A Complexity Analysis Matrix for Narrative Userly Texts

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Mission Zhobia: Validating a Narrative Game for Complexity

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Introduction

In this project, we are interested in measuring the effectiveness of a narrative userly text[1] for the cognitive reduction of complexity (Knoller 2019). We study the serious narrative game Mission Zhobia: Winning the Peace, developed by Dutch games studio &Ranj for the PeaceNexus Consortium, which trains learners in appropriating specific competences that are required to deal with the complexity of a conflicted country. While the game itself doesn't explicitly represent either of its complexities as complexities, we have some testament to its doing just that in the words of UN Assistant Secretary-General for Peacebuilding Support, Oscar Fernandez-Taranco, "Mission Zhobia ... simulates very realistic and common challenges of working in countries affected by conflict, such as rapidly changing political circumstances, low capacities, lack of trust and tense rivalries".[2]

Mission Zhobia, we suggest, simulates aspects of complexity on two distinct orders: the complexity of the world it describes, as well as the complexity of the challenge of conflict resolution or peacebuilding within that world. We are interested to test whether it is effective in achieving its stated learning outcomes and, moreover, whether its effectiveness can be attributed to its use of interactive narrative. In the study we therefore compare the learning outcomes of subjects who engage with the serious game to the learning outcomes of those who engage with an altered version. In the altered version, the multi-linear narrative component is replaced by a linear narrative, and the interaction model narrative mechanic of first person, mostly dialogue based interaction replaced by a narrated click-through.

Besides the question of learning effectiveness, we are also arguing that the narrative userly text performs, more specifically, a cognitive reduction of complexity. There is, as far as we know, no existing model that allows researchers to begin to describe complexity in narrative userly texts – let alone measure their ability to achieve any cognitive reduction of such complexity.

In the following, we propose a model to describe both orders of complexity involved in the learning experiences afforded by narrative userly texts, which extends a model from the learning sciences.

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[1] We use here the general terminological apparatus developed in (Knoller, 2012) and more recently in (Knoller, 2019). However, narrative userly texts are also commonly referred to using an array of other labels, most commonly as narrative games (although they are not always games) and, especially within the scholarly field of Interactive Digital Storytelling & Narrative as an Interactive Digital Narrative (IDN) artefacts or systems (cf. Koenitz et al. 2015).

[2] Source: https://www.usip.org/academy/catalog/mission-zhobia. accessed 5 October 2020

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Complexity Reduction: Yoon at al.'s Complexity Learning Progression model

 The Learning Progression model proposed by Susan Yoon and colleagues (Yoon, Goh, & Yang, 2019) operationalises complexity reduction as a cognitive learning process. The model breaks the complexity of a system down to six complex system ideas. Yoon et al.'s analysis of a number of studies lead them to hypothesise that the cognitive challenge the six different ideas pose to learners is not equal and can be ordered in the following ascending order, or learning progression:

- Scaling effects
- Networked interaction (non-linearity, interdependence, emergent patterns)
- Multiple causes
- Dynamics
- (Decentralised) order
- Non-determinism

Operationalisation of the Six Ideas, and Measurement of Understanding

To measure the level of learners' understanding, for each of the six complex-systems ideas, Yoon further used a four-level scale of complexity she'd developed and validated earlier (Yoon 2008), from "completely clockwork" to "completely complex". Clockwork responses are those that show linear, single-cause, non-networked, centralised, static or deterministic system interactions or states, whereas complex responses are those that demonstrate nonlinear, networked, multiple-cause, dynamic, decentralised or non-deterministic system interactions or states.

This results in a general matrix that can be used to analyse the content of responses by learners to questions asking them to describe a system, resulting in a coding matrix, or coding scheme (Table 1, adapted from the original to already reflect the progression).

> [Once] the coding matrix was constructed and vetted, its reliability was assessed with two independent doctoral student raters coding 20% of the written responses. An acceptable inter-rater agreement of 0.8 was achieved collectively across categories using the Cronbach alpha reliability test. The remainder of the responses were subsequently coded by the first two authors using the coding scheme, with any discrepancies discussed.
> (Yoon et al., p. 7-8)

Methodology: qualitative content analysis

Yoon et al. further developed a qualitative content analysis methodology:
> we developed eight open-ended, short-answer questions, so that we had two such questions for each of four biology units that were part of the larger study. These questions were developed by PhD-level biology content experts, while others were selected from the OECD Programme for International Student Assessment (PISA; 2006). We wanted to administer this test to students in grades 8 to 12 who had already learned some biology content in order to determine the range of conceptual difficulties.
> (Yoon et al., p. 6)

Learners were then asked to answer the open questions, and given as much time as they needed, which lasted about 1 hour. A qualitative content analysis was then carried out by the researchers, who looked for

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presence in the text of statements that describe the system according to the six ideas. They rated the answers according to the matrix to derive the measure of a learner's understanding of the system from completely clockwork to completely complex.

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Category/Level	Level 1: Completely clockwork	Level 2: Somewhat clockwork	Level 3: Somewhat complex	Level 4: Completely complex
Scaling effects *Three components are considered:* *(i) the relative scale of outcomes caused by action;* *(ii) the cascading effects or 2nd order impacts or ripple effects of the action; and* *(iii) the time scale at which changes happen.*	Response indicates (i) small actions only lead to small effects; (ii) there is a sense that the action only causes localised changes; and (iii) the changes are immediate and do not sustain for a long time.	Response indicates one complex component (out of three) of the scaling effects. (See Level 4)	Response contains two complex components (out of three) of the scaling effects. (See Level 4)	Response indicates (i) small actions can lead to large effects; (ii) the action can produce both localized changes (one-to-one) and cascading (ripple) effects; and (iii) the changes can take place both immediately and over a long period of time.
Networked Effects *Three components are assessed:* *(i) interdependency among parts in the system;* *(ii) nonlinearity in reasoning; and* *(iii) emergent patterns over scale.*	(i) The parts of a system are isolated with no interdependency among them; (ii) the interactions between parts are linear with no feedback; and (iii) the patterns at the system level are the same from those at the component level.	There is one complex component (out of three) of networked interactions. (See Level 4.)	There are two complex components (out of three) of networked interactions. (See Level 4.)	(i) The parts are interdependent; (ii) the interactions between parts are non-linear with feedback; (iii) the patterns at the system level are emergent.
Multiple causes *The focus is on the number of causes that may/will contribute to the outcome(s) of an event.*	Response attributes the outcome(s) of an event to one cause/factor.	Response attributes the outcome(s) of an event to two causes/factors.	Response attributes the outcome(s) of an event to three causes/factors.	Response attributes the outcome(s) of an event to four or more causes/factors.
Dynamic Processes *Processes refer to the dynamism of the mechanisms that underlie the phenomena or, to how the system works or is thought to work.*	The system is composed of static events. While perturbations in the system cause change to occur, the change terminates once an outcome is achieved (i.e., a definite end).	The system is somewhat composed of static events with suggestions that these events take time to reach the outcome(s).	The system is somewhat of an on-going process. Perturbations take a long time to reach the final outcomes, which are at a larger scale than the initial event(s).	The system is an on-going, dynamic process. System continues to be in a state of flux. The parts adapt or evolve, and continue to do so accordingly.
Order *The focus is the organization of the system or phenomenon – centralized or decentralized.*	The system is controlled by one central agent, that is, all action is dictated by a leader. Order in the system is established 'top-down' or determined with a specific purpose in mind.	The system is largely controlled by 2–3 central agents, (i.e., there are other parts that may dictate how the system behaves). Order in the system is established 'top-down.'	The system is largely decentralized and the control lies with 4–5 components. However, there is little evidence to show that the order in the system is self-organized.	The system is decentralized and control lies with more than 5 parts. Order in the system is self-organized or 'bottom-up', and emerges spontaneously.
Deterministic effects *The emphasis is on the predictability of the effects caused by the variable in question.*	The way in which a variable operates or affects other variables is described as completely predictable or deterministic. No alternative is offered in the response.	There are 1-2 ways in which a variable operates or affects other variables in a way that is described as somewhat predictable or deterministic.	There are 3-4 ways in which a variable operates or affects other variables in a way that is somewhat unpredictable or nondeterministic.	The way in which a variable operates or affects other variables is unpredictable or nondeterministic. Patterns might emerge over time.

Table 1: *Complex Systems Category Code Descriptions, adapted from Yoon et al. (2019), pp. 8-9. Ordered according to ascending level of complexity from left to right, and of cognitive challenge from top to bottom.*

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Adapting the Matrix to Narrative Userly Texts

Yoon's model is useful in two main respects. First, it can be employed to break down what patterns of complexity are present in three components of the complexity triad (Knoller 2020):
(a) Environment/world complexity
(b) Encoded Storyworld complexity and
(c) the internal representation of the learner (subjective complexity).

A simple measure of storyworld complexity accounts for how many elements and ways of them interacting are modelled. Second, Yoon et al.'s learning progression may inform the design of narrative userly texts that attempt to represent a complex subject, and especially the way in which they pace the introduction of complexity.

However, this model was only developed for studying complex systems as *first-order* systems, with the learner "scripted" as an observer remaining outside the system. To fully account for the potential of narrative userly texts, it requires an extension to *second-order* effects, i.e. effects caused by the interactor's intervention in the complex narrative system

Extension to a Description of Second Order (Interactive) Systems

There are two proposed steps in extending the original matrix to account for second-order effects.

First, we have to distinguish between several possible types of narrative userly text systems and how their interaction model positions the interactor in relation to the encoded storyworld:

1. Non-interactive userly texts only afford interaction that does not affect either the presentation/discourse level or the diegesis of the encoded storyworld. This is in fact an empty category ontologically, but it might not be empty phenomenologically: interactors may experience the userly text this way, as essentially no more interactive than a video or a book;
2. Navigational userly texts have an interaction model that allows the interactor to affect the presentation/discourse levels of the representation of the complex system, but without being an agent in the system's storyworld. For example, they allow (or even suggest) perspective-switching between characters, but no decision making on behalf of those characters and no effect on outcomes. Navigational userly texts can represent first-order complex systems, but are not second-order systems.
3. Enactive narrative userly texts allow the interactor to perform as the central agent in the system, affecting the outcomes and causing delayed or cascading consequences for their actions, causing patterns to emerge, entering into feedback relations, responding and adapting to dynamic changes, potentially experiencing the system as partially decentralised with control coming from multiple (non-human) agents, as well as non-deterministic and thus with multiple unpredictable outcomes. Such enactive systems have the potential to become second-order systems.
4. Social, multi-agent/multiplayer narrative userly texts would allow the player to further interact with other fully human agents – experiencing actual (complex) social systems with even more

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decentralised control and greater scope for emergent social patterns. Such systems are by necessity second-order systems (and perhaps third-order?)[3]

Actually existing systems up to the time of writing generally fall into either type 2 (navigational), or type 3 (enactive). Type 4 systems are usually multiplayer first-person shooters games with rather simple, predictable and linear narrative structures, that cannot represent much narrative complexity, but there have been some attempts to create emergent-narrative social systems that prove an exception to this rule[4].

To summarise the first step, enactive and social systems can both function as representations of first-order complex systems, as well as constitute second-order representations of interacting with a complex system as an agent within it.

However, not every artefact is likely to afford second-order effects for each and every of the six categories, or to the same extent. A second analytic step is required to describe this in enough detail to allow proper analysis and evaluation of experiential and other subjective effects such as learning.

A second step would thus require us to describe, for a specific narrative userly text, precisely to which extent the system makes it possible for the interactor to be a cause of such second-order effects, and how complex these actually are. We considered two options for extending the matrix. The first option was to extend the matrix by adding a fifth column to Yoon's Clockwork-to-Complex scale, to account for second order effects as an additional level of complexity; However, since second order complexity itself can be more-or-less complex, a more nuanced design would split each row between first-order complexity and second-order effects, both of which can then independently be described as completely clockwork, somewhat clockwork, somewhat complex or completely complex.

Extension to content analysis of second-order effects

Once we have established the complexity analysis of the system, it is possible to create a specific coding matrix for a narrative userly text, which then allows us to assess self-reporting of second-order perceptions of complexity represented as declarative statements about the learner's enactive performance in interacting as an agent in the complex system and her reflective understanding of the ranges of effects her performance had on the system (and vice versa, where appropriate). This can then allow us to find correlations between (1) the design of the system's complexity structure (first and second-order), (2) the actual performance of the learner (measurable, for example by the system or through observation), (3) the subjective experience of the learner (using either objective measures or self-reporting), (4) the resulting declarative knowledge outcomes (using common testing methods), and (5) the procedural knowledge outcomes (measurable using a post-test separate simulation or role playing assessment task) – all of which can then be described in terms of both first-order and second-order complexity understanding, on a 4-level scale.

As an example of the usefulness of the matrix in describing a narrative userly text, we include a preliminary analysis of Mission Zhobia: Winning the Peace as an Appendix.

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[3] This typology can be compared to Ryan's typology of interactivity in Avatars of Story (Ryan 2006, pp. 108-125), but a comparison shows that the two typologies do not map neatly. Type 1 would be outside her typology. Type 2 would encompass the external and exploratory types. Type 3 may correspond to the internal-ontological type in a single-player text. Type 4 can be conceived as an elaboration of the internal-ontological multiplayer sub-type in Ryan's system, which includes multiplayer shooters and the multiplayer version of the Sims.

[4] Apart from the multiplayer version of the Sims, Fort McMoney (Dufresne 2013) may also partly qualify as type 4, for its use of the discussion and (weighted) voting mechanics that affect the development of its narrative.

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Appendix: Complexity Analysis of Mission Zhobia: Saving the Peace

This preliminary analysis was performed by Noam Knoller, Christian Roth and Dennis Haak on the 25th and 27th November 2020

Category/Level	Level 1: Completely clockwork	Level 2: Somewhat clockwork	Level 3: Somewhat complex	Level 4: Completely complex
Scaling effects *Three components are considered:* *(i) the relative scale of outcomes caused by action;* *(ii) the cascading effects or 2nd order impacts or ripple effects of the action; and* *(iii) the time scale at which changes happen.*	**(i) Small actions only lead to small effects; (ii) there is a sense that the action only causes localised changes; and (iii) the changes are immediate and do not persist for a long time.**	**One complex component (out of three) of the scaling effects. (See Level 4)**	**Two complex components (out of three) of the scaling effects. (See Level 4)**	**(i) Small actions can lead to large effects; (ii) the action can produce both localised changes (one-to-one) and cascading (ripple) effects; and (iii) the changes can take place both immediately and over a long period of time.**
Mission: Zhobia First-order aspects (no-influence on the system)				Actions taken in the culture and history of Zhobia have produced localised and cascading effects (e.g. fuelling the conflict between North and South). Some effects have escalated the conflict directly, some effects had a more long-term effect.
Second-Order aspects (influence on the system)	Order of looking at the documents (unless it affects the learners understanding of the first-order)	Order of looking at the documents (if it does affect the learner's understanding of the first-order complex storyworld)		- The order in which the learner talks to stakeholder, as well as showing or not showing contextual knowledge, both impact the availability of solutions - 6 months later impact of your decisions as a player

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Networked Effects *Three components are assessed:* *(i) interdependency among parts in the system,* *(ii) nonlinearity in reasoning, and* *(iii) emergent patterns over scale.*	**(i) The parts of a system are isolated with no interdependency among them.** **(ii) the interactions between parts are linear with no feedback; and** **(iii) the patterns at the system level are the same from those at the component level.**	**There is one complex component (out of three) of networked interactions.** **(See Level 4.)**	**There are two complex components (out of three) of networked interactions.** **(See Level 4.)**	**(i) The parts are interdependent,** **(ii) the interactions between parts are non-linear with feedback, and** **(iii) the patterns at the system level are emergent.**
Mission: Zhobia *First-order aspects (no-influence on the system)*			(i) interdependency between the various parts that constitute the political, cultural, and societal systems of Zhobia. (ii) There is communication between stakeholders behind your back (iii) no emergent patterns over scale	
Second-Order aspects (influence on the system)		(ii) The interactor can somewhat impact the interactions between stakeholders through deciding whom to engage with first in conversation.		
Multiple causes *The focus is on the number of causes that may/will contribute to the outcome(s) of an event.*	**Response attributes the outcome(s) of an event to one cause/factor.**	**Response attributes the outcome(s) of an event to two causes/factors.**	**Response attributes the outcome(s) of an event to three causes/factors.**	**Response attributes the outcome(s) of an event to four or more causes/factors.**
Mission: Zhobia *First-Order aspects* *(no influence on the system)*				DH: The status quo in Zhobia at the start of the game is the result of a multitude of political, cultural, historical and societal causes/factors.
Mission: Zhobia *Second-Order aspects* *(influence on the system)*			DH: The outcome of the game is determined by the three choices in the implementation plan that you make for 1) the courthouse location, 2) the legal regime and 3) who to train.	DH: The outcome of each interactive dialog (e.g. trust level) is driven by more than four decision points in a conversation, as well as previous causes (e.g. having talked to someone first)

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Dynamic Processes *Processes refer to the dynamism of the mechanisms that underlie the phenomena or, to how the system works or is thought to work.*	**The system is composed of static events. While perturbations in the system cause change to occur, the change terminates once an outcome is achieved (i.e., a definite end).**	**The system is somewhat composed of static events with suggestions that these events take time to reach the outcome(s).**	**The system is somewhat of an on-going process. Perturbations take a long time to reach the final outcomes, which are at a larger scale than the initial event(s).**	**The system is an on-going, dynamic process. System continues to be in a state of flux. The parts adapt or evolve, and continue to do so accordingly.**
Mission: Zhobia *First-Order aspects* *(no influence on the system)*	Zhobia as an encoded storyworld belongs into this category; as the changes usually terminate once an outcome is achieved.			The represented concept of Zhobia would be here.
Mission: Zhobia *Second-Order aspects* *(influence on the system)*				Completely dynamic at runtime: the interactor effects changes, and there are changes to story events that are caused by code responding to the interactor, or triggered by story states (e.g. a new justice minister and the responses of stakeholders to the first implementation plan)
Order *The focus is the organisation of the system or phenomenon – centralised or decentralised.*	**The system is controlled by one central agent, that is, all action is dictated by a leader. Order in the system is established 'top- down' or determined with a specific purpose in mind.**	**The system is largely controlled by 2–3 central agents, (i.e., there are other parts that may dictate how the system behaves). Order in the system is established 'top-down.'**	**The system is largely decentralised and the control lies with 4–5 components. However, there is little evidence to show that the order in the system is self-organised.**	**The system is decentralised and control lies with more than 5 parts. Order in the system is self-organised or 'bottom-up', and emerges spontaneously.**
Mission: Zhobia *First-Order aspects* *(no influence on the system)*				Zhobia as a storyworld system is decentralized. Perhaps even radically so - it almost can't hold as a system and is on the verge of collapse.
Mission: Zhobia *Second-Order aspects* *(influence on the system)*		In Zhobia there is an agent, being the interactor (agent 1), who affects the system (agent 2). Most actions are initiated by the interactor and the system responds and influences the interactor's behaviour.	The interactor can bring some order into the system by solving a coordination problem and improving internal communication that has broken down. The world remains decentralised, but the communication is now able to hold it together.	

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Deterministic effects *The emphasis is on the predictability of the effects caused by the variable in question.*	**The way in which a variable operates or affects other variables is described as completely predictable or deterministic. No alternative is offered in the response.**	**There are 1-2 ways in which a variable operates or affects other variables in a way that is described as somewhat predictable or deterministic.**	**There are 3-4 ways in which a variable operates or affects other variables in a way that is somewhat unpredictable or nondeterministic.**	**The way in which a variable operates or affects other variables is unpredictable or nondeterministic. Patterns might emerge over time.**
Mission: Zhobia *First-Order aspects* *(no influence on the system)*	The code is essentially deterministic			
Mission: Zhobia *Second-Order aspects* *(influence on the system)*			In the best-case scenario, the interactor's perception of this aspect of complexity is here, and the interactor is also able to describe it as such	