long workshops and was attended by eight participants, including the previous trio of leaders and five graduate and PhD students from various humanities disciplines. The end result of this workshop was a fully-realized schema for *VESPACE* consisting of 10 categories and a total of 113 types, as well as a rich rule set of 230 rules. Following this week-long workshop, we tasked all eight participants with composing an 8-12 page formal reflection outlining their experience, asking them to describe any difficulties they faced. We then conducted an informal analysis of these reflections, maintaining a list of challenges described by the authors. Following the informal analysis, we performed a more thorough analysis, keeping track of the frequency with which each challenge was mentioned, combining closely related challenges into categories, looking for keywords indicating a particular challenge’s severity, and collecting illustrative quotes for the paper. The results of this analysis are an important source of experiential data concerning the authorial challenges which we will codify and analyze in this paper.

## 2.2 Authoring *Vox Populi: The Ustradian Games*

*Vox Populi: The Ustradian Games* is a game-based assessment of cross-cultural competency and meta-cognition, created in collaboration with education and assessment specialists, that integrates complex social simulation technologies with gameplay. In the game, players seek to achieve objectives through having conversations with the people of an unknown artificial culture. The player’s dialogue options and the non-player character responses are determined by a modified version of Ensemble called the Social Practice Engine [33]. The game roughly conforms to the “Visual Novel” game genre, but rather than simply navigating pre-scripted dialogue trees, the responses are dynamically selected based on the social state and history of player choices. Because the results of

conversations are based on a rich model of the non-player character’s culture, to successfully play the game, players must focus on gaining an understanding of the culture, rather than memorizing socially appropriate sequences of actions, or simply enumerating all paths through dialogue trees.

The *Vox Populi* project followed a more informal collaborative approach, conducted in the form of meetings and emails, but the conclusions reached were the same as those of *VESPACE*, illustrating how social physics can be used fruitfully for the production of interactive experiences in other cross-disciplinary projects. Creating the artificial unknown culture required the authoring of many social rules and was largely done by a team of education and assessment researchers. Having these non-artificial intelligence researchers create this content required that they be trained in how Ensemble works. This training was done via several day-long workshops, as well as through emails and many remote meetings over the course of two years.

### 3 Challenges in Social Physics Authoring

The collaborative experiences of developing social physics content for *VESPACE* and *Vox Populi* have revealed numerous difficulties in training social physics authors. In this section, we will enumerate and analyze the most important of those challenges, and later in the paper we will outline our pedagogical approaches for resolving these challenges through the development of a tutorial game.

Authored content for Ensemble can be subdivided into several different data structures and whose relationships can be seen in Figure 1, including *schema*, *rules*, *actions*, and *state*. Of these four, we will discuss significant difficulties in the authorship of the first three, as they have presented the most noteworthy challenges to new authors. By comparison, the authoring of state and the related authoring of characters have posed fewer challenges in workshop, and while we may indirectly address them as they relate to the authoring of schema, rules, and actions, we have refrained from a direct analysis of authoring those structures.

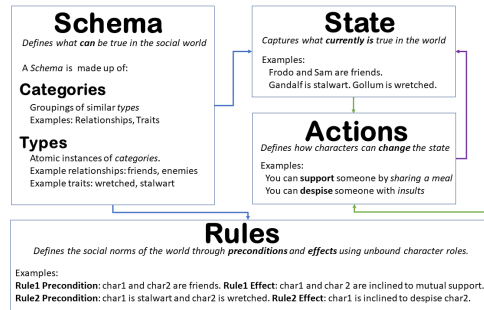


Fig. 1: Data Structures in Ensemble Authoring

### 3.1 Schema Authoring Challenges

The realm of possible states and truths in the Ensemble engine are defined in the authoring of a *schema*. Whereas the earlier social physics engine CiF included a predefined schema containing social, psychological, or sociological categories such as character traits, temporary emotional statuses, and relationships, authors using the Ensemble engine must build a schema from scratch, consisting of abstract *categories* which are themselves populated by specific *types*. For example, a category of “relationship” might have types such as “friends” and “enemies.” However, this authorial flexibility comes with additional complexity. Schema authoring can be challenging due to its open-ended nature, leading authors to develop schemata which are overdeveloped, underdeveloped, or difficult to use. Experienced Ensemble authors rely on various informal heuristics during schema authoring, but new authors may either feel bewildered or will develop ineffective schemata. The rule authoring process relies on the development of a robust, well-planned schema, but schema authoring is difficult for authors without previous knowledge of social physics or computer science concepts. These authors must first learn these concepts before they can begin the schema authoring process, resulting in a steep learning curve for many authors-to-be.

**Unfamiliar Computer Science Concepts** Authoring for the Ensemble engine can prove challenging for any author, but it is perhaps most difficult for users who are less familiar with computer science concepts and modalities. At a basic level, many authors will have a tendency to envision rules in terms of individual states, for example “Fido is mean,” whereas computer science leverages variables in the form of rule binding, such that “Fido” is replaced by a variable which can potentially bind with any character. In addition, Ensemble leverages even more complex computer science concepts, including networks and graphs, network directionality (and bidirectionality), weighted edges, first-order predicate logic, enums, Boolean and scalar values, and time steps. For example, the abstract schema categories that define the realm of possible states in an Ensemble schema must be declared as either undirected, directed, or reciprocal. For example, if an author were to define a reciprocal category in order to reflect relationships between characters, predicates in that category could be formally represented as a fully-connected network, where all character relationships of a given type could be illustrated in the form of a graph.

The use of computer science terms and concepts has remained a persistent hurdle for new authors of CiF and Ensemble content, and in general, researchers have attempted to strike a balance between minimizing computer science terminology and training authors in the necessary technical concepts. For example, despite the design of the Ensemble system being based on social phenomena and terminology, previous iterations of CiF and Ensemble authoring tools have shielded users from unnecessary terminology. Nevertheless, in some cases, this is unavoidable. For example, during our *VESPACE* training sessions, we found that participants unfamiliar with computer science terminologies found it more difficult in particular to get started in creating schemata, which is reasonable,

since schemata are the most abstract data structures in Ensemble and heavily leverage predicate logic and network theory. In order to overcome this, we ultimately designed the schema authoring portion of our authoring tool to function as a questionnaire, in which we asked users a series of questions while providing them with examples. Based on their responses, we empowered users to construct new categories or add new types to existing categories, minimizing as much as possible the use of computer science terms.

**Generalizing Abstractions from Source Material** For many researchers, such as the literary historians working on the *VESPACE* project, the research process involves a close analysis of source texts for specific examples or citations. Through aggregation of numerous examples, a researcher might extrapolate to develop an abstract grouping or concept, but beginning from observations or individual details helps to prevent the researcher from imposing an abstract concept onto the source material. Therefore, requiring authors to begin with a category and then populate it with types went against the typical research workflow. One *VESPACE* workshop participant described this challenge, stating, “First-time rule authors often try to code the exact scene from the source they are using, but rules authorship is above all an interpretive gesture, in which the literary instance serves as the basis for an abstraction that can be applied across different specific situations.” In order to accommodate working from the specific to the general, we designed the schema authoring component of the Ensemble authoring tool such that users first create types and then either add these types to an existing category or build an enclosing category up from the new type.

**Managing Schema Size** According to our analysis, authors working to design a schema from a large corpus of source texts or from general knowledge have an authorial tendency to create schemata that are too big. This can be a problem, as there is a “non-linear” relationship between schema types and the number of social rules that need to be authored. Ideally, authors should strike a balance between generality and expressivity, but determining the ideal schema size is not immediately intuitive and rather depends on an understanding of the relationship between schema and rules and between rules and actions. For example, if authors create different types for “joyful” and “happy”, they will need to create rules pertaining to both, as well as actions for characters to express both states, while the authors may not be particularly attached to the differentiation. There is no right answer as to how many types and classes there should be, but to alleviate the authorial burden introduced by excessive combinations and complexity [25] [1] [4], authors should be conservative when adding to the schema.

Adding to this difficulty is the fact that Ensemble requires the presence of a schema before rules can be authored, meaning authors must start from the most abstract, atomic elements of the world space, which can be quite challenging; authors may define schemata which are too large or too specific, due to an authorial tendency of starting from the specific and moving to the general and abstract. Some *VESPACE* authors found this particularly challenging,

with one workshop participant writing that “Complex and less concrete elements in the schema were much more difficult to agree upon and incorporating them revealed both the constraints and the possibilities of thinking within the Ensemble authoring system. For example, my group was very concerned with the issue of theater etiquette, but baffled by the question of how the intricate rules of eighteenth-century public conduct could be summed up by the kind of one-word terms that comprised the schema.”

### 3.2 Rule Authoring Challenges

In Ensemble, rules can be thought of as the character tendencies or social norms that the system will use to determine what actions a character might take. This places rules at the core of the Ensemble authoring process, and is where authors must expend the most time and effort. For example, a schema could have between six to ten categories, with perhaps ten to fifteen types each, whereas a given interactive narrative will likely require hundreds or even thousands of rules. Though rule authoring itself is less challenging conceptually than schema authoring, it requires a knowledgeable approach in order to produce a successful experience. For example, the kinds of rules authored—and by extension the number of those kinds—will effect the realm of possible social interactions, and the weights of individual rules can drastically affect the ramifications of player choices. Accounting for these challenges requires the use of several authoring heuristics, which we will endeavor to instill in authors through our tutorial game.

**Achieving Social Rule Coverage** Developing an effective rule corpus requires achieving sufficient “social rule coverage,” which means crafting enough of those rules which define the most generic social norms or behaviors of a particular society or group. Some participants in the *VESPACE* authoring workshops found it difficult to construct rules which would correlate to corresponding actionable behaviors by characters; one participant reflected that “it was challenging to read the texts we chose and then transpose elements from them to write rules governing what the characters in the game would want to do and could actually do, given the particular qualities assigned to them.” Related to this, in our experience, authors tend to focus more frequently on highly specific scenarios, but they often do not remember to take into account the “base” effect of single predicate rules. For example, an author might construct a more specific rule defining the concept “the enemy of my enemy is my friend” yet may forget to define the underlying effect of that rule, that “people are less likely to want to be friends with their enemy.”

**Determining Authored Rule Space** Through its relationship with the schema—which defines the realm of all possible states within a given Ensemble social world—the set of rules will occupy some percentage of the total possible “potential rule space.” However, the Ensemble authoring tool does not currently provide a means of determining how much of that potential rule space has been covered



by authored content. We have developed a general heuristic for approaching this problem in the form of a set authoring order; during the authoring process, we first consider all relationships, then networks, then statuses, and so on. However, this heuristic approach should ultimately be replaced by more exact methods, for example author assistance visualization techniques [8] informing authors on the current authored rule space, which could be filtered by category or type.

### 3.3 Action Authoring Challenges

Actions in Ensemble define the range of all possible decisions that a player or NPC can make in a game. Because actions have preconditions and effects (how the action changes the the social state), authors must make deliberate choices when composing both rules and actions, so that rules will have a real effect on the range of possible and probable actions, making for rich social experiences.

**Understanding Action Selection** One frequent challenge in social physics action authoring concerns the inherent tension between the tendency towards authorial control in traditional authoring and the player freedom and agency offered by emergent systems [22] [3], as well as the related balancing act between player agency and character agency [5]. For example, the very concept of dynamic “action selection” (the purpose of Ensemble) caused a lot of confusion with the extended team for *Vox Populi: The Ustradian Games*, with authors developing workarounds to assert more authorial control. Rather than seeing a character’s action selection as the emergent result of many rules being true over a semantically meaningful social state that represented the inner feelings of agents, they created actions with effects that merely flagged that specific events had occurred, and then created heavily weighted rules to guarantee that specific characters would choose specific actions subsequently. Authoring in this way eliminated the need to use Ensemble at all, and made the interactive experience a simple branching narrative. Similarly, authors can feel stifled by the uncertain frequency with which characters will choose actions, such as when *VESPACE* authors translating source materials felt anxious about being too general or too specific for effective action selection. One workshop participant noted “if there are too many preconditions for a volition rule, no characters will (likely) meet all the conditions, and the rule will never come into play. Similarly, if there are too few predicates, and the rule is very general and could apply to many or all of the characters... it might become overused in the game.”

### 3.4 Time to Feedback

Due to the open-ended nature of social physics experiences, the approach employed in social physics authoring may not be immediately intuitive to authors-in-training; one way to overcome this challenge is to allow authors to learn by doing, which means diminishing the time to feedback or feedback loop becomes an important pedagogical tool. If authors can visualize, experience, and play

with the effects of their authorial choices, they can begin to develop an intuitive sense of how authoring decisions relate to the creation of social worlds.

Previous research has identified *expressive range* as a measure of generative space, whereby a set of quantitative metrics and models can be defined for graphing and analyzing an expressive range with an ultimate goal of qualitative interpretation and analysis [29] [30] [16]. Others have discussed methods for expanding expressive range [32] [15], but there may also be uses for decreasing or modulating expressive range depending on the context. Our tutorial game seeks to intentionally constrain the expressive range of the system as players begin, making the range manageable for learning, then gradually releasing that expressive range as players accomplish in-game goals in order to guide them naturally through the learning experience.

## 4 Gameplay as a Pedagogical Answer to Authoring Challenges

Our analysis of the pedagogical challenges in training Ensemble authors, which we have formally codified in this paper, has led naturally to the development of a tutorial game for training aspiring Ensemble authors. Previous social physics-based games have used pre-authored schemata and rules, while our tutorial game will allow players to gradually author their own schemata and rules through gameplay. It will therefore leverage the open-ended exploration and experimentation of social physics-based games in order to deeply integrate learning outcomes and Ensemble familiarity with the mechanics of the game, so that players directly experience the effects of the decisions they make as content authors.

The tutorial game centers around the lives of pets in a household, with the initial cast of characters consisting of three dogs, three cats, and one human. The initial schema will be only minimally predefined, containing four categories—relationships, traits, statuses, and directed statuses; furthermore, players will start the game with an even more simplified active subset of the initial schema, with the option of unlocking categories and types as they complete goals and quests. As players unlock more characters and more social state, each of the characters will have a minimal set of predefined predicates determining the social history of that character. For example, the character Mr. Woof is defined as being a dog (trait), playmates with another dog character named Chaplin (relationship), and hungry (status). Another character named Kitty is defined as being a cat (trait), playful towards Chaplin as well as another cat character named Madame Meow (directed statuses), and social (trait).

Starting from a predetermined schema, cast, social history, and list of actions, players will have the freedom to explore and experiment by adding characters, changing state, and modifying the schema, all while being guided by a system of incentives and quests through which players can level up their skill tree, unlocking new ways to add to or modify the Ensemble authored content. Players will see the effects of their choices gradually play out in the social world, experi-

encing immediate feedback in the form of character actions and responses that will illustrate the expressive range of the Ensemble engine.

#### 4.1 Teaching Schema Authoring through Gameplay

Recall that an Ensemble schema defines what can be true in the social world. Starting players off with a small, manageable schema will be very important, because as we have found in our analysis of pedagogical challenges, schema authoring tends to be the most daunting authorial process. The four initial categories—trait, relationship, status, and directed status—will be described in detail using colloquial language, leveraging the correlations between Ensemble data structures and natural human sociological states and behaviors. As players level up their schema skill tree, they will first be given the option to add new types to a category, with the possible new types initially determined by the game; beginning with types aligns with our analysis that starting with category authoring is unnatural for many authors, especially researchers who value specificity, evidence, and citation. Furthermore, guiding players through a gradual expansion of the schema will aid authors in gaining an intuitive feel for the effect that schema manipulation and schema size have on the range of possible gameplay scenarios, starting with types and gradually extending to new categories.

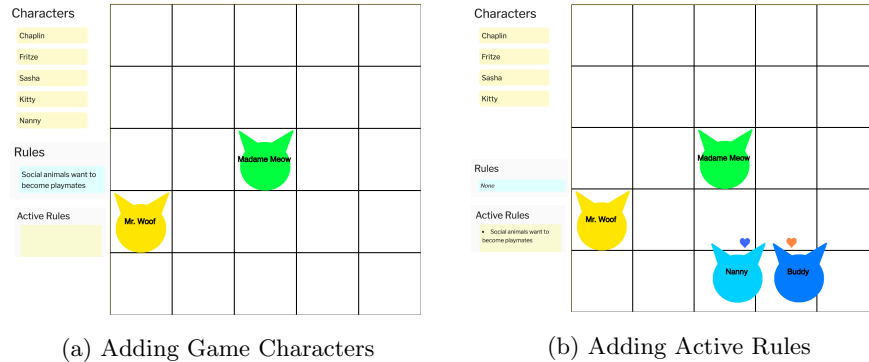


Fig. 2: Tutorial Game Screens

#### 4.2 Teaching Rule Authoring through Gameplay

Rules are the core of the Ensemble authoring process as well as—according to our analysis—one of the more intuitive aspects of authoring. However, while rule authoring itself may be less challenging, the *effects* of rule authoring are less intuitive, especially the relationships between rule authoring and rule coverage, space, and tuning. Therefore, early quests in our tutorial game will challenge users to expand social rule coverage in order to make certain behaviors and

responses possible, with the anticipation that experiencing these effects in real time will give authors a more intuitive sense of the correlation between rule authoring and the range of possible social behaviors. We will begin by allowing players to only activate rules from a predetermined set, requiring them to select rules wisely in order to achieve some social responses in the game. As illustrated in Figure 2 (a), not every rule is initially active; only volition rules managed by the player will be leveraged by the game. As a core aspect of gameplay, players can activate rules and experience immediate feedback as they change the range of narrative potential. Figure 2 (b) shows that once a player has activated the rule “Social animals want to become playmates” and brought new characters into the game world having the “social” trait, those characters can now be affected by the rule, leading them to potentially become playmates. This is a pedagogically valuable interaction whereby players learn the effects of authoring by experiencing them directly. Gradually, players can unlock the capacity to modify existing rules and to forge new rules, but only after they have witnessed the narrative effects of changes in rule space.

Eventually, as players level up their rule authoring skills, they will gain the option of creating entirely new rules in order to accomplish some goal. As players modify the list of active rules, we will provide visualizations of social rule coverage and existing rule space, in order to illustrate the effects of rule authoring in a more theoretical sense. Due to the importance of weight balancing in the Ensemble authoring process, yet another branch of rule authoring on the skill tree will involve weight tuning, wherein players will gain the ability to modify rule weights so that the impacts of particular rules will change, with quests challenging the player to modify rule weights in order to achieve some goal.

## 5 Conclusions / Future Work

One of the strengths of social physics is its ability to foster collaboration and creative problem solving across disciplines; due to its underlying reliance on first-order logic predicates as opposed to statistical models, researchers and creators of various backgrounds can leverage this authoring paradigm to develop immersive, rich interactive experiences. However, there is a learning curve to the authoring process, which means it will be important to produce effective authoring tools and learning materials that can address the particular difficulties involved in social physics authoring. In this paper, we have compiled data from previous authoring collaborations in order to codify and analyze the most persistent and troublesome challenges in social physics authoring pedagogy. We have also introduced our tutorial game design, which will minimize the feedback loop and gradually introduce player-authors to Ensemble paradigms in intuitive ways, directly addressing the challenges laid out in the paper through the design choices enumerated. With our analysis of pedagogical challenges complete and the tutorial game designed and prototyped, our next step will be to complete development of the game and submit it to user testing and user studies, adjusting game elements as necessary based on user feedback and success studies.

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