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A Structured Approach for Designing Collaboration Experiences for Virtual Worlds

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Abstract

While 3D virtual worlds are more frequently being used as interactive environments for collaboration, there is still no structured approach developed specifically for the combined design of 3D virtual environments and the collaborative activities in them. We argue that formalizing both the structural elements of virtual worlds and aspects of collaborative work or collaborative learning helps to develop fruitful collaborative work and learning experiences. As such, we present the avatar-based collaboration framework (ABC framework). Based on semiotics theory, the framework puts the collaborating groups into the center of the design and emphasizes the use of distinct features of 3D virtual worlds for use in collaborative learning environments and activities. In developing the framework, we have drawn from best practices in instructional design and game design, research in HCI, and findings and observations from our own empirical research that investigates collaboration patterns in virtual worlds. Along with the framework, we present a case study of its first application for a global collaborative learning project. This paper particularly addresses virtual world designers, educators, meeting facilitators, and other practitioners by thoroughly describing the process of creating rich collaboration and collaborative learning experiences for virtual worlds with the ABC framework.

***Keywords**: Group Collaboration, Collaboration Patterns, Embodied Collaboration, Presence, Virtual Worlds, Design Science Research, Online Collaboration, Immersion.*

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A Structured Approach for Designing Collaboration Experiences for Virtual Worlds

1. Introduction

An ideal online, three-dimensional (3D) virtual environment would provide a space in which users can move freely, interact intuitively with all kinds of objects, recognize familiar people, and communicate in a natural manner with others – all in a realistic setting that evokes a feeling of really being a part of the virtual world. Additionally, it would allow displaying complex content or data in innovative and useful ways that neglect the limitations imposed by physical reality. Such an environment has the potential to move remote collaboration and learning to another level of quality. But even if such platforms were available today (and they soon will be), without the right kind of choreography, script, or setup, users might still not know how to best benefit from such an infrastructure.

We believe that today's available virtual worlds are already capable of adding significant value to collaborative work and collaborative learning. However, an exploration of collaborative activities in the virtual world Second Life has shown that companies, institutions, and educators mostly do not make use of the distinct features of a 3D environment, although there are promising approaches (Schmeil & Eppler, 2009). These distinct opportunities of virtual worlds make them an interesting new medium for collaborative activities, much more than the possibility of simulating the physical world (Irani, Hayes, & Dourish, 2008). Others agree that in order to maximize the benefits from using virtual worlds the capabilities of the medium have yet to be thoroughly examined (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009).

Moreover, many of the virtual environments that are currently (mid 2011) advertised as offering great productivity boosts for collaborative work emphasize the collaborative editing of text documents, spreadsheets, and presentation slides that are mounted on big virtual walls – a method of working together that may work just as well (or even better) without gathering in a 3D virtual space. Working on two-dimensional (2D) tasks (on interactive walls) in a 3D environment can be understood as a step back in the ongoing paradigm shift in the design of interaction. It also ignores the opportunities of embodied interaction; being embodied as the natural form of human existence lets collaborators interact and communicate naturally using their bodies (Dourish, 2001). Virtual environments that feature virtual embodiment (or avatars) provide "an interesting ecology of embodied interaction" (Jarmon, 2009). Fortifying the positive impact of virtual embodiment, research into mirror neurons and body language has shown it is important to people to see their body and the bodies of others (Bray & Konsynski, 2007).

Consequently, our premise is that embodiment in an immersive and configurable environment allows for new, valuable, and innovative forms of working and learning together. Firstly, our research formally describes the necessary elements for online, visual, and spatial collaboration to improve collaboration in these virtual environments or virtual. Secondly, it develops and identifies novel and existing collaboration patterns that can be described in that formalism. In this paper, we present our framework for avatar-based collaboration in online 3D virtual environments based on semiotics theory. The framework represents a blueprint for how collaborative group interaction patterns in virtual environments can be described or generated. The framework is distinctive with respect to its two ways of use: collaboration patterns can be generated or documented either by starting with a goal, or by starting with the infrastructure of objects and actions available. We also present a study of the first application case of the framework, which showcases 13 collaborative learning patterns. We believe that this framework forms a first important step in the process of formalizing collaboration in virtual environments – a task that is crucial in order to progress the application of 3D virtual environments for serious and productive uses.

The remainder of this paper is structured as follows: In Section 2, we define online virtual environments and present their advantages for collaboration. In Section 3, we present our framework that helps to formalize the design elements and necessary infrastructure of collaboration patterns in online virtual environments. We also describe the development of the framework in detail and the research methodology that we followed. In Section 4, we discuss the case study. We conclude by reviewing our contribution and highlighting directions of future research.

2. Virtual Worlds and the Design of Collaboration

In general, virtual environments attempt to provide an environment where the user feels fully immersed and present. This presence is a psychological phenomenon that has been defined as the sense of “being there” in an environment, and is based on the technologically – if not physically – founded base of immersion (Slater, Usoh, & Steed, 1994). Immersion in the traditional sense denotes the technology of the virtual environment and its user interface that, together, lead to a sense of presence. Immersion can be achieved to varying degrees, which stimulates a variable number of human senses. However, the expression immersion is often also used for online, desktop-based, virtual environments that are controlled only by a keyboard and mouse. Here, we speak of mental immersion. When discussing online virtual environments in particular, the term virtual presence has been established, which emphasizes the absence of a physical presence. Hence, the term found application for online virtual worlds, where all data is stored on online servers instead of in a local database. Beck, Fishwick, Kamhawi, Coffey, and Henderson’s (2011) paper, which is based on the analysis of 97 research articles that deal substantively with presence, provides an excellent descriptive ontology of the concept(s) of presence and its relation to the two different types of immersion (physical and mental).

In the ongoing scientific discourse in the research community, a virtual world has recently been defined as “a synchronous, persistent network of people, represented as avatars, [that is] facilitated by networked computers” (Bell, 2008). This general, vague definition – and the lack of more definite ones – indicates that scholars have yet to formalize virtual worlds and their constituent elements or thoroughly examine their opportunities (Davis et al., 2009). To date, there are many virtual worlds available that cater for varying age groups and areas of interest. Most of the available virtual worlds are held online by the operators on their proprietary servers, but some can be installed on one’s own servers to connect to a restricted intranet or the Internet. While systems like Second Life, OpenSim and Active Worlds enable users to design their worlds and to create static and interactive content themselves, others like Sun’s Wonderland and Teleplace focus on productivity in conventional tasks (e.g., editing text documents, spreadsheets, and presentation slides). In these latter systems, users can only upload and download documents and reposition furniture. In others such as Forterra’s Olive, users can create training scenarios for learning and exercise. New virtual worlds are launched almost monthly, and it seems like each new one tries to fill another niche (Salomon, 2009, provides an overview of current platforms and the big companies that use them; we have discussed the advantages that collaborative virtual worlds bring for knowledge, work, and education in Schmeil & Eppler, 2009). Nevertheless, for most application domains, it is still unclear what value virtual worlds adds to the existing modes of communication and collaboration, just as it remains unclear which features and enhancements are needed to maximize the benefit of using virtual worlds (Bainbridge, 2007).

Whatever virtual worlds, massively multiplayer games, and other virtual environments are designed for, the scientific community around them agrees on the fact that, lessons from two-dimensional (2D) environments and computer-supported cooperative work (CSCW) and computer-supported cooperative learning (CSCL) should be thoroughly migrated, not just copied bit for bit (Benford, Greenhalgh, Rodden, & Pycock, 2001; Davis et al., 2009; Ducheneaut, Moore, & Nickell, 2007; Santos, 2010). This implies that a method for the design of virtual environments is required that takes into account both the technical infrastructure of the target platform, and the context in which the resulting environment is meant to be deployed. Thus, a new design discipline that designs for the entire experience, instead of one that focuses on either the graphical, spatial, or architectural design of the environment or merely the planning of activities, is needed (Bardzell & Odom, 2008; Santos, 2010).

The discipline of experience design was created in the marketing field, where the fundamental idea was to sell whole compelling experiences instead of just products. Today, experience design has become an increasingly important discipline in various fields, and is being recognized as a full-fledged design discipline (Buxton, 2007; Hassenzahl, 2010). In the realm of virtual environments, we can observe a trend from developing learning towards the orchestration or ‘scaffolding’ of holistic learning experiences, based upon exploratory and experiential learning paradigms rather than on knowledgecentered approaches (de Freitas & Neumann, 2009; Santos, 2010). The hopes of educators – and researchers – are that this approach will lead to more effective and accelerated learning, and to greater learner motivation and engagement.

We believe that experience design provides an interesting approach for virtual worlds because connecting links between technical elements (i.e., the building blocks) of the medium with the desired resulting experiences can be created with ease, compared to the application of experience design in physical environments. Virtual worlds are a fast-prototyping environment for the most diverse sorts of experiences, which makes them a magnificent environment for various fields of research (Bainbridge, 2007).

3. The Avatar-Based Collaboration Framework

The development – and deployment – of frameworks to guide the purposeful design of virtual worlds and spaces, activities in virtual environments, and virtual world applications has set in only in recent years. In this time, scholars have proposed several design frameworks and structured guides for most of the major application domains that virtual worlds are used in. De Freitas & Oliver (2006) combine the two main strands – learning theory and human-computer interaction (HCI) – in order to build the four-dimensional (4D) framework, which merges the four elements of learner, learning theory, representation of environment, and context. Minocha and Roberts (2008) apply the Socialization, Externalization, Combination, Internalization (SECI) model of Nonaka and Takeuchi (1995) to the design of activities involving a combination of 3D virtual worlds and 2D tools, which results in a simple guide for the organization of 2D and 3D activities in distance education scenarios. In the context of business and innovation, Nambisan & Nambisan (2008) present four sets of virtual customer environment strategies and practices. Companies can apply these as a basis for developing different strategies for the use of virtual collaborative environments, which leads to predictable impacts on the customer experience. Tuukkanen, Iqbal, and Kankaanranta (2010) react to the growing trend of children using virtual worlds, and present a framework of children's virtual participation in virtual worlds. Their framework is structured in four levels to consider the form of participation, the child's role, the role of the virtual world, and the affordances of the virtual world. While all these approaches provide guidance for the organization and a rough conception of virtual world activities in their respective domains, none of them assist virtual world designers or managers with actually designing engaging collaborative activities and innovative behavior patterns.

Therefore, we developed the avatar-based collaboration framework as a blueprint on which diverse collaboration and collaborative learning tasks can be designed, formulated, and executed. The framework is based on theoretical key distinctions of semiotics (i.e., syntactic, semantic, and pragmatic levels – see Section 3.2). We discuss the use of this well-known semiotic triad in our framework in more detail by means of an illustration in Section 3.5. In Section 4, we describe the various steps that we have taken in developing of the avatar-based collaboration framework.

The methodology for the research that we present in this article is based on design science research (DSR). Fuller and McHale (1963) coined the term design science to describe a structured, systematic form of designing. It has since been found that design benefits from structure and formalization. Consequently, design principles and methodologies were developed. The seminal paper by Hevner, March, Park, and Ram (2004) overviews the application of DSR in the information systems field, and presents seven design-science research guidelines. While our goal was not to fully satisfy all of these guidelines (some of which can be seen as too stringent or not applicable; see Venable, 2010, for an investigation and a discussion on adhering to these guidelines), we do meet several of these requirements for good design-science research.

First, we produce a viable artifact in form of a framework. Second, we explain a new method, namely one that uses the framework along with instantiations of it (patterns created with the framework provided as examples). Third, we improve the use of virtual worlds for collaborative work and learning tasks, an area in need for structure and formalization. Fourth, we identify and communicate the contribution's novelty, generality, and significance. And fifth, we subject the research to the academic audience's expectations of rigor by building on previous research in previous disciplines, and to the professional audience's expectations of relevance by providing a structure and formalization that improves online collaboration for various types of use cases.

In the DSR spectrum, the research presented here covers the development of a framework and the description of a first case study, which includes the first users' feedback on the framework and the designed product (in our case the students of lecture exercises that we designed with the method). Thus, in the DSR cycle of iterative design, application, and evaluation, our paper presents the first cycle. Our future research will include more evaluative findings into a new iteration of the framework design and present an application in the second cycle. Overall, the research we present here is both the application of design-science research and the development of a tool to implement design-science research.

3.1. Describing Virtual Embodied Collaboration through Patterns

While identifying group interaction patterns of collaborative work and learning in the virtual world Second Life (Schmeil & Eppler, 2009), we noticed the need for a solid formal framework that is capable of describing collaboration in virtual worlds in all its aspects. Patterns are a useful and concise approach to classify and describe different forms of online collaboration. A pattern is defined as "a solution to a recurrent problem in a context" (Alexander et al., 1977), and is also often described as pairing a problem statement and a solution. Patterns can be general or specific. Originally developed for the field of architecture, patterns are today applied in various domains such as software engineering, human-computer interaction, education science, and technology-enhanced learning (Goodyear & Retalis, 2010).

The pattern concept was conceived to solve a problem or to reach a goal in a defined context or situation. Patterns are thus a viable format to describe collaboration tasks in various multi-user settings. Gottesdiener's (2001) definition of a collaboration pattern as "a set of techniques, behaviors, and activities for people who share a common goal of working together in a group" provides a basic structure for a formalization of collaboration. We extend this definition by adding the notions of tools and a shared location, which results in the following definition: A collaboration pattern is a set of tools, techniques, behaviors, and activities for people who meet at a place to work together in a group or community toward a common goal. We explain how this definition fits with the resulting framework in Section 3.5 (see Figure 1).

3.2. The Semiotic Triad as an Organizing Schema

Semiotics is the science of signs, it investigates the interpretation of signals in interpersonal communication (Eco, 1978). Semiotics is understood as applied linguistics; it extends the concept of vocabulary beyond words, and encompasses all possible types of signs. In the domain of virtual worlds, concepts from linguistics are (often implicitly) referred to when using terms such as vocabulary to describe pools of available virtual artifacts or alphabet to denote affordances in virtual worlds (Jarmon, 2009). We describe how semiotics can be applied to the domain of virtual worlds in the following paragraphs.

From a theoretical point of view, we can understand collaboration activities as interpretive actions and collaboration spaces as sign systems in need of joint interpretation. Visual, spatialized on-screen events have to be interpreted by virtual environment users as relevant, meaningful, context-dependent signs that contribute towards joint sense-making and purposeful co-ordination. As in any sign interpretation system or (visual) language, semiotic theory informs us that three different layers can be fruitfully distinguished – that is, the syntactic, semantic, and pragmatic layers (Morris, 1938). The syntactic layer is basic layer. It defines signs and relations among signs and thus provides a formal structure as a base on which the other layers build. Semantics, the middle layer, builds on this elementary structure and connects defined signs to the things they refer to. The semantic layer relates the elementary signs to meaning. The highest layer is pragmatics. It connects signs to the final effects they can or should have on those who interpret the signs, which it achieves through the meanings the signs are related to. This threefold distinction has already been effectively applied to various forms of information systems and social online media (see, for example, Shanks, 1999, or Schmid & Lindemann, 1998). These three distinct interpretive layers form the basis of the avatar-based collaboration (ABC) framework, and we henceforth apply them to immersive virtual worlds as described in the following paragraphs.

The ABC framework's syntactic layer encompasses the infrastructure, the main visible components of a collaboration pattern. They can be understood as building blocks with which patterns are constructed. Through a clearly structured formalization of actions (see Section 3.3) and virtual objects (see Section 3.4), the syntactic dimension ensures the readability of a collaboration pattern. Also, it provides the necessary elements and mechanisms that can be combined to create new patterns.

The semantic layer refers to the acquired meaning of elements and to the conventions used in a collaboration pattern. It outlines which infrastructure elements assume which kind of meaning in the given context. While the syntactic layer illustrates which elements a collaboration pattern contains, the semantic layer defines their relationships and meaningful combinations that make sense with regard to the pattern's goals. In this sense, the semantic level is a liaison layer between the virtual world and the participant's objectives.

The pragmatic layer reflects the participants' social context, practices, goals, and expectations. These aspects need to be supported through the dramaturgy (semantic layer) and the infrastructure (syntactic layer). This layer clarifies in which situations which types and combinations of dramaturgy use and infrastructure use make sense.

3.3. Action and Interaction in 3D Virtual Environments

In our understanding, supporting action and interaction forms a major part of a virtual environment's infrastructure. It determines how users can act and affects their behavior when they are alone or in groups. Moreover, the way users can control their avatars and perform actions can heavily influence the user's satisfaction level and thus may, in the end, determine whether or not collaborative work or other planned tasks in the virtual environment succeed or fail (compare Davis et al., 2009). In order to manage action and interaction, we believe that a formalization of the concept in various forms in virtual environments on a high abstraction level is required.

In the field of human computer interaction (HCI), virtual reality (VR), and 3D user interfaces (3D UI), there is a generally accepted distinction among navigation and manipulation techniques (Bowman, Kruijff, Poupyrev, & LaViola, 2005). Navigation techniques comprise techniques for moving one's position and for changing one's view in the virtual or digitally augmented environment. Manipulation techniques designate all interaction methods that select and transform or modify objects in a virtual space. In some cases, the side category "system control" is used, which comprises all actions that serve to change modes and modify parameters, and other functions that alter the virtual experience itself. 3D user-interface expert Doug Bowman and colleagues refine this classification by adding a fourth category called "symbolic input", which describes the communication of symbolic information (text, numbers, and other symbols or marks) to the system (Bowman et al., 2005). This "traditional" HCI / 3D UI classification provides a clear general distinction between two main categories of action from both a goal-driven and a terminology point of view. This classification is a viable fundament to build on and develop a formalization of action and interaction specific to the realm of virtual environments.

Thus, for our purpose of formalizing (inter)actions for collaboration, we build on this clear classification, extend it, and make adjustments in order to align it with the requirements of the area of online 3D multi-user virtual environments.

However, first we need to consider a category that was not considered in the described classification: communication. The importance of communicating text, numbers, symbols, and speech to the system (and through the system to other avatars or users, interactive objects, or the environment itself) has increased significantly in recent years with the advancements in computing power and graphics processing, the enhancements in Internet connectivity and bandwidth, and the improvement of virtual world platforms themselves. We call this first category “communicative actions”. A sub-division differentiates between verbal (i.e., text and voice chat) and non-verbal communication (i.e., nodding, gesturing).

HCI and VR systems do not necessarily assume the existence of an avatar as a personalization device in the virtual environment. Therefore, we can combine navigation techniques and methods for changing the view in one shared category; without the embodiment of an avatar, navigating and changing the viewpoint can be considered as the same action. In our classification, changing one’s view falls into the communicative-actions category. It is a non-verbal form of informing others where the user’s current focus of attention is, or to communicate a point or object of interest to others in the virtual environment. As a result, our second category, “navigation”, merely comprises walking, flying, swimming, and teleporting.

We rename the manipulation techniques category (selecting and modifying objects) to “object-related actions”. Actions referring to the creation or insertion of virtual objects also belong to this category, as do selection and modification techniques. By insertion, we mean, for example, the result of uploading or purchasing virtual objects.

All interactions concerning system control are much less important in contemporary virtual worlds than they are in classic virtual reality systems. Due to the often-customized or prototype forms of VR applications, system control is in many cases developed and tailored to a single application. In virtual worlds, by contrast, the viewer software (i.e., the client application used to enter the virtual environment) is usually standardized, and provides a predefined set of system control options. Hence, we do not use the system control category for the description of collaboration patterns. Table 1 overviews this two-level classification of action and interaction in virtual worlds.

Table 1. Two-Level Classification of Action and Interaction in Virtual Worlds

Category	Subcategory	Description	Specific examples or applications
Communicative actions	Verbal	Voice chat, text chat (public and private messages)	Oral presentation, discussion in local chat, private messages, podcasts
	Non-verbal	Gestures, gaze, facial expressions, body posture, avatar appearance	Waving goodbye, sad face, exhausted body pose, white beard
Navigation	Walk	Walking, running, moving sideways	Moving from A to B, walking around an object, getting closer to somebody
	Fly / swim	Flying in air, floating, swimming/diving	Roaming a floating 3D exhibition, diving for a treasure
	Teleport	Switching (“beaming”) to another location without moving	Traveling long distances in an instant, bypass difficult terrain or obstacles
Object-related actions	Select	Putting objects in personal focus, e.g. for subsequent actions	Refer to objects during a presentation, start modifying an object
	Create / insert	Creating new objects from scratch or importing objects	Making a chair to sit on, importing a model home created outside the world
	Modify	Transforming, moving, activating, reshaping, re-coloring an object	Making a couch wider, changing the wallpaper in a house, kicking a ball

If we were to put these actions on a continuous spectrum, they could also be distinguished in terms of their virtual world effects, or their level of invasiveness or (space) intrusion. Talking, typing, or changing one's avatar appearance, view, or position is far less intruding than moving an object, triggering a rocket, or blocking a door. However, note that that these distinctions and the resulting classification do not include virtual objects. Those require a separate classification that takes their manifold types and functions into account. In Section 3.4, we discuss this other central element of a virtual environment's infrastructure.

3.4. Classifying Virtual Objects

In his book "The design of everyday things", Donald Norman postulates that people's actions and human behavior in general profits from everyday objects being designed to provide straight-forward affordances; that is, the objects should communicate how they should be used (1988). He argues that less knowledge is required (to perform well) when there is (what he calls) "knowledge in the world" (p. 56). This insight can be fruitfully applied to virtual worlds by building on the latent knowledge that users have and by providing cues that reuse appropriate representations (Smith & Harrison, 2001). This not only motivates practitioners to use virtual environments for collaborative tasks, but implies that objects in virtual environments and their design are of great importance. Hence, we understand virtual objects as forming another major part of a virtual environment's infrastructure that goes along with the previously discussed part of action and interaction. Affordances can (and should) be used to signal users about how to interact with a particular object, or how objects with built-in behaviors may act without any direct influence from the user.

One problem that arises is that, with those mental representations - or mental models, as Norman calls them - users may overestimate how objects and the environment behaves; that is, they may expect something that current virtual worlds cannot provide (Norman, 1988). In contrast, users might not anticipate any functionality when acting in a virtual environment, and might get easily confused or disoriented when things happen without a direct command. As a result, two extreme types of users of virtual environments are possible: those who underestimate and those who overestimate a virtual world's capabilities. In fact, this might partially explain why it takes (or took) so long for virtual worlds to become accepted and viewed as being more than just environments for playful behavior, despite the fact that they have been debated in research and practice for many years. Regardless, a fact is that, for a long time, virtual environments researchers and developers have focused largely on graphical representation and rendering issues.

With the launch (and the hype) of Second Life, a new era of accessible online virtual environments began. Following the trend of enabling users to create content – also an essential element of Web 2.0 – Second Life users could for the first time create and edit virtual objects, and customize their avatars' appearance directly in a persistent virtual world (however, note that this disregards Active Worlds, which provided content-creation features long before Second Life but was unfortunately never widely used).

With the possibility of scripting objects (i.e., programming them in order to make them responsive to user actions, execute animations or follow behaviors, or simply update their own states continuously), virtual objects have become a powerful instrument in designing memorable user experiences in virtual worlds. In fact, interactive virtual objects represent technology in virtual environments; without active and interactive objects, any virtual environment would be nothing more than a virtual version of a world without technology.

In spite of their crucial functional importance, little research has been conducted on classifying virtual objects thus far. More work has been done on their technical side; for instance, including detailed solutions for all possible interactions with an object into its definition (Kallmann & Thalmann, 1998). These so-called smart objects integrate descriptions for sub-objects about how to behave and about positions for avatars or agents to interact with. They also provide gestures up to the precision of finger splay. Another later-presented framework takes on this idea and adds inter-object interaction definitions (Jorissen & Lamotte, 2004). Currently – to the authors' knowledge – at least the two virtual world platforms – Second Life and OpenSim – support defining avatar positions for interaction in an object definition and in inter-object communication.

Smith and Willans (2006) proposed a first informal classification of virtual objects while investigating the requirements of virtual objects in relation to interaction needs. The authors state that the user's task requirements define the behavioral requirements of any object. Consequently, they distinguish between background objects, which are not critical to the scenario; contextual objects, which are part of the scenario but not in the focus; and task objects, which are central to the scenario and the actions of the user (Smith & Willans, 2006). While this distinction may be useful for determining virtual objects' level of importance (e.g., in the requirements-analysis phase), it does not distinguish objects based on their actual function.

Hence, we classify virtual objects into the following three categories.

1. "Static objects", which solely exist; they do not follow any kind of behavior and do not respond to any of the user's actions. We distinguish fixed objects that are not meant to be moved (such as statues, furniture, architecture) from portable objects that are meant to be picked up or carried around, held, or worn (such as handheld objects, items that hover over the avatar, and hats and distinctive clothes in general). This quality does not have to be persistent; the categorization should work in order to describe the collaboration pattern.

2. "Automated objects", which either execute animations repeatedly or by being triggered. Alternatively, they follow a behavior (that range from simple behaving schemes, such as following an avatar, to highly complex autonomous, intelligent behaviors). We further separate the most rudimentary of all object behavior forms into an extra sub-category – the behavior of merely continuously updating its state or content.

3. "Interactive objects", which generally represent the notion of a tool or instrument; they either produce an output as a response to a given input, execute actions on direct user commands (e.g., a remote control), or act as vehicles, which means that the user directly controls their movement (with or without the user's avatar on it) by using the primary navigation controls.

The border between automated and interactive objects may seem fuzzy at first, but it is clearly delineated by whether a user deliberately triggers an object to act or not. This classification does not aim to be formally mutually exclusive; rather, it is meant to be applied as a means of structuring and formalizing objects by their primary function or characteristic in the particular collaboration pattern in which they occur. Table 2 overviews this two-level classification of virtual objects

Considering alternative classification properties; for example, an object's size, whether the object can be entered or not, whether the object follows physical laws (e.g., moving in the wind), is, in our belief, of secondary importance – especially for the use cases we try to support with our contribution (i.e., collaboration tasks).

Table 2. Two-Level Classification of Objects in Virtual Worlds

Category	Subcategory	Description	Specific examples
Static objects	Fixed	Objects that are fixed and not meant to be moved	Statues, symbols, buildings, most furniture, static plants and trees
	Portable	Objects that are portable and meant to be picked up and carried around	Flags, name tags, distinctive marks, symbols, teddy bears
Automated objects	Update state	Objects that update their state over time or through external sources	Visitor counters, calendars, weather displays, webcam images
	Execute animation	Objects that execute pre-defined animations (navigate or manipulate)	Machines, clocks, drifting or growing plants, animals, animated plays
	Follow behavior	Objects that act according to given behavior rules and react to events	Robots and chatbots, complex plants and animals, non-player characters
Interactive objects	Input / output	Objects that produce an output to discrete user input	Text and voice translators, calculators, web browsers, photo booths
	Tools, instruments	Objects that execute actions as direct translation of user input	Remote controls, gadgets, weapons, chainsaws, machetes, fishing rods
	Vehicles	Objects that move as direct trans-lation of user navigation control	Cars, airplanes, helicopters, boats, unicycles, flying carpets, parachutes

3.5. A Blueprint for Avatar-Based Collaboration

The ABC framework supports and fosters the development of innovative collaboration patterns for virtual worlds by providing a formalization that connects the distinct features of the medium (the infrastructure) with specific collaboration and learning goals in given contexts. To establish this connection, it provides a dramaturgy layer that adds semantic values to the syntactic elements of the medium (i.e., available actions and objects), which defines macro-actions, settings, roles, steps, timing, and so on.

Figure 1 illustrates the framework for avatar-based collaboration based on the distinctions described in the previous sections. It is intended as a blueprint for embodied collaboration in virtual environments. As such, it can be used as a basis to develop or describe collaboration patterns in virtual worlds such as Second Life or OpenSim. Its three-tier architecture reflects the syntactic, semantic, and pragmatic level of a collaboration medium, which Section 3.2 discusses. In Section 3.5.1 to Section 3.5.3, we explain the parts of the framework in top-down order.

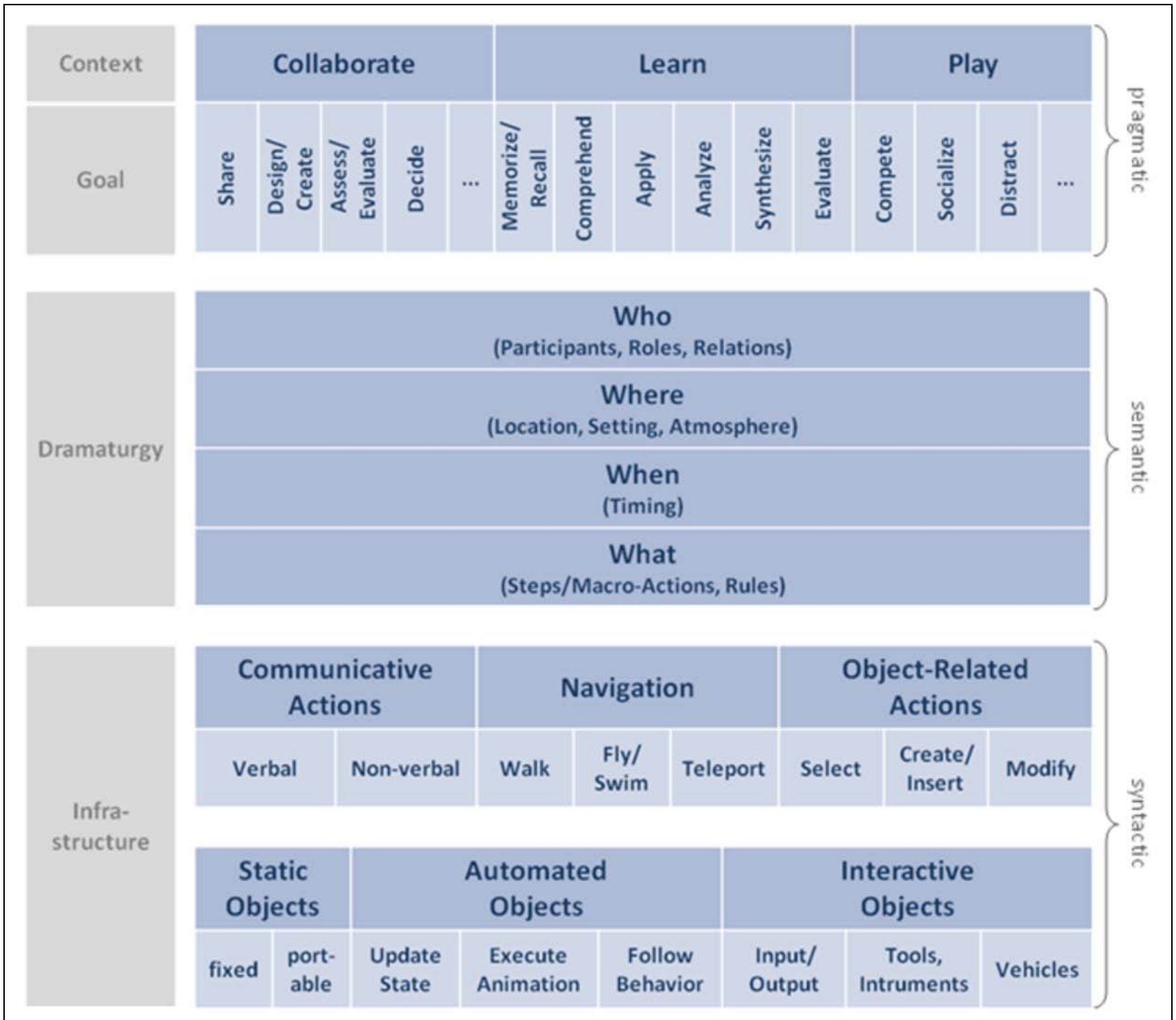

Figure 1. The Avatar-Based Collaboration Framework

3.5.1. Context and Goal

The context describes the application domain of a collaboration pattern, while the goal more specifically defines what kind of activity a pattern aims to support. A first category comprises patterns that aim for collaborative work in the traditional sense; that is, having main goals such as sharing information or knowledge; collaboratively designing or creating a draft, a product, or a plan; assessing or evaluating data or options; making decisions; and so on. Because these goals do not necessarily have to be associated with work in the narrow sense of the word, we label the first context category "collaborate". The category "'earn" frames the domain of education. We assigned six goals, selected according to Bloom's taxonomy of educational objectives (1956), to it. Bloom distinguishes between different levels of learning goals starting with the simple (e.g., memorizing or recalling information) to the more complex (e.g., comprehending, applying knowledge, analyzing, synthesizing or even evaluating new knowledge regarding its limitations or risks). We classify the category "play" into game-oriented goals such as competition, socializing, forming relationships, and distraction. This integrates both Yee's (2007) three main motivation components (achievement, social, and immersion) and Caillois' (1962) four fundamental categories of play (competitive play – Agôn, chance-based play – Alea, role-playing and make-believe play – Mimicry, and playing with the physical sensation of vertigo – Ilinx). We deemed the chance-based play and vertigo categories less important for the formalization of goal-driven collaboration patterns and thus left them out of the main categories we included in the framework. For both the collaborate and play contexts, we included a wildcard category for the user to add their goals.

3.5.2. Dramaturgy

Goffman (1959) first adapted the term dramaturgy, which describes a construct in which all interpersonal behaviors, rules, and activities are orchestrated, into sociology from theatre. He explained social interactions using a theatre metaphor. The sociological perspective of symbolic interactionism, in which dramaturgy is embedded, is closely related to semiotics (Denzin, 1987). Thus, dramaturgy fits perfectly into the ABC framework because it designates the way in which the infrastructure in the virtual world is used to reach a specific collaboration goal or, in other words, support a group task. It comprises the necessary participants and their roles and relations (the “who”), the participants’ interaction spaces and repertoire (the “where”), and the timing and sequencing of the participants’ interactions (the “when”). The dramaturgy also specifies the participants’ actions (the “what”) and the social norms and rules they should follow in a given collaboration pattern. While the goals and contexts specify the why of a collaboration pattern, and the infrastructure specifies the how, the dramaturgy consequently addresses the who, where, when and what of purpose-driven online interactions. The dramaturgy defines in which ways the participants can use the infrastructure of a virtual world to achieve a common goal.

3.5.3. Infrastructure

The final, most basic level of the blueprint contains the previously discussed elements actions and objects. In Sections 3.3 and 3.4, we discuss the categorization of action and interaction into communicative, navigational, and object-related actions, and, in particular, the categorization of virtual objects into static, automated, and interactive virtual objects (categories).

In Section 3.1, we define a collaboration pattern as being a set of tools, techniques, behaviors, and activities for people who meet at a place to work together in a group or community toward a common goal. This translates to a set of objects, actions, rules, and steps for participants with roles who meet at a location to collaborate on a common goal in a given context. A specific collaboration pattern is then an instance of the framework, and can be defined using the parameters positioned in the framework.

There are two distinct ways in which the above blueprint can be used to create collaboration patterns. First, it can be used in a top-down manner from goal to infrastructure in order to specify how a given goal can be achieved using an online 3D virtual environment. Here, the given context(s) and the goal(s) of the pattern are specified, the dramaturgy is developed, and the required actions and objects are filled in (in that order). Alternatively, the blueprint can be used bottom-up in order to explore how an existing virtual world infrastructure can enable innovative dramaturgies that help achieve a certain collaboration (or learning) goal. Using this approach, existing objects and available actions are filled in, a dramaturgy is developed, and the goal(s) and the context(s) is/are specified (in that order). The bottom-up approach seems more feasible for situations where a virtual world that includes objects and tools is already available (or for situations where virtual world developers and 3D modelers to create infrastructure are unavailable), while the top-down approach may be better for creating collaboration patterns when specific goals are to be achieved (or developers and modelers are available to create new content and functionality). The top-down and bottom-up approaches can also be mixed or used in combination or succession as an iterative development process.

We do not strive for mutually exclusive and collectively exhaustive categories in the framework – the categories are meant to serve as a structure to describe and develop collaboration patterns rather than to provide an entirely unambiguous way of formalizing collaboration patterns.

The case study in the next section illustrates the application of the ABC framework in more detail, and also illustrates the advantages and difficulties in using it to develop collaboration tasks and, in this case, collaborative learning exercises.

4. Case Study: Designing Collaborative Learning Experiences for the ShanghAI Lectures

As a first use case, the ABC framework was deployed in 2009 and 2010 to develop a dozen exercises for a 3D virtual world that would accompany a global series of lectures on natural, artificial, and embodied intelligence (the ShanghAI Lectures). This section describes the entire process from the ideation of collaborative learning patterns in the given context to the output of specific requirements to 3D designers and modelers, and virtual world developers and scripters.

4.1. The ShanghAI Lectures

The ShanghAI Lectures (http://shanghailectures.org) is a cross-reality global teaching and international student collaboration project. Its core components are a lecture series on natural, artificial, and embodied intelligence (presented by Professor Rolf Pfeifer, director of the Artificial Intelligence Lab at the University of Zurich), and exercise assignments for multicultural student teams from all over the world. The lectures are broadcasted via video-conference. In both the first and the second year of the project, approximately 300 students collaborated in self-managed global virtual teams on weekly group assignments, viewed video-recorded lectures and expert talks together, and met online with their peers and tutors while avatars in a virtual world. As an environment for working and socializing, we created UNIworld, which builds on the virtual world platform Open Wonderland (open-source, independent software formerly developed by Sun Microsystems). Open Wonderland enables users (or virtual world designers/administrators/hosts) to customize the virtual environment's design, and offers collaboration features such as shared applications, the extension of communication tools, and the implementation of tailored extensions, such as authentication schemes and social features. Further, we chose to create a second virtual environment, ShanghAI Island, with OpenSim (open-source software that came out of the Second Life platform). The idea behind this was for the students to "travel" to a virtual seminar location twice in the semester in order to work on additional exercises for extra credits. For the project, it was an option to test a virtual world platform different from Open Wonderland.

4.2. Main Development Task and Key Challenges

The fact that students from all around the world worked together in small teams for the exercises of the ShanghAI Lectures, and the fact that a virtual world was chosen as the single place to facilitate and foster this intercultural collaborative learning, made it a compelling case to investigate.

The main development task was to create an appropriate number of exercises about the contents of the lecture series for teams of students to work on together. These exercises heavily influenced the architectural design because they constitute the key activity in UNIworld. UNIworld's final design was created around team "arenas": team rooms that facilitate collaborative work in a private setting. In total, we developed 13 virtual world exercises to accompany seven lectures over the whole semester. With many of the students being first-time virtual world users, the first exercise needed to serve as a virtual world training task to make the students familiar with navigating, communicating, and interacting with tools in UNIworld. However, a second exercise not related to the topic of the lecture was required. Thus, we created a team-building task with all the students (from 23 different universities) assigned to a different teams. We developed the eleven remaining exercises on the contents of the lectures.

Key challenges in the development of the exercises were to transfer exercises that accompanied an earlier (traditional) version of the same lecture from their paper-based form to a format for use in a virtual world to harness the distinct features of the medium. The decision to deploy a virtual world as an environment in which to conduct the exercises had come out of the thought of illustrating embodied intelligence in a more comprehensible way than having exercises solely on paper sheets or flat web pages. After we achieved this, however, problems concerning the virtual world platform that had been chosen arose. For instance, the virtual world did not have the promised functionality, we could not hire additional developers to solve this problem, the platform developers could not guarantee the system stability in general. As such, we fundamentally modified the already developed collaboration patterns for the exercises to use less-interactive tools (or none at all) – which meant that the virtual world decreased in quality and originality than was originally planned for. Eventually, we decided to include a second virtual world in order to host additional exercises in a “remote” location. This, however, added an additional key challenge: we had to modify/redesign the collaboration patterns for the additional exercises so that the environment was a place to work on the current exercise and not a place to socialize or have a team venue. We finally had to design this second virtual world, and the exercises in it, as sort of a seminar getaway.

4.3. Approach and Design Process

The main source of information and contextual input to the design of the collaboration patterns for the exercises were: the lecture slides of an earlier (face-to-face) version of the lecture series, the (paper-based) exercise sheets to that lecture, and further contextual information about the domain and the contents of the lecture in form of a textbook that served as a basis for the lecture. As a source of inspiration for the development of innovative dramaturgies for the collaboration patterns, we used data from previous research; that is, virtual world collaboration pattern descriptions from an exploratory investigation in Second Life (see Schmeil & Eppler, 2009). Combining these two input sources eventually led to novel ideas and innovative patterns for exercises to accompany the lecture series in the ShanghAI Lectures. The design process was not entirely defined at the beginning of the project but rather evolved during this first application of the ABC framework. We describe how it unfolds in the following paragraphs (and three example patterns are illustrated in the appendix).

As a first step for the development of a pattern, context(s) and goal(s) are specified roughly. The respective fields are filled with keywords or brief descriptions of the specific goals (note: a pattern can by all means address more than one goal in more than one context). Then, the designated procedure of the exercise in an initial rough form is drafted into the agenda section of the dramaturgy layer; this is the start of the first essentially creative part of the pattern creation. Using the rough idea as a scaffold, existing patterns and other sources are used as inspiration to ideate a dramaturgy for the exercise. While the dramaturgy layer gets filled in, single action and object elements are added in the infrastructure layer whenever their requirement for any of the sections in the dramaturgy becomes apparent. Single fields in the actions and objects categories in the infrastructure layer are filled in with brief descriptions or explanatory keywords. When the upper parts of the dramaturgy layer are completed, the agenda and the context/goals sections are updated for the last time if required. As a final step, with the context(s), goal(s), and the entire pattern in mind, the infrastructure layer is traversed section by section and field by field with the aim to discover whether or not any additional actions or objects can be deployed for the pattern to make it more engaging or exciting. This step is done with the thought to use the distinct features and capabilities of the medium. Whenever any amendments or modifications are made during this traversal, any affected sections in other parts of the framework are updated (and those are in turn affected by that update, and so on).

The fully completed formalization of a collaboration pattern is then used to deduct requirements for 3D modelers (or architects), virtual world designers, and developers/scripters. These are outlined as notes at the right edge of the framework sheet or formalized and given out on separate documents.

4.4. Implementation

Table 3 lists the final 13 exercises that we developed. Note that, due to the lack of functionality and stability of Open Wonderland as a virtual world platform and the lack of dedicated virtual world programmers and scripters in the ShanghAI Lectures project, we had to modify a number of exercises in order to implement them.

Table 3. The 13 Collaboration Patterns That Were Developed for the ShanghAI Lectures 2010

Exercise name	Description	Comments
WL tutorial (WL)	This “first contact with Wonderland” exercise teaches the students basic WL functionality, such as navigation, camera control, communication, and the use of different tools. Tasks and instructions are provided along a path in-world.	Individual exercise; basic tutorial
Design team room (WL)	The student teams work together to furniture their team room in order to make it unique, to feel like home, and to convey the spirit of the team in the room’s design. Ideally, the team rooms should look different from each other also from the outside. Drag & drop import of 3D objects from the 3D model library Google Warehouse is supported.	Team-building exercise
Embodied memory (WL)	Students stand in front of a four-point path and have to point in given directions. After, they move on the four-point path and have to point in the same directions again, now being turned by moving on the four-point path. Students should learn to orient themselves in this exercise.	
Anticipate robot behavior (WL)	After receiving a robot design (as images in WL), the student team has to anticipate how the robot will behave in certain situations. The situations are provided as images as well; for example, a parcours the robot is (imaginatively) put into. The students use a whiteboard and a sticky notes board to put together their solution; alternatively, they could be asked to perform a sort of role play for their tutor as a more active solution.	Exercise simplified for use of whiteboard
Redesign robots (WL)	Student teams are shown videos (or schematic designs) of robots that are not designed perfectly. For each video, they discuss the robot with their group and develop a redesign of that robot that is supposed to overcome the flaws and shortcomings that the students discover with the original design. Whiteboard and sticky notes are used for this exercise.	Exercise simplified for use of whiteboard
Experience situatedness (OS)	The student team mounts a robot. The robot starts driving around in a parcours to show behavior typical for its model/type. The students get a situated experience, a “first-person view”. After the performance, the students get off the robot and walk up a hill to watch the robot behave again, now as spectators from outside. They discuss the differences between the two experiences. With all this fresh in mind, they log out of OpenSim and get back to their team room in UNIworld, where they write down their comparison on a sticky note board.	
Tag and annotate videos and images (WL)	In this exercise, student teams are asked to watch videos and images, discuss each of them, and write down notes, comments, or comparisons on a sticky note board (or sketch something on a whiteboard). This is rather a scaffold for an exercise – content is fairly open here.	Exercise simplified for use of whiteboard

Table 3. The 13 Collaboration Patterns That Were Developed for the ShanghAI Lectures 2010 (cont.)

Exercise name	Description	Comments
Which robot am I? (OS)	The student team watches a robot behave/move/act in an arena (a parcours) and guesses which kind of robot it is (the performing robot is initially “cloaked”: the team cannot tell what robot it is by appearance). After the student team comes to an agreement and makes their guess, the robot reveals its identity by “decloaking” itself to illustrate whether or not the team’s guess was correct. This is done for several robots. The student team makes their decision by “voting by feet”; that is, by moving their avatars to robot prototypes (an agreement is made when all team members have moved to the same robot).	
Anticipate self-assembly (WL)	After obtaining a design of a self-assembly robot (as images in WL), the student team has to anticipate how the robot would self-assemble. The student team uses a whiteboard and sticky notes board to put together their solution.	Exercise simplified for use of whiteboard
Categorize robots in framework (WL)	On a whiteboard with a framework as background image that allows categorizing robots according to different classifications, the student team marks the different robots they encounter during this exercise (robots can wait along a path, drive by, or simply park in a line).	Exercise simplified; not realized
Robot colorization (WL)	The student team walks along a path on which (single-colored) robots are aligned. For each robot, the students have to colorize, according to a given categorization (e.g. sensors – actuators), its parts. This can be repeated for several robots and for different categorizations per robot.	Exercise simplified; not realized
Robot pantomime / role play (WL / OS)	Each student team designs and practices a choreography to illustrate typical behavior of a particular swarm of robots. One after another, the teams perform their play on stage in front of the other teams. The other teams have to guess what swarm or what swarm situation is illustrated.	Not realized
Develop own virtual world exercise	The student teams ideate and formalize their own virtual world exercise by making use of their experience in the virtual world and choosing any content of the lecture as a contextual input.	Not realized

In Section 4.4.1 to Section 4.4.3, we describe three of these 13 exercises as examples of innovative collaboration patterns in detail. We focus on the features of the medium that the particular exercises use. The appendix shows these three collaboration patterns in the ABC framework’s structure.

4.4.1. Experience Situatedness

This exercise demonstrates situatedness for the students. Using a 3D virtual world with an orchestrated immersive experience, this exercise illustrates not only the meaning, but also the feel, of situatedness. To this extent, students experience both a first-person and a third-person view of the same robot movement, and are asked to directly compare the two. In order to make the experience a memorable (and hopefully an exciting) one, the exercise harnesses the virtual world features of immersion and spatiality (the sensation of sitting on a ”real” robot while it moves around on a parcours). This would be difficult to deliver in a face-to-face setting (and close to impossible with hundreds of globally dispersed students), while videos of first-person and third-person views of a robot would lack the interactive character of the experience.

4.4.2. Which Robot Am I?

This exercise one of a couple of exercises on robot behavior and artificial intelligence. It has a game-like character, and incorporates interactive elements and a responsive environment. Thus, it harnesses the feature of a virtual world allowing for an extensively configurable and scriptable environment that can support and foster collaboration and increase engagement. Among other sources, we were inspired by a children's TV show (for the voting-by-feet part, see Table 3) to develop a fun activity and an overall enjoyable experience for the students. Furthermore, the decloaking effect (see Table 3) gives memorable immediate feedback to the student team's decisions, and the fact that the virtual world automatically sends an email containing the team's results for the exercise to their respective tutor demonstrates the interoperability of the medium.

4.4.3. Anticipate Robot Behavior (+ Robot Pantomime / Role Play)

This exercise requires the student teams to synthesize their knowledge in order to develop a performance about robot behavior. They deliver embodied experiences to their respective tutors, who profit by both orchestrating the performance and by participating in it as robots. Moreover, the exercise emphasizes collaboration on various levels, which requires the students to work together as a team to both stage and delivere their performances. This exercise integrates influences of the robot pantomime / role play exercise, which itself was not implemented.

4.5. Discussion of Findings and Experiences from this first Use Case

First, we note that the author of the case study was also this paper's first author, and thus not a neutral user of the ABC framework because he was heavily involved in its development in the first place. In the application of the framework – the ideation and development of the 13 exercises – up to nine people were involved. Three of the main users of the framework read this case study description and judged it as authentic and representative; as such, this should sufficiently prove that any positive bias of the main author was limited.

Comments from users and other involved people on the framework were generally positive, but also pointed out some shortcomings that should be looked at in future modifications and iterations of the framework.

On the positive side, we found that the framework helped harness the distinct features of virtual worlds in order to develop more engaging ways of collaborating and learning together. Indeed, breaking down the infrastructure of virtual worlds does seem to foster innovative thinking. Having a pool of options for possible actions and objects in the virtual environment to pick from invites different combinations. Innovation and "thinking outside the box" is fostered by not forcing the combinations to adhere to any rules; any combination of actions and objects can be constructed with the framework and consequentially implemented in a virtual environment. The fact that virtual worlds do not have to adhere to actual-world physics and other (logical) limitations is an enormous advantage that can be made use of already in the design of collaboration patterns. These novel patterns are then likely to result in more innovative uses of the virtual worlds medium and thus in engaging and memorable experiences. The framework also seemed to ensure that the collaboration designer does not overlook any options the medium offers to support engagement and interaction. This can be an important aspect for people with non-technical backgrounds because they understand what is possible in virtual worlds by merely looking at the laid out infrastructure in the framework. This allows non-technical collaboration designers – or those new to virtual worlds – to include even the most complex objects and actions in their patterns, which might pose challenges to scripters and modelers. We deliberately suppressed a distinction between infrastructure elements that are easy to realize and those that are more complex to realize in the development of the ABC framework. The framework focuses on the resulting experience, instead of emphasizing the potential difficulty in implementing certain elements. This approach is fortified by considering that we conceived it as a structure for all kinds of virtual worlds instead of for one specific platform. We also considered the framework as a checklist, which returns to the point of not forgetting to use distinct features of the medium that one might not think of when, for example, they design for a virtual world for the first time. Following a structure in the process of designing is beneficial for the design outcome. If that was not the case, fields like design science would not even exist (Fuller & McHale, 1963), and design would not have principles (Suh, 1990). The formalization offered with the ABC framework helps designers structure their ideas and supports the creators from initial thought to implementation. In this sense, following a structure gives much more guidance than writing continuous descriptive text. One point we made sure to consider is that the structure must be open enough not to constrain the designers in their design thinking process in any way, but rather provide a space for them to organize their thoughts.

Another point the first users of the framework raised was that the framework serves as a tool for fast-prototyping, especially in combination with existing collaboration patterns (e.g., from actual-world classes, from face-to-face collaboration meeting agendas, from games) that provide inspiration and guidance. Having an idea of the process (i.e., the agenda and the major steps) that the pattern to design should implement is already a big step in the total design. This is because the black boxof dramaturgy, so to speak, is arguably the most difficult part in the pattern creation process – it requires most creativity and design thinking. With an already existing idea of the resulting pattern, the central part in the dramaturgy (i.e., the what part) can be completed in a short amount of time, and the infrastructure parts can be filled in following the idea, which transfers the pattern to the medium of virtual words and uses the medium’s features.

Feedback from students who worked on the exercises created for the ShanghAI Lectures was positive – they considered moving, interacting, and exploring in a virtual environment to bea great addition to traditional distance-based learning. This provides proof that the emphasis on using the medium’s specific capabilities, its distinct features, bears fruit. This is an important point because students – or any other type of younger clients – have become critical with regards to technology. They are quick to say “you could do much more with this technology” and expect the latest functionality to be put to best use in order to be satisfied with the product or service (or class) offered. To this end, the focus on using the distinct features of virtual worlds, an aspect we cannot stress enough, was key in the development of the framework.

On the negative side, users’ most notable point was that there was no description of where to start and how to go through the framework (for first use); that is, they mentioned that a path to guide first-time users through the framework would be a valuable addition. Here, future research could provide insight on how to best design patterns. For example, a controlled experiment could be designed that compares the process and outcome of one group of designers who use the framework top-down and another group who use it bottom-up. While the developer or designer of a pattern naturally can read and remember their own created patterns without a problem, a person not involved in the development of a pattern might have difficulties understanding it. Guidelines for how to fill in the different sections to make patterns comprehensive for others might help resolve this issue, and might also support the collaborative design of patterns. Other comments were that the process of constructing the output for 3D modelers and virtual world developers and scripters is not structured at all and that there is no option to connect the content to the patterns. This concerns the lack of standards of virtual-world objects and designs. Today, there are many different virtual0world platforms on the market, but efforts to agree on a common standard that would enable the transport of objects or even avatars from one world to another have not yet yielded any mentionable results. Apparently, the technology is still too young for cross-platform standards to emerge. The current policy of virtual world creators and providers is rather to develop and refine their proprietary systems and to secure the biggest possible market share. Open-source platforms have emerged and have a growing user base but are still small compared to the big player in the genre, Second Life.

5. Conclusion and Future Research Directions

In this paper, we present the ABC framework, a systematic framework that organizes the necessary elements for the design and implementation of collaboration patterns in virtual worlds. The framework is based on three layers – that is, the pragmatic or contextual layer, which includes the goals of an online interaction; the semantic or dramaturgic layer, which defines how elements and actions are used (and interpreted) in time to achieve the collaboration goal; and the syntactic or infrastructure layer, which comprises the actual objects and (inter)actions that are combined to implement a collaboration dramaturgy. We present a first case study to describe an application of the framework that covered the whole process of developing collaboration patterns, showcase a list of 13 exercises that were developed for a global education project, and describe three of these instantiation in more detail.

The first use case indicates that the ABC framework supports the design of novel collaboration patterns and the realization of innovative ideas in terms of collaboration activities, settings, or technological support. Through providing a blueprint, non-designers are also able to create environments and dramaturgies in them that yield fruitful, engaging, and memorable collaboration experiences. The ABC framework was designed (and found) to be self-explanatory for the description and development of patterns and comes ready to use without any necessary training. On the other hand, users asked for indications of how to use the ABC framework for the design of collaboration experiences, and an associated design method would be a valuable addition to the ABC framework. We discuss these and other points raised by the ABC framework's first users and the resulting critical insights that the ABC framework offers.

A next step in our research will be a formal evaluation of the framework against a set of clear criteria that include validity, completeness, usefulness or meaningfulness, and ease of use. Continuing to follow the iterative cycle of design-science research, our subsequent steps will be to integrate the findings and experiences from the first use case and the evaluation in a refinement (or a redesign) of the framework and possible extensions to it. Following the DSR cycle, the framework is subject to perpetual change in ongoing design iterations. As the medium of virtual worlds develops and matures – and is accepted by a broader subset of the general public – the infrastructure of the medium will change (due to technological advancements), priorities and preferences in terms of how to design collaborative activities will change (affecting the semantics of virtual world elements). Moreover, societal change may demand modifications (concerning the pragmatics) of the design framework and method.

Having established a systematic map of the elements required to devise and implement innovative and engaging collaboration patterns, two questions remain. The first concerns which patterns are more effective than others in terms of their benefit in supporting knowledge-intensive collaboration tasks in groups. The second concerns which aspects of designing collaboration patterns support the intended goals better than others. To this end, we are conducting controlled experiments in order to empirically investigate which aspects and factors of virtual world collaboration patterns and designs are beneficial for process and outcome of collaboration in virtual worlds. In their paper "Beyond being there", authors Hollan & Stornetta (1992) consider whether or not environments can be created that offer a higher richness than when physically "being there" with others in a face-to-face setting. We believe it could be possible soon if we change the goal we are aiming for from trying to best simulate the actual world and face-to-face interaction to best using of the distinct features of the environment at hand. Regarding specific categories, different media offer different possibilities and can thus surpass plain face-to-face interaction in media richness.. Investigating the power of online virtual worlds by evaluating different design approaches is one line of research we are pursuing.

Another research direction is to further evaluate the framework against criteria such as performance, effectiveness, human effort, scalability, integration, and compatibility. This leads toward two different investigations. The first compares the ABC framework to other design techniques and frameworks, and the second addresses whether this semiotics-based approach for designing for collaboration experiences can be extended or transferred to support other digital and digitally-augmented environments (e.g., pervasive and ubiquitous computing, augmented reality, web-based collaboration and distance learning, and physical technology-enhanced learning environments).

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Appendix. Collaboration Patterns Developed Using the ABC Framework

Goal/Context

Collaborate				Learn						Play				
Share	Decide	Design/ Create		Memorize/ Recall	Compre-hend	Apply	Analyze	Synthesize	Evaluate	Enjoy	Challenge	Socialize	Distract	
						Sketch, draw, dramatize		Hypotesize						

Dramaturgy

Who

PARTICIPANTS	ACTORS	ROLES	RELATIONS
• Team of 4-5 students			

Where

LOCATION	SETTING	ATMOSPHERE
Team arena	Screens with robot designs along a path, with one whiteboard each	

When

DATE	TIMING

What

AGENDA

I. Discussion of case
II. Cartoon development

STEPS / MACRO-ACTIONS

1. Student team gets a robot design (or walks to a board displaying it)
2. They discuss and take notes of how the robot would behave in a given situation (eg. on the provided sticky notes board)
3. They stage a short performance for one or more members of the team to deliver to the tutor at the next tutor meeting
4. The tutor assesses the performance and gives feedback
5. [Repeat 1-4] for more robots

RULES

Infrastructure

Communicative Actions		Navigation			Object-Related Actions		
Verbal	Non-verbal	Walk	Fly / Swim	Teleport	Select	Create / Insert	Transform
• Discuss the robot design		• Simulate robot behavior					• (move the obstacles to demonstrate movement?)

Static Objects		Automated Objects			Interactive Objects		
Fixed	Portable	Update State	Execute Animation	Follow Behavior	Input/Output	Tools, Instruments	Vehicles
• Designs of robots (on screens?) • Obstacles			• (Robot design and whiteboards move away after work on them is finished?)			• Whiteboard with several frames → cartoon • Also noteboard?	

Figure 2. Anticipate Robot Behavior (Robot Pantomime / Role Play)

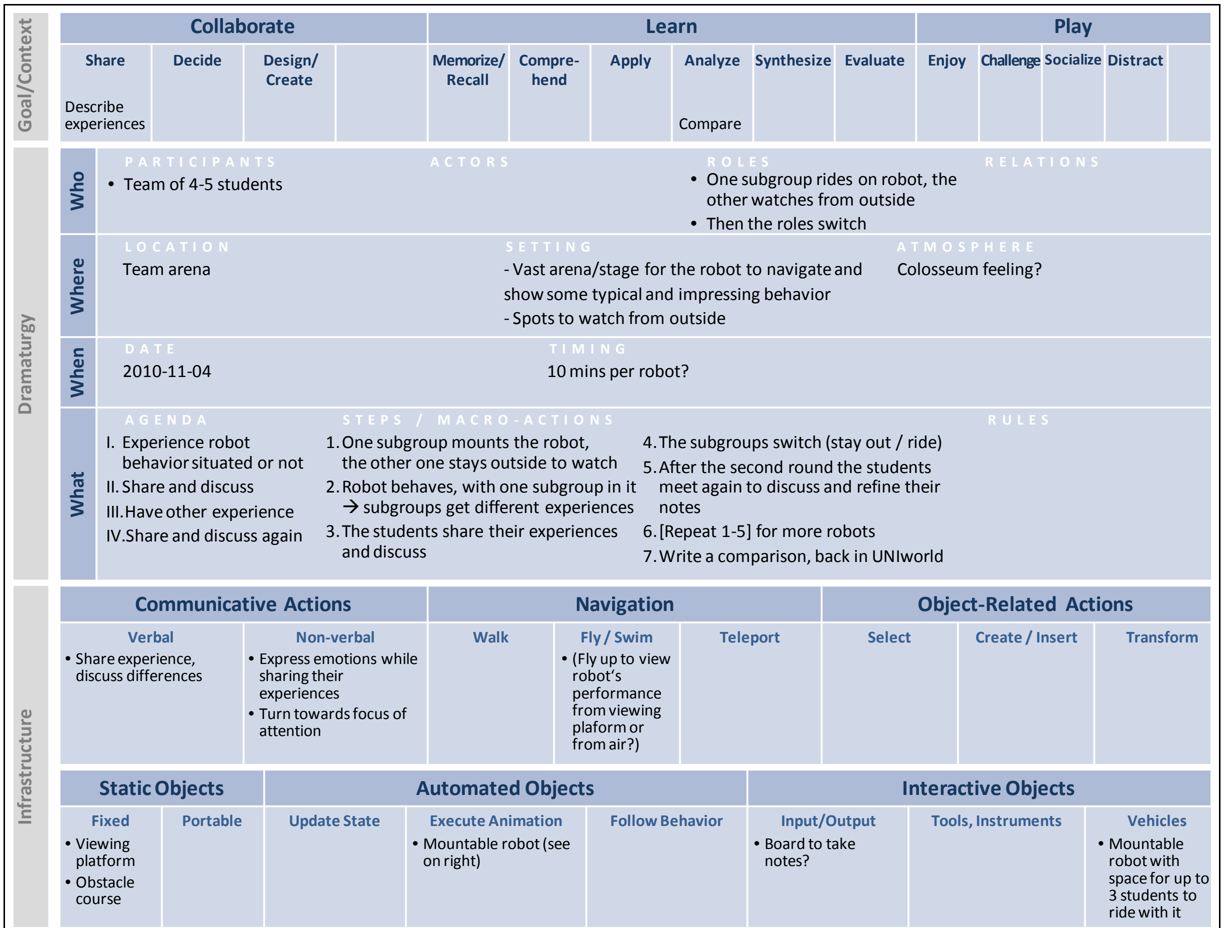

Figure 3. Experience Situatedness

Goal/Context

Collaborate				Learn						Play				
Share	Decide	Design/ Create		Memorize/ Recall	Compre-hend	Apply	Analyze	Synthesize	Evaluate	Enjoy	Challenge	Socialize	Distract	
	Agree on an answer				Match, explain		Identify, differentiate							

Dramaturgy

Who	PARTICIPANTS • Team of 5 students	ACTORS	ROLES	RELATIONS
Where	LOCATION	SETTING Robot acting arena: course with obstacles , on which robots perform / show their behavior Robot selection area: a place (circle arc?) where robots stand ‚in line' to be selected by the team	ATMOSPHERE Automated world. Robots feel when you are about to select them and come closer (reacting to proximity) // Confrontation	
When	DATE	TIMING		
What	AGENDA	STEPS / MACRO-ACTIONS 1. Cloaked robot performs in acting arena 2. Students discuss and make a choice positioning themselves between the robots in the selection area → robots move towards student team, one of them is selected 3. Behaving cloaked robot from acting arena and the selected one meet → decloak → either unite or not 4. [Repeat 1-3] for more robots	RULES	

Infrastructure

Communicative Actions		Navigation			Object-Related Actions		
Verbal	Non-verbal	Walk	Fly / Swim	Teleport	Select	Create / Insert	Transform
• Discuss		• Students get closer to robots to make them feel proximity and come closer					

Static Objects		Automated Objects			Interactive Objects		
Fixed	Portable	Update State	Execute Animation	Follow Behavior	Input/Output	Tools, Instruments	Vehicles
• Robots for the students to make their choice („1, 2, oder 3")			• Robots that execute their typical behavior	• Robots come closer when approached			

Figure 4. Which Robot Am I?

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